GPM103: NUMERICAL METHODS AND COMPUTER PROGRAMMING   Credits: 4

1. Numerical Methods: Solution of algebraic and transcendental equations, bisection and Newton-Raphson methods, solution of simultaneous linear equations, matrix inversion method, interpolation, Newton and Lagrange formula, numerical differentiation, numerical integration, Simpson, trapezoidal and Gaussian quadrature methods, least square curve fitting, straight line and polynomial fits, numerical solution of ordinary differential equation, Euler and Runga-Kutta methods, finite difference methods.
2. Computer Programming: Low level and high level languages, overview of compilers, interpreters and operating systems, problem solving on a computer, algorithms and flow charts integer and floating point arithmetic, Fortran preliminaries, constants, variables, data types and expressions, built in functions, executable and non-executable statements assignment, control and input /output statements, subroutines and functions, operations with files.

Suggested Books:
1. Sastry: Introductory Methods of Numerical Analysis
2. Jain, Iyengar & Jain: Numerical Methods for Scientific and Engineering Computation
3. Raja Raman: Numerical Analysis
4. Raja Raman: Fundamentals of Computers
5. Raja Raman: Fortran Programming
6. Ram Kumar: Programming with Fortran 77

GPM104: PRACTICAL BADED ON COURSE GPM101   Credits: 2

1. Clinometer compass and its use for determination of dip and strike of different beds.
2. Geological problems on slope, dip and thickness of the beds.
3. Drawing of geological sections of the given maps.
4. Study of the physical properties pf rock forming minerals (given in theory syllabus).
5. Megascopic study of rocks given in theory syllabus.

GPM105: PRACTICAL BADED ON COURSE GPM102   Credits: 2

1. Familiarization with meteorological instruments and record surface meteorological observations.
2. Study of surface weather and upper air codes.
3. Exercises in coding and decoding.
4. Exercises in plotting station models.

GPM106: PRACTICAL BADED ON COMPUTER PROGAMMING   Credits: 2

To write and execute computer programs in FORTRAN language for the following problems:

1. Solution of transcendental or polynomial equation by Newton Raphson methods.
2. Numerical integration using Simpson/Gaussian quadrature method.
3. Solution of first order differential equation using Runga-Kutta method.
4. Linear curve fitting and calculation of linear correlation coefficients.
5. Matrix inversion and solution of simultaneous equations.
6. Numerical first order differentiation of a given.

GPM107: EXCURSION AND TOUR REPORT   Credits: 2

During the first Semester, the students will be required to visit some geophysical establishments and laboratories in the country to acquaint themselves with various geophysical activities and submit the tour report to the tour In-charge. The visit may be arranged during the intra/inter Semester break.

GPM108M: FUNDAMENTALS OF METEORLOGY   Credits: 3

1. Composition and structure of the atmosphere.
2. Evaporation, condensation, fog, cloud, precipitation and thunderstorm.
3. Thermodynamic: Thermodynamic principles, properties of dry and moist air, adiabatic processes, hydrostatic stability and instability, parcel method.

4. Radiation: Solar and terrestrial radiation, definitions, laws of radiation, albedo, green house effect.
5. Local winds: Land and sea breezes, mountain and valley winds, anabatic and katabatic winds, foehn or Chinook.
6. Condensation, precipitation, air masses, front, jet stream, extra-tropical and tropical cyclones, western disturbances, anticyclones, tornado.
7. General Circulation of the Atmosphere: N.E. And S.W. Monsoon, seasons, climate and weather.

Suggested Books:
1. Byers: General Meteorology IV edition
2. Cole: Introduction to Meteorology
3. Pettersen: Introduction to Meteorology
4. Banerjee & Upadhyay: Mausam Vigyan
5. Lutgens & Tarbuck: The Atmosphere: An Introduction to Meteorology
6. Das: The Monsoon

SEMESTER-II

GPM201: GEOHYDROLOGY   Credits: 4

1. Hydrology cycle, origin of groundwater, subsurface distribution of water, springs.
2. Hydrology Properties of Water Bearing Materials: Porosity, void radio, permeability, transmissivity, storativity, specific yield, specific retention, diffusivity, laboratory methods of determination of permeability.
3. Mode of occurrence of groundwater , classification of rock with respect to their water bearing characteristics, aquifers, aquicludes, aquitards, classification of aquifers and groundwater provinces.
4. Movement of groundwater and aquifer performance tests, Darcy's law and its range of validity, theory of groundwater flow under steady and unsteady conditions, determination of permeability, transmissivity and storativity by discharging methods.
5. Precipitation, evaporation, evapotranspiration, seepage, infiltration and runoff.
6. Groundwater exploration, surface geological and geophysical methods of exploration, and subsurface geophysical methods.
7. Hydro-geochemistry: Physical and Chemical characteristics of groundwater, classification of groundwater in respect to domestic, irrigation and industrial use, pollution of groundwater.
8. Ground Water Exploration and Management: Natural and artificial recharge of groundwater, water balance, analysis of hydrograph, conjunctive and consumptive use of groundwater.

Suggested Books:
1. Worcester: A Text Book of Geomorphology
2. Todd: Groundwater Hydrology
3. Ward: Principles of Hydrology
4. Chow: Handbook of Applied Hydrology
5. Health & Trainer: Introduction to Groundwater Hydrology
6. Singh: Elements of Hydrology
7. Raghunath: Introduction to Hydrology
8. Tolman: Hydrology
9. Karanth: Development, Assessment and Management of Water Resources

GPM202: GEOEXPLORATION AND SURVEYING   Credits: 4

1. Basic principles of geophysical exploration.
2. Physical properties of minerals and rocks.
3. Gravity Method: Stable and unstable gravimeters, Worden, Lacoste and Romberg, Hartley Askania and Gulf gravimeters, field procedure and reduction gravity data.
4. Magnetic Method: Fluxgate and Proton Precession magnetometers. Anomalies due to point pole and dipole, field practices and corrections.
5. Electrical Method: Elements of SP,IP and resistivity methods, Wenner and Schlumberger configurations. Methods of resistivity profiling and sounding, theory of images, Tagg's method of interpretation.

6. Seismic Method: Elementary principle of reflection and refraction methods, two layered reflection and refraction problems including inclined layer, fundamentals of conventional seismic instruments, fan shooting, profile shooting, continuous profiling and correlation methods of surveying.
7. Radiometric Method: Physical and geological principles of radiometric method, successive disintegrations equilibrium conditions, GM counter, scintillation counter and gamma ray spectrometer, radon measurements.
8. Basic principles of electromagnetic and GPR methods.

Suggested Books:
1. Dobrin & Savit: Introduction to Geophysical Prospecting
2. Parasnis: Principle of Applied Geophysics
3. Telford et al : Applied Geophysics
4. Sharma: Geophysical Prospecting for Geologists and Engineers
5. Israel & Krebs : Nuclear Radiation in Geophysics

GPM203: STRATIGRAPHY, ECONOMIC & PETROLEUM GEOLOGY   Credits: 4

1. Stratigraphy: Principles of Stratigraphy, elements of stratigraphic classification; geological time scale. Basic concepts of sequence Stratigraphy and seismic stratigraphy Geophysical methods of stratigraphic correlation. Physical and structural divisions of Indian subcontinent and their characteristics. Classification, lithology and economic importance of the following: Dharwar supergroup of Karnataka, Cuddapah supergroup of Andhra Pradesh, Vindhyan Supergroup of Son valley, Gondwana Supergroup of peninsular India and Tertiary of Assam, Siwaliks of Himalaya.
2. Economic Geology: Definition of ore, ore mineral and gangue, Classification of ore deposits, Chemical composition, diagnostic characters, usages and distribution in India of the following metallic and non-metallic minerals: Haematite, magnetite, pyrolusite, psilomalane, chromite, ilmenite, wolframite, cassiterite, chalcopyrite, boronite, galena, sphelerite, pyrite, bauxite sulphur, graphite, gypsum, fluorite, barite, magnesite, dolomite, apatite, calcite, kyanite, sillimanite, beryl, muscovite, kaolinite, halite and talc.
3. Petroleum Geology: Origin of petroleum; source rocks; reservoir rocks; reservoir pore spaces; reservoir traps. Migration and accumulation of oil and gas. Geological modelling in petroleum exploration, Brief geological account of oil and gas fields in India: Assam, Gujarat, Tamil Nadu and Bombay Offshore.

Suggested Books:
1. Jensen and Bateman: Economic Geology
2. Krishna Swami: India's Mineral Resources
3. Sharma & Ram: Introduction to India's Economic Minerals
4. Levorsen: Geology of Petroleum
5. Evans & Mathur: Oil in India
6. Krishman: Geology of India and Burma
7. Wadia: Geology of India.
8. Ravindra Kumar: Historical geology and stratigraphy of India
9. U. Prasad: Economic geology.

GPM204: SOLID EARTH GEOPHYSICS   Credits: 4

1. History of development and scope of geophysics, monistic and dualistic hypotheses for the origin of solar system, Kepler's law of planetary motion, planet and satellites of the system and their characteristics, shape and size of the earth, international gravity formula and rotation of the earth. Concept of isostasy, Airy, Heiskanan and Pratt-Hayford hypotheses.
2. Internal constitution of the earth, characteristics of lithosphere, and asthenosphere, causes of geodynamical process, geodynamic models, continental drift. Ocean floor spreading, plate tectonics and its geological implications, new global tectonics and plate margin process, geomagnetic time scale, Benioff zones, oceanic ridges, evolution of the triple junction, trenches and island arcs, hot spots, geodynamics of Indian subcontinents and formation of Himalayas, 90^0 E ridge.
3. Origin of geomagnetic field, secular variations and westward drift, geomagnetic storms, Earth's current, sun spot, solar flares, lunar and solar variations, Palaeomagnetic studies of rock samples and their applications in geophysics, polar wandering, reversals of geomagnetic field.

4. Importance of heat flow, thermal history of the earth, sources of heat generation and temperature distribution inside the earth, Jacob's hypothesis for liquid nature of the outer core. Radiometric dating principles and ages of rocks and the earth.

Suggested Books:
1. Howell : Introduction to Geophysics
2. Stacey: Physics of the Earth
3. Gubbins: Seismology and Plate Tectonics
4. Condie: Plate Tectonics and Crustal Evolution
5. Lowrie: Fundamentals of Geophysics
6. Bird & Lacks: Plate Tectonics
7. Chapman: Earth's Magnetism
8. Jacobs: Core and Geomagnetism

GPM205: PRACTICAL BASED ON COURSE GPM201   Credits: 2

1. Determination of average rainfall.
2. Determination of evaporation and evapotranspiration.
3. Determination of storativity coefficient and transmissivity.
4. Determination of porosity and permeability.

GPM206: PRACTICAL BASED ON COURSE GPM202   Credits: 2

GEOEXPLORATION
1. Handing of gravimeter and magnetometer.
2. Interpretation of resistivity sounding data by Tagg's method.
3. Determination of velocities and depth of the interface by refraction method.

SURVEYING
1. Handling of surveying instruments- theodolite, dumpy-level, microptic alidade, electronic distance measuring devices, GPS.
2. Preparation of site map with the help of plane table.
3. Determination of height using theodolite.

GPM207: PRACTICAL BASED ON COURSE GPM203   Credits: 2

1. Preparation of lithostratigraphic maps of India showing distribution of Dharwar, Cuddapah, Vindhyan and Gondwana Super groups.
2. Study of about 15 rock specimens from the important stratigraphic horizons of India.
3. Study of mega-scopic characters of about 25 economic minerals.
4. Distribution of important mineral deposits of India.
5. Exercises on accumulation of oil and gas in different types of traps.
6. Distribution of important petroliferous basins of India.

GPM208M: GENERAL GEOPHYSICS   Credits: 3

1. History of development and scope of geophysics, monistic and dualistic hypotheses for the origin of solar system, Kepler's law of planetary motion, planet and satellites of the system and their characteristics, shape and size of the earth, international gravity formula and rotation of the earth. Concept of isostasy, Airy, Heiskanan and Pratt-Hayford hypotheses.
2. Internal constitution of the earth, continental drift, ocean floor spreading, plate tectonics and its geological implications, new global tectonics and plate margin process, oceanic ridges, trenches and island arcs, geodynamics of Indian subcontinents and formation of Himalayas.
3. Origin of geomagnetic field, polar wandering, secular variations and westward drift, geomagnetic storms, earth's current, sun spot, solar flares, lunar and solar variations, Fundamentals of palaeo-magnetic studies and palaeo-magnetism of rocks.

Suggested Books:
1. Howell: Introduction to Geophysics
2. Stacey: Physics of the Earth
3. Gubbins: Seismology and Plate Tectonics
4. Condie: Plate Tectonics and Crustal Evolution

5. Lowrie: Fundamentals of Geophysics
6. Bird & Lacks: Plate Tectonics
7. Chapman: Earth's Magnetism
8. Jacobs: Earth's Core and geomagnetism

SEMESTER-III

GPM301: SEISMOLOGY   Credits: 4

1. Introduction to earthquake phenomena, concept of focus, focal depth, epicentre, great Indian earthquakes, intensity and magnitude scales and energy of earthquakes, foreshocks and aftershocks, elastic rebound theory, seismicity of India, Himalayas and global seismicity, seismic zonation, seismic micro-zonation, seismic zoning of India, induced seismicity, concept of inhomogeneity and anisotropy, types and causes of earthquakes.
2. Seismic ray theory for spherically stratified earth and velocity structure from travel time data, propagation and characteristics of body waves, surface waves, group and phase velocities, different phases of body waves and their applications, preparation of preliminary reports and identification of phases, determination of epicentre, focal depth and magnitudes, theory of elasticity, reflection of body waves, focal mechanism solutions and tectonic implications, earthquake generation models, hazard analysis, reflection of seismic waves from the free surface.
3. Principle of electromagnetic seismograph, displacement meters, velocity meter, accelerometer and strain meter seismographs, WWSSN stations, seismic arrays for detection of nuclear explosions, wideband seismometry, strong motion seismograph.

   Suggested Books:
1. Richter: Elementary Seismology
2. Bullen & Bolt: An Introduction to the Theory of Seismology
3. Agrawal: Engineering Seismology
4. Gutenberg: Internal Constitution of the Earth
5. Rikitake: Earthquake Prediction
6. Bath: Introduction to Seismology
7. Slawomir & Andrezej: An introduction to Mining Seismology
8. Stein & Wysession: An Introduction to Seismology, Earthquakes and Earth structure

GPM302A: GEOELECTRICAL METHODS   Credits: 4

1. General: Electrical properties of rocks & minerals and their determinations, fundamentals of direct current flow, relationship between point and line pole potential distribution.
2. Measuring System: Quantities measured in various electrical methods and description of the instruments used, discussion of various configurations used in electrical method and field procedure adopted.
3. D.C. Resistivity Methods: Potential distribution at the surface of horizontally stratified earth, Kernel function and its relation to the subsurface parameters, apparent resistivity function, computation of apparent resistivity model curves, principle of digital linear filtering.
4. Vertical Electrical Sounding: Interpretation of resistivity VES data, empirical methods for interpretation of resistivity sounding data, indirect interpretation techniques, auxiliary point method, partial curve matching, complete curve matching, direct interpretation techniques, automatic direct interpretation method, Dar Zarrouk parameters, inversion techniques in resistivity method of interpretation, computer-aided resistivity data interpretation (softwares), principles of equivalence, suppression and detectibility problems, effects of deviations from the fundamental assumptions, electrical resistivity imaging.
5. Electrical Profiling: Profiling near a vertical contact and thin vertical dykes and discussion of the expected apparent resistivity curves.
6. Self Potential Method: Mechanism of SP field techniques, field due to vertically polarized sphere and interpretation.
7. Induced Polarized Method: Mechanism of IP instruments and principles of measurements both in time and frequency domain, interpretation of IP.
8. Other methods: Principles, application and interpretation of potential drop ratio method, equipotential lines method and telluric current methods.

   Suggested Books:
   1. Bhattacharya & Patra: D.C. Geoelectric Sounding: Principles and Interpretation
   2. Kuntez: Principles of Direct Current Resistivity Prospecting

3. Keller & Frischknecht: Electrical Methods in Geophysical Prospecting
4. Nostrand & Cook: Interpretation of Resistivity Data
5. Wait: Over-voltage Research and geophysical application
6. Koefoed: Geosounding Principe-I: Resistivity Sounding Measurements
7. Patra & Nath: Schlumberger Geoelectric Sounding in Ground Water
8. Ghosh: The Application of Linear Filter theory to the Direct Interpretation of Geoelectrical Resistivity Measurements

GPM302B: AGRICULTURAL METEOROLOGY   Credits: 4

1. Meaning and scope of agricultural meteorology, Intent and extent of agricultural meteorology, plant physiology, long term and short term modifications of growth process, avoidable and unavoidable dangers.
2. Agrometeorological observations: Air, surface and soil temperature, air and soil humidity, wind, precipitation, sunshine, radiation intensity and microclimatic measurements.
3. Solar Radiation and Plants: Reflection, transmission and absorption, incoming, outgoing and net radiation, Spectral distribution of solar radiation and physiological response to plants, Light distribution in canopy, Phototropism and Photoperiodism: Meteorological factors in photosynthesis.
4. Environmental Temperature and Plants: Effect of low and high ambient temperature, growing degree days and other heat indices, soil temperature and factors affecting them, thermal properties of soil, Cardinal temperatures, soil moisture and its measurement, weekly water balance, water use and plant growth, evaporation and evapotranspiration, wind effect on evapotranspiration, wind damage to plants, transportation of pollen disease and insects by winds, wind profile near ground.
5. Climatic Requirements of Important Crops: Rice, wheat, cotton, soyabean and sugarcane, pearlmilet, groundnut and mustard.
6. Plant and Crop Diseases: The effect of weather on pathogenic agents- Insects, Fungi, Bacteria, Bacilli and Virus, combating plant diseases, natural and artificial methods, the integrated campaign, insect against insects, Bacteria and Bacilli against insect, Virus against Insects, effect of weather on the host.
7. Meteorological Hazards and Agriculture: Frost and frost fighting methods, hail damage and hail modification method, wind damage and wind breakers, Agricultural drought, its severity and management, flood, flood damage and flood fighting.
8. Soils: Composition, structure and physical properties of soils, simple classification of soils, soil air, soil erosion, soil improvement devices and drainage.
9. Agrometeorological forecasts systems, short, medium and long range forecasts, yield forecasts model, system stimulation its concept, application and importance.

10. A brief outline of remote sensing in agriculture.

Suggested Books:
1. Smith: Methods in Agricultural Meteorology
2. Seemann et. al.: Agrometeorology
3. Vitchewich: Agrometeorology
4. WMO Compendium of lecture notes
5. Mavi: Introduction to Agrometeorology

GPM303A: SEISMIC METHODS   Credits: 4

1. Historical development and background of refraction and reflection methods. Difference between refraction and reflection surveys. System of observations for reflection and refraction surveys. Propagation of seismic waves in homogeneous/ inhomogeneous media, waveforms and their characteristics, N-layered case, continuous increase of velocity. Refraction data interpretation.
2. Seismic data enhancement and test shooting, explosive and non-explosive sources of seismic energy for P-wave, seismic operation on land, common depth point technique, special weathering shots and noise analysis, elevation, weathering and dynamic corrections in refraction and reflection data, random and non random noises, grouping of geophones, diffraction and its analysis, controlled source seismic sounding.
3. Inverse filtering of seismic data, hidden layer problem, sequence of seismic processing, determination of average seismic velocities, principles of tomography, synthetic seismograms.

4. Analysis of multiples and ghost reflections, processing of seismic data, imaging of 2-D, 3-D seismic data, time and depth sections, record surface and reflection surface, vertical and horizontal resolution.
5. Mapping of geological structures (faults, reef, pinchouts, anticlines), migration techniques (classical and modern), wave equation migration, time and depth migration, depositional sequence and pit falls of seismic interpretations.

Suggested Books:
1. Clarbout: Fundamentals of Geophysical Prospecting
2. Telford et. al.: Applied geophysics
3. Sheriff: Seismic Stratigraphy
4. Dobrin & Savit: Introduction to Geophysical Prospecting
5. Waters: Reflection Seismology
6. Sheriff & Geldart: Exploration Seismology

GPM303B: CLIMATOLOGY   Credits: 4

1. Introduction: Concept of weather and climate, climatic elements, climatic factors, earth-sun relationship, ecliptic and equatorial plane, rotation and revolution of the earth, equinox, solstice, perihelion, cause of seasons, radiation balance.
2. World distribution of isolation, air temperature, mean sea level pressure and wind, effect of land and ocean on circulation, diurnal and annual variations of surface air temperature at different latitudes and over the globe, upper air circulation over the whole world.
3. World distribution of precipitation, effects of continents, oceans and topography on rainfall, diurnal and annual variation of precipitation, world distribution of atmospheric perils.
4. Air masses, their classifications, source regions, modification and associated weather. Extra- tropical cyclones, their origin and associated weather.
5. Climatic Classification: Koppen and Thornthwait schemes applicable to India.
6. Climatic changes and cycles, elements of microclimatology, palaeoclimatology.
7. Indian Climatology: Principal seasons of India, annual and seasonal rainfall and its variability. Definition and concept of drought, aridity, drought indices and drought assessment.
8. Climatic change: climatic system- an overview, observed climate variability and change, physical climate processes and feedback, detection and projection of future climate scenario.

Suggested Books:
1. Sellers: Physical Climatology
2. Trewartha: Introduction to Climates
3. Haurwitz & Austin: Climatology
4. I.M.D. Forecasting Manuals
5. Lockwood: World Climatology

GPM304A: PRACTICAL BASED ON COURSE GPM302A   Credits: 2

Experiments with resistivity meter.

1. Plotting of equipotential traces and current lines for a point source.
2. Interpretation of S.P. Anomalies.
3. Interpretation of I.P. Data.
4. Interpretation of profiling data.
5. Interpretation of field resistivity sounding curves.
6. Computer-aided interpretation of sounding curve data.

GPM304B: PRACTICAL BASED ON COURSE GPM302B   Credits: 2

1. To study the Agrometeorological instruments used for observations.
2. Computation of various components of weekly water balance during crop growing period and assessment of agricultural drought.
3. Computation of evaporation, evapotranspiration and potential evapotranspiration using various approaches and methods.
4. Forecasting of crop yield on the basis of weather parameters using crop growth models.
5. Crop phenological changes and heat units requirement of the crops.
6. Prediction of minimum temperature and frost under Eastern UP condition.

7. Medium range weather forecast and preparation of agrometeorological advisory bulletins for farmers.

GPM305A: PRACTICAL BASED ON COURSE GPM303A   **Credits: 2**

1. Computation of seismic records and plotting section.
2. Determination of velocity.
3. Interpretation of reflection and refraction data.
4. Plotting of seismic section.
5. Testing and handling of seismic prospecting units.
6. Automatic migration and mapping techniques.
7. Preparation of structural maps.
8. Seismic modelling and working at the seismic signal processing laboratory.

GPM305B: PRACTICAL BASEDON COURSE GPM303B   **Credits: 2**

1. Basic analysis of global distribution of mean climatic parameters.
2. Computation of weighted and running means of a time series.
3. Computation of rainfall variabilities and coefficient of variation.
4. Computation of mean wind, resultant wind, prevailing wind and persistence.
5. Computation of climatic types according to Koeppen and Thornthwaite.
6. Exercise in curve fitting, least square, correlation and regression.

GPM306/GPM306B: GEOPHYSICAL FIELD TRAINING   **Credits: 2**

Field training of the Second year students (fourth semester) will undergo field training for familiarization at specialized centers/field work for about 2-3 weeks during semester break after third semester and submit the report to the field training Incharge.

GPM307: PRACTICAL BASED ON COURSE GPM301   **Credits: 2**

1. Identification of different phases on a seismogram and to determine the epicentral distance of an earthquake.
2. Determination of group velocity from a record and draw the group velocity dispersion curve.
3. Use of stereographic projection map for locating the epicentre of an earthquake.
4. To prepare the intensity map and find out the epicentre and focal depth for an earthquake.
5. Determination of magnitude from a given seismic records.
6. To draw travel time curve for body waves and find out the velocities of the upper mantle.
7. Demonstration seismological instruments-seismometer.

GPM308M: FUNDAMENTALS OF GEOEXPLORATION   **Credits: 3**

1. Basic principles of geophysical exploration.
2. Physical properties of minerals and rocks.
3. Gravity Method: Worden, Lacoste and Romberg, gravimeters, field procedure and reduction of gravity data.
4. Magnetic Method: Flux gate magnetometer, field practices and corrections.
5. Electrical method: elements of SP, IP and resistivity methods, Wenner and Schlumberger configurations, methods of resistivity profiling and sounding, theory of images, Tagg's method of interpretation.
6. Seismic Method: Elementary principle of reflection and refraction methods, two layered reflection and refraction problems, Travel-time curves. Fundamentals of conventional seismic instruments, Fan shooting, Profile shooting.
7. Radiometric Method: Physical and geological principles of radiometric method, GM counter, scintillation counter and gamma ray spectrometer.

Suggested Books:
1. Dobrin & Savit: Introduction to Geophysical Prospecting
2. Parasnis: Principle of Applied Geophysics
3. Telford et al: Applied Geophysics
4. Sharma: Geophysical Prospecting for Geologists and Engineers
5. Israel & Krebs: Nuclear Radiation in Geophysics

GPM401: MATHEMATICAL METHODS IN GEOPHYSICS   Credits: 4

1. Complex variables: Analytic function, Cauchy's theorem, Laurent series, residues of analytic and contour integration, applications in geophysics.
2. Integral transforms: Fourier transform, Laplace transform, Hankel transform, and their applications in geophysics.
3. Numerical solution of partial differential equations: Classification of linear partial differential equations, wave and diffusion equations, Laplace equations, and their applications in geophysics.
4. Orthogonal functions: Bessel's function, Hermite, Laguerre and Legendre polynomials, introduction and applications of orthogonal systems and Green's function, and their applications in solving geophysical problems.
5. Non-linear Systems: Non-linear equations and their application in solving geophysical problems.
6. Analysis of statistical and variance analysis, tests of significance and their applications in geophysics.
7. Finite element methods: Introduction to various element shapes, descritization of structures; applications of finite element and finite difference methods in solving geophysical problems.

   Suggested Books:
1. Sastry: Introduction Methods of Numerical analysis
2. Gerald: Applied Numerical Analysis
3. Gerald et. al.: Finite Element Simulation in Surface and Subsurface Hydrology
4. Bath: Mathematical Aspects of Seismology
5. Jain, Iyengar & Jain: Numerical Methods for Scientific and Engineering Computation
6. Jain: Numerical Solution of Differential equations
7. Mitchell: Computational Methods in Partial Differential Equations

GPM402: PETROLEUM GEOPHYSICS AND STRATIGRAPHY   Credits: 4

Seismic source energy for S-wave, Shear wave prospecting. Shear wave velocity and shear modulus estimation from P-wave data. Application of shear wave and shear modulus in processing and interpretation of seismic data. Data acquisition for vertical seismic profiling (VSP), 3D-VSP and its applications. Multi-component seismic data acquisition for recording of P and S waves. Relation between rock properties and AVO response, seismic inversion.

4-D and 5-D seismics, passive seismics. AVO/AVA analysis, splitting of P wave energy into P and S seismic reflected and refracted waves, Zoeppritz equations. Offset dependent reflectivity. Seismic stratigraphy and sequence analyses, seismic facies analyses, reflection and amplitude character analyses, bright spot. Seismic lithologic modelling, Vp/Vs and lithology, gas detection using AVO.

   Suggested Books:
1. Clarbout: Fundamentals of Geophysical Prospecting
2. Telford et. al. : Applied Geophysics
3. sheriff: Seismic Sratigraphy
4. Dobrin & Savit: Introduction to geophysical Prospecting
5. Waters: Reflection Seismology
6. Sheriff & Geldart: Exploration Seismology
7. Fundamentals of geophysical interpretations by Laurence R. Lines and R.T. Vavrick.

GPM403: INSTRUMENTATION AND SIGNAL PROCESSING   Credits: 3

1. Amplitude and frequency response characteristics of geophones, critical and optimum damping, seismic amplifier and its frequency response, principles of magnetic tape recording, digital multiplexed recording and shot moments, principles of binary gain ranging amplifier and floating point, dynamic range, Automatic gain Control (AGC) circuit, Programmable Gain Control (PGC), timing system and recording formats (SEG A,SEG B and SEG C).
2. Pilot balloon, theodolite, radiosonde, rawin and radar, radiation instruments. Automatic weather station, VHRR, VTPR, APT, VHPR.

3. Analogue filters: Low and high pass filters and their alpha/beta diagrams, Characteristic impedance of symmetrical T and pie networks; band pass, comb, and active filters.
4. Analogue and digital signal recording and processing: mechanisms of signal recordings. Transmission and receiving of meteorological data through satellite. Wireless seismic recording. Seismic signal recording and enhancement of S/N ratio, Satellite digital data process: retrieval technique, cloud top temperature, S.S.T. Retrieval algorithms, very high resolution radiometer, vertical temperature profile radiometer, automatic picture transmission, vertical humidity profile radiometer.
5. Different types of display of digital and magnetic recording wiggle trace, variable area and variable density records.

Suggested Books:
1. Kennedy & Davis: Electronic Communication Systems
2. Anstey: Seismic Prospecting Instruments Vol. 2
3. Ryder: Network, Lines and Fields
4. Rabinet & Gold: Theory and application of Digital Signal Processing
5. Remote sensing of the atmosphere: J.T. Houghton, F.W. Taylor and C.D. Rodgess.
6. Satellite meteorology: An introduction- S.Q. Kidder and T.H. Vanderhaor
7. Introduction to environmental remote sensing: E.C. Barette and L.F. Curtis.

GPM404A: GRAVITY AND MAGNETIC METHODS   Credits: 4

1. Basic Theory: Magnetic elements I.G.R.F., inverse square law, concept of potential, Poisson's and Laplace's equations, magnetism on atomic scale, Dia- para- ferro magnetic materials, susceptibilities and densities of various rocks and minerals, factors affecting density and susceptibilities, and susceptibility determination.
2. Instrumentation: gravity prospecting instruments: borehole and airborne gravimeters, magnetic prospecting instruments, Rubidium vapour magnetometer.
3. Data Acquisition and Correction: Aeromagnetic surveys, plan of the field surveys, station spacing, corrections for gravity and magnetic data, calculation of derivatives, continuation methods, polynomial fitting for regional- residual separation of gravity and magnetic anomalies, filter theory and filtering of potential field data, Gravity anomalies over spheres, cylinders, dykes, faults and sheets, Magnetic anomalies over single pole, dipole, line pole, spheres, cylinders, faults and dykes, graticules and anomalies of irregular bodies, relation between gravity and magnetic potentials, depth estimation, curve matching techniques, transformation of gravity and magnetic anomalies in frequency domain, spectral representation of field data and interpretation of gravity and magnetic profiles.
4. Processing and interpretation.
5. Gravity and magnetics for the exploration of the minerals, oil/gas and groundwater.

Suggested Books:
1. Grant & West: Interpretation Theory in Applied Geophysics
2. Nettleton: Gravity and Magnetics in Oil Prospecting
3. Rao & Murthy: Gravity and Magnetics
4. Dobrin & Savit: Introduction to Geophysical Prospecting
5. Telford et. Al: Applied Geophysics
6. Murthy & Mishra: Interpretation of Gravity and Magnetic Anomalies in Space and Frequenies Domain

GPM404B: DYNAMIC METEOROLOGY   Credits: 4

1. Principles of thermodynamics: First law of thermodynamics, internal energy, specific heat capacity and enthalpy, adiabatic process, entropy and the second law of thermodynamics.
2. Thermodynamics of water Vapour and Moist Air. Isotherms on an , e diagram, equation of state of moist air, Clausius Clapeyron equation, adiabatic processes of saturated air and moisture variables.
3. Thermodynamics Diagrams: General considerations, emagram, tephigram, skew T/ log P diagram, stuve diagram, choice of a diagram.
4. Hydrostatic Equilibrium: Hydrostatic equation, geo-potential height computations for upper-air sounding, hydrostatic of homogeneous, isothermal, constant lapse rate and dry adiabatic atmosphere, standard atmosphere.
5. Hydrostatic Stability and Instability: General consideration, slice method, entrainment.
6. Fundamental forces, gravitation and gravity, geo-potential.

7. Equation of motion in different coordinate systems, tangential, local, rectangular coordinates, spherical polar coordinates, natural coordinates, scale analysis of the equations of motion, approximate equations, Rossby number.

8. Continuity equation in cartesian, isobaric and spherical coordinate.

9. Balanced Motion: Inertial wind, geostrophic wind, gradient wind, cyclostrophic wind and thermal wind.

10. Viscosity and Turbulence: Fundamental laws of viscosity, equations of mean motion in turbulent flow, mixing length theory, planetary boundary layer, power law, Ekman layer, Richardson number, Rrynold's number, Froud number.

11. Circulation and Vorticity: Kelvin's circulation theorem, Bjerknes theorem, potential vorticity, vorticity equation, divergence equation, Helmholtz theorem.

12. Tendency equation, Bjenknes Holmboe theory, isallobaric wind.

13. Vertical Motion: Kinematic, adiabatic and omega equation.

Suggested Books:
1. Hess: Introduction to Theoretical Meteorology
2. Pisharoty: Thermodynamic Diagram and some of Their Uses (IMD Tech. Note)
3. Gordon: Introduction to Dynamic Meteorology
4. Holton: An Introduction to Dynamic Meteorology
5. Haltiner: Numerical Weather Prediction
6. Haltiner & Martin : Physical and Dynamic Meteorology
7. Haltiner & William: Numerical Weather Prediction and Dynamic Meteorology
8. Astel & Wiin-Nielsen: Compendium of Meteorology, Vol. I. Dynamic Meteorology, W.M.O. No. 364

GPM405A: WELL LOGGING AND RESERVOIR GEOPHYSICS   Credits: 4

1. Reservoirs characteristics and objectives of well logging. Reservoir Rocks: Clastic and carbonate rocks. Reservoir Properties: Porosity, permeability, fluid saturation, need of drilling fluids and its properties, invasion process and various profiles, classification of formation evaluation methods, objective of well logging methods, logging operational field system and its procedure.

2. Electric-Logging: Spontaneous Potential (SP) logging: Spontaneous potentials in boreholes and its sources, SSP and its measurements, SP curves and its interpretation factors affecting the shape and amplitude of SP curve, Non-focussed, focused and induction logging, principles and sondes, Interpretation of electric Log Data: Determination of resistivity of interstitial water Rw, porosity . and water saturation Sw of clean and shaly sandstones, determination of Rw of clean sandstone from SP curve, estimation of permeability.

3. Radiation Well Logging: Gamma ray logging, details of the radiation logging, density or gamma-gamma logging, principle of the neutron-gamma logging, neutron-epithermal-neutron logging, neutron-thermal-neutron logging, interpretation and applications of radiation logging for evaluation of reservoir characteristics.

4. Other Miscellaneous Logging Techniques: Acoustic velocity (Sonic) logging, Cement Bond Log (CBL), Litho-density Tool (LDT), Thermal log, caliper or section gauge log, Casing Collar Locator's (CCL), dip and direction logging, gravity logging, nuclear magnetic resonance logging.

5. Advanced Logging Tools: Introduction of induced gamma-ray spectrometry, chlorine logging, introduction to natural Gamma-ray Spectrometry (NGS), Cased Hole Neutron Tool (Thermal Decay Time or TDT) measurements.

6. Cross Plots: Resistivity-porosity cross plots, Porosity Cross plots: neutron-density, sonic density and sonic neutron density cross plots. Application of well logging to ground water mineral and petroleum resources.

Suggested Books:
1. Lynch: Formation Evaluation
2. Wyllie: Fundamentals of Well Log Interpretation
3. Vaish : Geophysical Well Logging : Principles and Practices
4. Schlumberger: Schlumberger Log Interpretation Principles/ Applications
5. Schlumberger: Schlumberger Log Interpretation Charts
6. Serra: Fundamentals of Well - Log Interpretation
7. Pirson: Hand book of Well log Analysis for Oil and Gas Formation Evaluation
8. Deveton: Log analysis of subsurface Geology: Concepts and Computer Methods.

GPM405B: PHYSICAL METEOROLOGY   **Credits: 4**

1. Radiation: Laws of radiation, nature of solar radiation, solar constant, geographical and seasonal distribution of solar radiation, direct beam normal flux at the earth's surface, direct beam insolation at the earth's surface, Basis of Elsasser treatment, Elsasser chart; radiative heating and cooling, radiative equilibrium and the stratosphere, mean heat balance of the earth atmospheric system, poleward transport of energy, fundamental link with general circulation, radiation parameterization.

2. Cloud Physics: Atmospheric aerosols and condensation nuclei, nucleation, physics of initial stages of condensation, curvature and solution effect, growth and evaporation of cloud droplets by diffusion, the physics of precipitation in warm clouds, collision-coalescence theory, collection efficiency, terminal velocity, precipitation from mixed clouds, Bergeron and Findeisen's theory, artificial cloud seeding of warm and cold clouds, rain making experiments and weather modification, cumulus parameterization, horizontal and vertical diffusion.

3. Atmospheric Optics: Attenuation of light, refraction, scattering, turbidity, optical phenomena, rainbow, halo, corona, glory, mirage etc., atmospheric and terrestrial refraction, looming, towering, stooping, sinking.

4. Radar Meteorology: Basic radar equation, wavelengths used for detection of cloud, thunderstorm and cyclone, PPI and RHI scopes, meteorological applications of radar, radar echoes, estimation of precipitation, rain water content and upper winds using radar.

5. Atmospheric Ozone: Mechanism of formation and destruction, measurement of ozone, Dobson's ozone spectrometer, seasonal and latitudinal variation, Umkehr effect, vertical distribution of ozone, ozone-weather relationships, ozone hole.

6. Atmospheric Electricity: Electrical field of the earth in fair and disturbed weather, atmospheric ionization, air-earth electric current and its maintenance, supply current, theories of charge generation and separation in thunderstorm, lightning discharges.

7. Satellite Meteorology: Equation of orbital motion, types of meteorological satellites, description of important sensors on board, visible and infra red data and their interpretation, identification of typical weather systems from cloud picture, estimation of winds, vertical temperature and humidity profile and rainfall from satellite observations, tropical cyclone grading using Dvorak's technique.

   Suggested Books:
1. Johnson: Physical Meteorology
2. Mason: Physics of Cloud
3. Dobson: Exploring the Atmosphere
4. Retallack: Compendium of Meteorology Vol. I, Part-III, Physical Meteorology. W.M.O. 364
5. Baton: Radar Observes the Weather
6. Kidder & Vonder Harr: Satellite Meteorology
7. Taba: Ozone Observations an Introduction and their Meteorological Applications, W.M.O. Technical Note No. 36, W.M.O. No. 108
8. Haltiner & Williams: Numerical Prediction and Dynamic Meteorology

GPM406A: PRACTICAL BASED ON COURSE GPM404A   **Credits: 2**

1. Determination of density by Nettleton method.
2. Handling of gravimeter and its calibration.
3. Structure contouring from subsurface informations
4. Preparation of a residual map by (a) Graphical method and (b) Grid method.
5. Upward and downward continuation of gravity and magnetic fields.
6. Computation of gravity effect of a sphere, horizontal cylinder and fault.
7. Computation of effect of a magnetic dipole of finite length, sphere and horizontal cylinder.

GPM406B: PRACTICAL BASED ON COURSE GPM404B   **Credits: 2**

1. Analysis of tephigram: (a) Computation of derived parameters, LCL,CCL and LFC, (b) Computation of precipitable water content, (c) Computation of heights of pressure surfaces by adiabatic and isothermal methods, (d) Study of stability and instability of various layers and forecasting of fog, thunderstorm, etc., (e) Determination of height of tropopause, thickness of isothermal and inversion layers etc.

2. Preparation of geostrophic wind scale and computation of geostrophic wind from constant pressure charts with the help of above scale.
3. Computation of geostrophic vorticity, geostrophic wind.
4. Exercise in graphical addition and subtraction.

GPM407A: PRACTICAL BASED ON COURSE GPM405A   Credits: 2

1. Qualitative interpretation of well logs and their correlation
2. Computation of porosity.
3. Computation of formation factor.
4. Computation of water saturation.
5. Computation of oil saturation.
6. Computation and estimation of producible oil per acre.
7. Applications of cross plots for estimation of various parameters.

GPM407B: PRACTICAL BASED ON COURSE GPM405B   Credits: 2

1. Measurement of total amount of atmospheric ozone by Dobson's ozone spectrophotometer.
2. Numerical computation in radiation, atmospheric optics, cloud physics, satellite meteorology and radar meteorology.

SEMESTER-V

GPM501: ADVANCED COMPUTER PROGRAMMING   Credits: 3

1. Programming Language C: Constants, variables, data types, expressions operators, conditional statements, iterative statements, array, function, storage, class, pointers, structure, union and file handling.
2. Object Oriented Programming: Procedural approach VI, object approach, object oriented methodology, concept of object and class, reusability, encapsulation and polymorphism.
3. C++ An Object Oriented Language: Class, object, constructor, destructor, operator, overloading, function overloading, inheritance, virtual function, multiple inheritage, generic classes.
4. Software: application software, system software, support software and firmware.
5. Introduction to UNIX operating system.
6. Introduction to JAVA, Visual BASIC and data base management system.
7. Internet, intranet, multimedia and LAN.

   Suggested Books:
1. Balagoswami: Programming in C
2. Gotfried: Programming in C
3. Yashwant Kanetkar: C Programming
4. Yashwant Kanetkar: C++ Programming
5. Robert Lafore: Object Oriented Programming C++
6. Hasbest Scheilds: Object Oriented Programming
7. Stephen Prata: Advanced Unix-A Programmers Guide

GPM502: COMMUNICATION THEORY   Credits: 4

1. Introduction: Historical development of time series, classification of data, analogue and discrete signals, digitization, sampling interval and aliasing, wavelets, Z transform, linear system, Dirac delta function and impulse response of a linear system, impulse response function, minimum delay, maximum delay and mixed delay wavelets.
2. Convolution and Correlation Techniques: Convolution, method for Convolution, properties of Convolution, autocorrelation, cross-correlation, and their applications, time domain and frequency domain concepts.
3. Fourier series and Fourier transform, Hilbert transform, Walsh transform, orthogonal function and Dirichlet conditions, complex form of Fourier Series and Fourier transform, physical significance and interpretation of Fourier transform, properties of Fourier transform, Fourier transform of a symmetrical rectangular pulse, reciprocity Fourier transform (FFT), two dimensional Fourier transform and its applications.

4. Digital Filtering: Low, high and band pass filters, truncation of unit impulse response function, illustration of Gibb's phenomenon. Butterworth filters, Chebysev filter, recursive filters.
5. Weighting Functions (Windows): Hamming window, Hamming window and their comparison, triangular window, Bortlett window, practical applications of windows.
6. Techniques for Spectral Estimation: Power spectrum, method for calculation of power spectrum, three basic data models, Moving Average (MA) method, Maximum Entropy Method (MEM), Maximum Likelihood Method (MLM), Autoregressive process (AR), comparison of MA, MEM, MLM and AR techniques.
7. Deconvolution: Introduction, white spectrum, Wiener inverse and its mathematical details, homomorphic applications of deconvolution filtering.
8. Applications of Time Series in various branches of Geophysics: Seismic method, gravity and magnetic methods, resistivity and well-logging methods, use of spectral techniques in meteorology, oceanography and groundwater hydrology.

Suggested Books:
1. Silvia & Robinson: Deconvolution of Geophysics Time Series in the Exploration for Oil and Natural Gas
2. Robinson & Trietel: Geophysical Signal Analysis
3. Kanasevich: Time Sequence Analysis in Geophysics
4. Bath: Spectral Analysis in Geophysics
5. Oppenheim & Schafer: Digital Signal Processing
6. Papoulis: The Fourier Integral and its Applications

GPM503A: GEOELECTROMAGNETIC METHODS   Credits: 4

1. Basic Principles and Theory: Maxwell's equations, electromagnetic potential and wave equations, boundary conditions, long wavelength approximation, depth of penetration, electromagnetic field due to straight wire, rectangular and circular loops, elliptical polarizations, amplitude and phase relations, real (in phase) and imaginary (quadrature) components.
2. Methods of Prospecting: Bieler Watson method, Dip angle methods-fixed vertical loop transmitter, broadside and shoot back methods, two frame method, compensator method, Turam method, Moving source-receiver methods- horizontal loop (Slingram) method, AFMAG and VLF methods, Airborne EM systems- rotary field method, INPUT method, EM profiling and sounding.
3. Interpretation: Principles of EM similitude and modelling, response of conducting sphere to uniform alternating magnetic field and infinitely long horizontal cylinder to line source, response of sheet conductors to dip angle, Turam and horizontal loop EM systems, dip angle characteristic curves and phasor diagrams for horizontal loop EM system for sheets, effect of overburden on EM anomalies, Principles and practices of Ground Penetrating Radar.
4. Magnetotelluric (MT) method: Origin and characteristic of MT fields, MT instrumentation, field practices, MT effect over a conducting half space and two layer model.

Suggested Books:
1. Parasnis: Mining Geophysics
2. Grant & West: Interpretation Theory in Applied Geophysics
3. Telford et. al: Applied Geophysics
4. Patra & Mallick: Geosounding Principles Vol.II
5. SEG Publication: Mining Geophysics Vol. II

GPM503B: SYNOPTIC AND TROPICAL METEOROLOGY   Credits: 4

1. Meaning and scope of synoptic meteorology, Plotting of synoptic observations on different   maps, analysis of surface and upper air charts, vertical time section and cross   section analysis.
2. Scales of Atmospheric Weather Systems: Primary, secondary and tertiary circulations.
3. Kinematics of horizontal motion, characteristics of wind fields, construction of streamlines, isotach, trajectories, relation between stream line and trajectories, Blatons equation.
4. Kinematics of pressure fields, mechanism and influence of pressure changes.
5. Frontogenetical Functions: Frontogenesis in horizontal velocity field, frontogenetical and frontolytical sectors, kinematic and dynamic boundary conditions, pressure distribution over front, Morgules formula.
6. Jet streams, their classification and characteristics, PFJ, STJ, TEJ, low level jet stream of Asian monsoon, structure, formation, maintenance and associated weather, zonal index, index cycle, cutoff lows, highs, blocking.

7. Principle of Weather Prediction: Short range, medium range and long range weather prediction, limits of predictability, forecast evaluation.
8. Tropical Meteorology: Mean tropical atmosphere, equatorial trough (ITCZ), basic currents, trade wind inversion, easterly waves and their dynamical aspects, formation and forecasting of easterly waves, QBO.
9. Tropical cyclones, classification of tropical disturbances, global climatology, life cycle, surface and upper air structure, thermal structure, the eye and wall cloud, rainfall, energy aspects, theories of formation, CISK, detection, movement tracks, recurvature, Fujiwara effect, forecasting, storm surges, cyclone warning.
10. Monsoons: Monsoon regions in the tropics, causes of monsoon, the Indian summer monsoons, rainfall distribution, elements of the monsoon system, monsoon disturbances, MTC, monsoon variability, onset and advancement of monsoon, withdrawal, fluctuations in monsoon activity, active, weak and break monsoon conditions, intra seasonal and inter-annual variability of summer monsoon, biweekly and 30-50 day oscillation, southern oscillation and El Nino, monsoon rainfall and teleconnections, long range prediction of monsoon, monsoon over China, S.E. Asia, N. Australia, east and west Africa.
11. General Circulation Features over India during other seasons: Winter seasons, western disturbances, cold waves, fog, Pre Monsoon Seasons: different convective phenomenon, Norwesters and tropical storms, Post monsoon Season: N.E. Monsoon, tropical storms and their differences with tropical storms of pre monsoon season.

   Suggested Books:
   1. Riehl: Tropical Meteorology
   2. Palmen & Newton: Atmospheric Circulation System
   3. Reiter: Jet Stream Meteorology
   4. Ramage: Monsoon Meteorology
   5. Saucier: Principles of Meteorological Analysis
   6. Wiin-Nielson: Compendium of Meteorology, Vol. I, Part 3, Synoptic Meteorology, Geneva, W.M.O. No. 364.
   7. Asnani: Tropical Meteorology,Vol. I and II
   8. Das: Monsoons, Geneva, WMO No. 613
   9. Keshavamurty & Sankar Rao: The Physics of Monsoons
   10. Tarakanov: Tropical Meteorology
   11. Krishnamurthi: Compendium of Meteorology, Vol. II, Tropical Meteorology, Geneva, W.M.O. No,364

GPM504A: DIGITAL ELECTRONICS AND MICROPROCESSOR   **Credits: 4**

1. Number Systems: Decimal, binary, octal and hexadecimal number systems, Interconversion of decimal, binary and hexadecimal numbers, BCD numbers, BCD addition and subtraction.
2. Logic gates: AND, OR, NOT, NAND, NOR, and exclusive OR gates, NAND and NOR gates as universal gates.
3. Logic Families: TTL logic circuits (NAND and NOR gates), comparison of TTL, ECL and CMOS.
4. Boolean Algebra: De Moegan's theorems, standard POS and SOP forms, min-term and max-term representation of Boolean functions, simplification of Boolean functions using K-maps (up to 4 variables).
5. Combinational Circuits: Half and full adders, half and full subtractors, multiplexer, demultiplexer, encoder, decoder, BCD to seven segment decoder.
6. Flip-flops: R-S, J-K, master-slave and edge triggered J-K, T and D Flip-flops.
7. Sequential Circuits: Shift registers, ring counters, ripple and synchronous counter, modulo-N counter, decade counter, digital-to analog converter (binary weighted register and ladder types), and analog -to-digital converter (using D/A converter and comparator).
8. Digital Wave form Generator: Concept of timer IC 555 and its use for waveform generation (astable and monostable).
9. OP-AMP: Concept and characteristics of OP-AMP and its use as: Adder, subtractor, differentiator, integrator, logarithmic and exponential operator, inverting and non-inverting amplifier, differential amplifier, CMRR, analog computer (for 2nd order differential equations).
10. Memories: Concept of Random Access Memory (RAM) , static and dynamic RAM, Read Only Memory (ROM), PROM and EPROM.
11. Introduction to Microprocessors: Evolution of microprocessors, organization, architecture and pin description of 8085 microprocessor, addressing modes and instruction set, input/ output interfacing

devices (8255, 8251), simple programs for addition/ subtraction, developmental trends in microprocessors technology (8086, 80186, 80286, 80386, 80486 and Pentium).

12. Application of Microprocessors: Application of Microprocessors in Geophysical Instrumentation: Microprocessors based data acquisition, frequency, temperature and voltage measurements using microprocessors.

Suggested Books:
1. Jain: Modern Digital Electronics
2. Malvino: Digital Computer Electronics
3. Puri: Digital Electronics
4. Mathur: Introduction to Microprocessors
5. Sheth & Hebber: Microprocessors
6. Gaonkar: Microprocessors Architecture, Programming and Applications
7. Ram: Microprocessors and Microcomputers
8. Gaikwad: Operational Amplifier.

GPM504B: ADVANCED DYNAMIC METEOROLOGY   Credits: 4

1. Numerical Weather Prediction: Historical review, filtering of sound and gravity waves, filtered forecast equation, forecasting of stream function. Barotropic model, equivalent barotropic model, baroclinic model-two level, multilevel quasigeostrophic model, primitive equation models, spectral and finite element model, Sigma coordinate, hydrodynamic equations in Sigma coordinate Eta coordinate, Eta model, precipitation forecasting, range of predictability.
2. Objective analysis: Cressman method, method of optimum interpolation, initialization: static initialization, dynamic initialization, normal mode initialization, Newtonian relaxation or Nudging, nonlinear stability, Aliasing, Arakawa Jacobian, Staggered grid systems.
3. Hydrodynamic Instability: Barotropic, inertial and baroclinic instability.
4. Numerical Methods: Finite difference, truncation error, linear computational instability, Neuman condition, implicit and semi-implicit method, relaxation method, simultaneous and sequential.
5. Atmospheric Waves: Perturbation theory, properties of waves, sound waves, gravity waves, vertical stability, internal gravity waves, Rossby waves, mountain waves.
6. Scale analysis of momentum, continuity, vorticity, divergence, thermodynamic and omega equation, diagnostic analysis of synoptic scale motion in middle latitude.
7. Sutcliffe's Development Theory: Thickness and vorticity advection.
8. General Circulation: Longitudinally averaged and varying flow, constraints on the theories of the general circulation, maintenance of mean zonal circulation (angular momentum consideration), experimental approach.
9. Energetics: Energy equation, internal and available potential energies, generation, conversion and dissipation of energies.

Suggested Books:
1. Hess: Introduction to Theoretical Meteorology
2. Holton: An Introduction to Dynamic Meteorology
3. Haltiner: Numerical Weather Prediction
4. Haltiner & Martin: Dynamic and Physical Meteorology
5. Atkinson: Dynamic Meteorology: An Introductory Selection
6. Thompson: Numerical Weather Analysis and Weather Prediction
7. Wiin-Nielsen: Compendium of Meteorology, Vol. I Geneva, W.M.O.

GPM505A: PRACTICAL BASED ON COURSE GPM503A   Credits: 2

1. Computational of dip angle response over sheet type bodies.
2. Analysis of dip angle data and its interpretation.
3. Computation of Turam profiles over sheet type bodies.
4. Reduction of Turam data and its interpretation.
5. Interpretation of Slingram profiles over sheet conductors using phasor diagrams.

GPM505B: PRACTICAL BASED ON COURSE GPM503B   Credits: 2

1. Plotting and analysis of surface weather charts for different seasons and issue of inferences.

2. Plotting and analysis of constant pressure charts.
3. Plotting and analysis of vertical time section and cross section chart.
4. Streamline and isotach analysis.
5. Prognostication of synoptic systems like lows, trough etc. by kinematic methods.
6. Computation of zonal index.

GPM506A: PRACTICAL BASED ON COURSE GPM504A   Credits: 2

1. Experiment with logic gates.
2. Experiment with Flip-flops.
3. Experiment with digital ICs.
4. Experiment with 555 timer.
5. Experiment with microprocessors.

GPM506B: PRACTICAL BASED ON COURSE GPM504B   Credits: 2

1. Preparation of Bellamy grid and computation of divergence, vorticity and deformation field by Bellamy grid.
2. Preparation of curvature circle nomogram and computation of divergence and vorticity by curvature circle.
3. Computation of divergence and vorticity by finite difference method.
4. Problems in dynamic Meteorology.
5. Simple exercises in numerical model.

GPM507: PRACTICAL BASED ON COURSE GPM501   Credits: 2

1. Numerical solution of non-linear equations using available software.
2. Solution of differential equations using available software.
3. Interpretation of data by finite difference method.
4. Development of programme and solution of some problems by finite element method.

GPM508: PRACTICAL ON GEOPHYSICAL DATA PROCESSING   Credits: 2

1. To digitize analogue signal by graphical method choosing different sampling intervals, plotting the digitized record and examining the aliasing phenomenon.
2. To convolve the two signals (wavelets), plot and examine the results.
3. To compute the autocorrelation and cross-correlation functions for a given data set, plot and examine the results.
4. To perform digital filtering after designing a low, high and band pass filters and to examine the effects of truncation.
5. To apply Hanning and Hamming windows on a given set of data points.
6. To compute the amplitude, phase and power spectra of a given time series.
7. To apply Wiener inverse filtering to seismic data, comment on wavelet extraction problems.
8. To perform the spectral analysis of gravity, magnetic and meteorological data.
9. Computer modelling of some geophysical problems.

SEMESTER-VI

GPM601: PHYSICAL OCEANOGRAPHY AND MARINE GEOPHYSICS   Credits: 4

Section I: PHYSICAL OCEANOGRAPHY   Credits: 2

1. Physical properties of Sea Water: Chlorinity, salinity, thermal properties, density, pressure, optical properties, transmission of sound, water masses, T-S diagram, variation of salinity, heat budget of the ocean, Bowen ratio.
2. Acquisition of Ocean Data: Salinity measurements, Nansen bottle, light in sea, measurement of SST, reversing thermometers, Bathy thermograph, current meters.
3. Ocean Currents: Hydrodynamic equations of motion, inertia currents, geostrophic currents in homogeneous and stratified ocean; relative and slope currents, thermohaline currents, drift current in

homogeneous water, Ekman theory, the major surface current systems of the ocean, upwelling and sinking with special reference to Indian ocean and their effects.

4. Waves: Wave velocity, group velocity, theory of surface gravity waves, short and long waves, generation and growth of wind waves, long waves in canals, standing waves in closed basins, seiches, swell, breakers and surf, internal waves, storm surges, tsunami.
5. Tides: Tide generating forces, principal harmonic components, theories of tides, description and types of tides, prediction of tides, tidal gauges.
6. Air Sea Interaction: Structure of the boundary layer, exchange coefficients and profiles, transfer of heat and water vapour.

Section II: MARINE GEOPHYSICS   Credits: 2

1. Ocean and Seas: classification, growth and decline of ocean basins, turbidity currents, submarine sedimentation and stratigraphy, physiography and divisions of the sea floor, continental shelves, slopes, aprons and abyssal planes, occurrence of mineral deposits and hydrocarbon in offshore.
2. Gravity and magnetic Surveys: Types of magnetometer used in a survey ship, towing cable and fish, data collection their reduction and interpretation, underwater gravity measurements, ship borne gravimeters, Graf sea gravimeter, vibrating string accelerometer, Lacoste Romberg gravimeter, problems with shipborne gravity measurements, survey procedure, data reduction and interpretation.
3. Seismic Surveys: Marine energy sources, Finger, Boomer, Sparker, explodor, airgun, vapour cook etc. hydrophones active section and streamer towing gear, shooting methods near offshore and offshore exploration techniques, analysis of seismic data their processing and interpretation, refraction survey with Sonobuoy's and interpretation.
4. Radio Positioning System: Short range and long range Doppler Sonar, satellite navigation, GPS & GIS.

   Suggested Books:
1. Duxbury: The Earth and its Oceans
2. WMO No.364: Marine Meteorology
3. Sverdrup, Johnson & Fleming: The Oceans
4. Defant: Physical Oceanography, Vols. I and II
5. McLellen: Elements of Physical Oceanography
6. Jacob, Russel & Willson: Physics and Geology
7. Dobrin & Savit: Introduction to Geophysical prospecting
8. Telford et.al.: Applied Geophysics

GPM602(P-Z): ELECTIVE PAPER   Credits: 4

GPM602 (P-Z): [ELECTIVE PAPER]

GPM602P: ADVANCED HYDROLOGY

1. Surface water, evaporation formulae and theories of surface flows, safe yield, floods, estimation of flood flow, method of unit hydrograph, synthetic hydrographs, their application, flood routing through rivers and reservoirs, statistical methods in hydrology.
2. Water resources: Partially saturated soils, Darcy's law in unsaturated medium, derivation of Darcy's law from Navier stokes theorem, different forms of unsaturated flow equation, nature of the physical parameters in unsaturated flow, infiltration theories, concepts of diffusion, dispersion and redistribution in groundwater, groundwater hydrographs, application of finite difference and finite element techniques, simulation method, analog and digital modelling of aquifers, tracer techniques.
3. Water Management: urban hydrology, practical aspects of flow of groundwaters to wells, analysis of pumping test, conservation and utilization of water and its management.

   Suggested Books:
1. Ward: Principles of Hydrology
2. Todd: Groundwater Hydrology
3. Heath & Trainer: Introduction to Groundwater Hydrology
4. Guide Book on Nuclear Techniques in Hydrology
5. Dury: Face of the Earth
6. Chow: Handbook of Applied Hydrology
7. Childs: Introduction to Soil Water Physics

8. Walton: groundwater Evaluation
9. Tolman: Groundwater.

GPM 602Q: ADVANCED SEISMOLOGY

1. Measurement and characteristics of strong ground motion, dispersion of surface waves, ray theory, travel-time curves for body waves and inversion techniques, tomography, 3-D earth structure, attenuation, diffraction and scattering of seismic waves, fault asperities inferred from seismic waves, crust and mantle structures inferred from surface waves, broad band seismometry, and recent Indian earthquakes.
2. Seismic arrays, tectonic and volcanic earthquakes and their characteristics, seismic hazard, risk analysis, seismic gaps and regions of high seismic potential, earthquake source studies, earthquake processes and source modeling, earthquake prediction problem, application of fractals and chaotic dynamics in seismology, non-linear propagation and geodynamics.

   Suggested Books:
   1. Kanamori & Baschi: Earthquakes: Observation, theory and Interpretations
   2. Ewing: Elastic Waves in Layered Media
   3. Bath: Mathematical Aspects of Seismology
   4. Bullen: Introduction to Seismology
   5. Aki & Richard: Quantitative Seismology, Vol. I and II
   6. Slawomir & Andrezej: An Introduction to Mining Seismology.

GPM 602R: REMOTE SENSING AND GIS

1. Fundamentals of Remote Sensing: Energy sources, principles of solar and terrestrial radiation, laws of radiation, energy interactions, spectral patterns and signatures.
2. Characteristics of aerial photographic imagery, photogrammetry, airphoto interpretation for terrain evaluation.
3. Application in geological mapping and mineral resource evaluation, concepts of GIS and applications, theory and principles, structural concepts, geological interpretation and its ambiguity, geological guides, characteristics for mineral resource.
4. Application to water resources evaluation and soil moisture determination; watershed parameters, physiographic measurements, surface water, flood plain delineation, precipitation, ice and snow monitoring, evaporation and evapotranspiration, subsurface water information system and analysis.
5. Developments of satellites and remote sensing developments in India.
6. Development in remote sensing platforms, constant level and tethered balloons, aircrafts, rockets and satellites.
7. Kepler's laws of planetary motion, circular and elliptical orbits of satellites, polar, geosynchronous and geostationary satellites.
8. Types of sensors, photographic and TV cameras, visible and infrared sensing, radiometer, side looking radar.
9. Historical development, various meteorological satellite system, INSAT system, data acquisition system, Automatic Picture Transmission (APT).
10. Remote sensing application in meteorology , visible and infrared pictures of clods, recognition of various clouds and weather systems, estimation of surface temperature and cloud tops, vertical profiles of temperature and water vapour, wind estimation, role of weather satellites in global coverage of observation in synoptic and climatological studies.

   Suggested Books:
   1. Barret & Curtis: Introduction to Environmental Remote Sensing.
   2. Lillesand & Kiefer: Remote Sensing and Image Interpretation.
   3. Reeves (Ed.): Manual of Remote Sensing, Vols. I and II, American Soc. Photogrammetry.
   4. Siegal & Gellospie: Remote Sensing in Geology.
   5. Teekshadulu & Rajan: Remote Sensing , Indian Academy of Sciences.
   6. Kidder & Vonder Haar: Satellite Meteorology an Introduction.

GPM602S: ENVIRONMENTAL GEOPHYSICS

1. Earth and environment, elements of environment, man and environment.

2. Atmosphere : Origin, composition and structure, the troposphere as an Environmental layer, air pollution, pollutants and its impact on weather, the ozone shield, green house effects and role of trace gases, global warming, acid rains.
3. Hydrosphere: Ocean and environment, the hydrologic cycle and global water balance, surface water hydrology, water pollutants and their effects on surface and ground water, heavy mentals (Hg, Cd and As) in ground water, their detection and abatements.
4. Mineral resources and environment, impact of mining and mineral resources.
5. Energy and Environment: Coal, oil and gas, geothermal energy, nuclear energy, solar energy.
6. Role of geophysics in Environmental protection.

   Suggested Books:
1. Jorgensen: Principles of Environmental Sciences and Technology
2. Keller: environmental geology
3. Ramade & Strahler: Environmental Geoscience-Interaction Between Natural System and Man
4. Tyler & Mitter: Jr. Environmental Science
5. Sharma: Environmental Geophysics

GPM602T: GEOMAGNETISM

1. Earth's Magnetic Field: Internal and external fields, main field and variational field, components of the main field, magnetic and geomagnetic coordinates, measurement and recording of the main field: measurements of horizontal, vertical, declination, inclination and total field, magnetometers and variographs, Theories of the earth's main magnetic field: A brief introduction of the various of the main field and its secular variation, dynamo theory of the main field, Geomagnetic indices: Ci, CR, Ks, Kp indices, concepts of quiet and disturbed days.
2. Transient Variations: Definition, computation, morphological features, current systems and causes of solar quiet day variation (Sq), disturbance daily variation SD, storm time variation Dst and lunar variation L, Morphology of the equatorial electrojet, geomagnetic storms: morphological features of geomagnetic storms, gradual and sudden commencement storms, DS and Dst fields, ring current, Van allen belts theories of the geomagnetic storms.
3. The Sun, Sunspots and Solar Flares: A brief introduction of the structure of the sun, morphological features and classification of sun sport indices, morphological features of solar flares, classification of solar flares, Morphological feature, classification and causes of auroras, Morphological features, classification, observation and causes of geomagnetic micropulsation, morphological features, composition, structure and production of various layers of the ionosphere, sudden ionospheric disturbances, Earth currents, its measurements, morphological features and interrelation with geomagnetism.

   Suggested Books:
1. Chapman & Bartels: Geomagnetism
2. Matsushita & Campbel: Physics of the Geomagnetic Phenomena
3. Jacob: Earth's Core and Geomagnetism
4. Mitra: Upper Atmosphere

GPM602U: NON-LINER SYSTEMS IN GEOPHYSICS

1. Kinematics of deformation - the deformation gradient tensor, the strain tensor, homogeneous deformations, deformation of surface and volume elements, material and spatial coordinates, analysis of stress, Cauchy's equation of motion, balance laws, constitutive equations for elastic and thermoelasticity.
2. Introduction to constructive aspects of bifurcation and implicit function theorem, imperfect bifurcation, bifurcation and non-linear eigen value problems.
3. Non-Linear stability and folding of rock strata, convection in magma chambers and mantle, core convection and dynamo theory, earthquakes and chaos.
4. Non-linear elastic waves and solutions, group velocity, dynamical treatment, fractals and multifractals measures in geophysics.

   Suggested Books:
1. Alkin & Fex: An Introduction to the theory of Elasticity
2. Fang: Foundation of Solid Mechanics
3. Mal & Singh: Deformation of Elastic soils

4. Spencer: Continuum Mechanics
5. Robinowitz: Application of Bifurcation Theory
6. Atherton: Stability of Non-Linear System
7. Bhatnagar: Non-Linear Waves in One-Dimensional Dispersive Systems

GPM603V: GEOTOMOGRAPHY AND COMPUTER MODELLING

1. Concept of Tomography: Inversion, linear and non-linear inversion, inversion technique-traditional, Monte-Carlo, Backus-Gilbert, Tau method, non-linear least square, ray tomography, diffraction tomography, borehole tomography, 2D and 3D imaging, applications in various branches of geophysics.
2. Finite element and finite difference methods and their formulations, numerical modelling, super computers, Lax- Wondroff second order scheme, MacDormack fourth order scheme, stability conditions, computer simulation of P-SV, SH and acoustic cases and other geophysical problems.

Suggested Books:
1. Mitchell: Computational Methods in Partial Differential Equations
2. Noye: Numerical Simulation fluid Motion
3. Krishnamurthy & Sen: Computer Based Numerical Algorithms
4. Gold & Rader: Digital Processing of Signals
5. Boarding er. al.: Application of Seismic Travel Time tomogrphy
6. Dines& Lytle: Computerized Geophysical Tomography
7. Wu et. al.: Diffraction Tomography and Multisource Holography Applied to Seismic Imaging.
8. Aiyer et. al.: Geotomography.

GPM602W: MODERN TECHIQUES IN SEISMIC INTERPRETATION AND MIGRATION

1. Seismic Sources: Explosive and non-explosive sources.
2. Seismic Refraction Method: Travel time equations for simple one layer case and for variable velocity case, expressions for dipping layer and faulted bed cases, Gardener delay time method, hidden layer problems, field techniques for refraction survey, fan shooting.
3. Seismic Reflection Method: The travel time equations for horizontally layered medium, expressions for dipping interfaces, field techniques for reflection survey, split spread, end on spread, broad side configurations, 2D, 3D and 4D configurations, common depth point technique, presentation formats of seismograms, selection of field survey parameters.
4. Data processing sequence, static and dynamic correction, weathering and datum corrections, CDP stacking, migration and depth section preparation.
5. Velocity Depth Determination: Velocity-depth relation from measurements in boreholes, velocity depth relation from surface observations, T^2-X^2, T-ΔT and hyperbola method.
6. Noise Elimination Method: The structure of noise and its classification using frequency and spatial filters (arrays), multiples identification, suppression of multiples VSP.
7. Mapping of hydrocarbon bearing and water bearing structures, gas hydrates, pattern recognition, thin bed modelling, seismic lithologic modelling, geological interpretation, location of stratigraphic traps, direct detection of hydrocarbons, wave equation migration and its various forms, artificial intelligence, artificial neural network (ANN) and gas detection using AVO analysis.

Suggested Books:
1. Dobrin & Savit: Introduction to geophysical Prospecting
2. Telford et.al.: Applied Geophysical
3. Keary & Brooks: Introduction to Geophysical Exploration
4. Waters: Reflection Seismology
5. Robinson: Basic Exploration Geophysics
6. Scheriff: Seismic Stratigraphy
7. Lavergne: Seismic Methods.

GPM602X: ADVANCED PHYSICAL METEORLOGY

1. Physics of tropical monsoon clouds, precipitation mechanism from convective, stratiform and orographic clouds, artificial modification of the precipitation, artificial dissipation of fog and low cloud, atmospheric electoral and boundary layer processes.
2. Precipitation chemistry, aid rain, atmospheric aerosols and trace gases, tropospheric chemistry.

3. Atmospheric chemistry, dynamics of the middle atmosphere and troposphere-stratosphere coupling, monsoon activity, climatic change, measurement of atmospheric minor constituents and climatic effects.
4. Physics of the Upper Atmosphere: Composition and structure, energy exchanges by collisions, transport processes, mean circulation and eddy transport, the ionosphere, composition and general properties, observational methods, aurora and air glow, noctilucent clouds, nacreous clouds.
5. Atmospheric Visibility: Attenuation of light by the atmosphere, the air-light and visual range in daytime, visibility of point light sources at night, objective measurement of visual range, oblique visual range.
6. Meteorological Acoustics: Doppler effect, effect of temperature and humidity on sound velocity, sound path in a calm atmosphere, effect of wind on sound propagation, attenuation of sound, propagation of sound through stratosphere, sound origination from meteorological elements.
7. Meteorological Physics: Coronas and related phenomenon, twilight phenomenon, colour and polarisation of sky light.

Suggested Books:
1. Johnson: Physical Meteorology
2. Mason: Physics of Cloud
3. Dobson: Exploring the Atmosphere
4. Retallack: Compendium of Meteorology Vol. I, Part-III, Meteorology. W.M.O. 364
5. Baton: Radar Observes the Weather
6. Kidder & Vonder Harr: Satellite Meteorology
7. Mitra: The Upper Atmosphere.

GPM602Y: APPLIED METEOROLOGY

1. Aviation meteorology: Requirements of climatological data for sitting of runways, meteorological observations and forecasts required for aircraft operations, organization of KAO, DGCA and air traffic control, coordination between MFT and ATC, special observations for aviation, METAR, SPECT, TREND, SIGMENT, aviation forecasts and warnings, documentation and briefing for national and international flights, aviation climatology.
2. Maritime Meteorology: Voluntary observing flight routine and special observations from ship at sea weather bulletins for shipping, storm warning bulletins, storm signals at ports, weather routing of ships, climatological atlas for oceanic regions, atlas of storm tracks.
3. Biometeorology: Thermal balance between heat production and heat loss effect of climatic factors, influence of weather and diseases caused by viruses, bacteria and metabolic disorders, acclimatization, climate and insect pests, thermal comfort and comfort indices, urban and building climatology.
4. Environmental Pollution: Extent of pollution, atmospheric ventilation, meteorological factors affecting the concentration of pollutants, monitoring for prevention control of pollution UNEP.
5. Atmospheric Transport and Diffusion: Classical diffusing theory (K-theory), similarity theory, theory of turbulence, Plum rise, short term modelling and prediction technique for pollutants.
6. Effects of air pollution on climate, human health.

Suggested Books:
1. Stern: Air pollution
2. HMSO, London: Handbook of Aviation Meteorology
3. Munn: Biometeorology
4. WMO Note: Urban Climatology
5. WMO Technical Note: Air Pollutants, Meteorology and Plant Injury.

GPM602Z: ADVANCED CLIMATOLOGY

1. Climatic classification based on atmospheric circulation and geographical conditions. Genetic classification, classification based on the effect originated at the surface. Types of climate, Various classifications of climate, Koepen, thornthwaite, Handdel etc.
2. Function and physical description of the climates of the different continents and ocean.
3. Radiation properties of natural surfaces, radiation in crops forest canopies, cities, vertical variation and distribution of various climatic elements, heat exchange and conduction near soil surface, atmospheric pollution.

4. Elements of bioclimatology, urban building climatology, climatic change, fundamental meteorological factors affecting the climate, past climate revealed by meteorological observation, methods of palaeoclimatology, possible causes of climatic change, influence of man on climatic changes, climatological statistics.
5. Introduction to climate system, role of green house gases, global warming, climatic change and its impacts on agriculture.
6. Asian Summer Monsoon: Global teleconnections, basic concepts of climatic modelling, energy cycle, Tropical Ocean and their role in climate control.
7. Physical processes in general circulation.

Suggested Books:
1. Miller: Climatology
2. Lamb: Climate Present, Past and Future
3. Barry & Parry: Synoptic Climatology
4. Stringer: Fundamentals of Climatology
5. Winter School on Climate Change and its Impacts, IIT, Delhi.

GPM603: SEMINAR   **Credits: 2**

Each student is required to prepare a seminar note (about 1500 words) in the form of a report and give oral lecture (40 minutes) on the topic assigned by the Head of the Department in consultation with respective supervisor.

GPM604A/GPM604B: COMPEHENSIVE VIVA- VOCE   **Credits: 3**

At the end of sixth Semester, each student will be examined in this paper on the entire M.Sc. (Tech.) Geophysics courses by a Board consisting of three internal and one external examiner in each specialization.

GPM605A/GPM605B: PROJECT WORK/DISSERTATION   **Credits: 8**

During sixth semester, students may go for 2-4 weeks for their Project work/dissertation at the laboratories of their field of specialization or with field parties depending upon the facilities in the summer vacation. For dissertation work, the co-supervisor is also allowed. The topic of their project work/dissertation will be decided towards the end of the fourth Semester by the Head of the Department in consultation with the supervisors.

<u>NOTE</u>

1. *Students of Semester-IV will initiate dissertation/ project work during summer vacation at laboratories outside Varanasi, if required.*
2. *Students of Semester-II will carry out Summer Training at different laboratories outside Varanasi, if desired by the students.*
3. *Students of Semester-III will carry out their Field Training during the Semester Break.*
4. *For dissertation work, the co-supervisor(s) be allowed for the outside organization.*

M.A./ M.Sc. HOME SCIECE (FOODS & NUTRITION)
Department of Home Science
Banaras Hindu University

Semesterwise distribution of Courses and Credits

Course Code	Titles	Credits
Semester-I		
HFM101	Research Methods and Scientific writing	3
HFM102	Applied Physiology	3
HFM103	Nutritional Biochemistry and Methods of Investigation	3
HFM104	Institutional food Administration	3
HFM105	Women's Health and Nutrition	3
HFM106M	*Minor Elective:* Indian Socio-economic environment and perspectives	3
HFM107	*Practicals based on course* HFM101	2
HFM108	*Practicals based on course* HFM102	2
HFM109	*Practicals based on course* HFM103	2
	Total	**24**
Semester-II		
HFM201	Statistics	3
HFM202	Advanced Nutrition -I	4
HFM203	Food Safety, quality control and sensory evaluation of foods	3
HFM204	Food Science and Microbiology	3
HFM205	Science and Technology for Rural Development	3
HFM206M	*Minor Elective:* Computer application	3
HFM207	*Practicals based on course* HFM203	2
HFM208	*Practicals based on course* HFM204	2
	Total	**23**
Semester - III		
HFM301	Pilot Survey for Dissertation and Synopsis Formulation and Seminar	4
HFM302	Experimental Foods	3
HFM303	Advanced Nutrition - II	3
HFM304	Nutritional Epidemiology	3
HFM305	Community Nutrition	3
HFM306M	*Minor Elective:* Development Project Management	3
HFM307	*Practicals based on course* HFM302	2
HFM308	*Practicals based on course* HFM303	2
	Total	**23**
Semester -IV		
HFM401	Dissertation	6
HFM402	Therapeutic Nutrition and Biochemical correlates	3
HFM403	Internship (6-8 weeks spread over two years)	9
HFM404	*Practicals based on course* HFM402	2
	Total	**20**
	Grand Total	**90**

* To be opted by all students specializing in Extension and Communication

Ist Semester

Major Elective
HFM101: RESEARCH METHODS AND SCIENTIFIC WRITING   Credits 3
PART – A – RESEARCH METHODS

Science, scientific methods, scientific approach
Role of statistics and research in Home Science discipline: Objectives of research: Explanation, control and prediction.
Types of Research: Historical, survey, experimental, case study, social research, participative research. Definition and Identification of a Research Problem**,** Selection of research problem**,** Justification**,** Theory, hypothesis, basic assumptions, limitations and delimitations of the problem.
Types of variables
Theory of probability: Population and sample**,** Probability sampling: systematic random sampling, two stages and multi stage sampling, cluster sampling, Non-Probability sampling: purposive, quota and volunteer sampling/snowball sampling.
Basic Principles of Research Design and hypothesises: Purposes of research design; Fundamental, applied and action exploratory and descriptive experimental, survey and case study, ex-post facto, Longitudinal and cross sectional
Qualitative Research Methods: Theory and design in qualitative research, Definition and types of qualitative research, Methods and techniques of data collection, Informal group discussions**,** Interviews; Key informants, in-depth interviews**,** Observations
Data Gathering Instruments: Observation, questionnaire, interview, scaling methods, case study, home visits, reliability and validity of measuring instruments.
Scales of measurement and the appropriate statistical techniques.
Critical analysis of research.

References
1. Bandarkar, P.L. and Wilkinson, T.S. (200): Methodology and Techniques of Social Research, Himalaya Publishing House, Mimbai.
2. Bhatnagar, G.L. (1990): Research Methods and Measurements in Behavioural and Soxial Sciences, Agri. Cole Publishing Academy, New Delhi.
3. Dooley, D. (1995): Strategies for interpreting Qualitative Data; Saga Publications, Claifornia.
4. Gay, L.R. (1981, 2nd Ed.): Educational Research, Charles, E. Merill, Columbus, Ohio.
5. Long, J.S. (Ed.) (1988): Common Problems Proper Solutions: Avoiding Errors in Quantitative Research Beverly Hills, Sage Publications, California.
6. Mukherjee, R. (1989): The Quality of lIfe: Valuation in Social Research, Saga Publications, New Delhi.
7. Stranss, A. and Corbin, J. (1990): Basis of Qualitative Research: Grounded Theory Procedures and Techniques, Saga Publications, California.

PART – B – SCIENTIFIC WRITING

Scientific writing as a means of communication: Different forms of scientific writing
Articles in journals. Research notes and reports. Review articles, Monographs, Dissertations, Bibliographies.
How to formulate outlines: The reasons for preparing outlines**,** guide for plan of writing**,** skeleton for the manuscript**,** Kinds of outline**,** topic outlines**,** conceptual outline**,** sentence outlines**,** combination of topic and sentence outlines
Drafting Titles, Sub Titles, Tables, Illustrations: Tables as systematic means of presenting data in rows and columns and lucid way of indicating relationships and results, formatting Tables: Title, Body stab, Stab Column, Column Head, Spanner Head, Box Head, appendices; Use and guidelines
The writing process: Getting started**,** Use outline as a starting device**,** Drafting, Reflecting, Re-reading**,** Checking organization**,** Checking headings**,** Checking content**,** Checking clarity**,** Checking grammar**,** Brevity and precision in writing**,** Drafting and Re-drafting based on critical evaluation

Parts of Dissertation/Research report/Article: Introduction**,** Review of Literature**,** Method**,** Results and Discussion**,** Ask questions related to content, continuity, clarity, validity internal consistency and objectivity during writing each of the above parts.

Writing for Grants: Clearly state the question to be addressed**,** Rationale and importance of the question being address**,** Emperial and theoretical conceptualization**,** Presenting pilot study/data**,** Research proposal and time frame**,** Clarity, specificity of method**,** Clear organization**,** Outcome of study and its implications**,** Budgeting**,** Available infra-structure and resources**,** Executive summary

PRACTICAL

HFM107: RESEARCH METHODS AND SCIENTIFIC WRITING (Credits 2)

1. Abstract of different types of research should be given and discussed in the practical classes.
2. Students should be asked to collect data from the household of B.H.U. Campus by using different sampling techniques in a group.
3. The Student should be given exercises on different kinds of Scientific Report writings.
4. Presentation should be made by the students on their field work reports.

References

1. APA (1984): Publication Manual of American Psychological Association (3rd Edition), Washington, APA
2. Copper, H.M. (1990): Integrating Research: A Guide for Literature Reviews (2nd Edition), California, Sage.
3. Dunn, F.V. & Others (ed.) (1994): Disseminating Research Changing Practice, NY: Sage.
4. Haman, E. & Montagnes, I. (Eds.) (1997): The Thesis and the Book, New Delhi: Vistaar.
5. Locke, L.F. and Others (1987): Proposals that work: A Guide for Planning Dissertations & Grant proposals (2nd Ed.), Beverly Hills: Sage.
6. Mullins, C.J. (1977): A Guide to Writing and Publishing in Social and Behavioral Sciences, New York: John Wiley & Sons.
7. Richardson, L. (1990): Writing Strategies, Reaching Diverse Audience, California: Sage.
8. Stemberg, R.J. (1991): The Psychologist's Companion: A Guide to Scientific Writing for Students and Researchers, Cambridge, OUP.
9. Thyer, B.A. (1994): Successful Publishing in Scholarly Journals, California: Sage.
10. Wolcott, H.F. (1990): Writing up Qualitative Research Newbury Park: Sage.

Core Course

HFM102: APPLIED PHYSIOLOGY **Credits 3**

General Physiology: Revision of structure of cells tissues, muscles, organs, system phenomena of life, constancy of internal environment.

Body Fluids: Blood; Blood composition, volume, plasma proteins; origin, composition and function, blood groups. Red blood cells; structure and functions, origin and life history; number of blood cells in the blood, Haemoglobin, its composition and functions Regulation of red blood cell formation.

Circulatory System: Working of the heart, anatomy, properties of heart muscle: Origin of the heart beat, heart; sounds, control of heart rate, reflexes involving the heart, velocity of blood flow, resistance to blood flow and blood pressure. Blood vessels, arteries, capillaries, veins, control of blood vessels, pulse physiological constancy of blood pressure. Origin and propagation of cardiac cycle.

Digestive System: Review of structure and function, Secretary, digestive and absorptive functions, Role of liver, pancreas and gall bladder and their dysfunction Motility and hormones of GIT.

Respiratory System: Organs, structure, function, composition of inspired and expired and alveolar air respiration internal and external, its rate, factors affecting it, artificial respiration anoxia.

Excretory System: Urinary system, organs, structure, function, mode of formation of urine, process of maturation, Skin-its structure and function, Temperature of the body and its regulation, maintenance of acid-base balance, electrolytes.

Reproduction: Reproductive organs-the ovary, development of graffian follicle, the testis, maturation of the sperm, fertilization development of the ovum, implantation, pregnancy, fetal membrane, parturition, lactation and its regulation, ovarian and uterine cycle and their regulations, Effect of hormones on menstruation, ovulation.

Musculoskeletal System and sensory organs:

The spinal cord and brain, the neurons synapses, chemical, theory of conduction across nerve, pathways of the spinal cord, Reflux action, kinds of reflexes, functions of the different part of the brain, Sensory mechanisms, Different kinds of receptors with reference to the sense organs, Automatic nervous system sensory organs; Eyes, Ear, Nose, Tongue and Skin.

Endocrine System: Endocrine glands and their hormones, hormonal regulation of function.

Immune System: Cell mediated and humoral immunity Activation of WBC and production of antibodies, role in inflammation and defence

HFM108: APPLIED PHYSIOLOGY PRACTICALS   **Credits 2**

1. Examination of slides of connective tissues, nerve tissues, muscular tissues, epithelial tissues. Section of kidney, skin, respiratory tract, lung, blood vessels, ovary tests, uterus, endocrine glands, different regions of the alimentary canal, digestive glands.
2. Recording of number and type of respiration, vital capacity, artificial respiration.
3. Estimation of haemoglobin; blood film preparation, staining, blood grouping and matching study of cells in normal coagulation of blood, Clotting and bleeding time, colour index, Heart sound, blood pressure, pulse, clinical examination and recording.
4. Urine examination – normal abnormal physical examination and chemical examination, estimation of sugar and albumin.

References:

1. Ganong, W.F. (1985): Review of Medical Physiology, 12th Edition, Lange Medical Publication.
2. Moran Campell E.J., Dickinson, C.J. Slater, J.D. Edwards, C.R.W, and Sikora K (1984): Clinical Physiology, 5th Edition, ELBS, Blackwell Scientific Publications.
3. Guyton, A.C. (1985): Function of the Human Body, 4th Edition, W.B. Sanders Company, Philadelphia.
4. Guyton, A.C. and Hall, J.B. (1996): Text Book of Medical Physiology, 9th Edition, W.B. Sanders Company, Prism Books (Pvt.) Ltd., Bangalore.
5. Wilson, K.J.W. and Waugh, A. (1996): Ross and Wilson Anatomy and Physiology in Health and Illness, 8th Edition, Churchil Livingstone.
6. McArdle, W.D., Katch, F. I. and Katch, V.L. (1996): Exercise Physiology, Energy, Nutrition and Human Performance, 4th Edition, Williams and Wilkins, Baltimore.
7. Jain, A.K.: Textbook of Physiology. Vol. I and II. Avichal Publishing Co., New Delhi.

HFM103: NUTRITIONAL BIOCHEMISTRY AND METHODS OF INVESTIGATION   **Credits 3**

PART – A - NUTRITIONAL BIOCHEMISTRY

Scope and importance of Biochemistry, Important physical phenomenon influencing the reactions of living matter; Surface tension, Colloidal state, Permeability, Osmotic pressure Hydrogen ion concentration, Chemistry of carbohydrates; glycolysis, gluconeogenesis, citric acid cycle, hexose monophosphate way path, Chemistry of lipids; beta oxidation, synthesis and break down of unsaturated fatty acids, cholesterol, phospholipids, triglycerides,

Chemistry of proteins, Amino Acids, peptide linkage, Nucleic aids, DNA replication and transcription, regulation of gene expression protein synthesis, RNA, Electrolytes, pH buffers, Chemistry of vitamins sources requirements, functions, deficiency, Chemistry of minerals and trace elements, water balance, Acid base balance, Detoxification in the body; metabolism of foreign compounds.

PART – B - METHODS OF INVESTIGATION

Electrolytic dissociation: Acids, bases, salts, buffers, Hendersen; Hasselbach equation. Theory of indicators and principles of measurement of pH.

Basics of Instrumentation: Physico; chemical principles and methodology; Colorimetry, photometry, fluorimetry, flame photometry and atomic absorptiometry.

Chromatography: Principles and application in paper (circular, ascending and descending), ion-exchange, column, thin layer, gas liquid and high performance liquid chromatographic techniques.

Electrophoresis: Principle and applications in paper and gel electrophoresis.

Bioassays: Animal studies, Human studies, Microbiological assays.

Use of Isotopes: Radioactive and stable isotopes.

NMR and its applications.

Immunological Methods: RIA, ELISA.

PRACTICALS

HFM109: NUTRITIONAL BIOCHEMISTRY AND METHODS OF INVESTIGATION (Credits 2)

PART – A- NUTRITIONAL BIOCHEMISTRY

This course will enable the students to:

Perform biochemical analysis with accuracy and reproducibility.

1. **Proteins:** Estimation of protein in food stuffs, Estimation of albumin, globulin and albumin/globulin ratio in serum and urine, Estimation of hemoglobin.
2. **Glucose:** Estimation of glucose in blood and urine.
3. **Cholesterol**: Estimation of cholesterol in blood.
4. **Urea and Creatinine**: Estimation of urea and creatinine in serum and urine.
5. **Survey of pathological laboratories:** To obtain information about the methods used for blood/serum analysis.

PART – B – METHODS OF INVESTIGATION

Objectives

This practicals will enable the students to :

1. Orient them selves regarding the use of various analytical techniques for specific estimations.
2. Comprehend better the principles involved in different methods of investigation.
3. Become efficient in the use of some of the most commonly used techniques and instruments in High quality research.
4. **Acid and Alkalis:** Preparation of dilute solutions of common acids and alkalis and determining their exact normalities.
5. **Buffers:** Preparation of phosphate, carbonate-bicarbonate, boric acid, acetate, chloride and pthalate buffers and determination of their pH by the use of indicators and pH meters.
6. **Spectrometry:** Beer Lambert Law, absorption maximum, preparation of standard curve and nutrient estimations in UV and visible range, AAS, AES, Flamephotometry.
7. **Fluorimetry:** Estimation of thiamin and riboflavin.
8. **Chromatography:** Paper; Identification of amino acids by circular, ascending and descending methods. Ion-exchange; separation of amino acids. Column - Separation of proteins. Thin layer; Identification of amino acids. Gas-liquid; Estimation of fatty acids. HPLC – Estimation of β-carotene and α-tocopherol.

9. **Electrophoresis**: Fractionation of plasma proteins.

References:
1. Boyer, R. (2000). 3rd Ed. Modern Experimental Biochemistry. Person Education, Asia.
2. Dawes, E.A. (1980) 6th Ed. Quantitative Problems in Biochemistry. Longman Group Ltd.
3. Khosla, B.D., Garg, V.C. and Khosla, A. (1987). 5th Ed. Senior Practical Physical Chemistry. R. Chand and Co., New Delhi.
4. Oser, B.L. (1965). 14th ed. Hawk's Physiological Chemistry. Tata McGraw-Hill Publishing Co. Ltd.
5. Raghuramulu N.; Madhavan Nair and K. Kalyanasundaram, S. (1983). A Manual of Laboratory Technique. NIN, ICMR.
6. Sharma, B.K. (1999). 8th Ed. Instrumental Methods of Chemical Analysis. Gel Publishing House.
7. Srivastava, A.K. and Jain, P.C. (1986). 2nd Ed. Chemical Analysis: An Instrumental Approach. S. Chand and Company. Ltd.
8. Varley, H.; Gowenlock, A.H. and Bell. M. (1980). 5th ed. Practical Clinical Biochemistry. Heinemann Medical Books Ltd.
9. Vogel, A.I. (1962). 3rd Ed. A Textbook of Quantitative Inorganic Analysis by the English Language Book Society and Longman.
10. Murray, R. K. Granner, D. K. Mayes, P.A. and Rodwell, V.W. (2000): 25th Ed. Harpers Biochemistry, Macmillan Worth Publishers.
11. Nelson, D.L. and Cox, M.M. (2000): 3rd Ed. Lehninger's Principles of Biochemistry, Macmillan Worth Publishers.
12. Devlin, T.M. (1997): 4th Ed. Textbook of Biochemistry with Clinical Correlation; Wiley Inc.
13. Stryer, L. (1998): 4th Ed. Biochemistry, WH Freeman and Co.
14. Conn, E.E., Stumpf, P. K. Bruening, G. and Doi, R.H. (2001): 5th ed. Outlines of Biochemistry, John Wiley and Sons.
15. Voet, D. Voet, J.G. and Pratt, C.W. (1999): Fundamentals of Biochemistry.
16. Oser, B.L. (1965): 14th ed. Hawk's Physiological Chemistry. Tata McGraw-Hill Publishing Co. Ltd.
17. Varley, H. Gowenlock, A.H. and Bell, M. (1980). 5th ed. Practical Clinical Biochemistry, Heinemann Medical Books Ltd.
18. Tietz, N.W. (1976) Fundamentals of Clinical Chemistry, WB Saunders Co.
19. Vogel, A.I. (1962). 3rd ed. A Textbook of Quantitative Inorganic Analysis. The English Language Book Society and Longman.
20. Raghuramulu, N.; Madhavan Nair and K. Kalyanasundaram, S. (1983). A Manual of Laboratory Techniques. NIN. ICMR.
21. King, E.J. and Wootton, IDP (1956). 3rd ed. Micro-Anlysis in Medical Biochemistry. J and A Churchill Ltd.
22. Plummer, D.T. (1987). 3rd ed. An introduction of Practical Biochemistry. McGraw Hill Book Co.
23. Winton, A.L. and Winton, K.B. (1999). Techniques of Food Analysis. Allied Scientific Publishers.

Code: HFM104: INSTITUTIONAL FOOD ADMINISTRATION   **Credits 3**

Introduction to Food Service Systems, Evolution of the food service industry, Characteristics of the various types of food service units, Approaches to Management, Theories of management, Aspects of management, Styles of management, Management tools, Strategies in Planning, Conceptual strategy, Marketing strategy, Financial strategy, Types of plans, Management of Resources, Finance, Determining the finance needed to establish or run an

unit, Budgets, Sources of finance, Planning adequate cash flow, Space & Equipment, Steps in planning layouts, Determining equipment, Selection and placement, Layout analysis, Material, Menu planning, Planning the material needed, Methods of selection, Storage, Quantity food production, Service and modes of delivery, Planning Menus, banquet, outdoor, catering, packed meals, Restaurant, Staff, Manpower planning, Manpower placement, Recruitment, induction, training, motivation and performance appraisal, Time and Energy, Measures for utilisation and conservation, Techno-economic feasibility of food production/service enterprise, Cost Accounting / analysis, Food cost analysis, Records to be maintained, Reports and trend analysis, Marketing and sales management, Marketing strategies, Sales analysis, Market promotion, Quality assurance, Food quality, Total quality management, Market Survey and analysis of processed and finished products, Visit to any food service unit

References:
Management
1. West, B Bessie & Wood, Levelle (1988) Food Service in Institutions 6th Edition. Revised by Harger FV, Shuggart SG & Palgne-Palacio June Macmillian Publication Company New York.
2. Sethi Mohini (1993) Catering Management An Integrated Approach 2nd Edition Wiley Publication.
3. Kotas Richard & Jayawardardene, C (1994): Profitable Food and Beverage Management, Hodder & Stoughton Publication.
4. Brodner, J., Maschal, H.T., Carlon, H.M. (1982): Profitable Food and Beverage Operation 4th Edition, Hayden Book Company, New Jersey.
5. Green, E.F., Drake, G.G. Sweeny, J.F. (1978) Profitable Food and Beverage Management; Planning, Operations, Hayden Book Company, New Jersey.
6. Knootz, H, O Donnel C (1968): Principles of Management McGraw Hill Book Company.
Personnel Management
7. Desseler, Garry (1987) Personnel Management Modern Concepts and Techniques, Prentice Hall, New Jersey.
8. Kumar, H.L. (1986) Personnel Management in Hotel and Catering Industries, Metropolitan Book Company N. Delhi.
9. Hitchcock, M.J. (1980): Food Service System Administration, Macmillan Publishing Company.
Cost Control
10. Keiser, J & Kaillo, E. (1974): Controlling and Analysis of Cost in Food Service Operations, Wiley and Sons N. York.
11. Khari, W.L. (I) (1977): Introduciton to Modern Food and Beverage Service. (1979) Advanced Modern Food and Beverage service. Printice Hall Series.
12. Coltman, M.M. (1977): Food and Beverage Cost Control. Printice Hall Series.
13. Levson (1976): Food and Beverage Operation Cost Control & System Management. Printice Hall Series.
Layout and Design
14. Kazarian, E.A. (1989) Food service Facilities Planning. 3rd Editon, Von Nostrand Reinhold.
15. Kotschwar, L.H. & Terrell, M.E. (1977): Food Service Planning and Layout and Equipment 3rd Edition John Wiley and Sons, N York.
16. Avery, A.C. (1980): Modern Guide to Food Service Equipment. Boston CBI Publishing Company.
17. Brichfield, J. (1988): Design and Layout of Food Service Facilities, New York. Van Nortrand Reinhold.

18. Tovel, A.P. (1984): Standardising Food Service for Quality and Efficiency. AVI Publishing Company INC.

Code: HFM105: WOMEN'S HEALTH AND NUTRITION   **Credits 3**

Role of Women in National Development: Women in Family and Community; Demographic changes, menarche, marriage, fertility, morbidity, mortality, life; expectancy, sex ratio, aging and widowhood, female-headed families.

Women and Work: Environmental stress, nutrition, health and gender, living conditions, occupational health, health facilities.

Women's nutritional requirements and food needs.

Women and Society: Women's role, their resources and contribution to family and community and effect on nutritional status, Effect of urbanisation on women, Impact of economic policies, industrialization and globalization on women.

Women and Health: Health facilities, Disease patterns and Reproductive health, Gender and health, Health seeking behaviour, Women; pregnancy and lactation, Safe motherhood, Care of at-risk mothers, Family planning, Women and aging; Special concerns in developed and developing societies: menopause, osteoporosis, chronic degenerative diseases, neurological problems, Women and AIDS

Women and nutrition: Situation of women in global, national and local context, Improving the nutritional and health status, Interventions throughout the life cycle.

Policies and legislations: CEDAW (Convention on Elimination of all forms of Discrimination Against Women), Women's Right to Life and Health (WRLH), Legal status of women.

Empowerment of Women: Role of Education and various national schemes and programmes for women development

Problems and issues related to women in India: Child marriage, Female foeticide, infanticide, Socialization of girl child, Dowry, Employment, Women in Politics, Domestic Violence

Reference
1. ACC/SCN Policy Discussion Papers
2. Wallance, H.M. and Giri, K. (1990): Health Care of Women and Children in Developing Countries, Third Party Publishing Co., Oakland, California.
3. UNICEF (1994): The Urban Poor and Household Food Security, UNICEF.
4. IDRC (1993): Gender, Health and Sustainable Development.
5. NGO Committee on UNICEF (1997): Women and Children in Urban Poverty – What Way Out?
6. Census Reports, Government of India.
7. NFHS Reports
8. UNICEF – State of the World's Children.
9. Weil, D.E.C.; Alicbusan, A.P.; Wilson, J.F.; Reich, M.R. and Brdley, D.J. (1990). The impact of Development Policies on Health. A Review of the Literature, World Health Organization. Geneva.
10. International Nutrition Foundation – Micronutrient Initiative (1999): Preventing Iron Deficiency in Women and Children; Technical Consensus on Key issues.
11. Gopalan, C. and Kaur, S (Eds) (1989): Women and Nutrition in India, Nutrition Foundation of India.

Minor Elective

Code: HFM106M : INDIAN SOCIO-ECONOMIC ENVIRONMENT PERSPECTIVES   **Credits 3**

Indian economy—structure and organisation of rural, urban and tribal areas: Land ownership, occupational hierarchy, dependence on agriculture**,** Caste, class and institutions**,** Roles and status of women**,** Poverty, inequality, unemployment, stagnation**,** Impact of industrialisation of urban life; socio-economic aspects of metropolitan life, Historical overview of tribal welfare.

Socio economic changes since independence: Economic planning and achievements**,** Growth vs Development, Development index, PWLI, HDI, CPI, etc.**,** Rural development; concepts, objectives, importance and historical overview**,** Employment policy; cottage and small industries**,** Land reforms; future programmes**,** Tribal development strategies and policies**,** New economic policy and its impact

Industry and agriculture: Industrial development and diversification**,** Industrial policies since 1981**,** Agriculture price and credit policy**,** New economic policy and agriculture

Co-operatives: Philosophy, objectives, types and progress

References

1. Ahluwalia, M.S. (2000): India's Economic Reforms and Development, Oxford University Press.
2. Bhattacharya, B.: Urban Development in India, Shree Publishing House, Delhi.
3. Bose Ashish: India's Urbanisation, Institute of Economic Growth, Delhi University.
4. Bulsara, J.F.: Patterns of Social Life in Metropolitan Areas.
5. Das Ram: Socio-economic Transformation of Millions through Rural Development, 21st Century Publishers, Meerut.
6. Dreze, J. and Sen, A.K. (1995): India, Economic Development and Social Opportunity, Oxford University Press.
7. Gulati, A: Indian Agriculture and Open Economy.
8. Hussain, N.: Tribal India Today, Hamam Publishing House.
9. Krishan, K.L.: Industrial Growth and Diversification.
10. M.B. Nanavati and Anjana, J.J.: Indian Rural Policies.
11. Sen, A.K.: Growth Economics.
12. Singh, A.K. : Tribal Development in India, Amar Prakashan, Delhi.

Journals
1. Economics and Political Weekly.
2. Journal of Rural Development
3. Kurukshetra, Publication of Development, Govt. of India, New Delhi.
4. Social Change (Council of Social Development, New Delhi).
5. Vohra, Publication of Development, Govt. of India, New Delhi.

IInd SEMESTER

Major Elective

Code: HFM201: STATISTICS   **Credits 3**

Conceptual understanding of statistical measures, Classification and tabulation of data. Measurement of central tendency, measures of variation, Frequency distribution, histogram, frequency, polygons, Oliver, Binomial distribution, Normal distribution; Use of normal probability tables, Parametric and non-parametric tests, Testing of hypothesis; Type I and Type II errors, Levels of significance, Chi-square test, Goodness of fit, Independence of attributes 2×2 and $r \times c$ contingency tables, Application of student 't' test for small samples. Difference in proportion for means and difference in means, Co-relation, coefficient of co-relation, rank co-relation, Regression and prediction, Analysis of variance; one way and two-

way classification, Experimental Designs; Completely randomized design, Randomized block design, Latin square design, Factorial design, Trend analysis.

References

1. Edwards: Experimental Design in Psychological Research
2. Garrett, Heny E. (1971): Statistics in Psychology and Education, David Haley & Co.
3. Kerlinger: Foundation of Educational Research

HFM202: ADVANCED NUTRITION – I   **Credits 4**

Energy: Energy content of foods. Physiological fuel value – review. Measurement of Energy Expenditure: BMR, RMR, thermic effect of feeding and physical activity, methods of measurement. Estimating energy requirements of individuals and groups. Regulation of energy metabolism: control of food intake, digestion, absorption and body weight.

Utilization of digestive nutrients and desirability

Carbohydrates: Types, classification, digestion, and transport; review, dietary fibre, fructo-oligosaccharides, resistant starch; chemical composition and physiological effects Glycemic index of foods. Sweeteners nutritive and non-nutritive.

Proteins: Classification, digestion, absorption and transport – review. Metabolism of proteins: Role of muscle, liver and gastro intestinal tract. Protein quality, methods of evaluating protein quality. Protein and amino acid requirements. Therapeutic applications of specific amino acids: Branched chain, glutamine arginine, homocysteine, cysteine, taurine.

Lipids: Classification, digestion, absorption, transport – review. Functions of EFA. Role of n-3, n-6 fatty acids in health and disease. Requirements of total fat and fatty acids. Trans fatty acids. Prostaglandins.

Minerals: (Note: for each nutrient sources, bioavailability, metabolism, function, requirements, RD/ESADDI, deficiency and toxicity, interactions with other nutrients are to be discussed).

Macro minerals: calcium, phosphorous, magnesium, sodium, potassium and chloride.

Micro minerals: Iron, Copper, zinc, manganese, iodine, fluoride.

Trace minerals: Selenium, cobalt, chromium, vanadium, silicon, boron, nickel.

Vitamins: Historical background, structure, food sources, absorption and transport, metabolism, biochemical function, assessment of status. Interactions with other nutrients. Physiological, pharmacological and therapeutic effects, toxicity and deficiency with respect to the following:

Fat soluble: Vitamins A, D, E & K.

Water soluble: Thiamine, riboflavin, niacin, biotin, pyridoxine, folic acid, pantothenic acid, ascorbic acid, cyanocobalamin, choline, inositol.

References:

1. Annual Reviews of Nutrition. Annual Review Inc, California, USA.
2. Shils, M.E.; Olson, J.; Shike, M. and Roos, C. (1998): Modern Nutrition in Health and Disease. 9th edition. Williams and Williams. A Beverly Co. London.
3. Bodwell, C.E. and Erdman, J.W. (1988) Nutrient Interactions. Marcel Dekker Inc. New York.
4. World Reviews of Nutrition and Dietetics.
5. European Journal of Clinical Nutrition.
6. International Journal of Vitamin and Nutrition Research.
7. International Journal of Food Science and Nutrition.
8. Nutrition Research
9. Ann Nutr Metab.

3.

HFM203: FOOD SAFETY, QUALITY CONTROL AND SENSORY EVALUATION OF FOODS

Credits 3

PART – A (FOOD SAFETY AND QUALITY CONTROL)
Introduction to quality assurance and food safety assurance, Current concepts of quality control, Quality assurance programme; Quality plan, documentation of records, products standards, Product and purchase specifications, process control and HACCP, hygiene and housekeeping, corrective action, quality and programme and total quality process.
Product Evaluation: Specifications and food standards. International, National; Mandatory, Voluntary, Tests for specific raw food ingredients and processed, Proximate principles, Nutrient analysis, Quality parameters and tests to adulterants, Consumer Protection.

PART – B (SENSORY EVALUATION OF FOOD)
Introduction to sensory analysis and uses of sensory tests.
General testing conditions.
Selection of test subjects and training of panel.
Types of tests: Discrimination/difference test: Paired test, triangle test and duo-trio test; tests for multiple samples, difference from control/reference, Qualitative Difference Tests; Ranking, Numerical scoring test, magnitude estimation, Descriptive Tests; Rating for sensory profile, Threshold tests, Acceptance test; Monadic, paired and sequential monadic.
Descriptive analysis, concept alignment and selection of terms.
Consumer acceptability using sensory evaluation.

PRACTICAL
HFM207: FOOD SAFETY, QUALITY CONTROL AND SENSORY EVALUATION OF FOODS

Credits 2

PART – A –FOOD SAFETY AND QUALITY CONTROL
1. To test different foods for their quality
2. To detect adulteration in different foods.
3. To be familiar with tests used for quality control.
4. Assessment of purity and quality using appropriate standard tests for the following: Milk and milk products, Ice creams and sherbets, Spices and condiments and salt, pickles, sauces and chutneys, Tea and coffee, Canned, dehydrated, frozen and bottled fruit/vegetable products, Flesh foods, Fruit juices, concentrates and beverages.

PART – B –SENSORY EVALUATION OF FOOD
1. Establishing sensory panels: Selecting and recruiting panelists, screening for trained panels, training panelists, monitoring performance. Recognition tests for 4 basic tastes, odour and aroma. Tests with other senses. Threshold tests.
2. Analytical tests: (i) Difference (ii) Ranking (iii) Descriptive (iv) Scoring and (v) Rating.
3. Planning a Sensory Experiment: (i) Designing the questionnaire and scorecard, (ii) identifying descriptors.
4. Conducting the Test
5. Preparing samples, Presenting samples, Using reference samples, Reducing panel response error, Consumer oriented tests, Product oriented tests, Shell life studios, Product matching, Product mapping, Taint Investigation and Prevention
6. Report Writing

References:
1. Martens, M.; Dalen, G.A.; Russwurm, H. (eds) (1987): Flavour Science and Technology, John Wiley and Sons, Chichester.
2. Jellinek, G. (1985): Sensory Evaluation of Food Theory and Practice. Ellis Horwood, Chichester.
3. Piggott, J.R. (ed.) (1988): Sensory Analysis of Foods. Elsevier Applied Science, London.
4. Moskowitz, H.R. (1983): Product Testing and Sensory Evaluation of Foods: Marketing and R & D approaches. Food ad Nutrition Press, Connecticut.
5. Watts, B.M., Ylimaki, G.L., Jeffery, L.E. and Elias, L.G. 91989): Basic Sensory Methods for Food Evaluation. The International Development Research Centre, Ottawa, Canada.
6. BIS 6273 (1972): Guide for Sensory Evaluation of Foods. Optimum Requirement. Part I. Bureau of Indian Standards, Manate Bhavan, New Delhi.
7. Early, R. (1995): Guide to Quality Management Systems for the Food Industry, Blackie, Academic and Professional, London.
8. Ranganna, S. (1986): Handbook of Analysis and Quality Control for Fruit and Vegetable Products, 2nd edition, Tata McGraw Hill Publishing Co. Ltd., New Delhi.
9. Bryan, F.L. (1992): Hazard Analysis Critical Control Point Evaluations. A Guide to Identifying Hazards and Assessing Risks Associated with Food Preparation and Storage. World Health Organisation, Geneva.
10. Food and Agricultural Organisation (1980): Manuals of Food Quality Control. 2. Additives Contaminants Techniques, Rome.
11. Bureau of Indian Standards: Specifications and Standard Methods.
12. Herschderfer (1987): Quality Control in Food Industry, Food Science and technology – A series of Monographs, Academic Press, London.

Code: HFM204: FOOD SCIENCE AND MICROBIOLOGY   **Credits 3**
PART – A – FOOD SCIENCE
Introduction to food chemistry
Enzymes: Review of nomenclature, properties and isolation; Factors influencing enzymes, Enzyme inactivation and control, Food modification by enzymes, Immobilized enzymes in food processing, Enzymes in waste management, Enzymes and health/nutrition/food issues
Lipids: Role of food lipids in favour; Effects of processing on chemical structure and physical properties, Precursors of Aroma compounds, Physiological effects of lipids and safety issues, Lipids exposed by frying conditions, hydrogenated fat and irradiated foods, Lipids; protein complexes
Carbohydrates: Use of polysaccharides in food: Individual Polysaccharides; Agar, Aliginates, Carageenans, Gum Arabic, Xanthan, Guar gum, Tamarind flour, Pectins, Polysaccharide hydrolyses, Modified Starches; mechanically damaged starches, extruded starches, pregelatinized, tin boiling starch, cross-linked starches, starch ethers and esters, oxidized starches, Use of non-starch polysaccharides in food
Flavours: Methods of flavour analysis, Taste and non-specific saporous sensation, Individual aroma compounds: Vegetable, fruit and spice flavour, flavours from lactic acid / ethanol fermentation, flavour volatiles from fats and oils, flavour volatiles in muscles foods and milk, Thermally induced process flavours, Volatiles from oxidative cleavage of carotenoids, Interactions with other food constituents, Natural and synthetic flavours
Food Colorants: Pigments in animal and plant tissues, Food colours; Types and properties, regulatory aspects, safety issues.
Beverages: Harvesting, processing and by-products; Coffee, tea, cocoa, alcoholic beverages.

Problems of chemical residues in food: Recent advances in biotechnology; Recombinant DNA techniques, genetically modified foods.

PART – B – MICROBIOLOGY

Introduction to historical developments in food preservation, spoilage, infections and legislation, Factors affecting the growth of micro-organisms in food, Intrinsic and Extrinsic parameters that affect microbial growth, Methods of Isolation and detection of micro-organisms or their products in food, Conventional methods, Rapid methods (Newer techniques), Immunological methods: Fluorescent, antibody, Radio immunoassay, ELISA etc., Chemical methods: Thermostable nuclear, ATP measurement and PCR (Polymers chain reacitons) – only principles in brief, Spoilage of different groups of foods: Cereal and cereal products, vegetables & fruits, meat & meat products, eggs and poultry, fish and other sea foods, milk and milk products, canned food, Food borne diseases: bacterial, and viral food-borne disorders, Food-borne important animal parasites, Mycotoxins, Role of microbes in fermented foods and genetically modified foods.

PRACTICALS

HFM208: FOOD SCIENCE AND MICROBIOLOGY   **Credits 2**

PART – A –FOOD SCIENCE

1. a. Study of structure of starch from different sources. Effect of processing on starch – swelling and retrogradation, starch hydrolysis.
    b. Viscosity measurement – in swelling and gelatinization of starch.
    c. Estimation of starch and non-starch polysaccharides.
2.   Thermal stability of protein. Effect of added components; acid, alkali, organic solvents, organic solutes and detergents.
3. a.   Effect of Factors affecting fat Lipolysis; Fatty acid composition, temperature, moisture, surface area, presence of pro and anti-oxidants: Measurement of peroxide value, TBA, total and volatile components.
4.   Surface tension: Measurement in hydrophilic, hydrophobic fluids and in emulsions.
5.   Measurement of browning in a food system.
6. Polyphenol oxidase activity in enzymatic browning

PART – B – MICROBIOLOGY

1. Preparation of common laboratory media and special media for cultivation of bacteria, yeast & molds.
2. Staining of bacteria: Gram's staining, acid-fast, spore, capsule and Flagellar staining, Motility of bacteria, Staining of yeast and molds.
3. Cultivation and identification of important molds and yeast. (Slides and mould culture).
4. Study of environment around us as sources of transmission of micro-organisms in foods. Assessment of surface sanitation of food preparation units' swab and rinse techniques.
5. Demonstration of available rapid methods and diagnostic kits used in identification of micro-organisms or their products.

References:

1. Pelezar, M.I. and Reid, R.D. (1993) Microbiology McGraw Hill Book Company, New York, 5th Edition.
2. Atlas, M. Ronald (1995) Principles of Microbiology, 1st Edition, Mosby-Year Book, Inc, Missouri, U.S.A.
3. Topley and Wislson's (1983) Principles of Bacteriology, Virology and Immunity, Edited by S.G. Wilson, A. Miles and M.T. Parker, Vol. 1: General Microbiology and Immunity, II: Systematic Bacteriology. 7th Edition. Edward Arnold Publisher.

4. Block, J.G. (1999) Microbiology Principles and Explorations, 4th Edition John Wiley and Sons Inc.
5. Frazier, W.C. (1988) Food Microbiology, McGraw Hill Inc. 4th Edition.
6. Jay, James, M. (2000) Modern Food Microbiology, 6th Edition. Aspon Publishes, Inc., Maryland.
7. Banwart, G. (1989) Basic Food Microbiology, 2nd Edition. CBS Publisher.
8. Garbutt, J. (1997) Essentials of Food Microbiology, 1st Edition, Arnold International Students Edition.
9. Doyle, P. Benehat, L.R. and Mantville, T.J. (1997): Food Microbiology, Fundamentals and Frontiers, ASM Press, Washington DC.
10. Adams, M.R. and M.G. Moss (1995): Food Microbiology, 1st Edition, New Age International (P) Ltd.
11. Bensaon, H.J. (1990) Microbiological aplications, C. Brown Publishers, U.S.A.
12. Roday, S. (1999) Food Hygiene and Sanitation, 1st Edition, Tata McGraw Hill, New Delhi.
13. Venderzant, C. and D.F. Splitts Toesser (1992): Compendium of Methods for the Microbiological Examination of Foods 3rd Edition. American Public Health Association, Washington D.C.
14. Belitz, H.D. and Grosch, W. (1999) Food Chemistry, Springer – Verlag, Berlin Heidelberg.
15. Damodaran, S. and Parot, A (editors), (1997) Food Proteins and their Applications. Marcol Dekker Inc.
16. Davis, M.B., Austin, J. and Partridge, D.A. (1991) Vitamin C: Its Chemistry and Biochemistry. The Royal Society of Chemistry T.G. House, Science Park, Cambridge CB4 4WF.
17. Diehl, J.F. (1995) Safety of Irradiated Foods Marcel Dekker Inc, New York.
18. Friberg, S.E. and Larsson, K. (editors) (1997) Food Emulsions. Marcel Dekker, New York.
19. Goldberg, I. (ed.) (1994) Functional Foods Chapman and Hall, Inc.
20. Gunaskekaran, S. (ed) (2001) Nondestructive Food Evaluation Marcel Dekker Inc, New York.
21. Tombs, M.P. (1991) Biotechnology in the Food Industry Prentice – Hall Inc, India.
22. O'Brien, L.O., Nabors and Gelardi, R.C. (1991) Alternative Sweeteners. marcel Dekker, New York.
23. Risch, S.J. and Hotchkiss, J.H. (ed.) (1991) Food Packaging Interactions II. ACS Symposium Series 473, American Chemical Society, Washington D.C.
24. Marwaha, S.S. and Arora, J.K. (2000) Food Processing: Biotechnological Applications Asiatech Publishers Inc, New Delhi.
25. Mahindru, S.N. (2000) Food Additives – Characteristics – Detection and Estimation Tata McGraw Hill Publishing Co. Ltd.
26. Mahindru, S.N. (2000) Food Additives – Characteristics – Detection and Estimatin Tata McGraw Hill Publishing Co. Ltd.
27. Borwankar, R.P. and Shoemaker, C.E. (1992) Rheology of Foods. Elsevier Science Publisher Ltd., England.
28. Charalambour, G. (1990) Flavours and Off-Flavours' 89, Elsevier Science Publisher Ltd., P.O. Box 211, 1000 AE Amsterdam, The Netherlands.
29. Salunke, D.K. and Kodam, S.S. (2001): Handbook of Vegetable Science and Technology, marcol Dekker, Inc., 270, Madison Avenue, New York, NY, 10016.
30. FAO Food and Nutrition Paper: manual of Food Quality Control – Parts 14/1 (1979) to 14/8 (1986), FAO of the United Nations Rome.

Journals
1. Journal of Food Science Published by the Institute of Food Technologies, Chicago In. U.S.A.
2. Journal of Food Science and Technology published by Association of Food Scientists and Technologists (India) CFTRI – MYSORE.
3. Food technology published by the Institute of Food Technologists, Chicago Iu. U.S.A.

HFM205: SCIENCE AND TECHNOLOGY FOR RURAL DEVELOPMENT   **Credits 3**

Appropriate Technology: Meaning of appropriate technology, affordable technology, need classification.

Science and Technology in Agriculture: Scientific methods of cultivation, post harvest Technology; Improved grain storage at domestic level, farm level and at large scales. Methods available for scientific food processing.

Waste Recycling: Waste, concept of waste recycling, classification, Agriculture, households, Industrial Waste, methods of recycling; Vermi Composting.

Science and Technology in the Field of Nutrition: Science and Technology as applied to the Field of nutrition; Low cost, indigenous, fast and convenience foods.

Food Preservation: Principles of Preservation, Methods of Preservation using sugar, jam, jelly, marmalade. Chemical preservatives; squash, cordial, crush and syrup, spices, salt and oil-pickles, sauses, ketchups.

Fuel Management: Use of fuel wood; Present practices and problems Smokeless Chulah, Use of 'alternate' non-conventional sources of energy including wind and wave.

Biogas: Biogas-Scope and principles Models promoting the use of biogas.

Use of Solar Energy: Scope for and advantages of the use of solar energy, Solar energy devices; different modes

Agencies involved in promoting Science and Technology for Rural Development: Institutions involved; DST, CAPA RT, Indian Renewable Energy, Development Agency (IREDA) Ministry of Non-conventional Energy Sources.

References
1. Raj Mohini, S. Women in Agriculture Kaveri Printers, New Delhi, 1991.
2. Campbell, M.J. (Ed.) New Technology and Rural Development, Billings and Sons Ltd., Great Britain, 1990.
3. Punia, R. K. Women in Agriculture, Vol. I and II, Northern Book Centre, New Delhi, 1991.
4. Chawla, O.P. Advances in Bio-gas Technology, Indian Council of Agricultural Research, New Delhi, 1989.
5. Garg, H.P. and Prakash, J. Solar Energy – Fundamentals and Applications, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1997.
6. David Elliot, Energy, Society and Environment – Technology for a sustainable future, Routledge Publishers, London, 1997.
7. Swaminathan, M., Advanced Textbook on Food and Nutrition, The Bangalore Printing and Publishing Co. Ltd., 2nd Edition, 1985.
8. Department of Science and Technology, Models for Rural Application, Progressive Printers, New Delhi, 1995.
9. Prescott, B.C. and Proctor, B. K. Food Technology, McGraw Hill Book Company, New York, 1987.
10. Vinkata Ramana. P. Rural and Renewable Energy: Perspectives from Developing Countries, Tata Energy Research Institute, New Delhi.
11. Qasim, S.Z. Science and Quality of Life, The off setters, New Delhi, 1992.

12. Centre of Science for Village, Wardha – Science and Technology for Women (A Compendium of Technologies), Department of Science and Technology, New Delhi, 1989.

13. Siddappa, L. S. and Tandon, G. M. Preservation of Fruits and Vegetables, ICAR, New Delhi, 1984. Prescott, S.C. and Proctor, B. K., Food Technology, McGraw Hill Book Company, New York, 1987.

Journals
a. Science for Villages.
b. Yojana
c. CAPART Press Clippings.
d. Khadi Gramodyog
e. Construction on Rural Technology

Code: HFM206M: COMPUTER APPLICATION   **Credits 3**

Overview of a computer system: Introduction; Software and hardware; Block diagram of computer; CPU, I/O and memory. Basics of operating systems MS-DOS and WINDOWS. Basic use of MS-WORD, MS-EXCEL and Power point packages.
Statistical Analysis using MS-EXCEL /R /SPSS software with special emphasis to the following topics:
1. Diagrammatic, graphical and Tabular representation of data
2.   Measures of central tendency and dispersion
3.   Linear regression and correlation
4.   t-test
5. χ^2-test
6. ANOVA

IIIrd Semester

Code: HFM301: PILOT SURVEY FOR DISSERTATION AND SYNOPSIS FORMULATION AND SEMINAR   **Credits 3**
For this paper students are required to do the following:
Conduct pilot survey for collecting the data and formulate the synopsis for the dissertation.
Deliver a seminar for their above work

Code: HFM302: EXPERIMENTAL FOODS   **Credits 3**
Introduction to Food Science: Evolution of the Food Industry and Allied Industries. Development of Food Science as a discipline, Colloidal state, stabilization of colloidal systems, Rheology of food dispersions, Gels; Structure, formation, strength, types of permanence, Emulsions; Formation, stability, surfactants and emulsifiers, Foams; Structure, formation and stabilization.
Polysaccharides, Sugar and Sweeteners: Starch; Structure, gelatinization, methods for following gelatinizaiton changes, Characteristics of some food starches, Effects of ingredients and conditions on gelatinization, Modified food starches, Non-starch Polysaccharides; Cellulose, hemicelluloses, pectins, gums, animal polysaccharides, Sugars and Sweeteners; Sugars, syrups, sugar alcohols, potent sweeteners, sugar products, Sweetener chemistry related to usage in food products; Structural relationships to sweetness perceptions, hydrolytic reactions, solubility and crystallization, hygroscopicity, colligative properties, textural contributions, fermentation, non-enzymatic browning.
Cereals and Cereal Products: Cereal grains: Structure and composition, Cereal products, Flours and flour quality**,** Extruded foods, breakfast cereals, wheat germ, bulgar, puffed and flaked cereals.

Fats, Oils and related Products: Sources, composition, effects of composition on fat properties, Functional properties of fat and use in food preparations, Fat substitutes, Fat deterioration and antioxidants, Radiolysis, Inter-esterification of fats.

Proteins: Classification, composition, denaturation, non-enzymtic browning,

Enzymes: Nature of enzymes, stability and action. Proteolytic enzymes, oxidases, lipases, enzymes decomposing carbohydrates and applications. Immobilised enzymes duration of protein

Milk and Milk Products: Composition. Physical and functional properties. Denaturation, Effects of processing and storage, Dairy products; cultured milk, yogurt, butter whey, cheese, concentrated and dried products, frozen desserts, dairy product substitutes.

Meat and Poultry: Muscle composition Characteristics and structure, Post mortem changes, Processing, preservation and their effects. Heat-induced changes in meat, Variables in meat preparation, Tenderizers, meat Products.

Eggs: Structure and Composition, changes during storage, Functional properties of eggs, use in cookery, Egg processing, Low cholesterol egg substitutes.

Fish and Sea Food: Types and composition Storage and changes during storage, changes during processing, By-products and newer products.

Pulses and Legumes: Structure, composition, Processing, Toxic constituents.

Nuts and Oilseeds: Composition, oil extraction and by products.

Protein Concentrates, hydrolysates and textured vegetable proteins, milk substitutes.

Fruits and Vegetables: Plant anatomy, gross composition, structural features and activities of living systems, enzymes in fruits and vegetables. Flavour constituents. Plant phenolics. Pigments, Post harvest changes, Texture of fruits and vegetables, Effects of storage, processing and preservation.

Spices and Condiments: Composition, flavouring extracts – natural and synthetic.

Processed Foods: Jams, Jellies, Squashes, Pickles.

Traditional Processed Products: Fermented Foods; cereal-based, pulse; based, fruit/vegetable – based, vinegar, pickles.

Leavened Products: Leavening agents, Biologically leavened and chemically leavened products, Batters and dough.

Salt and substitutes.

PRACTICALS

HFM307: EXPERIMENTAL FOODS   Credits 2

1. Effect of solutes on boiling point and freezing point of water.
2. Effect of types of water on characteristics of cooked vegetables, pulses and cereals.
3. **Sugar and Jaggery Cookery:** Relative sweetness, solubility and sizes of sugars, stages of sugar cookery, caramelization, crystallization, factors affecting crystal formation.
4. **Starches, Vegetable, Gums and Cereals:** Dextrinization gelatnization, retrogradation, thickening power. Factors affecting gels. Gluten formation and factors affecting gluten formation.
5. **James and Jellies:** Pectin content of fruits, role of acid, pectin and sugar in jam and jelly formation. Use of gums and emulsifiers/stabilizers.
6. **Fat and Oils:** Flash point, melting point and smoking point. Role of fats and oils in cookery as: shortening agent, frying medium. Factors affecting fat absorption. Fat crystals. Plasticity of fats. Permanent and semi-permanent emulsions.
7. **Milk and Milk Products:** Scalding, denaturation. Effect of acid, salt, alkali, sugar, heat, enzymes, polyphenols on milk. Khoa, curd, paneer, cheese (ripened and un-ripened).
8. **Egg:** Structure, assessing egg quality. Use of egg in cookery: Emulsions, air incorporation, thickening, binding, gelling. Method of egg cookery and effect of heat. Egg white foams and factors affecting foams.
9. **Pulses:** Effect of various cooking and processing methods on various characteristics, functional properties of pulses and their products.

10. **Meat and Poultry:** Methods affecting tenderness of meat, effect of various methods of cooking and ingredients on colour, volume, texture, flavour, aroma and water holding capacity.
11. **Fish and Sea Food:** Effect of different cooking methods on various fish and sea foods.
12. **Gelatin:** Gelatin, gel strength and factors affecting gelation. Ability to foam.
13. *Fruits and Vegetables:* Pigments: Effects of cooking, metal ions, pH. Effect of various coking processes on different characteristics of vegetables. Prevention of enzymatic browning.
14. **Leavened Products:** Fermentation – Use of micro-organisms (lactic acid, yeast), steam as an agent, egg as an agent, chemical agents.
15. **Beverages:** Factors affecting quality of beverages.
16. **Frozen Desserts:** Factors affecting ice crystal formation. Quality characteristics of frozen desserts.

References:

1. Charley, H. (1982): Food Science (2nd edition), John Wiley & Sons, New York.
2. Potter, N. and Hotchkiss, J.H. (1996): Food Science, Fifth edition, CBS Publishers and Distributors, New Delhi.
3. Belitz, H.D. and Grosch, W. (1999): Food Chemistry, (2nd edition), Springer, New York.
4. Abers, R.J. (Ed.) (1976): Foam, Academic Press, New York.
5. Cherry, J.P. (Ed.) (1981): Protein Functionality in Foods, American Chemical Society, Washington, D.C.
6. Pomeranz, Y. (Ed) (1991): Functional Properties of Food Components, (2nd edition), Academic Press, New York.
7. Duckworth, R.B. (Ed) (1978): Water Relation to Foods, Academic Press, London.
8. Parihar, P., Agrwal, R., Jain, D.K. and Mandhyan, B.L. (1977): Status Report on Dehydration of Eggs, PHT/CAE/Publisher.
9. Marshall, K.R. and Harper, W.J. (1988): Why Protein Concentrates, IDF Bulletin No. 233.
10. Tindall, H.D. (1983): Vegetables in the Tropics, MacMillan, Press, London.
11. Julians, B.O. (Ed.) (1985): Rice Chemistry and Technology, (2nd edition), American Association of Cereal Chemists, St. Paul Mimesota, USA.
12. Bowers, J. (1992): Food Theory and Applications, (2nd edition), MacMillan Publishing Co., New York.
13. Peckham, G. and Freeland – Graves, G.H. (1979): Foundations of Food Preparation.
14. Becker, P. (1965): Emulsions: Theory and Practice, Reinhold, New York.

Journals
1. Journal of Food Science.
2. Advances in Food Research
3. Journal of Food Science and Technology
4. Journal of Agricultural and Food Chemistry.
5. Cereal Science
6. Journal of Dairy Sciences.
7. Journal of the Oil Chemists Society.

Code: HFM303: ADVANCED NUTRITION – II   **Credits 3**

Physiology of hunger and Satiety: Role of central nervous system, gastric contractions, intestinal absorption, glucostatic regulation.

Nutrient requirements: The basis upon which nutrient recommendations are made. Difference between requirements recommended allowances and desired intake.

Recommended intake for proteins, calories, fat, carbohydrates, vitamins, minerals and water, Traces elements in human nutrition, Nutrient interrelationships, Protein energy interrelationships, Amino acid interrelationships, "Amino acid" and "Vitamin" interrelationships, vitamin and mineral interrelationship, mineral, vitamin, hormones, enzymes interrelationships, Nutritional adaptations, Nutrition and natural resistance to infection and acquired immunity, Inborn errors of metabolism, The use of radio isotopes in the study of human nutrition.

PRACTICALS

HFM308: ADVANCED NUTRITION – II   (Credits 2)
1. Calculation of nutrient requirements of individuals and population groups.
2. Factors to be taken into consideration for determination of recommended allowances.
3. Study of Dietary Standards.
4. Diagnosis of nutritional deficiencies and their prevention.
5. Estimation of Protein Quality using different methods PER, B.V., N.P.U., NDP – Cal%.
6. Estimation of energy value of foodstuffs using bomb calorimeter.
7. Estimation of Energy Requirements; BMR, Energy expenditure on physical activities, Factorial approach
8. Balance studies; Nitrogen balance

References:
1. Mitchell: Comparative nutrition of man and domestic animal, 1. I, II. 1964.
2. Alabnese: New method of nutritional Biochemistry, Vol. II, 1965.
3. Annual Reviews of Nutrition. Annual Review Inc, California, USA.
4. Shils, M.E.; Olson, J.; Shike, M. and Roos, C. (1998): Modern Nutrition in Health and Disease. 9th edition. Williams and Williams. A Beverly Co. London.
5. Bodwell, C.E. and Erdman, J.W. (1988) Nutrient Interactions. Marcel Dekker Inc. New York.
6. World Reviews of Nutrition and Dietetics.
7. European Journal of Clinical Nutrition.
8. International Journal of Vitamin and Nutrition Research.
9. International Journal of Food Science and Nutrition.
10. Nutrition Research
11. Ann Nutr Metab

Code:HFM304: NUTRITIONAL EPIDEMIOLOGY   **Credits 3**

Introduction to Epidemiology and Branches of Epidemiology: Types of Epidemiology
Epidemiological Information: Collecting epidemiological data, Secondary Routine
Patterns of Disease: Descriptive Epidemiology, Cross sectional analysis, Prevalence and incidence, risk factors, risks and odds, Relative and Attributable risks, Principles of Nutritional Epidemiology.
Measurement Issues: Measurement of disease, Occurrence and Measures of association, Exposure and Outcome, Assessment of Food Consumption, Intake and validation of Assessment, Biochemical Markers of nutrient intake and nutritional status, Socio-demographic and psycho social variables, Anthropometric measurements, Design and planning of Nutritional Epidemiological studies, Assessing, Applying and Evaluating Epidemiological Studies, Discussion of selected case studies, Nutritional assessment as a tool for improving the quality of life of various segments of the population including hospitalized patients, Current methodologies of assessment of nutritional status, their interpretation and comparative applications of the following; Food consumption, Anthropometry, Clinical and Laboratory, Rapid Assessment & **PRA**,   Functional indicators such as grip strength,

respiratory fitness. Harvard Step test, Squatting test, Nutritional Surveillance; Basic concepts, uses and setting up of surveillance systems, Monitoring and Evaluation

References

1. Anisa Basheer (1995): Environmental Epidemology, Rawat Publications, Jaipur
2. Margetts, B.M. and Nelson, M. (1998): Design Concepts in Nutritional Epidemiology, Oxford, New York.
3. Moon, G., Gould, M. (2000: Epidemiology: An Introduction, **Open University**.
4. Cox, B. Blaxter, M. Buckle, A. et al. (1987): Health and Lifestyle Survey, 1984-85, Health Promotion Research Trust, London.
5. Farmer, R. Miller, D. and Lawerson, R. (1996): Lecture Notes on Epidemology and Public
6. Health Medicine, Oxford, New York.
7. Janes, C., Stall, R. and S. Gifford (1986): Anthropology and Epidemiology: Interdisciplinary approaches to the Study of Health and Disease Reidel, Dordrecht.
8. Gordis, L. (1996): Epidemiology, Saunders, Pennsylvania.
9. Morris, J. (1975): The uses of Epidemiology, Oxford: University Press, New York.
10. Norell, S.E. (1998): Workbook of Epidemiology. Oxford: University Press, New York.
11. Armstrong, B.K., White, E., and Saracci, R. (1992): Principles of Exposure Measurement in Epidemology, Oxford University Press.
12. HRSA/MCHB/UIC (1998): Analytic Methods in Maternal and Child Health, Division of Science, Education and Analysis, Maternal and Child Health Bureau, Health Resources and Services Administration, Editors Hardler, A, Roserberg, D., Monahan, C., Kennelly, J.
13. Kiely, M. (ed.) (1991): Reproductive and Perinatal Epidemology, CRC Press.
14. UK Nutritional Epidemiology Group (1993): Diet and Cancer: A review of the epidemology literature. The Nutrition Society, London.
15. Dunn, G (1989) Design and analysis of reliability studies. Edward Arnold, London.
16. Dwyer, J.H. Feinleib, M, Lipert, P., Hoffmeister, H (ed) (1992) statistical Models for Longitudinal Studies of Health. Oxford University Press, Oxford.
17. Ohlin, A; Ahlander, E.M.; Ekberg, A and Bruce, A (1994): Bibliography on Validations of Dietary Assessment Methods. National Food Administration, Uppasala, Sweden.
18. Thompson, F.E; Moter, J; E; Freedman, L; Clifpred, C. and Willet, W.C (1994): Dietary Assessment Calibration/Validation studies Register. National Cancer Institute, Bethesda, Maryland.
19. Kok, F.J. and Van't Veer, P. (ed) (1991): Biomarkers of ?Dietary Exposure. Smith-Gordon, London.
20. Gibson, R.S. (1990) Principles of Nutritional Assessment. Oxford University Press, Oxford.
21. Dunn, G. (1989): Design and Analysis of Reliability Studies Edward Arnold, London.
22. Jelliffe, D.B. and Jelliffe, E.F.P. (1989): Community Nutritional Assessment, Oxford University Press.
23. Beghin, I., Cap, M. and Dujardan, B. (1988): A Guide to Nutritional Status Assessment, WHO, Geneva.
24. Gopaldas, T. and Seshadri, S. (1987): Nutrition Monitoring and assessment, Oxford University Press.
25. Mason, J.B., Habich, J.P., Tabatabai, H. and Valverde, V. (1984): Nutritional Surveillance, WHO.
26. Lee, R.D. and Nieman, D.C. (1993): Nutritional Assessment, Brown and Benchmark Publishers.

27. Sauberlich, H.E. (Ed.) (1999): Laboratory Tests for the Assessment of Nutrition Status, CRC Press.
28. Cameron, N. (1984): Measures of Human growth, Sheridan House Inc. New York.

Code: HFM305: COMMUNITY NUTRITION   **Credits 3**

Concept of community nutrition: Relationship between health and nutrition, role of public nutritionists in the health care delivery.

Primary Health Care of the Community: National Health Care Delivery System**,** Determinants of Health Status**,** Indicators of Health

Food and Nutrition Security: Nutritional Status; Determinants of nutritional status of individual and populations, Nutrition and Non-nutritional indicators; socio-cultural, biologic, environmental and economic.

Major Nutritional Problems: Etiology, prevalence, clinical manifestations, preventive and therapeutic measures; Macro and micro nutrient deficiencies**,** Other nutritional problems like lathyrism, dropsy, aflatoxicosis, alcoholism and fluorosis/Overweight, obesity and chronic degenerative diseases.

National Food and Nutrition Policy, Plan of Action and Programmes: Health-based interventions, Food-based interventions, including fortification and genetic improvement of foods, supplementary feeding, Nutrition education for behaviour change.

1. Owen, A.Y. and Frankle, R.T. (1986): Nutrition in the Community, The Art of Delivering Services, 2nd Edition, Times Mirror/Mosby.
2. Park, K. (2000: Park's Textbook of Preventive and Social Medicine, 18th Edition, M/s Banarasidas Bhanot, Jabalpur.
3. State of the World's Children, UNICEF.
4. Census Reports.
5. Bamji, M.S., Rao, P.N. Reddy, V. (Eds.) (1996): Textbook of Human Nutrition; Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi
6. Gopalan, C. and Kaur, S. (Eds.) (1989): Women and Nutrition in India, Nutrition Foundation of India.
7. Gopalan, C. and Kaur, S. (Eds.) (1993): Towards Better Nutrition, Problems and Policies, Nutrition Foundation of India.
8. Gopalan, C. (Ed.) (1987): Combating Undernutrition – Basic Issues and Practical Approaches, Nutrition Foundation of India.
9. National Plan of Action on Nutrition (1995): Food and Nutrition Board, Dept. of WCD, Govt. of India.
10. National Nutrition Policy (1993): Dept. of WCD, Govt. of India.
11. World Health Organization (1998): World Health Report: Life in the 21st Century, Report of the Director General, WHO, Geneva, Switzerland.

HFM306M: DEVELOPMENT PROJECT MANAGEMENT AND SEMINAR   **Credits 3**

Basic concept of project planning: **Basic concepts: Need, problem, project feasibility, planning, project formulation, forecasting, appraisal, PRA, importance and objectives of project formulation; project development cycle and its stages, project classification, Project Identification: Identification of project opportunities, government policy, regulations, incentives and restrictions; methods and techniques of project identification, prioritisation of projects with people's participation; pre-feasibility study, Project formulation; Feasibility study and opportunity study; techno-economic analysis; project design and network analysis; input analysis, financial analysis; social cost-benefit analysis, Project Appraisal; Comprehensive appraisal of the key components of the project; project appraisal techniques; decision matrix, systems analysis, urgency and risk analysis, break even point analysis, pay back period analysis, rate of return, MPV profitability and I.R.R. analysis, risk analysis and social cost benefit analysis, Project Format; Common format of a project proposal - basic and supportive information required for a project; rules governing the preparation of project proposal writing up a project proposal.**

Related Experiences

1. Getting familiar with the proposal formats of different funding agencies.
2. Need identification and planning of a project for funding by appropriate agencies and developing project proposal.

References

1. Bhargava, B.S. et a!. (1977): Project Identification, Formulation and Appraisal, Metropolitan Book House, New Delhi.
2. Chandra, P. (1992): Project Preparation, Appraisal, Budgeting and Implementation, Tata McGraw Hill, New Delhi.
3. Emaberger et a!. (1990): Case Studies of Project Sustainabiity, Implications for Policy and Operations from Asian Experience, World Bank.
4. Goel, E.B. (1991): Project Management, Tata McGraw Hill, New Delhi.
5. Gupta, R.C. (1990): Management Information Systems, CDS Publishers, New Delhi.
6. Little I.M.D. Mirriess, J.A. (1974): Project Appraisal and Planning for Development Countries, Educational Books Company, New Delhi.
7. Mukherjee, A. (1991): Methodology and Database for Centralised Planning with Special Reference to Decentralised Planning in India, Vol. I, II & III.

IVth Semester

HFM402: THERAPEUTIC NUTRITION AND BIOCHEMICAL CORRELATES OF NUTRITIONAL THERAPY **Credits 3**

PART – A – THERAPEUTIC NUTRITION

Nutritional screening and assessment of nutritional status of hospitalized and outdoor patients: Identification of high-risk patients, Assessment of patient needs based on interpretation of patient data-clinical, biochemical, biophysical, personal etc.

Newer trends in delivery of nutritional care and dietary counselling.

Diet, nutrient and drug interaction: Effect of drugs on ingestion, digestion, absorption and metabolism of nutrients, Effect of food, nutrients and nutritional status on drug dosage and efficacy.

Nutritional support: Recent advances in techniques and feeding substrates.

Etiopathophysiology, metabolic and clinical aberrations, complications, prevention and recent advances in medical nutritional management of: Weight imbalances**,** Cardio vascular disorders**,** Diabetes mellitus and other metabolic disorders**,** GI Tract Disorders**,** Liver and gall bladder, Pancreatic disorders**,** Renal disorders**,** Stress and trauma**,** Cancer**,**

Neurological disorders, Musculo-skeletal disorders, Immuno-deficiency disorders, Genetic disorders, Infections, Respiratory problems

Childhood problems/disorders including inborn errors of metabolism and their nutritional management.

PART – B – BIOCHEMICAL CORRELATES OF NUTRITIONAL THERAPY

Biochemical tests used in nutrition: Merits and demands of various methods, Organ function tests; Organ function tests of liver, kidney, thyroid, gastric, pancreas, Nutrition and Cancer; Effects of cancer on nutritional requirements, Effects of food on incidence of certain cancers, Carcinogenic foods, Foods that prevent cancer, Nutritional management of non-nutritional conditions; Alcohol related diseases, Diseases due in tobacco chewing, betel leaf chewing, paan masala, etc., Dental diseases, Role of nutrition in skin and hair care: Cosmetic effects of diet; Cellulite, Allergies, Anti aging foods, Foods as cosmetic agents, Eating disorders; Anorexia nervosa, bulimia nervosa, Food and Endorphins; Alteration of mental states by food, Sepsis and trauma; Metabolic alterations in injury, sepsis, Protein metabolism in sepsis, cytokines, nutritional support in trauma and sepsis, AIDS.

PRACTICALS

HFM404: THERAPEUTIC NUTRITION AND BIOCHEMICAL CORRELATES OF NUTRITIONAL THERAPY (Credits 2)

PART A – THERAPEUTIC NUTRITION

1. Collection and storage of biological samples for clinical investigations
2. Market survey of commercial nutritional supplements and nutritional support substrates
3. Commonly used tests for diagnosis of various diseases; Interpretation of patient data and diagnostic tests and drawing up of patient diet prescription, using a case study approach, Follow up; acceptability of diet prescription, compliance, discharge diet plan.
4. Preparation of diet counselling aids for common disorders.
5. Planning and preparation of diets for patients with common multiple disorders and complications and discharge diet plans.

PART – B – BIOCHEMICAL CORRELATES

1. Diet planning for patients having multiple diseases
2. Case studies of selected patient/s in a local hospital.
3. Visit to the in-patient care section of a local hospital and evaluation of the kitchen in the hospital.

References

1. Mahan, L.K. and Escott-Stump, S. (2000): Krause's Food Nutrition and Diet Therapy, 10th Edition, W.B. Saunders Ltd.
2. Shils, M.E., Olson, J.A., Shike, M. and Ross, A.C. (1999): Modem Nutrition in Health and Disease, 9th Edition, Williams and Wilkins.
3. Escott-Stump, S. (1998): Nutrition and Diagnosis Related Care, 4th Edition, Williams and Wilkinson
4. Garrow, J.S., James, W.P.T. and Ralph, A. (2000): Human Nutrition and Diabetics, 10th Edition, Churchill Livingstone.
5. Williams, S.R. (1993): Nutrition and Diet Therapy, 7th Editioin, Times Mirror/Mosby College Publication.
6. Davis, J. and Sherer, K. (1994): Applied Nutrition and Diet Therapy for Nurses, 2nd Edition, W.B. Saunders Co.
7. Walker, W.A. and Watkins, J.B. (Ed.) (1985): Nutrition in Pediatrics, Boston, Little Brown & Co.

8. Guyton, A.C. and Hall, J.E. (1999): Textbook of Medical Physiology, 9th Edition, W.B. Saunders Co.
9. Ritchie, A.C. (1990): Boyd's Textbook of Poathology, 9th Edition, Lea and Febiger, Philadelphia.
10. Fauci, S.A. et al (1998): Harrison's Principles of Internal Medicine, 14th Edition, McGraw Hill.
11. World Cancer Research Fund (1997): Food Nutrition and the Prevention of Cancer – A Global perspective, Washington E.D. WCRF

Journals and Other Relevance Series
1. Nutrition Update Series
2. World Review of Nutrition and Dietetics
3. Journal of the American Dietetic Association
4. American Journal of Clinical Nutrition
5. European Journal of Clinical Nutrition
6. Nutrition Reviews

M. Sc. MATHEMATCIS
Department of Mathematics
Banaras Hindu University

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Semesterwise distribution of Courses and Credits

**Semester –I**		
Course Code	**Title**	**Credits**
MTM 101	Algebra-I	4
MTM 102	Real Analysis-I	4
MTM 103	Topology	4
MTM 104	Differential Geometry of Manifolds-I	4
MTM 105	Set Theory & Complex Analysis	4
MTM 106M #	*Minor Elective*: Mathematical Methods (for students of other PG programmes) *Minor Elective* (for Mathematics students)	3
	Total	**23**
Semester –II		
MTM 201	Algebra-II	4
MTM 202	Real Analysis-II	4
MTM 203	Analytic Dynamics	4
MTM 204	Differential Geometry of Manifolds-II	4
MTM 205	Theory of Optimization	4
MTM 206M #	*Minor Elective*: Mathematical Modeling (for students of other PG programmes) *Minor Elective* (for Mathematics students)	3
	Total	**23**
Semester –III		
MTM 301	Hydrodynamics	4
MTM 302	Normed Linear Spaces & Theory of Integration	4
MTM 303	Numerical Analysis	4
	Major Elective (Any two of following courses , each of 4 credits : MTM 304 - MTM 309)	8
MTM 304	Discrete Mathematics	
MTM 305	Operations Research	
MTM 306	Gravitation	
MTM 307	Structures on Differentiable Manifolds - I	
MTM 308	Advanced Topology	
MTM 309	Integral Equations	
MTM 310M #	*Minor Elective*: Computational Bioinformatics for students of other PG programmes) *Minor Elective* (for Mathematics students)	3
	Total	**23**
Semester –IV		
MTM 401	Functional Analysis	4
MTM 402	Partial Differential Equations	4
	Major Elective (Any two of following courses , each of 4 credits : MTM 403 - MTM 409)	8
MTM 403	Fluid Mechanics	
MTM 404	Numerical Solution of Partial Differential Equations	
MTM 405	Structures on Differentiable Manifolds-II *	
MTM 406	Algorithms and Data Structures	
MTM 407	Wavelets	
MTM 408	Cosmology **	
MTM 409	Category Theory.	
	Minor Elective (Any one of following courses , each of 3 credits : MTM 410 - MTM 416)	3
MTM 410	Fuzzy Sets and Applications	
MTM 411	Financial Mathematics	
MTM 412	Number Theory and Cryptography	
MTM 413	Operator Theory	
MTM 414	Bio-Mechanics	
MTM 415	Module Theory	
MTM 416	Advanced Graph Theory	

MTM 417	**Project**	**6**
	Total	**25**
	Grand Total	**94**

* For the course MTM 405, the Pre-requisite course is MTM 307

** For the course MTM 408, the Pre-requisite course is MTM 306

*** More Major Elective and Minor Elective courses can be added subject to availability of subject expert.

\# M.Sc. Mathematics students will opt 3 Minor Elective Courses (each of 3 credits) offered by other PG
  Programmes of the Faculty.

MTM 101   Algebra-I   **Credits : 4**

The class equation, Cauchy`s theorem, Sylow p-subgroups, Direct product of groups. Structure theorem for finitely generated abelian groups. Normal and subnormal series. Composition series, Jordan-Holder theorem. Solvable groups. Insolvability of S_n for $n \geq 5$.

Extension fields. Finite, algebraic, and transcendental extensions. Splitting fields. Simple and normal extensions. Perfect fields. Primitive elements. Algebraically closed fields. Automorphisms of extensions. Galois extensions.

Fundamental theorem of Galois theory. Galois group over the rationals.

References:
1. I. N. Herstein, *Topics in Algebra*, Wiley Eastern, 1975.
2. P. B. Bhattacharya, S. K. Jain and S. R. Nagpal, *Basic Abstract Algebra* (2nd Edition), Cambridge University Press, Indian Edition 1977.
3. Ramji Lal, *Algebra,* Vol.1, Shail Publications, Allahabad 2001.
4. Vivek Sahai and Vikas Bist, *Algebra*, Narosa Publishing House 1999.
5. D. S. Malik, J. N. Mordeson, and M. K. Sen, *Fundamentals of Abstract Algebra*, McGraw-Hill International Edition, 1997.

MTM 102   Real Analysis-I   **Credits : 4**

Definition and existence of Riemann-Stieltjes integral, Conditions for R-S integrability. Properties of the R-S integral, R-S integrability of functions of a function.

Series of arbitrary terms. Convergence, divergence and oscillation, Abel's and Dirichilet's tests. Multiplication of series. Rearrangements of terms of a series, Riemann's theorem.

Sequences and series of functions, pointwise and uniform convergence, Cauchy's criterion for uniform convergence. Weierstrass M-test, Abel's and Dirichlet's tests for uniform convergence, uniform convergence and continuity, uniform convergence and Riemann-Stieltjies integration, uniform convergence and differentiation. Weierstrass approximation theorem. Power series. Uniqueness theorem for power series, Abel's and Tauber's theorems.

References:
1. Walter Rudin, *Principle of Mathematical Analysis* (3rd edition) McGraw-Hill Kogakusha, 1976, International Student Edition.
2. K. Knopp, *Theory and Application of Infinite Series*.
3. T. M. Apostol, *Mathematical Analysis*, Narosa Publishing House, New Delhi, 1985.

MTM 103   Topology   **Credits : 4**

Definition and examples of topological spaces. Closed sets. Closure. Dense sets. neighborhoods, interior, exterior, and boundary. Accumulation points and derived sets. Bases and sub-bases. Subspaces and relative topology.

Alternative methods of defining a topology in terms of Kuratowski closure operator and neighborhood systems. Continuous functions and homeomorphism. First and second countable space. Lindelöf spaces. Separable spaces.

The separation axioms T_0, T_1, T_2, $T_{3\frac{1}{2}}$, T_4; their characterizations and basic properties. Urysohn's lemma. Tietze extension theorem.

Compactness. Basic properties of compactness. Compactness and finite intersection property. Sequential, countable, and B-W compactness. Local compactness. One-point compactification.

Connected spaces and their basic properties. Connectedness of the real line. Components. Locally connected spaces.

Tychonoff product topology in terms of standard sub-base and its characterizations.Product topology and separation axioms, connected-ness, and compactness (incl. the Tychonoff's theorem), product spaces.

Nets and filters, their convergence, and interrelation. Hausdorffness and compactness in terms of net/filter convergence.

References:
1. J. L. Kelley, *General Topology*, Van Nostrand, 1995.
2. K. D. Joshi, *Introduction to General Topology*, Wiley Eastern, 1983.
3. James R. Munkres, *Topology,* 2nd Edition, Pearson International, 2000.
4. J. Dugundji, *Topology*, Prentice-Hall of India, 1966.
5. George F. Simmons, *Introduction to Topology and Modern Analysis*, McGraw-Hill, 1963.
6. N. Bourbaki, *General Topology,* Part I, Addison-Wesley, 1966.

7. S. Willard, *General Topology,* Addison-Wesley, 1970.
8. S.W. Davis *Topology*, Tata McGraw Hill, 2006

MTM 104   Differential Geometry of Manifolds-I   Credits : 4

Tensor of the type(r,s). Definition and examples of differentiable manifolds. Tangent spaces. Jacobian map. One parameter group of transformations. Lie derivatives. Immersion and imbeddings. Distributions.

Riemannian manifolds. Riemannian Connection. Curvature tensors. Sectional curvature. Schur's theorem. Geodesics. Projective curvature tensor. Conformal curvature tensor. Semi-symmetric connections.

Submanifolds and Hypersurfaces. Normals. Gauss's formula. Weingarten equations. Lines of curvature. Generalized Gauss and Mainardi-Codazzi equations.

References:
1. R. S. Mishra, *A Course in Tensors with Applications to Riemanian Geometry*, Pothishala, Allahabad, 1965.
2. Y. Matsushima, *Differentiable Manifolds*, Marcel Dekker, 1972.
3. B. B. Sinha, *An Introduction to Modern Differential Geometry*, Kalyani Prakashan, New Delhi, 1982.
4. Y. Talpiert, Differential *Geometry with applications to Mechanics and Physics*, Marcel Dekkar Inc. 2001.
5. N.J. Hicks, *Notes on Differential Geometry*, D. Van Nostrand Inc. , 1965.

MTM 105   Set Theory & Complex Analysis   Credits : 4

Set Theory: Countable and uncountable sets, Cardinal numbers, Schroeder- Bernstien theorem, POSET, Zorn`s lemma and its application.

Complex Analysis: Complex Integration. Cauchy-Goursat Theorem. Cauchy's integral formula. Higher order derivatives. Morera's theorem. Cauchy's inequality and Liouville's theorem. The fundamental theorem of algebra. Taylor's Theorem. Maximum modulus Principle, Schwarz lemma.

Laurent's Series. Isolated singularities. Casporati-Weierstress theorem. Meromorphic functions. The argument principle. Rouche's theorem.

Residues. Cauchy's residue theorem. Evaluation of integrals. Branches of many valued functions with special reference to arg Z, Log Z, and Z^a.

Analytic continuation.

References:
1. K. Knopp, *Theory of Functions*, Vol. 1.
2. E. C. Titchmarsh, *The Theory of Functions*, Oxford University Press.
3. J. B. Conway, *Functions of One Complex Variable*, Narosa Publishing House, 1980.
4. E. T. Copson, *Complex Variables*, Oxford University Press.
5. L. V. Ahlfors, *Complex Analysis*, McGraw-Hill, 1977.
6. D. Sarason, *Complex Function Theory*, Hindustan Book Agency, Delhi, 1994.
7. P. Suppes, *Axiomatic Set Theory*, Van Nostrand, 1960.
8. P.R. Halmos, *Naive Set Theory*, Van Nostrand, 1960.
9. K.K. Jha, *Advanced Set Theory & Fundamentals of Mathematics*, P.C. Dwadesh Shreni & Co., Aligarh, 1993.

MTM 106M   Mathematical Methods   Credits : 3

The objective of the course is to introduce the mathematical methods to the PG students of Physical sciences for the possible requirements in the modeling of the problems in their respective discipline of studies.

Integral Transforms.
Z-Transforms.
Fourier Series.
Matrix Coputations.
Chebyshev Polynomials
Complex Integration.

References:
1. G.B. Thomas, R.L.Finney, M.D.Weir, Calculus and Analytic Geometry, Pearson Education Ltd, 2003.
2. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons, 1999.

MTM 201   **Algebra–II**   **Credits : 4**

Modules, submodules, Quotient Modules, Isomorphism theorems. Cyclic modules, simple modules and semi-simple modules and rings Schur's lemma. Free modules. Noetherian and Artinian modules and rings. Hilbert basis theorem .

Solution of polynomial equations by radicals. Insolvability of the general equation of degree ≥ 5 by radicals. Finite fields.

Canonical forms: Similarity of linear transformations. Invariant subspaces. Reduction to triangular forms. Nilpotent transformations. Index of nilpotency. Invariants of a nilpotent transformation. The primary decomposition theorem. Jordan blocks and Jordan form.

References:

1. I. N. Herstein, *Topics in Algebra*, Wiley Eastern, 1975.
2. P. B. Bhattacharya, S. K. Jain and S. R. Nagpaul, *Basic Abstract Algebra* (2nd Edition), Cambridge University Press, 1997.
3. K. Hoffman and R. Kunze, *Linear Algebra*, 2nd Edition, Prentice Hall of India, 1971.
4. D. S. Malik, J. N. Mordeson, and M. K. Sen, *Fundamentals of Abstract Algebra,* McGraw-Hill International Edition, 1997.
5. Vivek Sahai and Vikas Bist, *Algebra*, Narosa Publishing House, 1999.
6. Ramji Lal, *Fundamentals in Abstract Algebra*, Chakra Prakashan, Allahabad, 1985.
7. J.S. Golan, Modules & the Structures of Rings, Marcl Dekkar. Inc.

MTM 202   **Real Analysis-II**   **Credits : 4**

Functions of several variables. Derivative of functions in an open subset of $\mathfrak{R}^n$ into $\mathfrak{R}^m$ as a linear transformation. Chain rule. Partial derivatives. Taylor's theorem. Inverse function theorem. Implicit function theorem. Jacobians.

Measures and outer measures. Measure induced by an outer measure, Extension of a measure. Uniqueness of Extension, Completion of a measure. Lebesgue outer measure. Measurable sets. Non-Leesgue measurable sets. Regularity. Measurable functions. Borel and Lebesgue measurability.

Integration of non-negative functions. The general integral. Convergence theorems. Riemann and Lebesgue integrals.

References:

1. Walter Rudin, *Principle of Mathematical Analysis* (3rd edition) McGraw-Hill Kogakusha, International Student Edition, 1976.
2. H. L., Royden, *Real Analysis*, 4th Edition, Macmillan, 1993.
3. P. R. Halmos, *Measure Theory*, Van Nostrand, 1950.
4. G. de Barra, *Measure Theory and Integration*, Wiley Eastern, 1981.
5. E. Hewitt and K. Stromberg, *Real and Abstract Analysis*, Springer, 1969.
6. P. K. Jain and V. P. Gupta, *Lebesgue Measure and Integration*, New Age International, New Delhi, 2000.
7. R. G. Bartle, *The Elements of Integration*, John Wiley, 1966.

MTM 203   **Analytic Dynamics**   **Credits : 4**

Rotation of a vector in two and three dimensional fixed frame of references. Kinetic energy and angular momentum of rigid body rotating about its fixed point.

Euler dynamic and geometrical equations of motion.

Generalized coordinates, momentum and force components. Lagrange equations of motion under finite forces, cyclic coordinates and conservation of energy.

Lagrangian approach to some known problems-motions of simple, double, spherical and cycloidal pendulums, motion of a particle in polar system, motion of a particle in a rotating plane, motion of a particle inside a paraboloid, motion of an insect crawling on a rod rotating about its one end, motion of masses hung by light strings passing over pulleys, motion of a sphere on the top of a fixed sphere and Euler dynamic equations.

Lagrange equations for constrained motion under finite forces. Lagrange equations of motion under impulses, motion of parallelogram about its centre and some of its particular cases.

Small oscillations for longitudinal and transverse vibrations.

Equations of motion in Hamiltonian approach and its applications on known problems as given above. Conservation of energy. Legendre dual transformations.

Hamilton principle and principle of least action. Hamilton-Jacobi equation of motion, Hamilton-Jacobi theorem and its verification on the motions of a projectile under gravity in two dimensions and motion of a particle describing a central orbit.

Phase space, canonical transformations, conditions of canonicality, cyclic relations, generating functions, invariance of elementary phase space, canonical transformations form a group and Liouville theorem.

Poisson brackets, Poisson first and second theorems, Poisson. Jacobi identity and invariance of Poisson bracket.

References:
1. A. S. Ramsay, *Dynamic* –Part II.
2. N. C. Rana and P.S. Joag, *Classical Mechanics*, Tata McGraw-Hill, 1991.
3. H. Goldstein, *Classical Mechanics*, Narosa, 1990.
4. J. L. Synge and B. A. Griffith, *Principles of Mechanics*, McGraw-Hill, 1991.
5. L. N. Hand and J. D. Finch, *Analytical Mechanics*, Cambridge University Press, 1998.
6. Naveen Kumar, *Generalized Motion of Rigid Body*, Narosa, 2004.

MTM 204   Differential Geometry of Manifolds-II   Credits : 4

Topological groups. Lie groups and Lie algebras. Product of two Lie groups. One parameter subgroups and exponential maps. Examples of Lie groups. Homomorphism and isomorphism. Lie transformation groups. General linear groups.

Principal fiber bundle. Linear frame bundle. Associated fiber bundle. Vector bundle. Tangent bundle. Induced bundle. Bundle homomorphisms. Exterior Algebra. Exterior derivative.

Almost complex and Almost contact structures. Nijenhuis tensor. Contravariant and covariant almost analytic vector fields in almost complex manifold. F-Connexion.

Almost complex and almost contact submanifolds and hypersurfaces.

References:
1. B. B. Sinha, *An Introduction to Modern Differential Geometry*, Kalyani Prakashan, New Delhi, 1982.
2. K. Yano and M. Kon, *Structure of Manifolds*, World Scientific, 1984.
3. Y. Matsushima , *Differential manifolds*, Marcel Dekkar, 1972.
4. K. Yano, *Differential Geometry of Complex and almost Complex Spaces*, Pergaman Press, 1965.
5. R. S. Mishra, *Structures on a Differentiable Manifold and Their Applications*, Chandrama Prakashan, Allahabad, 1984.

MTM 205   Theory of Optimization   Credits : 4

Unconstrained Optimization: Introduction, Gradient methods, Conjugate Direction Methods, Newton's Method, Quasi Newton Method.

Linear Programming: Simplex Method, Duality and Non- simplex Methods.

Non- Linear Constrained Optimization: Introduction, Lagrange's multipliers, Kuhn- Tucker conditions, Convex Optimization.

Evolutionary Algorithms: Neural Networks: Introduction, Basic Hopfield Model, Delta Rule, Single Neuron Training, Backpropagation algorithm. Genetic Algorithm: Basic description, Simple real number algorithm.

References:
1. Edwin K. P. P. Chong, Stanislaw H. Zak, An Introduction to Optimization, Johan Welly & Sons Inc 2001.
2. M. C. Joshi & K.M. Moudgalya, Optimization Theory & Practice, Narosa Publ. New Delhi, 2004.
3. S.S.Rao, Engg. Optimization: Theory & Practice, New Age Intl. Pub. New Delhi, 2003.
4. Laurence, Fausett, Fundamentals of Neural Networks, Pearson education Ltd, 2005.
5. D.E. Goldberg, Genetic Algorithms in neural optimization and machine learning, Pearson Education. Ltd. 2004.

MTM 206M   Mathematical Modeling   Credits : 3

Simple situations requiring mathematical modeling, techniques of mathematical modeling, Classifications, Characteristics and limitations of mathematical models, Some simple illustrations.

Mathematical modeling through differential equations, linear growth and decay models, Non linear growth and decay models, Compartment models, Mathematical modeling in dynamics through ordinary differential equations of first order.

Mathematical models through difference equations, some simple models, Basic theory of linear difference equations with constant coefficients, Mathematical modeling through difference equations in economic and finance, Mathematical modeling through difference equations in population dynamic and genetics.

Situations that can be modeled through graphs. Mathematical models in terms of Directed graphs, Mathematical models in terms of signed graphs, Mathematical models in terms of weighted digraphs.

Mathematical modeling through linear programming, Linear programming models in forest management. Transportation and assignment models.

References:
1. J. N. Kapur, *Mathematical Modeling*, Wiley Eastern.
2. D. N. Burghes, *Mathematical Modeling in the Social Management and Life Science*, Ellie Herwood and John Wiley.
3. F. Charlton, *Ordinary Differential and Difference Equations,* Van Nostrand.

SEMESTER -III

MTM 301   **Hydrodynamics**   **Credits : 4**

Equation of continuity, Boundary surfaces, streamlines, Irrotational and rotational motions, Vortex lines, Euler's Equation of motion, Bernoulli's theorem, Impulsive actions. Motion in two-dimensions, Conjugate functions, Source, sink, doublets and their images, conformal mapping, Two-dimensional irrotational motion produced by the motion of circular cylinder in an infinite mass of liquid, Theorem of Blasius, Motion of a sphere through a liquid at rest at infinity. Liquid streaming past a fixed sphere, Equation of motion of a sphere.
Stress components in real fluid, Equilibrium equation in stress components, Transformation of stress components, Principal stress, Nature of strains, Transformation of rates of strain, Relationship between stress and rate of strain, Navier-Stokes equation of motion.

References:
1. W. H. Besant and A. S. Ramsey, *A Treatise on Hydrodynamics*, CBS Publishers and Distributors, Delhi, 1988.
2. S. W. Yuan, *Foundations of Fluid Dynamics*, Prentice-Hall of India, 1988.

MTM 302   **Normed Linear Spaces and Theory of Integration**   **Credits : 4**

Normed linear spaces and Banach spaces. The L^P-space. Convex functions. Jensen's inequality. Holder and Minkowski inequalities. Completeness of L^P. Convergence in measure, Almost uniform convergence.
Signed measure. Hahn and Jordan decomposition theorems. Absolutely continuous and singular measures. Radon Nikodyn theorem. Labesgue decomposition. Riesz representation theorem. Extension theorem (carathedory). Lebesgue-Stieltjes integral.
Product measures. Fubini's theorem. Baire sets. Baire measure. Continuous functions with compact support. Regularity of measures on locally compact spaces. Integration of continuous functions with compact support. Reisz-Markoff theorem.

References:
1. H. L. Royden, *Real Analysis*, Macmillan, 4th Edition, 1993.
2. P. R. Halmos, *Measure Theory*, Van Nostrand, 1950.
3. S. K. Berberian, *Measure and Integration*, Wiley Eastern, 1981.
4. A. E. Taylor, *Introduction to Functional Analysis*, John Wiley, 1958.
5. G. de Barra, *Measure Theory and Integration*, Wiley Eastern, 1981.
6. R. G. Bartle, The Elements of Integration, John Wiley, 1966.
7. Inder K. Rana, *An Introduction to Measure and Integration*, Narosa Publishing House, 1997.

MTM 303   **Numerical Analysis**   **Credits : 4**

Integral equations :Fredholm and Volterra equations of first and second types. Conversions of initial and boundary value problems into integral equations, numerical solutions of integral equations using Newton-Cotes, Lagrange`s linear interpolation and Chebyshev polynomial.
Matrix Computations: System of linear equations, Conditioning of Matrices, Matrix inversion method, Matrix factorization, Tridiagonal systems.
Numerical solutions of system of simultaneous first order differential equations and second order initial value problems (IVP) by Euler and Runge-Kutta (IV order) explicit methods.
Numerical solutions of second order boundary value problems (BVP) of first, second and third types by shooting method and finite difference methods.
Finite Element method: Introduction, Methods of approximation: Rayleigh-Ritz Method, Gelarkin Method and its application for solution of ordinary BVP.

References:
1. M. K. Jain, S. R. K. Iyenger and R. K. Jain, *Numerical Methods for Scientific and Engineering Computations*, New Age Publications, 2003.

2. M. K. Jain, *Numerical Solution of Differential Equations*, 2nd edition, Wiley-Eastern.
3. S. S. Sastry, *Introductory Methods of Numerical Analysis*,
4. D.V. Griffiths and I.M. Smith, *Numerical Methods for Engineers*, Oxford University Press, 1993.
5. C. F. Gerald and P. O. Wheatley, *Applied Numerical Analysis*, Addison- Wesley, 1998.
6. A. S. Gupta, *Text Book on Calculas of Variation*, Prentice-Hall of India, 2002.
7. Naveen Kumar, *An Elementary Course on Variational Problems in Calculus*, Narosa, 2004.

MAJOR ELECTIVE
(Any two of the following courses each having 3 Credits)

MTM 304   Discrete Mathematics   Credits : 4

Graph Theory: Graphs, planar graphs and their properties. Trees. Euler's formula for connected planar graphs. Bipartite graphs. Spanning trees, Minimal spanning trees, Kruskal's Algorithms, Matrix representations of graph, Directed graphs, Weighted undirected graphs, Dijkstra's algorithm. Warshal's algorithm, Directed trees , Search trees, Traversals.

Theory of Computation: Finite automata, Deterministic and non deterministic finite automata , Moore and Mealy machines. Regular expressions.Grammars and Languages, Derivations, Language generated by a grammar. Regular Language and regular grammar.Regular and Context free grammar, Context sensitive grammars and Languages. Pumping Lemma, Kleene's theorem.

Turing Machines: Basic definitions. Turing machines as language acceptors. Universal Turing machines. Turing machine halting problem.

References:
1. F. Harary, *Graph Theory*, Narosa.
2. Narsingh Deo, *Graph Theory with Applications to Engineering and Computer Science*, Prentice-Hall of India.
3. W. T. Tutte, *Graph Theory*, Cambridge University Press, 2001
4. D. Kelly, *Automata and Formal Languages: An Introduction*, Prentice-Hall, 1995.
5. J. E. Hopcroft, R. Motwani, and J. D. Ullman, *Introduction to Automata, Languages, and Computation* (2nd edition), Pearson Edition, 2001.
6. P. Linz, *An Introduction to Formal Languages and Automata*, 3rd Edition,

MTM 305   Operations Research   Credits : 4

Game Theory: Two person zero sum games, Games with mixed strategies, Graphical solution, Solution by linear programming.

Basic Concept of Multi Objective and Multi Level Optimization.

Integer Programming, Mixed Integer Programming. Linear Fractional Programming. Goal Programming. Sensitivity Analysis and System Reliability.

Geometric Programming: Constrained and Unconstrained Minimization Problems.

Dynamic Programming: Deterministic and Probabilistic dynamic programming.

Stochastic Programming: Stochastic Linear and Stochastic Non linear Programming.

Netwok Schedulig by PERT/CPM.

References:
1. F. S. Hiller and G. J. Leiberman, *Introduction to Operations Research* (6th Edition), McGraw-Hill International Edition, 1995.
2. G. Hadley, *Nonlinear and Dynamic Programming*, Addison Wesley.
3. H. A. Taha, *Operations Research –An Introduction*, Macmillan.
4. Kanti Swarup, P. K. Gupta and Man Mohan, *Operations Research*, Sultan Chand & Sons, New Delhi.
5. S. S. Rao, *Optimization Theory and Applications*, Wiley Eastern.
6. N. S. Kambo, *Mathematical Programming Techniques*, Affiliated East-West Press Pvt. Ltd., New Delhi.

MTM 306   Gravitation   Credits : 4

Newtonian theory : Attraction and potential of rod, disc, spherical shell and sphere. Surface integral of normal attractions-Gauss theorem, Laplace and Poission equations. Work done by self attracting systems. Distribution for given potentials. Equipotential surfaces.

Einstein's Theory : Principles of equivalence and general covariance, Geodesic postulate. Newtonian approximation of general relativistic equations of motion. Heuristic derivation of Einstein's field equations,

Newtonian approximation of Einstein's field equations. Schwarzschild external solution. Planetary orbit. The three crucial tests. Energy momentum tensor of a perfect fluid. Schwarzschild internal solution.

References:
1. S. L. Loney, *An Elementary Treatise on Statics*, Kalyani Publishers-New Delhi, 1979.
2. A. S. Ramsey, *Newtonian Attraction,* Cambridge University Press, 1964.
3. A. S. Eddington, *The Mathematical Theory of Relativity,* Cambridge University Press, 1954.
4. R. Adler, M. Bazin and M. Schiffer, *Introduction to General Relativity*, McGraw-Hill, 1965.
5. S. R. Roy and Raj Bali, *Theory of Relativity*, Jaipur Publishing House, 1987.
6. J. V. Narlikar, *General Relativity and Cosmology*, Macmillan, 1978.

MTM 307   Structures on Differentiable Manifolds-I   Credits : 4

Almost Hermite Manifolds : Definitions. Almost analytic vector fields, curvature tensor, linear connections, almost quaternion metric structure, submanifolds. F-connections.

Kahler Manifolds : Definition, curvature tensor, affine connections. Projective, conformal, concircular, conharmonic and Bochner curvature tensors. Contravariant almost analytic vectors, submanifolds, quaternion Kahler manifold.

Nearly Kahler Manifold : Definitions, certain properties, curvature identities, almost analytic vectors, immersions.

Almost Kahler Manifolds : Definitions, some properties, analytic vectors, conformal transformations, curvature identities, immersions.

Quasi-Kahler, Semi-Kahler Manifolds: Definitions, curvature identities, properties and immersion in a quasi-Kahler manifold.

References:
1. R.S. Mishra, *Structures on a Differentiable Manifold and Their Applications*, Chandrama Prakashan, Allahabad, 1984.
2. K. Yano, *Differential Geometry of Complex and Almost Complex Spaces*, Pergamon Press, 1965.

MTM 308   Advanced Topology   Credits : 4

The Stone-Cech compactification. Paracompact spaces, their properties and characterizations. Metrizable spaces and Metrization theorems. Uniform spaces, Weak uniformity, Uniformizability. Completion of uniform spaces.

Function spaces. Point-wise and uniform convergence.The compact open Topology. The Stone-Weierstrass theorem.

References:
1   S. Willard, General Topology, Addison Wesley, 1970.
2   S.W.Davis, Topology, Tata McGraw Hill, 2006

MTM 309   Integral Equations   Credits : 4

Classification. Modeling of problems as integral equations. Conversion of initial and boundary value problem into integral equations. Conversion of integral equations into differential equations. Volterra integral equations and their numerical solutions. Greens function for Fredholm Integral equations. Fredholm integral equations: Degenerate kernels, symmetric kernels. Fredholm Integral equation of second kind. Numerical Solution of Fredholm Integral equations.

Existence of the solutions: Basic fixed point theorems.

Integral equations and transformations: Fourier, Laplace and Hilbert transformation.

References:
1. Abdul J. Jerry, Introduction to Integral Equations with applications, Marcel Dekkar Inc. NY.
2. L.G.Chambers, Integral Equations: A short Course, Int. Text Book Company Ltd. 1976,
3. R. P. Kanwal, *Linear Integral Equations*.
4. Harry Hochsdedt, *Integral Equations*.
5. Murry R. Spiegal, *Laplace Transform* (SCHAUM Outline Series), McGraw-Hill.

MTM 310M   Computational Bio- informatics   Credits : 3

Introduction to DNA as information storage molecules for cells.

Data Searches and pair wise alignments: Dot plots, Gaps, Alignment. Dynamic Programming: Needleman and Wunch Algorithm. Global and Local Alignments.

Substitution Patterns: Estimating Substitution Numbers.

Phylogenetics: Distance–Based Methods: Phylogenetic trees, Distance Matrix Method. Character Based Methods: Parsimony, Searches, Tree confidence.

Computer Programming and Data structure: Programming fundamentals, Variables and Basic operations, Control and Looping. Structures, Data structure, Functions. Simple Program Creation in C and Execution. Introduction to Genetic Algorithms: Introduction, Coding of Parameters, Reproduction, Cross Over, Mutation, Simple algorithm at work.

References:
1. D.E. Krane, Michael L. Raymer, Fundamental Concept of Bio-informatics, Pearson Education Ltd. 2003.
2. T.K.Attwood, D.J.P.Smith, Intoduction to Bio-informatics, Pearson Education Ltd. 2003.
3. Bryan Bergaron, Bio-informatics computing, Pearson Education Ltd. 2003.

SEMESTER - IV

MTM 401   **Functional Analysis**   **Credits : 4**

Bounded linear transformations. B(X,Y) as a normed linear space. Open mapping and closed graph theorems. Uniform boundedness principle and its consequences. Hahn-Banach theorem and its application. Dual spaces with examples. Separability. Reflexive spaces. Weak convergence. Compact operators.

Inner product spaces, Hilbert spaces. Orthonormal sets. Bessel's inequality. Complete orthonormal sets and Parseval's identity. Structure of Hilbert spaces. Projection theorem. Riesz representation theorem. Riesz-Fischer theorem. Adjoint of an operator on a Hilbert space. Reflexivity of Hilbert spaces. Self-adjoint operators. Positive, projection, normal, and unitary operators.

References:
1. G. F. Simmons, *Introduction to Topology and Modern Analysis*, McGraw-Hill, 1963.
2. G. Bachman and L. Narici, *Functional Analysis*, Academic Press, 1966.
3. A. E. Taylor, *Introduction to Functional Analysis*, John Wiley, 1958.
4. B. V. Limaye, *Functional Analysis*, Wiley Eastern.
5. N. Dunford and J. T. Schwartz, *Linear Operators*, Part-I, Interscience, 1958.
6. R. E. Edwards, *Functional Analysis*, Holt Rinehart and Winston, 1965.
7. C. Goffman and G. Pedrick, *First Course in Functional Analysis*, Prentice- Hall of India, 1987.
8. K. K. Jha, *Functional Analysis and Its Applications*, Students' Friend, 1986

MTM 402   **Partial Differential Equations**   **Credits : 4**

Classisification, Characteristic equation. Some important linear PDE. Fundamental solution of Laplace's Equation. Mean value formulae, Harmonic functions and properties, Representation formula. Green's function, Green representation formula. Poisson representation formula, Solution of Dirichlet problem on the ball. Sub Hormonic functions. The maximum principle. Energy methods.

Fundamental solutions of Heat Equation, Mean value formulae, properties of solutions, Initial BVP for heat equation.

Wave Equation. Mean value Method, Solution of Wave equation with initial values, Energy methods.

References:
1. L. C. Evans, *Partial Differential Equations*, Graduate Studies in Mathematics, Vol. 19, AMS, 1999.
2. Jurgen Jost, Partial Differential Equations: Graduate Text in Mathematics, Springer Verlag Heidelberg, 1998.
3. Robert C Mcowen, Partial Differential Equations: Methods and Applications, Pearson Education Inc. 2003.
4. Fritz John, *Partial Differential Equations*, Springer-Verlag, 1986.
5. I.N. Sneddon, *Elements of Partial Differential Equations*, McGraw-Hill, 1988.

MAJOR ELECTIVE
(Any two of the following courses, each having 4 credits)

MTM 403   **Fluid Mechanics**   **Credits : 4**

Laminar flow of viscous incompressible fluids-Similarity of flows. Buckingham ∏-theorem. Flow between parallel flat plates: Couette and plane Poiseuille flows. Flow through a pipe: Hagen Poiseuille flow, flow between two co-axially cylinders and two concentric rotating cylinders. Unsteady motion of a flat plate. Lubrication.

Laminar boundary layer – Properties of Navier-Stokes equations. Boundary layer equations in two-dimensional flows. Boundary layer along a flat plate. Blausius solution. Boundary layer displacement and momentum-thicknesses. Momentum integral theorems with applications. Effect of pressure gradient on the boundary layer development. Separation of boundary layer flow.

Compressible Inviscid flow – Controlling parameters. Equations of continuity, motion, energy and pressure. Kelvin theorem. Propagations of motion. Formation of shock waves. Mach number, Mach lines and cones. Isentropic flow relations. Pressure density and temperature in terms of Mach number.

References:

1. F. Charlton, *A Text Book of Fluid Dynamics*, CBC, 1985.
2. S. W. Yuan, *Foundations of Fluid Mechanics*, Prentice-Hall, 1976.
3. S. I. Pai, *Introduction to the Theory of Compressible Flow*, Affiliated East-West Press, 1970.

MTM 404 Numerical Solutions of Partial Differential Equations   Credits : 4

Numerical solutions of parabolic PDE in one space: two and three levels explicit and implicit difference schemes. Convergence and stability analysis.

Numerical solution of parabolic PDE of second order in two space dimension: implicit methods, alternating direction implicit (ADI) methods. Non linear initial BVP.

Difference schemes for parabolic PDE in spherical and cylindrical coordinate systems in one dimension.

Numerical solution of hyperbolic PDE in one and two space dimension: explicit and implicit schemes. ADI methods. Difference schemes for first order equations.

Numerical solutions of elliptic equations, approximations of Laplace and biharmonic operators. Solutions of Dirichlet, Neuman and mixed type problems.

Finite element method: Linear, triangular elements and rectangular elements.

References:

1. M. K. Jain, S. R. K. Iyenger and R. K. Jain, *Computational Methods for Partial Differential Equations*, Wiley Eastern, 1994.
2. M. K. Jain, *Numerical Solution of Differential Equations*, 2nd edition, Wiley Eastern.
3. S. S. Sastry, *Introductory Methods of Numerical Analysis*, , Prentice-Hall of India, 2002.
4. D. V. Griffiths and I. M. Smith, *Numerical Methods of Engineers*, Oxford University Press, 1993.
5. C. F. General and P. O. Wheatley *Applied Numerical Analysis*, Addison- Wesley, 1998.

MTM 405 Structures on Differentiable Manifolds-II   Credits : 4

(Pre-requisite : MTM 307 Structures on Differentiable Manifolds-I)

Almost contact manifolds: Definitions, Certain properties, Lie-derivative, Normal contact structure, Affinely almost co-symplectic manifold, Almost contact 3-structure, Para contact structure.

Almost Grayan manifolds: Definitions, certain properties, D-conformal transformation, Particular affine connections, Almost contact Riemannian 3-structure, Subamnifolds.

Sasakian Manifolds: Definition, properties of a Quasi-Sasakian manifolds, Co-symplectic structure, some new definitions, 3-structure metric manifolds, sub-manifolds.

F-structure manifolds: Definitions, some properties, Integrability conditions, Almost quaternion and null-operations, Almost F-3-structure, Framed manifold.

Other Structures: Almost tangent structure and ∏-structure, Almost product and almost decomposable manifolds, A generalized structure and some of its properties.

Prequisite: Structures on Differentiable manifolds-I

References:

1. R.S. Mishra, *Structure on a Differentiable Manifold and their Applications*, Chandrama Prakashan, Allahabad, 1984.
2. K. Yano, *Differential Geometry of Complex and Almost Complex Spaces*, Pergamon Press, 1985.

MTM 406   Algorithms and Data Structures   Credits : 4

Fundamentals of C Programming, Structures, Pointers. Introduction to the concepts of an abstract data structure and its implementation.

Mathematical Basis: Asymptotic notations, Summations, Recursion formulas.

Basic Data Structures: Stacks, queues, lists, trees, priority queues, tables.

Searching Methods: Binary search Tree.

Sorting: General Background, Insertion sorts, Merge sorts and Heap sort.

References:

1. Y.Langsam, M.J. Augenstein,A.M. Tanenbaum, Data Structures using C and C++ , PHI, New Delhi, 2002.
2. T.H. Cormen, C.E. Leiserson, R.C. Rivest, Algorithms, PHI New Delhi, 2001.
3. B.W. Kernighan and D.M. Ritchie, The C Porgramming Language 2nd Edition, (ANSI features) Prentice Hall, 1989.

MTM 407   **Wavelets**   **Credits : 4**

Fourier Analysis: Fourier and inverse Fourier transforms, Convolution and delta function, Fourier transform of Square integrable functions. Fourier series, Basic Convergence Theory and Poisson's Summation formula.
Wavelet Transforms and Time Frequency Analysis: The Gabor Transform. Short-time Fourier transforms and the uncertainty principle. The integral wavelet transforms Dyadic wavelets and inversions. Frames. Wavelet Series.
Scaling Functions and Wavelets: Multi resolution analysis, scaling functions with finite two scale relations. Direct sum decomposition of $L^2(R)$. Linear phase filtering, Compactly supported wavelets, Wavelets and their duals, Orthogonal Wavelets and Wavelet packets, Example of orthogonal Wavelets. Identification of orthogonal two-scale symbols, Construction of Compactly supported orthogonal wavelets, Orthogonal wavelet packets, orthogonal decomposition of wavelet series.

References:
1. C.K.Chui, A First Course in Wavelets, Academic press NY 1996.
2. I. Daubechies, Ten Lectures in Wavelets, Society for Industrial and Applied Maths, 1992.

MTM 408   **Cosmology**   **Credits : 4**
                    (Pre-requisite : MTM 306 Gravitation)
An overview of the large scale structure of the universe. Einstein's modified field equations with the cosmological term.
Static cosmological models of the Einstein and de-Sitler; their derivation, geometrical and physical properties and comparison with the actual universe.
Hubble's law, non-static cosmological models, cosmological principles and Weyl's postulate.
Derivation of the Robertson-Walker metric and its geometrical properties. Hubble and deceleration parameters. Red shift in the Robertson-Walker geometry.
Einstein's equations for the Robertson-Walker metric, fundamental dynamical equations of the standard big-bang cosmology-Friedman Robertson-Walker models. Initial singularity-the bang, density and pressure in the present universe. Critical density- the open, closed and flat universes. Age of the universe. The radiation and matter dominated era of the universe. The red shift versus distance relation. Event and particle horizons.
Prequisite: Gravitation.

References:
1. R. C. Tolman, *Relativity, Thermodynamics and Cosmology,* Clarendon Press, Oxford, 1934.
2. S. Weinberg, *Gravitation and Cosmology*, John Wiley, 1972.
3. J. V. Narlikar, *Introduction to Cosmology*, Cambridge University Press, 1998.
4. J. N. Islam, *An Introduction to Mathematical Cosmology*, Cambridge University Press, 1999.
5. J. A. Peacock, *Cosmological Physics*, Cambridge University Press, 1999

MTM 409   **Category Theory**   **Credits : 4**
Categories, Functors and natural transformations. Monics, Epis and zeors. Construction on Categories, Duality. Contravariance and opposites. Products of categories, Functor Categories, Comma Categories, Universals and Limits. Universal arrows. The Yoneda lemma. Coproducts and Colimits. Products and Limits. Adjoints. Examples of Adjoints. Reflective Subcatgories. Equivalence of categories. Adjoints for preorders, cartesion closed categories. Limits, Creation of Limits, Limits by Products and Equailizer. Freyd's Adjoint Functor Theorem. Special Adjoint Functor Theorem. Adjoints in Topology. Monads and Algebras. Monads in a Category, Algebra for a Monad. The comparison with algebras. Words and free semi groups, Free Algebras for Monads. Beck's Theorem. Algebras are T-algebras. Compact Hausdorff Spaces.

 References:
1   S. MacLane, Categories for the Working Mathematician, Springer 1971.
2   M.A. Arbib and E. G. Manes, Arrows, Structures and Functors- The Categorical Imperative, Academic Press, 1975.
3   H. Herrlich and G.E. Strecker, Category Theory, Allyn & Bacon, 1973.
4   J. Adamek, H. Herrlich & G. E. Streeker, Abstract and Concrete Categories, John Wiley 1992.

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MINOR ELECTIVE
(Any one of the following courses, each having 3 credits: MTM 410- MTM 416)

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MTM 410   **Fuzzy Sets and Applications**   **Credits: 3**
Basic Concepts of Fuzzy Sets and Fuzzy Logic:Motivation. Fuzzy sets and their representations. Membership functions and their designing. Types of Fuzzy sets.Operations on fuzzy sets. Convex fuzzy sets. Alpha-level cuts. Geometric interpretation of fuzzy sets. Linguistic variables. Possibility measure and distribution. Fuzzy

rules. Fuzzy Relations and Fuzzy Arithmetic:Composition of fuzzy relations. Fuzzy numbers. Arithmetic operations on fuzzy numbers.

Fuzzy reasoning

Fuzzy mapping rules and fuzzy implication rules. Fuzzy rule-based models for function approximation. Types of fuzzy rule-based models (the Mamdani, TSK, and standard additive models). Fuzzy Implications and Approximate Reasoning:

Fuzzy Logic and Probability Theory :Possibility versus probability. Probability of a fuzzy event. Baye's theorem for fuzzy events. Probabilistic interpretation of fuzzy sets. Fuzzy measure.

Decision making in Fuzzy environment: Fuzzy Decisions, Fuzzy Linear programming, Fuzzy Multi criteria analysis, Multiobjective decision making.

Fuzzy databases and queries: Introduction, Fuzzy relational databases, Fuzzy queries in crisp databases.

References:
1. J. Yen and R. Langari: *Fuzzy Logic: Intelligence, Control, and Information,* Pearson Education*, 2003.*
2. G. J. Klir and B. Yuan: *Fuzzy Sets and Fuzzy Logic: Theory and Applications,* Prentice-Hall of India, *1997.*
3. H.J. Zimmermann, *Fuzzy Set theory and its Applications*, Kluwer Academic Publ, 2001.

MTM 411   **Financial Mathematics**   **Credits : 3**

Some Basic Definitions and Terminology. Basic option theory: single and multi-period binomial pricing models. Cox-Ross-Rubinstein (CCR) model, Black Scholes formula for potion pricing as a limit of CCR model. Brownian ad Geometric Brownian Motion. Theory of Martingales. Stochastic Calculus, Stochastic differential Equations, Ito's formula to solve SDE's. Feymann Kac theorem. Application of stochastic calculus in option pricing. Black Scholes partial differential equations and Black Scholes formula.

Mean Variance portfolio theory: Markowitz model for Portfolio optimization and Capital Asset Pricing Model (CAPM).

Interest rates and interest rate derivatives: Binomial lattice model, Vasicek, Hull and White and Cox-Ingersoll-Ross (CIR) Model for bond pricing.

References:
1   D.G. Luembergar, Investment Science, Oxford University press, 1999.
2   S.Ross, An Introduction to Mathematical Finance, Cambridge University press, 1999.
3   J.C.Parikh, Stochastic Process and Financial Markets, Narosa, 2003.
4   S. Roman, An Introduction the Mathematics of Finance, Springer, 2000.

MTM 412   **Number Theory and Cryptography**   **Credits: 3**

Number Theory: Introduction, Time estimates for doing arithmetic. Divisibilty and Euclidean algorithm. Congruencies. Some applications to factoring. Finite Fields and quadratic residues: Finite Fields, Quadratic Residues and Reciprocity.

Cryptography: Some simple crypto Systems. Enciphering matrices. Public Key: The Idea of Public key Cryptography. RSA. Discrete log. Knapsack. Zero-knowledge protocols and Oblivious Transfer. Pseudo Primes, Rho Method, fermat factorization and Factor bases.

References:
1. Neal Koblitz, A Course in Number Theory and cryptography: A Graduate Text, Springer (Second Ed).

MTM 413   **Operator Theory**   **Credits: 3**

Spectral Theory of Linear Operators in Normed Spaces, Spectral Theory in Finite Dimensional Normed Spaces, Basic Concepts, Spectral properties of Bounded Linear Operators, Further Properties of Resolvant and Spectrum, Use of Complex Analysis in Spectral Theory. Banach Algebras, Further properties of Banach Algebra. Gelfard- Naimark theorem.

References:
1   E. Kreysyig, Introductory Functional Analysis with Applications, John Wiley and Sons.
2   John B. Coway, A Course in Operator Theory: A Graduate Studies in Mathematics, Springer.
3   G.Bachman, L. Narici, Functional analysis, Academic Press, N.Y.
4   G. F. Simmons, An Introduction to Topology and Modern Analysis, Tata McGrawHill.

MTM 414   **Bio Mechanics**   **Credits: 3**

External Flow: Fluid Dynamic forces acting on moving bodies. Flying and swimming. Blood flow in Heart, Lung, arteries and veins. Micro and Macro Circulation. Respiratory gas flow. The Laws of Thermo dynamics. Molecular diffusion. Mechanism in Membrances and Multiphasic structure.

Mass transport in Capillaries, Tissues, Interistitial spaces. Lymphatics, Indicator dilution method and Peristlsis.

References:
1. Y.C.Fung, Bio Mechanics, Springer Verlag, NY 1990**.**
2. S.I. Rubinow, Introduction to Mathematical Biology, John Wiley, 1975.
3. Riccilardi, Biomathematics and Related Computational Problems, Kluwer Publ. 1988.
4. J. Keener, J. Sneyol, Mathematical Physiology, Springer, 2001
5. J.N.Kapoor, Mathematical Models in Biology and Medicine, EWP New Delhi, 1992.

MTM 415 **Module Theory** **Credits: 3**

Modules. Linear mapping. Transpose of a module, Homomorphism. Bimodules, Bilinear maps. Tensor product of modules. Exact and split-exact sequences. Small and essential submodules and their properties. Free modules, Projective modules, projective covers. Injective modules and injective envelopes.

References:
1. F.W.Anderson and K. R. Fuller, Rings and Categories of Modules. Springer, Verlag.
2. J. Lambek, Lectures on Rings and Modules, Blaisdell Publ. Co.
3. J.S. Golan, Modules and Structures of Rings, Marcel Dekkar Inc.

MTM 416 **Advanced Graph Theory** **Credits: 3**

Trees: Spanning trees and enumeration. Matching: Matching and Maximum Matching, Hall's Matching condition, Minimax Theorems. Independent Sets and Covers. Dominating Sets.
Connectivity: Connectivities of graphs, Cut-sets, Edge Connectivity and Vertex Connectivity. Menger's Theorem.
Network Flow problem, maximum network flows, flow augmenting paths, Ford-Fulkerson Theorem.
Coloring of graphs: Chromatic number and chromatic polynomial of graphs, Brook's Theorem. Four Color Theorem.
Planarity: Planar Graphs, Testing of Planarity, Kuratowski Theorem for Planar graphs, Random Graphs.

References:
1. D.B.West, Graph Theory , Pearson Publ. 2002.
2. F.Harary, Graph Theory. Narosa Publ. ND.
3. R. Diestel, Graph Theory, Springer, 2000.
4.

MTM 417 **Project** **Credits: 6**

Some innovation in form of the written project, in Mathematics/application of Mathematics, based on the knowledge gained during the course of studies in view of the developments in Mathematics.

M. Sc. MOLECULAR & HUMAN GENETICS
Department of Molecular & Human Genetics
Banaras Hindu University

Semesterwise distribution of Courses and Credits

Semester-I		
Course Code	**Title**	**Credits**
MGM101	Transmission Genetics & Model Genetic Systems	4
MGM102	Basic Human Genetics	3
MGM103	Molecular Genetics	3
MGM104	Biochemistry & Biochemical Techniques	3
MGM105	Lab work based on courses MGM101 & MGM102	3
MGM106	Lab work based on courses MGM103 & MGM104	3
MGM107M #	*Minor Elective*: Reproductive Genetics & Genetics of Pathogens *Minor El*ective: (*for students of other PG programmes and MHG students as well*)	3
	Total	**22**

Semester-II		
Course Code	**Title**	**Credits**
MGM201	Cell Biology & Microscopy	3
MGM202	Cytogenetics	3
MGM203	DNA Technology & Genetic Engineering	3
MGM204	Genomic Instability and Cancer & Bioinformatics	3
MGM205	Biochemistry & Metabolic Disorders	3
MGM206	Lab work based on courses MGM201 & MGM202	2
MGM207	Lab work based on courses MGM203 & MGM204	2
MGM208	Lab work based on course MGM205	2
MGM209M #	*Minor Elective*: Fundamentals of Molecular Biology (*for students of other PG programmes*) *Minor El*ective: (*for Molecular & Human Genetics students*)	3
	Total	**24**

Semester-III		
Course Code	**Title**	**Credits**
MGM301	Human Molecular Genetics	3
MGM302	Clinical Genetics & Genetic Counseling	3
MGM303	Developmental Genetics	3
MGM304	Immunogenetics	3
MGM305	Lab work based on courses MGM301 & MGM302	2
MGM306	Lab work based on courses MGM303 & MGM304	2
MGM307	Clinical Assignments	2
MGM308M #	*Minor Elective*: Basic Genetics and Genetic Disorders (*for students of other PG programmes*) *Minor El*ective: (*for Molecular & Human Genetics students*)	3
	Total	**21**

Semester-IV		
Course Code	**Title**	**Credits**
MGM T 401	Human Genome	3
MGM T 402	Population & Evolutionary Genetics	3
MGM T 403	Neurogenetics	3
MGM L 404	Lab work based on course MGM401	2
MGM L 405	Lab work based on courses MGM402 & MGM403	2
MGM L 406	Dissertation	6
MGM L 407	Comprehensive Viva-voce	2
MGM L 408	Seminar & Formulation of Research Project	2
	Total	**23**
	Grand Total	**90**

M.Sc. Molecular & Human Genetics students will opt 3 Minor Electives (3 credit each in semester I, II & III) offered by other PG Programmes of Faculty including Department of Molecular & Human Genetics.

SEMESTER - I

MGM101: Transmission Genetics & Model Genetic Systems   **Credits: 4**

Section A: Transmission Genetics	**Lecture hours**

1   Introduction to Genetics   1

2   Mendelism   9

     2.1   Mendel and his experiments
     2.2   Law of segregation
     2.3   Law of independent assortment
     2.4   Application of laws of probability (product rule, sum rule)
     2.5   Chromosomal basis of segregation and independent assortment

3   Chi-square test and its application in analysis of genetic data   1

4   Extensions of Mendelism   9

     4.1   Allelic variation and gene function- Dominance relationships, basis of dominant and recessive mutations
     4.2   Multiple allelism, allelic series
     4.3   Testing gene mutations for allelism: complementation test, intragenic complementation
     4.4   Visible, sterile and lethal mutations
     4.5   Genotype to phenotype: effect of the environment on phenotype development- Penetrance and expressivity, phenocopy
     4.6   Gene interactions and modifying genes
     4.7   Pleiotropy

5   Sex-linked inheritance, Linkage and crossing over   10

     5.1   Genetic recombination and construction of genetic maps in Drosophila
     5.2   Interference and coincidence
     5.3   Cytological demonstration of crossing over in Drosophila
     5.4   Mitotic recombination
     5.5   Intragenic recombination

6   Inheritance of quantitative traits   6

     6.1   Continuous and discontinuous variation
     6.2   Polygenic inheritance
     6.3   Genetic variance, heritability (narrow sense and broad sense)

7   Cytoplasmic inheritance, maternal effects, inheritance due to parasites and symbionts   3

Recommended Books:
1   Atherly et al (1999). The Science of Genetics. Saunders
2   Brooker (1999). Genetics – Analysis and Principles. Benjamin/Cumings
3   Fairbanks et al (1999). Genetics. Wadsworth
4   Gardner et al (1991). Principles of Genetics. John Wiley
5   Griffiths et al (2002). Modern genetic Analysis. Freeman
6   Griffiths et al (2004). An Introduction to Genetic Analysis. Freeman
7   Hartl and Jones (1998). Genetics – Principles and Analysis. Jones & Bartlett
8   Snustad et al (1998). Principles of Genetics. Wiley and sons
9   Strickberger (1985). Genetics. Mcmillan
10   Tamarin (1996). Principles of Genetics. WCB

Section B: Model Genetic System

1   Life cycles and advantages of the following organisms commonly used in genetic studies   8

     1.1   T4 and l phages
     1.2   Neurospora
     1.3   E.coli
     1.4   Saccharomyces cerevisea and Schizosaccharomyces pombe
     1.5   Caenorhabditis
     1.6   Drosophila

1.7 Zebra fish
1.8 Mouse

2   Conventions of nomenclature of genes and gene products in different model systems   5

Recommended Books
1   Ashburner (1989). Drosophila - A Laboratory Handbook. CSHL Press
2   Demerec & Kaufmann(1965). Drosophila Guide. Carnegie
3   Hood(1998). The Nematode: C. elegans. CSHL
4   Trends in Genetics(1998). Genetic Nomenclature Guide. Elsevier

MGM102: Basic Human Genetics   Credits: 3

1   History of Human Genetics   1

2   Pedigrees- gathering family history, pedigree symbols, construction of pedigrees, presentation of molecular genetic data in pedigrees   1

3   Monogenic traits   12

    3.1 Autosomal inheritance-dominant, recessive
    3.2 Sex-linked inheritance
    3.3 Sex-limited and sex-influenced traits
    3.4 Mitochondrial inheritance
    3.5 MIM number
    3.6 Complications to the basic pedigree patterns- nonpenetrance, variable expressivity, pleiotropy, late onset, dominance problems, anticipation, genetic heterogeneity, genomic imprinting and uniparental disomy, spontaneous mutations, mosaicism and chimerism, male lethality, X-inactivation
    3.7 Risk assessment; application of Bayes' theorem
    3.8 Allele frequency in population
    3.9 Consanguinity and its effects

4   Complex traits   10

    4.1 Approaches to analysis of complex traits- 'Nature -nurture' concept, role of Family and shared environment, monozygotic and dizygotic twins and adoption studies
    4.2 Polygenic inheritance of continuous (quantitative) traits, normal growth charts, Dysmorphology
    4.3 Polygenic inheritance of discontinuous (dichotomous) traits- threshold model, liability and recurrence risk
    4.4 Genetic susceptibility in multifactorial disorders (alcoholism, diabetes mellitus, obesity)
    4.5 Estimation of genetic components of multifactorial traits: empiric risk, heritability, coefficient of relationship

5   Human cytogenetics   10

    5.1 Techniques in human chromosome analysis
    5.2 Human karyotype: banding, nomenclature of banding
    5.3 Pathology of human chromosomes
    5.4 Nomenclature of aberrant karyotypes

    5.5 Common syndromes due to numerical chromosome changes
    5.6 Common syndromes due to structural alterations (translocations, duplications, deletions, microdeletion, fragile sites)
    5.7 Common chromosome abnormalities in cancer
    5.8 Genetics of fetal wastage

6   Pharmacogenetics and ecogenetics   5

Recommended Books

1   Connor & Smith (1997). Essentials of Medical Genetics. Blackwell
2   Davies (1993). Human Genetic Disease Analysis. IRL
3   Emery and Mueller (1992). Elements of Medical Genetics. ELBS
4   Gersen & Keagle (2005). The Principles of Clinical Cytogenetics. Humana
5   Jorde et al (2005). Medical Genetics. Elsevier
6   Korf (2006). Human Genetics. Blackwell
7   Lewis (2006). Human Genetics. WCB
8   Mange and Mange (2005). Basic Human Genetics. Sinauer Assoc
9   Maroni (2001). Molecular and Genetic Analysis of Human Traits. Blackwell
10   Nussbaum et al (2004). Genetics in Medicine. Saunders
11   Pasternak (2005). An Introduction to Molecular Human Genetics. Fritzgarald
12   Prichard & Korf (2004). Medical Genetics at a glance. Blackwell
13   Strachan and Read (2003). Human Molecular Genetics. Wiley
14   Vogel and Motulsky (1997). Human Genetics. Springer

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MGM103: Molecular Genetics   **Credits: 3**

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1   Properties and evolution of genetic material, flow of genetic information   2

2   Organization of viral and bacterial genomes   2

3   Eukaryotic genome   5

    3.1 C-value paradox
    3.2 Repetitive DNA
    3.3 General concept of a gene
    3.4 Gene families
    3.5 Non-coding genes

4   Replication in bacterial and eukaryotic chromosomes   5

    4.1 DNA polymerases
    4.2 Replicons, origin and termination
    4.3 Replisome
    4.4 Genes controlling replication

5   Transcription   5

    5.1 Prokaryotic RNA polymerase, sigma factors, initiation and termination
    5.2 Eukaryotic RNA polymerases and their promoters
    5.3 Processing of transcripts

6   Translation   2

    6.1 General mechanism
    6.2 Role of rRNA in translation

7   Regulation of gene expression   8

    7.1. Regulation of transcription initiation

      7.1.1. Operon and regulon
      7.1.2. Positive and negative regulation
      7.1.3. Enhancers and promoters

7.1.4. Transcription factors: types, DNA binding motifs

7.2. Regulation by attenuation and anti-termination

7.3. Post transcriptional regulation

    7.3.1. Alternative splicing
    7.3.2. Transport and targeting of RNA
    7.3.3. Post-transcriptional gene silencing

7.4. Translational control and targeting of proteins
7.5. Mechanism of steroid hormone and stress induced gene expressions

8	Mutation: Types and detection	3
9	Gene mapping in bacteria	4

    9.1. Transformation
    9.2. Conjugation
    9.3. Transduction
    9.4. Sexduction

10	Recombination, deletion and complementation mapping in T4 phage (rII locus)	3

Recommended Books

1   Alberts et al (1999). The Science of Genetics. Saunders
2   Benjamin (2003). Genetics: A Conceptual Approach. Freeman
3   Berg and Singer (1998). Genes and Genome.
4   Black (2002). Microbiology: Principles and Explorations. Wiley
5   Dale & Schartz (2003). From genes to Genome. Wiley & Sons
6   Griffiths et al (2002). Modern Genetic Analysis. Freeman
7   Griffiths et al (2004). An Introduction to Genetic Analysis. Freeman
8   Hartl et al (2002). Essential Genetics. Wiley & Sons
9   Klug & Cummings (2003). Essentials of Genetics. Prentice Hall
10   Latchman (1995). Gene Regulation. Chapman & Hall
11   Lewin (2007). Genes IX. Pearson
12   Maloy and Freifelder (1994). Microbial Genetics. Jones and Barlett
13   Meesfeld (1999). Applied Molecular Genetics. Wiley-Liss
14   Ptashne (1986). Genetic Switch. Blackwell
15   Russell (2002). Genetics. Benjamin
16   Streips & Yasbin (2002). Modern Microbial Genetics. Wiley
17   Trun & Trempy (2004). Fundamentals of Bacterial Genetics. Blackwell
18   Watson et al. (2004). Molecular Biology of the Gene. Pearson

MGM104: Biochemistry & Biochemical Techniques   **Credits: 3**

1   Nucleic Acids: 5

   1.1 structure and conformations
   1.2 Nucleic acid chemistry: non enzymatic transformation and methylation

2   Nucleotide Metabolism   4

   2.1. Synthesis and degradation of pyrimidine and purine nucleotides
   2.2. Disorders of nucleotide metabolism
   2.3. Functional diversity of nucleotides

3   Amino acids and peptides   6

   3.1. Essential and non-essential amino acids
   3.2. Amino acids related disorders
   3.3. Small peptides and their biomedical importance

4   Proteins   5

   4.1. Structure-conformation-function relationship (exemplified by Myoglobin, Hemoglobin,
          and Collagen)
   4.2. Protein degradation

5   Enzymes   9

   5.1. General properties
   5.2. Kinetics: derivation of Michaelis-Menten equation, L-B plot
   5.3. Enzyme inhibition
   5.4. Mechanism of action
   5.5. Regulation of enzyme activity

6   Biochemical techniques   10

   6.1. Centrifugation: types of rotors, clinical, highspeed and ultracentrifuges
   6.2. Colorimetry and spectrophotometry: Beer-Lambert law; absorption spectrum,
          fluorescence spectrum, introduction to mass spectrometry
   6.3. Chromatography: Paper, Thin layer chromatography; Columns: ion-exchange,
          gel-filteration, HPLC and affinity columns, electrophoresis
   6.4. Tracer techniques: Properties and units of radioactivity; half-life; measurement of
          radioactivity by GM counter, liquid scintillation counter; autoradiography; radio-
          immunoassay; safety rules in handling of radioisotopes and hazardous chemicals

   Recommended Books
   1   Berg et al (2006). Biochemistry. Freeman
   2   Bhagwan (2004). Medical Biochemistry. AP
   3   Devlin (2002). Biochemistry for the Molecular Sciences. Wiley
   4   Higgins et al (1994). Biochemistry for the Molecular Sciences Longman
   5   Murray et al (2006). Harpers Illustrated Biochemistry. Prentice Hall
   6   Nelson et at (2006). Lehninger's Principles of Biochemistry. McMillan
   7   Voet & Voet (2006). Biochemistry Vol. 1 and 2. Wiley
   8   Zubay et al (1995). Principles of Biochemistry. WCB
   9   Boney (1982). Cell Biology Level II. Macdonald & Evans
   10   Boyer (1993). Modern Experimental Biochemistry. Benjamin
   11   Clark & Switzer (2000). Experimental Biochemistry. Freeman
   12   Freifelder (1987). Physical Biochemistry. Freeman
   13   Boyer 2007 (2007). Concept of Biochem. 3rd Ed

   MGM105   Lab work based on courses MGM101 & MGM102   **Credits: 3**
   MGM106   Lab work based on courses MGM103 & MGM104   **Credits: 3**

MGM107M: Reproductive Genetics & Genetics of Pathogens   Credits: 3

Section A: Reproductive Genetics

1	Male and female reproductive systems	10

    1.1. Gonads and differentiation of sexual characters
    1.2. Hormonal regulation of sexual differentiation

2	Reproductive disorders	11

    2.1. Disorders of gonads, genital tracts and genitalia

        2.1.1. Pseudohermaphroditism
        2.1.2. True hermaphroditism
        2.1.3. Gonadal dysgenesis
        2.1.4. Anomalies of genital ducts

    2.2. Infertility

        2.2.1. Genetic basis of male infertility
        2.2.2. Genetic basis of female infertility
        2.2.3. Recurrent pregnancy loss

3	Technologies in reproductive assistance	3
4	Legal and ethical implications in reproductive assistance	2

Recommended Books
1   Besser & Thorner (2002). Comprehensive clinical endocrinology. Mosby
2   Rimoin et al (2002). Principles & Practice of Medical Genetics, Vol I-III. Churchill

Section B: Genetics of Pathogens

1	Host-pathogen interaction, evolution of pathogenecity and regulation of virulence	2
2	Mechanism of drug resistance in pathogens	2
3	Molecular biology of following pathogens: HIV, Hepatitis viruses, Mycobacterium tuberculosis, Vibrio cholerae, Plasmodium, Leishmania, Trypanosoma, Entamoeba	8
4	Molecular mechanisms for origin of new pathogens	1

Recommended Books
1   Heritage et al (1996). Introductory Microbiology. Cambridge Univ.
2   Madigen et al(1997). Biology of Microorganisms. Prentice Hall
3   Nesler et al (1995). Microbiology-A Human Perspective. WCB
4   Pelczar et al(1993). Microbiology. Tata
5   Prescott et al (1999). Microbiology. WCB
6   Reischel (1998). Molecular Diagnosis of Infectious Diseases. Humana
8   Streips & Yasbin (2002). Modern Microbial Genetics. Wiley
9   Trun & Trumpy (2004). Fundamentals of Bacterial Genetics. Blackwell
10   Volk et al (1991). Essentials of Medical Microbiology. Lippincott & Co

SEMESTER - II

MGM201: Cell Biology & Microscopy   Credits: 3

1 Plasma Membrane: organization and dynamics transport across membrane; mechanisms of endocytosis
   and exocytosis   4
2 Endomembrane system   5
   2.1. General organization of protein transport within and outside the cell
   2.2. Protein sorting and secretion
   2.3. Mechanism of intracellular digestion
3 Cytoskeleton   4
   3.1. Microfilaments: Structural organization, cell motility and cell shape
   3.2. Microtubule: Structural and functional organization, cilia, flagella, centriole
   3.3. Intermediate filaments
4 Mitochondria   2
   4.1 Ultrastructure
   4.2 Chemiosmotic theory and respiratory chain complexes
5 Structure and function of peroxisome   1
6 Nucleolus and biosynthesis of ribosome   2
7 Cell cycle and its regulation   3
8 Cell-Cell Interaction   5
   8.1. Cell adhesion molecules
   8.2. Cellular junctions
   8.3. Extracellular matrix
9 Signal transduction   5
   9.1. Intracellular receptor and cell surface receptors
   9.2. Signalling via G-protein linked receptors (PKA, PKC, CaM kinase)
   9.3. Enzyme linked receptor signaling pathways
9.4. Network and cross-talk between different signal mechanisms
10 Programmed cell death   1
11 Basic knowledge of principles and applications of the following microscopy techniques   7
   11.1. Light Microscopy
   11.2. Dark-field Microscopy
   11.3. Phase-contrast Microscopy
   11.4. Fluorescence Microscopy
   11.5. Confocal Microscopy
   11.6. Electron Microscopy
   11.7. Photography, Digital imaging and image Processing

Recommended Books

1 Alberts et al (1998). Essential Cell Biology. Garland
2 Alberts et al (2007). Molecular Biology of the Cell. Garland
3 Cooper (2007). The Cell: A molecular Approach. ASM Press
4 Gilbert (2006). Developmental Biology. Sinauer
5 Jeremy et al (2002). Biochemistry. Freeman
6 Karp (2005). Cell and Molecular Biology. John Wiley
7 Lewin (2007). Genes IX. Pearson
8 Lodish et al (2004). Molecular Cell Biology. Freeman
9 Pollard &Earnshaw (2002). Cell Biology. Saunders
10 Tobin and Morcel (1997). Asking about Cells. Saunders
11 Wilson & Hunt (2002). The Cell: A Problems Approach. Garland
12 Locquin and Langeron (1983). Handbook of Microscopy. Butterwaths
13 Tobin and Morcel (1997). Asking about Cells. Saunders

.

MGM202: Cytogenetics   **Credits: 3**

1 Chromatin structure   4

   1.1. Histones, DNA
   1.2. Nucleosome and higher level organisation

2 Chromosome organization   8

   2.1. Metaphase chromosome: centromere and kinetochore, telomere and its
       maintenance; Holocentric chromosomes and supernumerary chromosomes
   2.2. Chromosomal domains (matrix, loop domains) and their functional significance
   2.3. Heterochromatin and euchromatin, position effect variegation, boundary
       elements
   2.4. Chromosome bandings

3 Functional states of chromatin and alterations in chromatin organization   3

4 Structural and functional organization of interphase nucleus   2

5 Giant chromosomes   4

   5.1 Polytene chromosomes
   5.2 Lampbrush chromosomes

6 Mitosis   3

   6.1. Mitotic spindle and arrangement of chromosomes on equator
   6.2. Regulation of exit from metaphase
   6.3. Chromosome movement at anaphase

7 Meiosis   5

   7.1 Overview of the process
   7.2 Meiosis specific cellular changes
   7.3 Genetic control of meiosis (example: yeast)

8 Chromosomal anomalies   5

   8.1 Numerical
   8.2 Structural
   8.3 Meiosis in inversion and translocation heterozygotes; breakage-fusion-bridge
       cycles
   8.4 Induced chromosomal aberrations in somatic cells
   8.5 Sister chromatid exchanges and somatic crossing over

9 Dosage compensation in Caenorhabditis, Drosophila and mammals   5

Recommended Books

  1   Alberts et al (1998). Essential Cell Biology. Garland
  2   Alberts et al (2007). Molecular Biology of The Cell. Garland
  3   Bostoc and Sumner (1980). The Eukaryotic Chromosome. Elsevier
  4   Hamsew and Flavell (1993). The Chromosome. Bios
  5   Hawley & Walker (2003). Advanced Genetic Analysis. Blackwell
  6   Hennig (1987). Structure & Function of Eukaryotic Chromosomes. Springer
  7   Lewin (2007). Genes IX. Pearson
  8   Lodish et al (2004). Molecular Cell Biology. Freeman
  9   Obe and Natarajan(1990). Chromosome aberrations - Basic and Applied Aspects. Springer
  10   Risley (1985). Chromosome Structure and Function. Reinhold
  11   Rooney & Czepulkowski (1987). Human Cytogenetics – A Practical Approach. IRL
  12   Sumner. Chromosomes. Blackwell

.

MGM203: DNA Technology & Genetic Engineering   Credits: 3

1 Enzymes used in DNA technology   4

    1.1 Restriction and modification enzymes
    1.2 Other nucleases
    1.3 Polymerases
    1.4 Ligase, kinases and phosphatases

2 Cloning vectors   6

    2.1 Plasmids
    2.2 Phages
    2.3 Cosmids
    2.4 Artificial chromosomes
    2.5 Shuttle vectors
    2.6 Expression vectors

3 Construction of genomic and cDNA libraries   2

4 Screening and characterization of clones   5

    4.1 Preparation of probes
    4.2 Principles of hybridizations and hybridization based techniques (colony, plaque,
        Southern, Northern and in situ hybridizations)
    4.3 Expression based screening
    4.4 Interaction based screening: yeast two-hybrid system

5 Basic principles and applications of the following techniques   5

    5.1. DNA sequencing
    5.2. Oligonucleotide synthesis
    5.3. Polymerase Chain Reaction
    5.4. Microarray
    5.5. DNA fingerprinting

6 Promoter characterization: promoter analysis through reporter genes, electrophoretic mobility shift assay, DNA foot-printing   3

7 Mutagenesis   3

    7.1. Site directed mutagenesis
    7.2. Transposon mutagenesis
    7.3. Construction of knock-out mutants

8 Gene transfer techniques   5

    8.1 Electroporation and microinjection
    8.2 Transfection of cells: Principles and methods
    8.3 Germ line transformation in *Drosophila* and transgenic mice: Strategies and methods

9 Applications of Recombinant DNA Technology   6

    9.1 Crop and live-stock improvement
    9.2 Gene therapy: somatic and germ line gene therapy
    9.3 DNA drugs and vaccines
    9.4 Bio safety and ethical considerations

Recommended Books
1   Ausubel et al (2002). Short Protocols in Molecular Biology. Wiley
2   Brown (2000). Essential Molecular Biology VI. AP
3   Brown (2000). Essential Molecular Biology VII. AP
4   Brown (2006). Gene Cloning and DNA Analysis - An Introduction. Blackwell
5   Glick and Pasternak (2003). Molecular Biotechnology. ASM Press
6   Kracher. Molecular Biology - A Practical Approach.
7   Krenzer and Massey (2000). Recombinant DNA and Biotechnology. ASM

8   Micklos and Freyer (1990). DNA Science. CSHL
9   Primrose (2001). Molecular Biotechnology. Panima
10   Robertson et al (1997). Manipulation & Expression of Recombinant DNA. AP
11   Sambrook et al (2001). Molecular Cloning. CSHL
12   Twyman (1999). Advanced Molecular Biology. Viva
13   Watson et al (1992). Recombinant DNA. Freeman
14   Primrose and Twyman (2006). Principles of Gene Manipulation and Genomics. Blackwell

MGM204: Genomic instability and Cancer & Bioinformatics   Credits: 3

Section A: Genomic instability & Cancer

1 DNA repair   5

    1.1. Origins and types of DNA damage
    1.2. DNA repair pathways
    1.3. Error-prone repair and mutagenesis
    1.4. Damage signaling and checkpoint arrest

2 Recombination   4

    2.1. Homologous recombination: models and molecular mechanisms
    2.2. Gene conversion: molecular mechanisms
    2.3. Site specific recombination
    2.4. Transposons and transposition mechanisms

3 Cell transformation and tumourigenesis   8

    3.1. Cell cycle check point and cancer
    3.2 Oncogenes
    3.3. Tumour suppressor genes
    3.4. DNA repair genes and genetic instability
    3.5. Epigenetic modifications, telomerase activity, centrosome malfunction
    3.6. Genetic heterogeneity and clonal evolution

4 Familial cancers: Retinoblastoma, Wilms' tumour, Li-Fraumeni syndrome, colorectal, cancer, breast cancer   4

5 Genetic predisposition to sporadic cancer   1

6 Tumour progression: angiogenesis and metastasis   2

7 Tumour specific markers   1

8 Cancer and environment: physical, chemical and biological carcinogens   1

Recommended Books
1   Alberts et al (1999). The Science of Genetics. Saunders
2   Alberts et al (2008). Molecular Biology of the Cell. Garland
3   Benjamin (2003). Genetics: A Conceptual Approach. Freeman
4   Berg and Singer (1998). Genes and Genome.
5   Black (2002). Microbiology: Principles and Explorations. Wiley
6   Cowell (2001). Molecular Genetics of Cancer. Bios
7   Dale & Schartz (2003). From genes to Genome. Wiley & Sons
8   Ehrlich (2000). DNA Alterations in Cancer. Eaton
9   Gersen & Keagle (1999). Principles of Clinical Cytogenetics. Humana
10   Griffiths et al (2002). Modern Genetic Analysis. Freeman
11   Griffiths et al (2004). An Introduction to Genetic Analysis. Freeman
12   Hartl et al (2002). Essential Genetics. Wiley & Sons
13   Klug & Cummings (2003). Essentials of Genetics. Prentice Hall
14   Latchman (1995). Gene Regulation. Chapman & Hall
15   Lewin (2004). Genes VIII. Pearson
16   Lewin (2007). GenesIX. Pearson
17   Lodish et al (2004). Molecular Cell Biology. Freeman
18   Maloy and Freifelder(1994). Microbial Genetics. Jones and Barlett

19   Meesfeld (1999). Applied Molecular Genetics. Wiley-Liss
20   Ptashne (1986). Genetic Switch. Blackwell
21   Russell (2002). Genetics. Benjamin
22   Stillman (1994). Molecular Genetics of Cancer. CSHL
23   Streips & Yasbin (2002). Modern Microbial Genetics. Wiley
24   Trun & Trempy (2004). Fundamentals of Bacterial Genetics. Blackwell

Section B: Bioinformatics

1. Definition and Scope of Computational Biology and Bioinformatics   1
2. Major Bioinformatics Databases & Resources: NCBI, EBI, ExPASy   1
3. Biological **Sequence Analysis**   5
    3.1   **Sequence Similarity, Homology and Alignment:**
    3.1.1. Pairwise sequence Alignment, Global & Local Alignment algorithms, Basic concept of Scoring matrices (PAM & BLOSSUM), Dynamic programming Algorithms, Dot Plots for comparing sequences, Statistical significance of alignments score, motifs and pattern analysis
    3.1.2. BLAST and FASTA algorithms BLAST theory, other BLAST options, PSI-BLAST and PSSM, Applications of BLAST.
    3.2 **Multiple sequence alignment:**   2
    3.2.1 Introduction to Multiple sequence alignment and progressive alignment algorithm, MSA based software tools ClustalW. Applications of Multiple Sequence alignment.
    3.2.2 **Phylogenetic analysis:**   2
        Definition and description of phylogenetic trees and various types of trees, A primer on Computational phylogenetic analysis.
4. Computational Gene Prediction Methods (basic concept)   2
5. Lab Exercises   26

    5.1 Basics of Computer, Internet and Operating system
    5.2 Major Sequence and Structure Databases**:** Knowledge of the following databases with respect to: organization of data, contents and formats of database entries, retrieval of data using text-based search tools
        5.2.1 Nucleic acid sequence databases: GenBank, EMBL
        5.2.2 Protein sequence databases: SWISS-PROT, TrEMBL, PIR
        5.2.3. Genome Databases at NCBI, EBI, TIGR, SANGER
        5.2.4. Repositories for high throughput genomic sequences: EST, STS and GSS
        5.2.5. **Derived Databases**: basic concept of derived databases, PROSITE, PRODOM, Pfam, CATH, SCOP, DSSP, FSSP, DALI databases

    5.3 Protein Structure Visualization**: Schematic Representations of proteins using** Chimera, and Pymol, Protein Data Bank (PDB) and PDB format.

    Recommended Books
    1   Attwood & Parry-Smith (2002). Introduction to Bioinformatics. Pearson
    2   Barnes & Gray (ed) (2003). Bioinformatics for Geneticists. Wiley
    3   Lesk (2003). Introduction to Bioinformatics. Oxford
    4   Mount (2003). Bioinformatics: Sequence and Genome Analysis. CBS
    5   Rashidi & Buchler (2000). Bioinformatics Basics. CRC Press
    6   Rastogi et al (2003). Bioinformatics: Concepts, Skills and Applications. CBS
    7   Westhead et al (2003). Bioinformatics Instant Notes. Viva Books

MGM205: Biochemistry & Metabolic Disorders   **Credits: 3**

1   Carbohydrates   9
    1.1. Mucopolysaccharides and related disorders
    1.2. Glycolysis
    1.3. Krebs cycle
    1.4. Gluconeogenesis
    1.5. Glycogenesis and glycogenolysis,
    1.6. Disorders of glycogen metabolism

2   Lipids   8
    2.1. Fatty acids: synthesis and oxidation of fatty acids
    2.2. Ketogenesis
    2.3. Metabolism of cholesterol
    2.4. Lipoproteins: role in lipid transport and storage
    2.5. Prostaglandins: structure and function

3   Bioenergetics   5
    3.1. Second law of thermodynamics
    3.2. High energy compounds
    3.3. Oxidative phosphorylation

4   Hormones   8
    4.1 Characteristics
    4.2. Mechanism of action of peptide hormones
    4.3 Mechanism of action of steroid hormones and gene expression
    4.4 Hormonal regulation of fuel metabolism
    4.5. Hormone receptors and diseases

5   Vitamins   4
    5.1 Structure
    5.2 Function of water- and lipid-soluble vitamins

6   Inborn errors of metabolism   5
    6.1 Phenylketonuria
    6.2 Maple syrup urine syndrome
    6.3 Mucopolysaccharidosis
    6.4 Galactesemia
    6.5 Tay-Sachs disease

Recommended Books

1   Berg et al (2006). Biochemistry. Freeman
2   Bhagwan (2004). Medical Biochemistry. AP
3   Devlin (2002). Biochemistry: with clinical correlations. Wiley
4   Higgins et al (1994). Biochemistry for the Molecular Sciences. Longman
5   Murray et al (2006). Harpers Illustrated Biochemistry. Prentice Hall Int
6   Nelson et al (2006). Lehninger's Principles of Biochemistry. McMillan
7   Voet & Voet (2006). Biochemistry Vol. 1 and 2. Wiley
8   Zubay et al (1995). Principles of Biochemistry. WCB

MGM206	Lab work based on courses MGM201 & MGM202	**Credits: 2**
MGM207	Lab work based on courses MGM203 & MGM204	**Credits: 2**
MGM208	Lab work based on course MGM205	**Credits: 2**

MGM209M: Fundamentals of Molecular Biology   **Credits: 3**

1   Eukaryotic cell Organization   4

   1.1 Biomembrane
   1.2 Organelles of Eukaryotic cell

2   Nucleic Acids   6

   2.1 Base composition, structure and conformation
   2.2 Different forms and unusual structures
   2.3 Nucleic acid chemistry: Denaturation, hybrids, nonenzymatic transformation, methylation.
   2.4 Nucleosome &higher level Organization

3   DNA Replication   5

   3.1 DNA polymerases
   3.2 Replicons, origin and termination
   3.3 Replisome
   3.4 Genes controlling replication

4   Transcription   8

   4.1 Prokaryotic RNA polymerase, sigma factors, initiation and termination
   4.2 Eukaryotic RNA polymerases and their promoters
   4.3 Processing of transcripts
   4.4 Post transcriptional regulation:
   4.4.1 Alternative splicing
   4.4.2 Transport and targeting of RNA
   4.4.3 Post-transcriptional gene silencing5

5   Translation   3

   5.1 General mechanism
   5.2 Translational control

6   DNA Technology   13

   6.1 Enzyme used in DNA technology
   6.2 Purification & separation of nucleic acid
   6.3 Cloning
   6.4 Polymerase chain reaction & application
   6.5 DNA sequencing
   6.6 DNA fingerprinting
   6.7 Nucleic acid &protein hybridization techniques: southern, northern, western hybridization

Recommended Books
1   Lodish et al (2004). Molecular Cell Biology. Freeman
2   Gerald Karp (2005). Cell & Molecular Bology. Wiley & Sons
3   Brown (2001). Essential Molecular Biology. AP
4   Alberts et al (1999). The Science of Genetics. Saunders
5   Benjamin (2003). Genetics: A Conceptual Approach. Freeman
6   Berg and Singer (1998). Genes and Genome
7   Dale & Schartz (2003). From genes to Genome. Wiley & Sons
8   Griffiths et al (2002). Modern Genetic Analysis. Freeman
9   Griffiths et al (2004). An Introduction to Genetic Analysis. Freeman
10 Hartl et al (2002). Essential Genetics. Wiley & Sons
11 Klug & Cummings(2003). Essentials of Genetics. Prentice Hall
12 Latchman (1995). Gene Regulation. Chapman & Hall
13 Lewin (2007). GenesIX. Pearson
14 Watson et al (2004). Molecular Biology of the Gene. Pearson

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SEMESTER - III

MGM301: Human Molecular Genetics   **Credits: 3**

1 Genetic mapping of Mendelian traits   6

    1.1. Identifying recombinants and nonrecombinants in pedigrees
    1.2. Genetic and physical map distances
    1.3. Genetic markers
    1.4. Two-point mapping- LOD score analysis
    1.5. Multipoint mapping
    1.6. Homozygosity mapping

2 Genetic mapping of complex traits   6

    2.1. Difficulties in mapping complex traits
    2.2. Allele sharing methods- Affected sib pair analysis
    2.3. Allelic association, Linkage disequilibrium mapping, Transmission
        disequilibrium test

3 Physical mapping methods   6

    3.1. Low resolution mapping- Cell hybrids, mini- and microcells, synteny of genes,
        Radiation hybrid mapping
    3.2. Assembly of clone contigs
    3.3. Identifying genes in cloned DNA
    3.4. Integration of cytogenetic, genetic and physical maps

4 Identifying human disease genes   6

    4.1. Principles and strategies
    4.2. Position-independent and positional cloning. Candidate gene approaches
    4.3. Confirming a candidate gene- mutation screening, testing in animal models

5 Molecular pathology   7

    5.1. Nomenclature of mutations and their databases
    5.2. Loss-of-function and gain-of-function mutations in diseases
    5.3. Instability of the human genome: Pathogenicity associated with repeat
        sequences

6 DNA testing   8

    6.1. Direct testing

        6.1.1. Screening for unknown mutations
        6.1.2. Detection of known mutations

    6.2. Indirect testing – gene tracking
    6.3. DNA profiling: establishing identity and relationships
    6.4. Population screening - ethics, organization and advantages

Recommended Books

1   Davies (1993). Human Genetic Disease Analysis. IRL
2   Haines & Pericak (2006). Approaches to Gene Mapping in Complex Human
    Diseases. Wiley
3   Nussbaum et al (2004). Genetics in Medicine. Saunders
4   Pasternak (2005). An Introduction to Molecular Human Genetics. Fritzgerald
5   Rimoin et al (2002). Principles & Practice of Medical Genetics, Vol I-III. Churchill
6   Strachan & Read (1999). Human Molecular Genetics. Wiley
7   Sudbery (2002). Human Molecular Genetics. Prentice-Hall

MGM302: Clinical Genetics & Genetic Counseling   **Credits: 3**

1	An overview of the genetic basis of syndromes and disorders	1

2 Monogenic diseases with well known molecular pathology   6
   2.1. Cystic fibrosis
   2.2. Tay-Sachs syndrome
   2.3. Marfan syndrome
   2.4 Inborn errors of metabolism

3 Genome imprinting Syndromes: Prader-Willi & Angelman syndromes, Beckwith-   2
   Wiedeman Syndrome

4 Neurofibromatosis I   1

5 Disorders of muscle   3
   5.1 Dystrophies (Duchenne Muscular dytstrophy and Becker Muscular Dystrophy)
   5.2 Myotonias
   5.3 Myopathies

6 Disorders of Haemopoitic systems   4
   6.1 Overview of Blood cell types and haemoglobin
   6.2 Sickle cell anemia
   6.3 Thalassemias
   6.4 Hemophilias

7 Disorders of eye   3
   7.1 Retinitis pigmentosa
   7.2 Cataract
   7.3 Glaucoma
   7.4 Colour blindness

8 Multifactorial diseases   3
   8.1 Hyperlipidemia
   8.2 Atherosclerosis
   8.3 Diabetes mellitus

9 Mitochondrial syndromes   1

10 Management of genetic disorders   3

11 Historical overview of genetic counseling   2
   11.1 Models of Eugenic, Medical/Preventive, Decision making, Psychotherapeutic
        counseling; current definition and goals
   11.2 Philosophy and ethos of genetic services and counseling

12 Components of genetic counseling   2
   12.1 Indications and purpose
   12.2 Information gathering and construction of pedigrees
   12.3 Medical Genetic evaluation

      12.3.1 Basic components of Medical History
      12.3.2 Past medical history, social & family history

   12.4 Physical examination

      12.4.1 General and dysmorphology examination
      12.4.2 Documentation

13 Patterns of inheritance, risk assessment and counseling in common Mendelian and   3
    multifactorial disorders

14 Biochemical and molecular genetic tests   2
   14.1 In children
   14.2 Presymptomatic testing for late onset diseases (predictive medicine)

15 Prenatal and pre-implantation diagnosis   2

   15.1 Indications for prenatal diagnosis
   15.2 Indications for chromosomal testing
   15.3 Noninvasive methods

.

16 Legal and ethical considerations   1

Recommended Books

1   Cox and Sinclair(1997). Molecular Biology in Medicine. Blackwell
2   DeGrouchy and Turleau (1984). Clinical Atlas on Human Chromosomes. Wiley
3   Jankowski and Polak (1996). Clinical Gene Analysis and Manipulation. Cambridge
4   Korf (1996). Human Genetics – A Problem Based Approach. Blackwell
5   Pasternak (2000). An Introduction to Molecular Human Genetics. Fritzgarald
6   Rasko and Downes (1995). Genes in Medicine. Kluwer
7   Rimoin et al (2002). Principles & Practice of Medical Genetics, vol I-III. Churchill
8   Robinson and Linden (1994). Clinical Genetics Handbook. Blackwell
9   Strachan and Read (1999). Human Molecular Genetics. Wiley
10 Wilson (2000). Clinical Genetics: A Short Course. Wiley-Liss
11 Baker et al (1998). A Guide to Genetic Counseling. Wiley
12 Harper (2001). Practical Genetic Counseling. Arnold
13 Rose & Lucassen(1999). Practical genetics of primary care. Oxford
14 Young (1999). Introduction to Risk Calculation in Genetic Counseling. Oxford

MGM303: Developmental Genetics   **Credits: 3**

1   Early development   5

   1.1 Fertilization
   1.2 Types of cleavage
   1.3 Gastrulation: Cell movement and formation of germ layers in frog, chick and
        mouse
   1.4 Concept of determination, competence and differentiation

2   Development of vertebrate nervous system   5

   2.1 Formation of neural tube
   2.2 Formation of brain regions
   2.3 Tissue architecture of the central nervous system

3   12

   3.1 *Caenorhabditis*: Vulva formation
   3.2 *Drosophila*

      3.2.1 Maternal genes and formation of body axes
      3.2.2 Segmentation genes
      3.2.3 Homeotic genes function
      3.2.4 Imaginal disc development

   3.3 Vertebrates

      3.3.1 Axes formation and HOX genes
      3.3.2 limb formation in chick

4   Programmed rearrangements in genes   4

   4.1 Chromatin diminution
   4.2 Endoreplication cycles
   4.3 Gene amplification

5   Genome imprinting   1

6   Genetic determination of sex in *Caenorhabditis*, *Drosophila* and mammals   3

7   Regeneration   1

8   Senescence   1

9   Embryonic stem cells and their applications   2

10 Clinical embryology   5

10.1 Differentiation of germ cells and gametogenesis
10.2 Fertilization and implantation
10.3 Stages of human embryonic development
10.4 Congenital malformations and teratogenesis
10.5 Reproductive failure and infertility and assisted reproduction

Recommended Books

1   Alberts et al (2007). Molecular Biology of The Cell. Garland

2   Gilbert (2006). Developmental Biology. Sinauer

3   Kalthoff (1996). Analysis of Biological Development. McGraw Hill

4   Lewin (2007). GenesIX. Pearson

5   Monk (1987). Mammalian Development – A Practical Approach. IRL

6   O'Rahilly and Muller (1992). Human Embryology and Teratology. Wiley

7   Rana (1998). Human Embryology Made Easy. Harwood

8   Wolpert (2007). Principles of Development. Oxford

<div align="center">MGM304: Immunogenetics   Credits: 3</div>

1 An introduction to immune system
  1.1 Innate and adaptive immunity
  1.2 Cells and organs of the immune system   7
  1.3 Primary and secondary immune responses
  1.4 Antigens, antibodies and T cell receptors

    1.4.1 Antigens
    1.4.2 Structure and function of immunoglobulins
    1.4.3 Monoclonal antibodies
    1.4.4 B and T cell receptors and coreceptors
    1.4.5 Antigen-antibody interactions

2 Immunoglobulin and T-cell receptor genes   8
  2.1 Organization of Ig gene loci
  2.2 Molecular mechanisms of generation of antibody diversity
  2.3 Expression of Ig genes
  2.4 Regulation of Ig gene transcription
  2.5 Antibody engineering
  2.6 Organization of TCR gene loci
  2.7 Generation of TCR diversity

3 The HLA complex   3
  3.1 Organization of HLA complex
  3.2 Structure of class I and II HLA molecules
  3.3 Expression of HLA genes
  3.4 HLA polymorphism

4 Generation and regulation of immune responses   12
  4.1 Antigen processing and presentation
  4.2 MHC-restriction
  4.3 Cytokines
  4.4 T Cell Maturation, activation and differentiation
  4.5 B Cell Generation, Activation and differentiation
  4.6 Clonal selection and immunological memory
  4.7 Complement system
  4.8 Leukocyte, Activation and Migration
  4.9 Cell mediated cytotoxic responses
  4.10 Regulation of immune responses
  4.11 Immunological tolerance

5 Disorders of Human Immune System   5
   5.1 Primary and secondary immunodeficiencies
   5.2 Autoimmune disorders
   5.3 Hypersensitive reactions
   5.4 Cytokine-related diseases

6 Immune system in human health   4
   6.1 Immune response to infectious diseases and malignancy
   6.2 Concept of immunotherapy
   6.3 Vaccines
   6.4 Transplantation immunology

Recommended Books

1   Abbas et al (2007). Cellular and Molecular Immunology. Saunders

2   Barrett (1988). Text Book of Immunology. Mosloy

3   Benjamin et al (2003). Immunology – A Short Course. Wiley-Liss

4   Kuby (2006). Immunology. Freeman

5   Roitt (2003). Essential Immunology. Blackwell

6   Roitt et al (2001). Immunology. Mosloy

MGM305	Lab work based on courses MGM301 & MGM302	**Credits: 2**
MGM306	Lab work based on courses MGM303 & MGM304	**Credits: 2**

MGM307: Clinical Assignments   **Credits: 2**

Each student will visit the BHU hospital as per the schedule drawn each year and undertake analysis of some of the inherited diseases presented during these visits. Each student will maintain a detailed record of the visits and the patients analyzed and submit a Report on the same.

MGM308M: Basic Genetics and Genetic Disorders   **Credits: 3**

1 Mendelism and its extensions   7

   1.1 Law of segregation
   1.2 Law of independent assortment
   1.3 Chromosomal basis of segregation and independent assortment
   1.4 Linkage
   1.5 Crossing over
   1.6 Multiple allelism
   1.7 Pleiotropy
   1.8 Cytoplasmic inheritance

2 Cytogenetics   6

   2.1 Chromatin structure
   2.2 Heterochromatin and euchromatin
   2.3 Mitosis
   2.4 Meiosis
   2.5 Dosage compensation
   2.6 Chromosomal aberrations

3 Molecular Genetics   10

   3.1 Nature of genetic material and flow of genetic information
   3.2 DNA replication
   3.3 Transcription
   3.4 Translation
   3.5 Genetic code
   3.6 Regulation of gene expression

3.6.1. Transcriptional regulation (Operon, Enhancers and promoters)

3.6.2. Post transcriptional regulation (Alternative splicing, gene silencing)

3.7 Transposable elements

3.8 DNA damage and repair

3.9 Mutation

4   Human Molecular Genetics   6

4.1 Organization of human genome

4.2 Pedigree analysis

4.3 Monogenic and polygenic traits

4.4 Gene mapping and linkage analysis

4.5 Genetic counseling

4.6 Prenatal diagnosis

5.1 Molecular mechanisms of carcinogenesis

5 5.2 Oncogenes and tumour suppressor genes   3

5.3 Apoptosis and cancer

6   Genetic disorders   7

6.1 Inborn errors of metabolism: Phenylketonuria

6.2 Neurogenetic disorders: Alzheimer's disease

6.3 Muscle genetic disorders: Duchenne Muscular Dystrophy

6.4 Genetic disorders of Haematopoitic systems: Sickle cell anemia

6.5 Multifactorial disorders: Diabetes mellitus

6.6 Mitochondrial syndromes

6.7 Management of genetic disorders

Recommended Books

1   Strickberger (1985). Genetics. McMillan

2   Snustad & Simmons (2005). Principles of Genetics. Wiley

3   Griffiths et al (2002). Modern genetic analysis. Freeman

4   Hartl and Jones (1998). Genetics-Principles and Analysis. Jones & Bartlett

5   Nelson et al (2006). Lehninger's Principles of Biochemistry. McMillan

6   Alberts et al (2007). Molecular Biology of the Cell. Garland

7   Lewin (2007). Genes IX. Jones & Bartlett

8   Kasper et al (2005). Harrison's Principles of Internal Medicine. Vol. I & II. McGraw Hill

9   Strachan and Read (2003). Human Molecular Genetics. Wiley

10   Pritchard & Korf (2007). Medical Genetics at a glance. Wiley-Blackwell

11   Lodish et al (2004). Molecular Cell Biology. Freeman

12   Karp (2005). Cell and Molecular Biology. John Wiley

13   Rimoin et al (2002). Principles & Practice of Medical Genetics. Vol. I-III. Churchill

14   Weinberg (2006). Biology of Cancer. Garland

SEMESTER - IV

MGM401: Human Genome **Credits: 3**

1 The Genome project 8
   1.1. History, organization and goals of human genome project
   1.2. Mapping strategies, current status of various maps; DNA segment nomenclature
   1.3. Human genome diversity

2 Organization of human genome 8
   2.1. Mitochondrial genome
   2.2. Gross base composition of nuclear genome
   2.3. Gene density
   2.4. CpG islands
   2.5. RNA-encoding genes
   2.6. Functionally identical/similar genes
   2.7. Diversity in size and organization of genes
   2.8 Annotation

3 Gene families
   3.1 Multigene families – Classical gene families, families with large conserved domains, families with small conserved domains
   3.2 Gene superfamilies
   3.3 Gene families in clusters
   3.4 Pseudogenes
   3.5 Repetitive DNA and transposable elements
   3.6 Origin of gene families

4 Comparative Genomics 8
   4.1 Overview of prokaryotic and eukaryotic genomes
   4.2 C-value, number of genes and complexity of genomes
   4.3 Conservation and diversity of genomes
   4.4 Comparative genomics as an aid to gene mapping and study of human disease genes

5 Functional genomics 5
   5.1 Transcriptome and its analysis
   5.2 Proteome and Proteomics
   5.3 gene silencing

6. Disease and genomics 2

Recommended Books
1 Brown (2007). Genomes. Bios
2 Coleman and Tsongalis (1997). Molecular Diagnosis. Humana
3 Dale & Schartz (2003). From Genes to Genomes. Wiley
4 Hawley and Mori (1999). The Human Genome. Academic
5 Lewis (1999). Human Genetics. WCB
6 Liebler (2002). Introduction to Proteomics. Humana
7 Pasternak (2000). An Introduction to Molecular Human Genetics. Fritzgerald
8 Primrose & Twyman (2003). Principles of Genome Analysis & Genomics. Blackwell
9 Strachan and Read (2005). Human Molecular Genetics 3. Wiley
10 Sudbery (2002). Human Molecular Genetics. Prentice Hall
11 Alberts et al (2007). Molecular Biology of the Cell. Garland
12 Cowell (2001). Molecular Genetics of Cancer. Bios
13 Ehrlich (2000). DNA Alterations in Cancer. Eaton
14 Gersen & Keagle (1999). Principles of Clinical Cytogenetics. Humana
15 Lewin (2007). GenesI X. Pearson
16 Lodish et al (2004). Molecular Cell Biology. Freeman
17 Stillman (1994). Molecular Genetics of Cancer. CSHL

MGM402: Population & Evolutionary Genetics   **Credits:3**

1	Concept and theories of evolution	3
2	Microevolution in Mendelian population	5
	2.1 Mendelian Population	
	2.2 Allele frequencies and genotype frequencies	
	2.3 Hardy-Weinberg equilibrium and conditions for its maintenance	
3	Elemental forces of evolution	6
	3.1 Mutation	
	3.2 Selection (Types of selection, selection coefficient, selection in natural populations)	
	3.3 Genetic drift	
	3.4 Migration	
4	Chromosomal, DNA and allozyme polymorphism in natural population	5
	4.1 Adaptive genetic polymorphism	
	4.2 Balanced polymorphism and heterosis	
	4.3 Genetic coadaptation and linkage disequilibrium	
5	Isolating mechanisms	3
6	Concept of species and modes of speciation: sympatric, allopatric, stasipatric	3
7	Molecular population genetics	4
	7.1 Molecular evolution (neutral theory, punctuated equilibrium)	
	7.2 DNA-based phylogenetic trees	
	7.3 Molecular clock	
8	Nonrandom breeding	3
	8.1 Inbreeding and assortative mating	
	8.2 Path diagram construction and inbreeding coefficient, allelic identities by descent	
9	Human phylogeny	4
	9.1 Hominid evolution: anatomical, Geographical, Cultural	
	9.2 Molecular phylogenetics of Homo sapiens	
	9.3 Peopling of continents (Europe, Africa, Asia)10.	
10	Population Substructure	3
	10.1 Hierarchical population structure	
	10.2 Isolate breaking: The Wahlund principle	

Recommended Books
1   Brown (2007). Genomes. Bios
2   Hartl & Clark (1997). Principles of Population Genetics. Sinaur
3   Hartl and Jones(1998). Genetics _ Principles and Analysis. Jones and Bartlet
4   Hoelzel (1998). Molecular Genetic Analysis of Populations. Oxford Univ
5   Jobling et al (2004). Human Evolutionary Genetics. Garland
6   Moody (1964). Evolution. Harper and Row
7   Roberts & DeStefano (1986). Genetic Variation and its Maintenance. Cambridge Univ
8   Smith (1998). Evolutionary Genetics. Oxford
9   Strickberger (2000). Evolution. Jones and Barlett

MGM403: Neurogenetics   **Credits: 3**

1	Nervous system	12
	1.1 Major regions of human brain	
	1.2 Cellular components of nervous tissue	
	1.3 Sub cellular organization of the nervous system	
	1.4 Membrane potential and action potential	
2	Learning and memory	3
3	Circadian rhythms	2
4	Neurogenetic disorders	10
	4.1 Spinomuscular atrophy	

4.2 Syndromes due to triplet nucleotide expansion

4.3 Alzheimers disease

4.4 Parkinsons disease

5 Nature-nurture and behaviour   6

 5.1 Genetic experiments to investigate animal behaviour

   5.1.1 Selection studies
   5.1.2 Inbred strain studies

 5.2 Identifying genes for controlling behavior

   5.2.1 Induced mutations
   5.2.2 Quantitative trait loci
   5.2.3 Synteny/orthology

 5.3 Investigating the genetics of human behaviour

 5.3.1 Twin and adoption study designs, interpreting heritability
 5.3.2 Linkage and association studies
 5.4 Environmental influence- shared and non-shared environment

6 Psychopathology   6

 6.1 Schizophrenia
 6.2 Mood disorders
 6.3 Disorders of childhood

Recommended Books

1   Kaplan and Sadock (2007). Synopsis of Psychiatry. Williams & Wilkins

2   Plomin et al (2001). Behavioral Genetics. Freeman

3   Zigmond, Bloom et al., (2002). Fundamentals Neuroscience. Academic Press

4   Kandel, Schwartz et al. (2000). Principles of Neuroscience. Prentice Hall

5   Pasternak (2005). An Introduction to Molecular Human Genetics. Fritzgarald

6   Cox and Sinclair (1997). Molecular Biology in Medicine. Blackwell

8   Rasko and Downes (1995). Genes in Medicine. Kluwer

9   Rimoin et al(2002). Principles & Practice of Medical Genetics, vol I-III. Churchill

10   Robinson and Linden (1994). Clinical Genetics Handbook. Blackwell

11   Strachan and Read (2003). Human Molecular Genetics. Wiley

12   Wilson (2000). Clinical Genetics: A Short Course. Wiley-Liss

MGM L 404   Lab work based on course MGM401   **Credits: 2**
MGM L 405   Lab work based on courses MGM402 & MGM403   **Credits: 2**

MGM406: Dissertation (Credits: 6)

Each student will undertake an experimental project under supervision of one of the teachers during Semester 4 and submit TWO copies of the dissertation which will include: a) Review of the relevant literature, b) Objectives of the study, c) Materials and Methods, d) Results/Observations (supported by figures/tables etc as required), e) Discussion of the Results/Observations, f) Summary and g) References

MGM407: Comprehensive Viva-voice (Credits: 2)

MGM408: Seminar & Formulation of a Research Proposal (Credits: 2)

The student will deliver a comprehensive seminar on a current topic of his/her choice in the field of Molecular & Human Genetics. The topic of Seminar must be different from the topics covered in any of the courses.

M. Sc. PETROLEUM GEOSCIENCES
(Special Course of Study)
DEPARTMENT OF GEOLOGY
BANARAS HINDU UNIVERSITY

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The initial intake shall be limited to ten seats through the B. H. U. Entrance Test. Students having passed Three Year and/or Six Semester B.Sc. (Hons.) Geology of BHU with Physics and Mathematics at + 2 level or any other equivalent examination of other universities shall be considered eligible for appearing at the Entrance Test. In view of the course being customized to the requirements of the hydrocarbon industry, the Department proposes to run the course as fully self financed with a fee structure of Rs. 50,000/- per semester.

The M.Sc. Petroleum Geosciences shall be imparted to students for two academic sessions consisting of four semesters as given below. Candidates will be examined and evaluated on grade basis at the end of each semester in the different courses of theory and practical as per credits given against each course. The M.Sc. Petroleum Geosciences will consist of (a) Core Courses, (b) Minor Elective Courses of other Departments, (c) Industrial Training at oil companies (4-6 weeks) and (d) Project Oriented Dissertation (periodic seminars, final presentation and thesis).

d) The Core courses will be compulsory for all the students admitted to M.Sc. Petroleum Geosciences. There will be twelve core courses, covering major branches of Geology, each of 3 credits, seven laboratory work of 2 credits, two seminar and viva-voce of 2 credits and one seminar and viva-voce of 3 credits. The Semesters – I, II and III shall include four courses each.

e) M.Sc. Petroleum Geosciences incorporates three compulsory minor elective courses of other Departments, one in each semester and each of 3 credits.

c) The industrial training includes four to six weeks training at oil companies of 10 credits in semester IV. Besides, there will be one 'inter semester winter geological field training in hydrocarbon prospective basin' in semester-I and one 'inter semester summer geological field training in hydrocarbon producing basin' in semester-II, each of 3 credits.

d) Along with the above courses, there shall be a Project Oriented Dissertation of 12 credits in semester-IV.

Marks for theory and practical examinations shall be as under:

Exam. Components	Marks for Semester Exam.	**Sessional** Intra Semester Test + class assignment and regularity	**Sessional** Intra-semester practical assessment + class assignment and regularity	Total Marks
Theory	70	30 (20+10)	-	100
Practical	70	-	30 (20+10)	100

Semesterwise distribution of Courtses and Credits

SEMESTER – I		
Course Code	**Title**	**Credits**
PGM101	Structural Geology and Tectonics	3
PGM102	Sedimentology and Sequence Stratigraphy	3
PGM103	Applicative Paleontology and Stratigraphy	3
PGM104	Fundamentals of Petroleum Geology	3
PGM105	Seminar and Viva Voce-I	2
PGM106	Practicals connected to PGM101	2
PGM107	Practicals connected to PGM102	2
PGM108	Practicals connected to PGM103	2
PGM109	Inter semester winter Geological Field Training in hydrocarbon perspective basin - I	3
#	Minor Elective *(from other PG Programmes)*	3
	TOTAL	**26**
SEMESTER - II		
PGM201	Seismic Data Processing and Basin Analysis	3
PGM202	Geophysical Exploration and Petrophysics	3
PGM203	Hydrocarbon Geochemistry	3
PGM204	Reservoir Study	3
PGM205	Seminar and Viva Voce - II	2
PGM206	Practicals connected with PGM201 & PGM202	2
PGM207	Practicals connected with PGM203	2
PGM208	Inter semester summer Geological Field Training in hydrocarbon producing basin - II	3
#	Minor Elective: *(from other PG Programmes)*	3
	TOTAL	**24**
SEMESTER - III		
PGM301	Well Site Geological Techniques	3
PGM302	Drilling and Production	3
PGM303	Economics, Policy and Managements	3
PGM304	Non-conventional Petroleum Exploration	3
PGM305	Seminar and Viva Voce – III	2
PGM306	Practicals connected with PGM301 & PGM 302	2
PGM307	Practicals connected with PGM304	2
#	Minor Elective: *(from other PG Programmes)*	3
	TOTAL	**21**
SEMESTER - IV		
PGM401	Industrial Training at Oil Companies	10
PGM402	Project Oriented Dissertation	12
	TOTAL	**22**
	GRAND TOTAL	**93**

\#   M.Sc. Petroleum Geoscience students will opt 3 Minor Electives (3 credit each in semester I,II & III) offered by other PG Programmes of the Faculty.

SEMESTER - I

Course No. PGM101: STRUCTURAL GEOLOGY AND TECTONICS   **Credit: 3**

Concept of stress and strain; Translation, rotation and deformation, kinematics and dynamic analysis, description of folds, joints, faults, unconformities and salt domes, mechanisms of the above structures; Cleavage, lineation and foliation; Stereographic projections of linear and planar structures, maps and cross sections; Structure contour maps, isopach maps and other facies maps, balanced cross-section, their importance in unraveling the geological history; Composition and internal structure of the earth, concept of plate tectonics and its role in hydrocarbon exploration.

Books Recommended:

Condie, Kent. C. (1982): Plate Tectonics and Crustal Evolution, Pergamon Press Inc.

Gass I.G. (1982): Understanding the Earth. Artemis Press (Pvt) Ltd. U.K.

Ghosh, S.K. (1993): Structural Geology: Fundamental and Modern Developments. Pergamon Press.

Hobbs, B.E., Means, W.D. and Williams, P.F. (1976): An outline of Structural Geology, John Wiley and Sons, New
York.

Ramsay, J.G. (1967): Folding and fracturing of rocks, McGraw Hill.

Ramsay, J.G. and Huber, M.I. (1983): Techniques of Modern Structural Geology, Vol. I, Strain Analysis, Academic Press.

Ramsay, J.G. and Huber, M.I. (1987): Techniques of Modern Structural Geology, Vol. II, Folds and Fractures, Academic Press.

Ramsay, J.G. and Huber, M.I. (2000): Techniques of Modern Structural Geology, Vol. III (Application of continuum mechanics), Academic Press.

Turner, F.J. and Weiss, L.E. (1963): Structural analysis of Metamorphic Tectonites, McGraw Hill.

Windlley B. (1973): The Evolving continents, John Wiley and Sons, New York.

Course No. PGM102: SEDIMENTOLOGY AND SEQUENCE STRATIGRAPHY   **Credit: 3**

Introduction, scope of sedimentology; Processes of sedimentation and diagenesis; Classification of sedimentary rocks, textures of sediments and sedimentary rocks and their analysis; Interpretation of grain size data; Hydrodynamic conditions of sediment transportation and sedimentary structures; Statistical treatment of paleocurrent data; Mineralogy of sedimentary rocks (kinds of sedimentary particles); Heavy minerals and their relationships with provenance and plate tectonic setting.

Physical and chemical parameters of depositional environments, classification of environments, lithologs, structures and vertical sequences formed in alluvial, deltaic, coastal, deep sea and desert environments; Carbonate environments; Tectonics and sedimentation.

Sequence stratigraphy, its concept, evolution, order and duration, application and significance; Fundamentals of sequence stratigraphy, depositional sequence, sequence architecture, types and boundaries, condensation and starvation; Conformity and types of sequence unconformities; Flooding surface, maximum flooding surface, marine flooding surface; System tracts - lowstand system tract, transgressive system tract, transgressive surface and highstand system tract, overlap, offlap, toplap and onlap, aggradation, progradation, retrogradation, transgression and regression; Eustatic sea level changes; Outcrop, subsurface and offshore sequence stratigraphy and their integration; Seismic stratigraphy; Sequence stratigraphy in well sections and application of well logs; Sequence stratigraphic approach in basin analysis and case history of important petroliferous basins of India.

Books Recommended:

Blatt, H., Middleton, G.V. and Murray, R.C. (1980): Origin of sedimentary rocks, Prentice-Hall.

Boggs, S. (2001): Principles of Sedimentology and Stratigraphy, Prentice Hall.

Coe, Angela, Dan Bosence, Kevin Church, Steve Flint, John Howell and Chris Wilson (2002): The Sedimentary Record of Sea Level Change , Cambridge Univ. Press.

Collins, J.D., and Thompson, D.B. (1982): Sedimentary structures, George Allen and Unwin, London.

Emery, D, (1996): Sequence Stratigraphy, Blachwell Scientific Publ.

Lindholm, R.C. (1987) A practical approach to sedimentology, Allen and Unwin, London.

Miall, A.D. (1997): The Geology of Stratigraphic Sequence, Springer-Verlag.

Miall, A.D. (2000): Principles of basin analysis, Sjpringer-Verlag.

Pettijohn;, F.J. (1975): Sedimentary rocks (3rd Ed.), Harper and Row Publ.

Reading, H.G. (1997): Sedimentary environments and facies, Blackwell Scientific Publ.

Reineck, H.E. and Singh, I.B. (1980): Depositional sedimentary environments, Springer-Verlag.

Selley, R. C. (2000) Applied sedimentology, Academic Press.
Tucker, M.E. (1981): Sedimentary petrology: An Introduction, Wiley and Sons.
Tucker, M.E. (1990): Carbonate sedimentolgy, Blackwell Scientific Publ.

Course No. PGM103: APPLICATIVE PALEONTOLOGY AND STRATIGRAPHY   Credit: 3
Paleontology – scopes, branches and applications; Important groups of mega and microfossils; Types of microfossils, their description and uses; Sampling, selected groups of microfossils - foraminifera, ostracods, bioherms – stromatolites, diatoms, cocoliths, spores and pollens.

Changing concepts in stratigraphy, basic principles of stratigraphy, stratigraphic classification, international code of stratigraphic nomenclature, correlation, graphic representation of stratigraphic data, principles of litho, bio, chrono, magnetic and seismic stratigraphy; Sequence stratigraphy, stratigraphic maps and relationships; Stratigraphy of the important petroliferous basins.

Books Recommended:
Alfred, T. (1988): Paleopalynology, Unwin Hyman.
Bignot, G., Grahm and Trottman (1985): Elements of Micropaleontoogy, London.
Boardman, R.S., Cheethan, A.M. and Rowell, A.J. (1988): Fossil Invertebrates, Blackwell.
Boggs, S. (2001): Principles of Sedimentology and Stratigraphy, Prentice Hall.
Clarksons, E.N.K. (1998): Invertebrate Paleontology and Evolution, Allen and Unwin, London.
Dobzhansky, Ayala, Stebbins and Valentine (1977): Evolution, Freeman.
Doyle, P. and Bennett. M.R. (1996): Unlocking the stratigraphic Record, John Wiley and Sons.
Horowitz, A.S. and Potter, E.D. (1971): Introductory Petrography of Fossils, Springer Verlag.
Jones, T.P. and Rowe, T.P. (1999):Fossil Plants and Spores, Modern techniques, Geological Soc. of London.
Krishnan,M.S. (1982): Geology of India and Burma, C.B.S. Publ.
Kumar, R. (1985): Historical Geology and Stratigraphy of India, Wiley Eastern Ltd.
Lehmann, U. (1983): Fossils Invertebrate, Cambridge Univ. Press.
Mayr, E. (1971): Population, Species and Evolution, Harvard.
Moore, R.C., Lalicker, C.G. and Fischer, A.G.(1997): Invertebrate Fossils, CBS Publ.
Nield, E.W. and Tucker, V.C.T. (1985): Palaeontology: An Introduction, Pergmon Press.
Pascoe, E.H. (1968): A Manual of the Geology of India and Burma (Vols.I-IV), Govt. of India Press, Delhi.
Prothero, D.R. (2004): Bringing Fossil to Life – An Introduction to Paleontology (2nd Ed.), McGraw Hill.
Raup, D.M. and Stanley, S.M. (1985): Principles of Paleontology ,CBS Publ..
Schoch, Robert, M. (1989): Stratigraphy: Principles and Methods, Van Nostrand Reinhold, New York.
Smith, A.B.(1994): Systematics and Fossil Record – Documenting Evolutionary Patterns, Blackwell.
Strean, C.W. and Carroll, R.L. (1989): Paleontology – the record of life, John Wiley.

Course No. PGM104: FUNDAMENTALS OF PETROLEUM GEOLOGY   Credit: 3
Introduction, occurrence, surface indications and direct detection of hydrocarbons; Origin, generation, migration and accumulation of oil and gas; Physical properties of reservoir rocks; Petroleum traps, seals and fluids; Petroleum habitats; An outline of the oil belts of the world;

Books Recommended:
Barker, C. (1996): ThermalMmdeling of Petroleum Generation, Elsevier Science.
Holson, G.D. and Tiratso, E.N. (1985): Introduction of Petroleum Geology, Fulf Publ. Houston.
Hunt, J.M. (1996): Petroleum geochemistry and geology (2nd Ed.), Freeman, San Francisco.
Jahn, F., Cook, M. and Graham, M.(1998):Hydrocarbon Exploration and Production, Eslevier Science.
Makhous, M. (2000): The Formation of Hydrocarbon Deposits in North African Basins, Geological and Geochemical
Conditions, Springer–Verlag.
North, F.K. (1985): Petroleum Geology, Allen Unwin.
Selley, R.C. (1998): Elements of petroleum geology, Academic Press.
Tissot, B.P. and Welte, D.H. (1984): Petroleum formation and occurrence, Springer–Verlag.

Course No. PGM105: SEMINAR AND VIVA-VOCE - I   **Credit:2**

Course No.: PGM106: PRACTICALS (connected to PGM101)   **Credit:2**

Preparation and interpretation of geological maps and sections, structural problems based on orthographic and stereographic projections of linear and planar structures; Recording and plotting of field data; Study of the hand specimen of deformed structures, preparation of geotectonic maps.

Course No.: PGM107: PRACTICALS (connected to PGM102)   **Credit: 2**

Detailed study of clastic and non-clastic rocks in hand specimens; Study of assemblages of sedimentary structures in context of their palaeoenvironmental significance; Microscopic examination of important rock-types; Heavy mineral separation; their microscopic characters, graphic representation and interpretation; Grain-size analysis by sieving method; Plotting of size-distribution data as frequency and cumulative; Curves, computation of statistical parameters and interpretation; Exercises on sequence stratigraphic framework.

Course No.: PGM108: PRACTICALS (connected to PGM103)   **Credit: 2**

Study of the morphological characters of some important invertebrate fossils belonging to Brachiopoda, Bivalvia, Gastropoda, Ammonoidea, Trilobita, Echinoidea and Corals; Study of an assorted group of trace fossils; Techniques of separation of microfossils from matrix; Types of micrtofossils - calcareous, siliceous, phosphatic and organic walled microfossils; SEM applications in micropaleontology; Study of larger benthic foraminifera useful in Indian stratigraphy with special reference to Cenozoic petroliferous basins of India; Important palynomorphs of Cretaceous and Paleogene age; Study of rocks in hand specimens from known Indian stratigraphic horizons and type localities.

Course No. PGM109: INTER SEMESTER WINTER GEOLOGICAL FIELD TRAINING IN
**   HYDROCARBON PRSOPECTIVE BASIN- I   Credit: 3**

Course No.   #   : MINOR ELECTIVE (for other P. G. Programmes)   Credit: 3

SEMESTER - II

Course No. PGM201: SEISMIC DATA PROCESSING AND BASIN ANALYSIS   Credit: 3

Theory and geometry of seismic wave propagation, seismic wave velocities in rocks, synthetic seismogram and well to seismic tie, seismic interpretation – typical trap types and their seismic definition, velocity, structural and timing effects, preparation of depth map from time horizons; Basic concepts, definitions and objectives of seismic stratigraphy, stratigraphic patterns in seismic data, seismic attribute analysis, seismic sequence analysis - interpretation of depositional environment and lithology, eustatic sea level changes, seismic facies analysis- seismic reflection characteristics, simple and complex reflection configuration, seismic reflection character analysis- amplitude and continuity, seismic attribute extraction and analysis; Introduction to 3D volume based interpretation.

Course No. PGM202: GEOPHYSICAL EXPLORATION AND PETROPHYSICS   Credit: 3

Theory of gravity and magnetic exploration methods; Historical development and background of refraction and reflection methods; Difference between refraction and reflection surveys; System of observation for reflection and refraction surveys. Refraction data interpretation for two horizontal and dipping layer case; Seismic data enhancement and test showing explosive and non-explosive; Sources of seismic energy for P-wave; Special weathering shots and noise analysis, elevation, weathering and dynamic corrections to refraction and reflection data; Random and non-random noises and their eliminations; Processing of seismic data; Migration techniques (classical and modern); Pitfalls of seismic interpretations; Interpretation of geology from this data; Basic concepts of seismic data acquisition in 2D and 3D patterns; VSP data acquisition, processing and utilization concepts; Introduction to the electrical and electro-magnetic methods; Petro-physical properties of rocks.

Books Recommended:
Amadei, B (1997): Rock stress and its measurement, Champman and Hall, London.
Guegen, Y. and Palciauskas, V. (1994): Introduction to physics of rocks, Princeton Univ. Press.
Hardage, B. A. (1987): Seismic stratigraphy, Elsevier, Amsterdam.

J. C. and Cook, N.G.W. (1979): Fundamentals of rock mechanics (3rd Ed.), Champman and Hall, London.
Payton, C. E. (1977): Seismic stratigraphy – Applications to Hydrocarbon Exploration, Memoir of the American Association of Petroleum Geologists, Vol. 26.
Sheriff, R.E. and Geldart, L.P. (1995): Exploration seismology (2nd Ed.), Cambridge Univ. Press.
Tiab, D. and Donaldson, E.C. (1996): Petrophysics – Theory and Practice of Measuring Reservoir Rock and Fluid Transport Properties, Gulf Publ. Co., Houston.
Yillmaz, O. (2001): Seismic data analysis: Processing inversion and tnterpretation of seismic data (Vol. 1 and 2), Society of Exploration Geophysicists, Tulsa, Oklahoma.

Course No. PGM203: HYDROCARBON GEOCHEMISTRY   **Credit: 3**

Carbon cycle, origin composition and structure of organic matter, organic matter accumulation, maturation process and generation of hydrocarbons (oil and natural gas); Optical and geochemical methods for source rock characterization and maturation assessment; Coals, oil shales and other terrestrial source rocks for hydrocarbon generation; Modeling petroleum generations, migration and accumulation; Abnormal pressures; Soil analysis of surface seepages of oil and gas and surface geochemical exploration, Geochemical programme for petroleum exploration; Biomarkers and source rock-oil correlation, oil-oil correlation using biomarkers; Petroleum system; Prospect evaluation.

Books Recommended:
Bordenave, M.L. (Ed.) (1993): Applied Petroleum Geochemistry, Editions Technip, Paris.
Peters, K.E., Walters, C.C., Moldowan, J .M. (2005): The Biomarker Guide (Vol.1 and 2), Cambridge Univ. Press.
S. A. Tedesco (1994): Surface Geochemistry in Petroleum Exploration, Springer-Verlag.
Tissot, B.P., Welte, D. H. (1984.): Petroleum Formation and Occurrence, Springer-Verlag.
Welte, D.H., Horsfield, B., Baker, R. (1997): Petroleum and Basin Evolution: Insights from Petroleum Geochemistry, Geology and Basin Modeling, Springer-Verlag.

Course No. PGM204: RESERVOIR STUDY   **Credit: 3**

Carbonate reservoirs, deep water sandstone (turbidites) reservoirs, sandstone reservoirs, reservoir fluids, phase behaviour, reservoir pressure measurement and its significance, reservoir drive mechanisms; Concept of surface tension, wet ability, capillary, oil, water and gas saturations, fluid displacement etc; Calculation of reservoir parameters from well logs; Estimation of hydrocarbon reserves, classification of reserves; Development of oil and gas field. Recovery of hydrocarbon; Enhanced oil recovery /improved oil recovery; Reservoir management, well test analysis and pressure transient studies, bore hole studies and their importance.

Books Recommended:
Berg, R.R. (1986): Reservoir Sandstones, Prentice Hall.
Moore, C. H. (2001): Carbonate Reservoirs, Elsevier, Amsterdam.
Barwis, J.H. (1990): Sandstone Petroleum Reservoir, Springer-Verlag.
Zimmerle, W. (1995): Petroleum Sedimentology, Kluwer Academic Publ.

Course No. PGM205: SEMINAR AND VIVA-VOCE - II   **Credit: 2**
Course No.: PGM206: Practicals (connected with PGM201 & PGM202)   **Credit: 2**

Study of seismic maps; Identifications and correlation of seismic markers, preparation of time maps and depth maps.

Course No.: PGM207: Practicals (connected with PGM203)   **Credit: 2**

Megascopic and microscopic study of cores; Preparation of geological maps and sections, and derivation of geological history in relation to petroleum prospects; Calculation of oil reserves; Exercise on maturation studies; Petrographic characterization of petroleum source rocks.

Course No. PGM208: INTER SEMESTER SUMMER GEOLOGICAL FIELD TRAINING
       IN HYDROCARBON PRODUCING BASIN - II   **Credit: 3**

Course No. PGM301: WELL SITE GEOLOGICAL TECHNIQUES **Credit: 3**

Introduction, status of wells, geotechnical order, drilling methods, drilling fluids, cutting and core analysis, mud logging unit, sub-surface pressures, electro-logging (SP. GR. Resistivity, Neutron-density, Dipmeter, etc); Formation evaluation; Casing and cementation, drilling completions, formation testing, well completion, fundamental of reservoir, engineering and stimulation, documentation; Off-shore technology.

Books Recommended:
Asquith, G. and Gibson, C. (1982): Basic Well Log Analysis for Geologists, Academic Press.
Bateman, R. M. (1985): Open Hole Log Analysis and Formation Evaluation, Reidel, Dordrecht.
Gupta, P. K. and Nandi, P. K. (1995): Wellsite Geological Techniques and Formation Evaluation: A user's manual, Vol. Oil and Natural Gas Corporation, Dehradun.
Ransom, R.C. (1995): Practical Formation Evaluation, John Wiley and Sons.
Rider, M.H. (1985): The Geological Interpretation of Well Logs, Blackie, London.
Sera, O. (1984): Fundamentals of Well Log Interpretation, Vol. 1 and 2, Elsevier, Amsterdam.
Serra, O. (2003): Well Logging and Geology, Editions Technique Paris.
Whittaker, A. (1991): Mud Logging Handbook, Prentice Hall.

Course No**.** PGM302: DRILLING AND PRODUCTION Credit: 3

Drilling methods and equipment for directional, horizontal and multilateral wells; Geologic considerations in producing operations, reservoir considerations in well completion, well testing, primary cementing, well completion design, tubing strings, packers, surface control equipment, perforating oil and gas wells; Well completion and work over fluids. problem well analysis, through tubing production logging, squeeze cementing – remedial cementing, sand control, formation damage, surfactants for well treatments, acidizing, hydraulic fracturing, scale deposition, removal and prevention, corrosion control, work over jobs and work over planning.

Books Recommended:
Baker, R. (2001): A Primer of Oil Preparation of SP and Resistivity Logs for Hydrocarbon Reservoirs, Well Drilling: A basic text of oil and gas drilling, petroleum extension service, University of Texa.
Chilinger, G.V. and Vorabutr, P. (1981): Drilling and Drilling Fluids. Elsevier Science.
Hyne, N.J. (2001): Nontechnical Guide to Petroleum Geology, Exploration, Drilling and Production (2nd Ed.), Pennwell Co., Oklahoma.
Nguyen, J.P. (1996): Drilling, Editions Technique, Paris.

Course No. PGM303: ECONOMICS, POLICY AND MANAGEMENTS **Credit: 3**

Defining 'reserves', operating expenses, capital expenditures, inflation, factors affecting oil and gas prices, cash flow techniques, economic criteria - hurdle rate, time value of money, selection, ranking criteria, risk, uncertainty - types of risk, mathematical techniques, probabilistic models, uncertainty in economic analysis; Financing, ownership in the oil and gas industry - business arrangements between operators, between mineral owners; Accounting versus cash flow - accounting principles and definitions, differences between accounting cash numbers, depreciation, depletion, amortization; Budgeting - types, processes, selecting of projects for the budget, economic analysis of operations, computer economics software, tips on economic factors in computer spreadsheet analysis, ethics in economic analyses.

New exploration licensing policies (nelp) - implementation of nelp – speculative surveys, review/reassessment studies of fields including reserves, preparation of data packages. basic ideas of bidding, etc., monitoring of blocks, approvals/review – development plans, appraisal programme, annual work programme and budgets (be and re) monitoring of safety and environment aspects under psc – regular safety and environment audits and their compliance are carried out for companies operating under production sharing contract, e.i.a., iso certification, project management process; Manpower resources. Project- risk management, quality management in projects, communications, organization, team management; Case studies and exercises.

Books Recommended:
Carlo Danl (2004): International Energy Markets: understanding pricing, policies and profits, Pennwell Co.
D. Johnston (2003): International Exploration Economics, Risk and Contract Analysis, Pennwell Co.
Ian Lerche and James A. Mackay (1999): Economic Risks in Hydrocarbon Exploration, Pennwell Co.

Jim Bush and Daniel Johnston (2003): International Oil Company Financial Management in Non-technical language, Pennwell Co.
John Orban (2006): Money in the Ground, Meridian Press.
Lawrence J. Drew (1997): Undiscovered Petroleum and Mineral Resources: Assessment and Controversy, Plenum Press.
P. M. Harris and L. J. Weber (2006): Giant Hydrocarbon Reservoirs of the World, AAPG Memoir no. 88.
R. Hannessom (2001): Investing for Sustainability: The management of mineral wealth, Springer-Verlag.
Richard Barry (1993): The Management of International Oil Operations, Pennwell Co.
T. Aven and J. E., Vinnem (2007): Risk Management with Application from the Offshore Petroleum Industry, Springer-Verlag.

Course No. PGM304: NON-CONVENTIONAL PETROLEUM EXPLORATION   Credit: 3
Coal bed methane - definition, origin of coal bed methane, geological controls of methane generation from coal; Physical , optical and chemical characterization of coal; Global coal bed methane potentials, reserves, CBM exploration and exploitation, environmental problem-water quality and utilization, CBM policy/ regulations; Underground coal gasification - definition, concept, development of UCG to date, implications of burning UCG, estimation of coal reserves for UCG, environmental benefits of UCG, global potential areas, UCG process, advantages, policy on UCG; Gas hydrates - definition, structures, compositions, world occurrences, exploration methods, potential locations on Indian off-shores, environmental impacts and future prospects; Tar sands and oil shales; Occurrences, exploration and exploitations.

Books Recommended:
Chandra, D., Singh, R.M. Singh, M. P. (2000): Textbook of Coal (Indian context), Tara Book Agency.
Gayer,R. and Harris, I. (1996): Coal Bed Methane and Coal Geology, Geological Soc. Special Publ., London.
Singh, M.P. (Ed.) (1998): Coal and Organic Petrology, Hindustan Publ. Co.
Stach;, E., Mackowsky, M-Th., Taylor, G.H., Chandra, D., Teichumullelr, M. and Teichmuller R.(1982): Stach Texbook of Coal Petrology, Gebruder Borntraeger, Stuttgart.
Taylor, G.H., Teichmuller, M., Davis, A., Diessel, C.F.K., Littke, R. and Robert P. (1998): Organic Petrology, Gebruder Borntraeger, Stuttgart.
Thomas, Larry (2002): Coal Geology, John Wiley and Sons.
Van Krevelen, D. W. (1993): Coal (typology-physics-chemistry-constitution), Elsevier Science.

Course No. PGM305: SEMINAR AND VIVA-VOCE - III   Credit: 3

Course No. PGM306: Praticals (connected with PGM301 & 302)   Credit: 2
Study of drill cores; Preparation and interpretation of SP, resistivity and other logs for hydrocarbon reservoirs; Exercise on formation evaluation.

Course No. PGM307: Praticals (connected with PGM304)   Credit: 2
Macroscopic characterization of banded coals; Completion of outcrop in the given maps and calculation of coal reserve; Preparation of polished particulate mounts of coal; Microscopic examination of polished particulate mounts (identification of macerals).

Course No.   #   : MINOR ELECTIVE (from other P.G. Programme)   **Credit: 3**

SEMESTER - IV

Course No. PGM401: INDUSTRIAL TRAINING AT OIL COMPANIES   Credit: 10
This includes Industrial Training at oil companies of 4 to 6 weeks duration.

Course No. PGM402: PROJECT ORIENTED DISSERTATION   Credit: 12

This includes periodic seminars, final presentation and thesis.

M. Sc. PHYSICS
DEPARTMENT OF PHYSICS
BANARAS HINDU UNIVERSITY

Semesterwise distribution of Courses and Credits

SEMESTER – I

COURSE	TITLE	CREDITS
MPC-101:	MATHEMATICAL PHYSICS	4
MPC-102:	COMPUTATIONAL PHYSICS	3
MPC-103:	QUANTUM MECHANICS-I	4
MPC-104:	SEMICONDUCTOR DEVICES, INTEGRATED CIRCUITS AND COMMUNICATIONS	3
MPME-101*:	BASIC CONCEPTS IN PHYSICS: SMALL TO LARGE SYSTEMS	3
MPL-101:	ELECTRONICS LABORATORY	4
OR		
MPL-102:	GENERAL PHYSICS & OPTICS LABORATORY	4
MPL-103:	COMPUTATIONAL PHYSICS AND PROGRAMMING LABORATORY	2

* Not for M.Sc. Physics students

SEMETER – II

COURSE	TITLE	CREDITS
MPC-201:	CLASSICAL ELECTRODYNAMICS AND PLASMA PHYSICS	4
MPC-202:	ATOMIC, MOLECULAR PHYSICS AND LASERS	3
MPC-203:	ELEMENTS OF SOLID STATE PHYSICS	3
MPC-204:	ELEMENTS NUCLEAR PHYSICS	3
MPME-201:	APPLIED RADIATION PHYSICS	3
MPL-202:	GENERAL PHYSICS & OPTICS LABORATORY	4
OR		
MPL-201:	ELECTRONICS LABORATORY	4
MPL-203:	COMPUTATIONAL PHYSICS AND PROGRAMMING LABORATORY	2

SEMESTER - III

COURSE	TITLE	CREDITS
MPC–301:	STATISTICAL MECHANICS I	4
MPC–302:	QUANTUM MECHANICS II	3
MPS–301(A):	ANALOG COMMUNICATION SYSTEMS	4
MPS–301(B):	NUCLEAR PHYSICS:INTERACTIONS & MODELS	4
MPS-301(C):	VIBRATIONAL & ROTATIONAL MOLECULAR SPECTROSCOPY	4
MPS-301(D):	SOLID STATE PHYSICS: CRYSTALLOGRAPHY AND IMPERFECTIONS IN CRYSTALS	4
MPME-301:	EXPERIMENTAL TECHNIQUES FOR ANALYTICAL STUDIES	3
MPE-301:	PLASMA PHYSICS AND SPACE PHYSICS	3
MPE-302:	LASERS AND LASER APPLICATIONS	3
MPE–303:	CHARACTERIZATION OF SOLIDS	3
MPE–304:	MOLECULAR BIOPHYSICS	3
MPE–305:	METHODS IN THEORETICAL PHYSICS	3
MPE-306:	INSTRUMENTATION IN NUCLEAR PHYSICS	3
MPE-307:	SOLAR ENERGY, HYDROGEN ENERGY AND OTHER RENEWABLE ENERGIES	3
MPL-301(A):	ELECTRONICS LABORATORY	6
MPL-301(B):	NUCEAR PHYSICS LABORATORY	6
MPL-301(C):	SPECTROSCOPY LABORATORY	6
MPL-301(D):	SOLID STATE PHYSICS LABORATORY	6

SEMESTER – IV

COURSE	TITLE	CREDITS

MPC-401:	**STATISTICAL MECHANICS II**	3
MPS-401(A):	**DIGITAL COMMUNICTION SYSTEMS**	4
MPS-401(B):	**PARTICLE PHYSICS**	4
	MPS-401(C):MOLECULAR ORBITAL THEORY & ELECTRONICS SPECTRA OF MOLECULES	4
MPS-401(D):	**SOLID STATE PHYSICS: SOLID SURFACES & PROPERTIES**	4
MPS-402(A):	**MICROPROSCESSORS AND INTERFACING**	4
MPS-402(B):	**WEAK INTERACTIONS & ELECTROWEAK UNIFICATION**	4
MPS-402(C):	**PRINCIPLES & INSTRUMENTATION IN CONVENTIONAL & LASER SPECTROSCOPY**	4
MPS-402(D):	**SOLID STATE PHYSICS: MANY PARTICLE SYSTEMS**	4
MPE-401:	**EXPERIMENTAL TECHNIQUES & INSTRUMENTATION IN ATOMIC, MOLECULAR & OPTICAL PHYSICS**	3
MPE–402:	**NANOSCIENCE AND TECHNOLOGY**	3
MPE-403:	**PHYSICS OF ELECTRONIC MATERIALS & DEVICES**	3
MPE-404:	**SATELLITE COMMUNICATION & REMOTE SENING**	3
MPE-405:	**QUANTUM FIELD THEORY:PATH INTEGRAL APPROACH**	3
MPE-406:	**LIQUID CRYSTAL**	3
MPE-407:	**COMPUTATIONAL METHODS IN PHYSICS**	3
MPL-401(A):	**ELECTRONICS LABORATORY**	6
MPL-401(B):	**NUCLEAR PHYSICS LABORATORY**	6
MPL-401(C):	**SPECTROSCOPY LABORATORY**	6
MPL-401(D):	**SOLID STATE PHYSICS LABORATORY**	6
MPD-401:	**DISSERTATION**	2

SUMMARY OF M.Sc. SYLLABUS IN PHYSICS

Semester	No. of Papers			Credits		
	Theory	Practical	Total	Theory	Practical	Total
I	5	2	7	17	6	23
II	5	2	7	16	6	22
III	5	1	6	17	6	23
IV	4 Dissertation	1	5	14	6	20 2
Total	19+ Dissertation	6	25	64	24	90

MINOR ELECTIVES:

SEMESTER:		PAPER NO. AND TITLE	CREDITS
I	MPME-101:	BASIC CONCEPTS IN PHYSICS: SMALL TO LARGE SYSTEMS	3
II	MPME-201:	APPLIED RADIATION PHYSICS	3
III	MPME-301:	EXPERIMENTAL TECHNIQUES FOR ANALYTICAL STUDIES	3

MPC-101: MATHEMATICAL PHYSICS   **Credits: 4**

Theory of Functions of a Complex Variable:
Analyticity and Cauchy-Reimann Conditions, Cauchy's integral theorem and formula, Taylor's series and Laurent's series expansion, Zeros and singular points, Multivalued functions, Branch Points and Cuts, Reimann Sheets and surfaces, Residues, Cauchy's Residue theorem, Jordan's Lemma; Evaluation of definite integrals, Principal Value, Bromwitch contour integrals.

Fourier and Laplace Transforms:
Fourier transform, Sine, Cosine and Complex transforms with examples, Definition, Properties and Representations of Dirac Delta Function, Properties of Fourier Transforms, Transforms of derivatives, Parseval's Theorem, Convolution Theorem, Momentum representation, Applications to Partial differential equations, Discrete Fourier transform, Introduction to Fast Fourier transform, Laplace transform, Properties and examples of Laplace Transform, Convolution theorem and its applications, Laplace transform method of solving differential equations.

Group Theory:
Concept of a group (additive and multiplicative), Matrix representation of a group, Reducible and irreduciable representation of a group,The Great Orthogonality Theorem

Reference Books:

1.   Mathematical Methods for Physicists: Arfken.
2.   Mathematics for Physicists and Engineers: Pipes.
3.   Mathematical Method of Physics Ghatak.
4.   Mathematical Methods for Physics: Wyle.
5.   Mathematical Methods in Physical Sciences: Boas.
6**.**   Group Theory: Wigner

MPC-102:   COMPUTATIONAL PHYSICS AND PROGRAMMING   **Credits: 3**

Fortran:
Flow charts, Algorithms, Integer and floating point arithmetic, Precision, Variable types, Arithmetic statements, Input and output statements, Control statements, Executable and non-executable statements, Arrays, Repetitive and logical structures, Subroutines and functions, Operation with files, Operating systems, Creation of executable programs.

Numerical Methods of Analysis:
Solution of algebraic and transcendental equations: Iterative, bisection and Newton-Raphson methods, Solution of simultaneous linear equations: Matrix inversion method, Interpolation: Newton and Lagrange formulas, Numerical differentiation, Numerical Integration, Trapezoidal, Simpson and Gaussian quadrature methods, Least-square curve fitting, Straight line and polynomial fits, Numerical solution of ordinary differential equations: Euler and Runge-Kutta methods.

Simulation:
Generation of uniformly distributed random integers, Statistical tests of randomness, Monte-Carlo evaluation of integrals and error analysis, Non-uniform probability distributions, Importance sampling, Rejection method, Metropolis algorithm, Molecular diffusion and Brownian motion as random walk problems and their Monte-Carlo simulation.

Reference Books:
1. Computational Methods in Physics and Engineering: Wong.
2. Computer Oriented Numerical Methods: Rajaraman.
3. Computer Programming in FORTRAN 77: Rajaraman.
4. Applied Numerical Analysis: Gerald.
5. A Guide to Monte Carlo Simulations in Statistical Physics: Landau and Binder.
6. Numerical Recipes: Teukolsky, Vetterling and Flannery.

MPC-103: QUANTUM MECHANICS –I   **Credits: 4**

Linear Vector and Representation Theory:
Linear vector space, Dirac notations of Bra - Ket notation, Matrix representation of Observables and states, Determination of eigenvalues and eigenstate for observables using matrix representations, Change of representation and unitary transformations, Coordinate and momentum representations, Equations of motion in Schroedinger and Heisenberg pictures.

Theory of Angular Momentum:
Symmetry, invariance and conservation laws, relation between rotation and angular momentum, commutation rules, Matrix representations, addition of angular momenta and Clebsch-Gordon coefficients, Pauli spin matrices.

Green's Functions:
Green's function method of solving inhomogeneous differential equations, Boundary Conditions, Application to One-dimensional problems.

Scattering Theory:
Differential and total Scattering cross-sections laws, partial wave analysis and application to simple cases; Integral form of scattering equation, Born approximation validity and simple applications.

Approximation Methods:
Time-independent Perturbation theory (non-degenerate and degenerate) and applications to fine structure splitting, Zeeman effect (Normal and anomalous), Stark effect, and other simple cases, Variational method and applications to helium atom and simple cases; WKB approximation and applications to simple cases. Time-dependent Perturbation theory, Fermi's Golden rule, Semi-classical theory of interaction of atoms with radiation.

Reference Books:
1. Quantum Mechanics: L.I. Schiff.
2. Modern Quantum Mechanics: J.J. Sakurai.
3. Introduction to Quantum Mechanics : C.J. Joachain and B.H. Bransden.
4. Introduction of Quantum Mechanics: D.J. Griffiths.
5. Principles of Quantum Mechanics: P.A.M.Dirac.

MPC-104: SEMICONDUCTOR DEVICES INTEGRATED CICUITS AND COMMUNICATIONS   **Credits: 3**

Semiconductor Devices:
Metal/Semiconductor Contact, MOS Junction (Accumulation, Depletion and Inversion).

Integrated Circuits:
Fabrication of ICs (Planar, Monolithic, Active and Passive Including MOS).

Op-Amp (IC-741):
Internal Structure (Block Diagram) Slew Rate, Frequency Response and Compensation, Applications (Linear and Non- Linear).

Timer (IC-555):
Internal Structure (Block Diagram) Operation, Astable, Monostable and Applications.

Phase Locked Loops (IC-565):
Internal Structure (Block) Diagram) Application as Frequency Multiplication, Division FSK and FM Demodulation.

Digital ICs:
TTl, MOS and CMOS Gates, Parrallel Binary adder/subtractor, BCD Addition/Subtraction, Encoder, Decoder, MUX, DE-MUX, Flip-Flops, Shift Resister, Counter, Memory Concept, RAM and ROM. Introduction to Microprocessor 8085.

Communication:

Radio Wave Propagation through Ground, Stratosphere and Ionosphere. Radiation from short electric doublet. Monopole and Dipole Antenna, Antenna parameters, Antenna Arrays.

Reference Books:
1. Integrated Electronics: Millman and Halkias.
2. Physics of Semiconductors Devices: Sze.
3. Op-Amps and Linear Integrated Circuits: Gayakwad.
4. Digital Fundamental: Floyed.
5. Electronic Communication Systems: Kennedy
6. Linear Integrated Circuits: Choudhary and Jain.
7. Digital Electronics: Jain.

MPME-101: General Concepts in Physics: Large to Small Bodies   **Credit 3**

(This minor elective is open for M.Sc. students of other departments only)

Introduction
Historical Development of Physics; Classification of physics in terms of Length scales, Time scales and Energy scales.

Physics of Large Bodies
Evolution of universe and formation of stars. Newton's law of Gravitation; Planetary motion and Kepler's laws; Galilean relativity and concept of inertial frames. Einstein's theory of special relativity.

Physics of Small Bodies
Failure of classical ideas with examples of blackbody spectrum and Photoelectric effect; Heisenberg's Uncertainty Principle; Wave-particle duality. Double-slit experiment, Stern-Gerlach experiment. Concepts of discrete energy levels and spin. Elementary ideas of Schroedinger's Wave mechanics. Relation between Spin and Statistics; Bose-Einstein and Fermi-Dirac statistics, and Maxwell-Boltzmann statistics as classical limit. Elementary Particles (classification, quantum numbers) and Fundamental Interactions (classification, range, strength).

Reference Books:
1. Remarkable Physicists: From Galileo to Yukawa
2. The Feynman Lectures on Physics
3. Concepts of Modern Physics
4. University Physics

MPL-101:   ELECTRONICS LABORATORY   **Credits: 4**

Students assigned the electronics laboratory work will perform at least eight (08) experiments of the following:
1. Addition, Subtraction and Binary to BCD conversion
2. JK Flip-Flop and up-down counter
3. Transmission Line Experiment
4. Negative Feedback Experiment
5. Multivibrator
6. Differential Amplifier
7. Op-amps and its application
8. IC 555 Timer
9. Design of CE Amplifier
10. Design of Regulated Power Supply
11. Arithmetic Logic Unit
12. Receiver characteristics

  Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-102:   GENERAL PHYSICS & OPTICS LABORATORY   **Credits: 4**

Students assigned the general laboratory work will perform at least eight (08) experiments of the following:

1.   Ionization potential of Lithium
2.   Zeeman Effect
3.   Dissociation Energy of I_2 molecule
4.   Hall Effect
5.   Four Probe Method
6.   Electron Spin Resonance
7.   Telexometer
8.   Experiment on high intensity monochromator
9.   Faraday Effect
10.   Frank-Hertz experment
11.   Compton Effect
12.   Atomic Spectra of two-Electron Systems

  Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-103: COMPUTATIONAL PHYSICS & PROGRAMMING LABORATORY   **Credits: 2**

Students assigned the computer laboratory work will perform in Semester - I at least four (04) experiments of the following:

1.   Jacobi Method of Matrix Diagonalization
2.   Solution of transcendental or polynomial equations by the Newton Raphson method
3.   Linear curve fitting and calculation of linear correlation coefficient
4.   Matrix summation, subtraction and multiplication
5.   Matrix inversion and solution of simultaneous equation
6.   Lagrange interpolation based on given input data
7.   Numerical integration using the Simpson's method
8.   Numerical integrationg using the Gaussian quadrature method
9.   Solution of first order differential equations using the Rung-Kutta method
10.   Numerical first order differentiation of a given function
11.   Fast Fourier Transform
12.   Monte Carlo integration
13.   Use of a package for data generation and graph plotting.
14.   Test of randomness for random numbers generators

  Note: Addition and deletion in the list of experiments may be made from time to time by the department.

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SEMESTER – II
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MPC-201: CLASSICAL ELECTRODYNAMICS AND PLASMA PHYSICS   **Credits: 4**

Electrodynamics:

Four Potential and Four Field:
Electromagnetic field Tensor in Four dimensions and Maxwell's Equations, Dual Filed Tensor. Wave Equation for Vector and Scalar Potential and Solution, Retarded Potential and Lienard Wiechert Potential.

Acceleration of Charged Particles:
Electric and Magnetic fields due to a Uniformly Moving charge and An Accelerated Charge, Linear and Circular Acceleration and Angular Distribution of Power Radiated, Bremsstrahlung, Synchrotron Radiation and Cerenkov Radiation, Reaction Force of Radiation, Electromagnetic Mass of the Electron.

Dynamics of Charged Particles in E and B Fields:
Motion of Charged Particles in electromagnetic Field: Uniform E and B Fields, Non-uniform Fields Diffusion Across Magnetic Fields, Time Varying E and B Fields.

Plasma Physics:
Elementary Concepts: Plasma Oscillations, Debye Shielding, Plasma Parameters, Magnetoplasma, Plasma Confinement, Firt, Second, and Third Adiabatic Invariants (Pinch Effect, Magnetic Mirrors), Formation of Van Allen Belt.

Hydrodynamical Description of Plasma:
Fundamental equations, Hydromagnetic Waves: Magnetosonic and Alfven Waves, Magnetoconvection and Sun Spots, Bipolar magnetic Regions and Magnetic Buoyancy, Magnetised Winds (Solar Wind).

Wave Phenomena in Magnetoplasma:
Polarisation, Phase Velocity, Group Velocity, Cut-offs, Resonance for Electromagnetic Wave Propagating Parallel and Perpendicular to the Magnetic Field Propagation at Finite Angle.

Reference Books:

1. Classical Electricity and Magnetism: W.K.H. Panofsky and M. Phillips.
2. Plasma Physics: A Bittencourt.
3. Plasma Physics and Controlled Fusion: F.F. Chen.
4. Classical Electrodynamics: J.D. Jackson.

MPC-202: ATOMIC, MOLECULAR PHYSICS AND LASER   **Credits: 3**

Atomic Physics:
Dipole selection rules (examples with derivation), Width and shape of spectral lines, Spin-orbit coupling, Lamb shift and Retherford experiment, Hyperfine structure of lines, Normal and specific mass shifts, excitation and ionization processes in electron-atom collisions, experimental determination of collision cross section, Principle of ESR with experimental setup, chemical shift.

Molecular Physics:
Molecular Orbital and Electronic configuration of Diatomic molecules: H_2, C_2, O_2, NO and CN; Vibrational structure and vibrational analysis, Frank Condon Principle, Dissociation Energy, Rotational Raman spectra and influence of nuclear spin.

Lasers:
Requisites for producing laser light, Role of Plane and Confocal cavity resonators, Longitudinal and transverse cavity modes, Mode selection, Q-switching and Mode locking, Generation of Ultra short Pulses.

Reference Books:
1. Physics of Atoms and Molecules: Bransden and Joachain.
2. Lasers - Theory and Applications: K. Thyagrajan and A.K. Ghatak.
3. Introduction to Atomic Spectra: H.E. White.
4. Introduction to Atomic Spectra: HG Kuhn.

MPC-203: ELEMENTS OF SOLID STATE PHYSICS   **Credits: 3**

Structure and Symmetry:
Structural description of liquids and solids (amorphous and crystalline), External symmetry elements and concept of point groups, Direct periodic lattices, Basic concept of aperiodicity, Reciprocal lattice and diffraction conditions and its relation with Brillouin zones, Intensity of Bragg scattering from a unit cell and extinction conditions.

Lattice Vibrations:
Interatomic forces and lattice dynamics of crystals with up to two atoms per primitive basis, Quantization of elastic waves.

Electronic Properties of Solids:
Electrons in periodic potential, Band Theory, Tight Binding, Cellular and Pseudo potential methods, Symmetry of energy bands, density of states, Fermi surface, De Haas von Alfen effect, Elementary ideas of quantum Hall effect, Cyclotron resonance and magnetoresistance,

Introduction to superconductivity.

Reference Books:
1. Introduction of Solids: L.V. Azaroff
2. Crystallography Applied to Solid State Physics: A.R. Verma and O.N. Srivastava
3. Principels of Condensed Matter Physics: P.M. Chaikin and T.C. Lubensky
4. Solid State Physics-Structure and Properties of Materials : M.A. Wahab
5. Solid State Physics: N.W. Ashcroft and N.D. Mermin.

MPC-204:   ELEMENTS OF NUCLEAR PHYSICS   **Credits: 3**

Detectors and Accelerators:
Outline of interaction of charged particles and of Gamma-rays with matter.
Detectors: Gas Filled counters (ionization Chamber), Scintillation counter, Spark Chambers, Cerenkov detectors.
Accelerators: Ion Sources, Synchrotron, Introduction of Modern Colliders (LHC and RHIC), Storage Ring.

Nuclear Reactions:
Discussion of Direct and Compound nuclear reaction mechanisms, expressions for scattering and reaction cross-sections in terms of partial wave amplitudes, Resonances, Discussions and Applications of Breit-Wigner single-level formula, compound nucleus theory.

Nuclear Decay:
Electromagnetic interactions in nuclei, Multipole transitions in nuclei, Parity and angular momentum selection rules, Internal conversion, Fermi theory of beta-decay, Curie plots, Comparative half life, Allowed and forbidden transitions, Detection and properties of neutrino.

2-Body Problem:
Deuteron problem, Tensor force, S and D states, Neutron-Proton and proton-proton scattering,   Effective range theory, Spin-dependence of nuclear forces, Charge independence and charge symmetry of nuclear forces, Isospin formalism.

Particle Physics: Basic interactions in nature, Elementary particles, Quantum numbers and conservation laws, Concept of isospin, Quarks and colors, Quark model, Eightfold way, Mesons and Baryons, Bound states and resonance states.

Reference Books:
1. Atomic and Nuclear Physics Vol. II: Ghoshal.
2. Nuclear Structure: Preston and Bhaduri.
3. Nuclear Structure: Pal.
4. Introductory Nuclear Physics: Wong.
5. Nuclear Theory: Elton.
6. Nuclear Interactions: de Benedetti.

MPME-201:   APPLIED RADIATION PHYSICS   **Credits: 3**
(
This minor elective is open to M.Sc. students of Physics as well as other Departments)

Basic Nuclear Processes in Radioactive Sources:
Characteristics of nuclear radiations, alpha decay, beta decay, electron capture, gamma emission, annihilation radiation, neutron sources, source activity, radioactivity decay law, decay chains.

Passage of Radiation through Matter:
The cross section, interaction probability in a distance and mean free path, Stopping power of charge particles-Qualitative discussion of the Bethe-Bloch formula, Radiation length, Range of electrons, Interaction of photons, neutrons and charges particles.

Radiation Protection:

Dosimetric Units: The Roentgen, Absorbed dose, Relative Biological effectiveness (RBE), Equivalent dose, Effective Dose, Typical doses from sources (Natural, Environmental & Medical exposures), Radiation shielding and its safety (Gamma-rays, electrons, positrons, charged particles, Neutrons), Ethics of radiations.

Radiation Effects on Biological Systems:
High doses received in a short time, Low-level doses limits, direct ionization of DNA, radiation damage to DNA, Biological effects (Genetic, Somatic, Cancer and sterlity).

General Characteristics of Detectors:
Sensitivity, Detector response, Energy resolution, Response time, Detector efficiency, Dead time, Ionization mechanism and introductory idea about some detectors.

Reference Books:
1. A Primer in Applied Radiation Physics: F.A. Smith.
2. Introduction to Experimental Nuclear Physics: R.M. Singru.
3. Radiation Biophysics: E.L. Alpen.
4. Atom, Radiation and Radiation Protection: J. Turner.

MPL-201: ELECTRONICS LABORATORY   **Credits: 4**

Students assigned the electronics laboratory work will perform at least eight (08) experiments of the following:

1. Addition, Subtraction and Binary to BCD conversion
2. JK Flip-Flop and up-down counter
3. Transmission Line Experiment
4. Negative Feedback Experiment
5. Multivibrator
6. Differential Amplifier
7. Op-amps and its application
8. IC 555 Timer
9. Design of CE Amplifier
10. Design of Regulated Power Supply
11. Arithmetic Logic Unit
12. Receiver characteristics

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-202: GENERAL PHYSICS & OPTICS LABORATORY   **Credits: 4**

Students assigned the general laboratory work will perform at least eight (08) experiments of the following:

1. Ionization potential of Lithium
2. Zeeman Effect
3. Dissociation Energy of I_2 molecule
4. Hall Effect
5. Four Probe Method
6. Electron Spin Resonance
7. Telexometer
8. Experiment on high intensity monochromator
9. Faraday Effect and Kerr Effect
10. Frank-Hertz experiment
11. Compton Effect
12. Atomic Spectra of two-Electron Systems

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-203: COMPUTATIONAL **P**HYSICS **& P**ROGRAMMING **L**ABORATORY **Credits: 2**

Students assigned the computer laboratory work will perform in Semester – II at least four (04) experiments
(other than what they have done in Semester – I) of the following:

1. Jacobi Method of Matrix Diagonalization
2. Solution of transcendental or polynomial equations by the Newton Raphson method
3. Linear curve fitting and calculation of linear correlation coefficient
4. Matrix summation, subtraction and multiplication
5. Matrix inversion and solution of simultaneous equation
6. Lagrange interpolation based on given input data
7. Numerical integration using the Simpson's method
8. Numerical integrationg using the Gaussian quadrature method
9. Solution of first order differential equations using the Rung-Kutta method
10. Numerical first order differentiation of a given function
11. Fast Fourier Transform
12. Monte Carlo integration
13. Use of a package for data generation and graph plotting.
14. Test of randomness for random numbers generators

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

SEMESTER-III

MPC-301: STATISTICAL **M**ECHANICS **– I** **Credits: 4**

Review:
Canonical and Grand-Canonical ensembles, Partition function, Thermodynamic Functions, Bose Condensation,
Correlation in a Fermi gas.

Quantum Statistical Mechanics:
Density matrices, Density matrix in statistical mechanics, Linear Harmonic and anharmonic oscillators,
Wigner's function, Perturbation expansion of the density matrix.

Statistical Mechanics of Interacting Systems:
Cluster expansion for a classical gas, Mayer cluster expansion, Equation of state, Radial distribution function,
thermodynamic functions in terms of Radial distribution functions.
Quantum cluster expansion, exact treatment of second virial coefficient. Weakly interacting Bose gas,
excitation spectrum, super-fluidity in liquid He II, Low temperature behaviour of Bose and Fermi gases, Ising
model, mean-field theory in zeroth and first approximations, exact solution in one dimension.

Reference Books:
1. Statistical Mechanics: Parharia.
2. Statistical Mechanics: Haung.
3. Statistical Mechanics: Ma.
4. Statistical Mechanics: Landau and Lifshitz.

MPC-302: QUANTUM **M**ECHANICS **– II** **Credits: 3**

Identical Particles:
Permutation symmetry, symmetrization postulates, self consistent field approximation, Slater determinant,
Hartree Fock method.

Relativistic Quantum Mechanics:
Klein Gordon equation, Dirac equation, negative energy solutions, antiparticles, Dirac hole theory, Feynman
interpretation of antiparticles, Gama-matrics and their properties, Convariance of Dirac equation, Charge
conjugation, Parity & Time reversal invariance, Bilinear covariants, Plane wave solution, Two component
theory of neutrino, Spin & Helicity, Relativistic Hydrogen atom problem.

Field Quantization:
Lagrangian density and equation of motion for field, Symmetries and conservation laws, Noether's theorem, cononical quantization of scalar field, Complex scalar field, electromagnetic field and Dirac field, Problem in quanitizing electromagnetic field, Gupta & Bleuler method, Feynman rules (without derivation), Feynman diagrams.

Reference Books:
1. Relativistic Quantum Mechanics: J.D. Bjorken and S.D. Drell.
2. Relativistic Quantum Fields: J.D. Bjorken and S.D. Drell.
3. A First Book on Quantum Field Theory: Amitabha Lahiri and P.B. Pal.
4. Introduction to QFT: F. Mandle and G. Shaw.
5. Modern Quantum Mechanics: J.J.Sakurai.
6. Principles of Quantum Mechanic: R. Shankar.

MPS-301 (A): ANALOG COMMUNICATION SYSTEMS   **Credits: 4**

Microwave Electronics:
Microwave characteristic features & Application, Waveguides and Cavity Resonators, Two cavities Klystron, Reflex Klystron, Semiconductor Gunn diode characteristics. Microwave antenna, Detection of microwave, Dielectric constant measurement, Isolator and circulator, PIN diode modulator, Directional coupler.

Radar Communication:
Basic Radar systems, Radar range equation and performance factor, Radar Cross-section, Pulsed Radar system, Duplexer, Radar Display, Doppler Radar, CWIF Radar, FMCW Radar, Moving Target Indicator (MTI), Blind Speeds.

Analog Signal Transmission:
Introduction, Amplitude, Frequency & phase modulation, AM, FM, Modulating and Demodulating circuits, AM, FM Receivers functioning (BLOCK diagram) and Characteristic Features, Pulse modulation, Sampling processes, PAM, PWM and PPM modulation and demodulation, Quantization processes, Companding and Quantization noise, PCM, Differential PCM and Delta Modulation systems, Comparison of PCM and DM, Time division multiplexing.

Satellite Communication:
Principle of Satellite Communication, Satellite frequency allocation and band spectrum, Satellite orbit, trajectory and its stability, Satellite link design, Elements of Digital Satellite Communication, Multiple Access technique, Antenna system, Transponder, Satellite Applications.

Reference Books:
1. Communication System: Simon Haykin.
2. Electronics communication: Roddy and Coolen.
3. Microwave and Radar Engineering: M. Kulkarni.
4. Digital and analog communication systems : K.San Shanmugam.
5. Satellite Communication: Pratt and Bostiern.
6. Microwave: K.C. Gupta

MPS-301(B): NUCLEAR PHYSICS: INTERACTIONS AND MODELS   **Credits: 4**

N-N interaction:
Phenomenological N-N Potentials (Soft core & hard core) and meson theoretical potentials, Polarization in N-N scattering.
Probing charge distribution with electrons, Form factors, Proton form factors, Qualitative ideas on deep inelastic electron-proton scattering, Bjorken scaling and the parton model, Quark structure of the nucleon.

Nuclear Models:
Single particle model of the nucleus, Angular momenta and parities of nuclear ground states, Qualitative discussion and estimates of transition rates, Magnetic moments and Schmidt lines.

Classification of shells, Seniority, Configuration mixing, Pairing Force theory, Simple description of Two-particle shell model spectroscopy.

Deformable liquid drop and nuclear fission, Collective vibrations and excited states, Permanent deformation and collective rotations: Energy levels and electromagnetic properties of even-even and odd-A deformed nuclei, Nilsson model and equilibrium deformation, Coulomb Excitation Studies, Behaviour of Nuclei at high spin, Back-bending.

Reference Books:
1. Atomic and Nuclear Physics Vol. II: Ghoshal.
2. Nuclear Structure: Preston and Bhaduri.
3. Nucleon-nucleon Interaction: Brown and Jackson.
4. Introductory Nuclear Physics: S.S.M. Wong.
5. Nuclear Structure: M.K.Pal.

Credits: 4

MPS-301(C): Vibrational and Rotational Molecular Spectroscopy

Symmetry and Group Theoretical Treatment:
Molecular symmetry and Group Theory, Matrix Representations of symmetry elements of a Point Group. Reducible and irreducible Representations, Character Tables for C_{2v} and C_{3v} point groups. Normal modes of vibration and their distribution into symmetry species of the molecule, Infrared and Raman Selection rules, Overtone and Combination Bands, Vibrational Potentials with more than one minimum. Qualitative treatment of inversion vibrations and Torsional vibrations.

Vibration-Rotation Energy Levels and Spectra:
Rotational Energy of Spherical, Prolate and Oblate Symmetric Rotors, Rotational Raman and IR Spectra of linear molecules and Determination of their Geometry. Rotation-Vibration Band of a Diatomic Molecule, Parallel and Perpendicular type Bands in Linear and symmetric Rotor Molecules. Qualitative description of Type A, B and C bands in Asymmetric Rotor Molecules.

Reference Books:

1. Chemical Applications of Group Theory : F.A. Cotton.
2. Fundamentals of Molecular Spectroscopy : C.N. Banwell.
3. Introduction to Molecular Spectroscopy : G.M. Barrow.
4. Modern Spectroscopy : J.M. Hollas.

MPS – 301(D): Solid State Physics: Crystallography and Imperfection in Crystals   Credits: 4

Crystallography:
Elementary concepts of space group and its relevance to crystal structure. Principle of Powder diffractometer, Interpretation of powder photographs, Analytical indexing: Ito's methods. Accurate determination of lattice parameters – least-square method. Retvil analysis, Application of powder method.
Interpretation of oscillation photograph, X-ray method of orienting crystals about a crystallographic direction, Bernal chart, Indexing of reflections, Buerger's precession method.
Determination of relative structure amplitudes from measured intensity (Lorentz and Polarization factors), Fourier representation of electron density, The phase problem, Patterson function.

Imperfection of Crystals:
Mechanism of plastic deformation in solids, Stress and strain fields of screw and edge dislocations, Elastic energy of dislocations, Forces between dislocations, Stress needed to operate Frank-Read source, Dislocations in fcc, hcp and bcc lattices, Partial dislocations and stacking faults in close-packed structures.
Experimental method of detecting dislocations and stacking faults, Electron Microscopy: Kinematical theory of diffraction contrast and lattice imaging.

Reference Books:
1. Crystallography for Solid State Physics: Verma and Srivastava.
2. X-ray Crystallography: Azarof.

3. Elementary Dislocation Theory: Weertman and Weertman.
4. Crystal Structure Analysis: Buerge.
5. Electron Microscopy of Thin Crystals: Hirsh.

MPME-301: EXPERIMENTAL TECHNIQUES FOR ANALYTICAL STUDIES   Credits: 3
(This minor elective is open to M.Sc. students of Physics as well as other Departments)

Spectroscopic Techniques:
Dispersing devices and detectors: Dispersion and resolution of a prism and a grating spectrometer, Single and double monochromators, Photomultiplier tube, Charge coupled detectors (CCD).

UV and Visible absorption spectroscopy, IR and Raman spectroscopy: Identification of groups, hydrogen bonding and study of conformers, Time–resolved spectroscopy and study of biological samples.

Qualitative and quantitative analysis of trace elements.

Basics of nuclear magnetic resonance (NMR) and electron spin resonance (ESR) spectroscopy, Mössbauer spectroscopy, Microwave spectroscopy, Photoacoustic spectroscopy and their applications.

Laser as a source of radiation and its characteristics, Laser fluorescence and absorption spectroscopy, Multi-photon ionization and separation of isotopes.

Structural Characterization Techniques:
Microstructural characterization, Basics and applications of Scanning electron microscopy (SEM), Biological applications of scanning probe microscopy, Confocal microscopy, Focussed ion beam system.

Reference Books:
1. Spectroscopy Volume 1, 2 and 3: B.P. Straughan and S. Walker.
2. Modern Spectroscopy: J.M. Hollas.
3. Transmission Electron Microscopy of Metals: Gareth Thomas
4. Elements of X-ray Diffraction: Bernard Dennis Cullity.
5. Atomic Force Microscopy/Scanning Tunneling Microscopy: M.T. Bray, Samuel H. Cohen and Marcia L. Lightbody.

MPE-301: PLASMA AND SPACE PHYSICS   **Credits: 3**

Plasma Physics:
Trapped Particle Motion:
Collisions, Conductivity, Diffusion along and across magnetic field, convection electric field, Ring current.

Multifluid Theory:
Equation of state, Frozen in Field concept, Stationarity & Equilibria, MHD waves in Dipolar Magnetic Field, Sources of wave energy and instabilities.

Kinetic theory of Plasma:
Boltzmann-Vlasov Equation, Transport Equation, Landau Damping, Collision Damping, Wave Amplification, Role of magnetic field, Wave in Planetary Magnetosphere.

Space Physics:

Solar Phenomena:

Structure of the Sun, Solar Activity, Prominences, Coronal Heating, Solar Flares.

Solar Wind:
Properties, solar wind formations, Interaction of Solar Wind with Magnetized and Unmagnetized Planets.

Magnetophere:
Magnetopause, Magnetotail, Magnetic reconnection, Magnetosphere, Plasma flow in the magnetosphere.

Ionosphere:
Structure, Ionospheric Irregularities, Aurora, Borealis, Magnetosphere- Ionosphere coupling.

Reference Books:
1. Basic Space Plasma Physics: W. Baumjohau and R. A. Treumann.
2. Introduction to Space Physics: Edited by M. G. Kevilson and C. T. Russell.
3. Space Plasma Physics: A.C. Das.
4. Plasma Physics and Introductory Courses: Edited by Rechered Dendy.
5. Introduction of Plasma Physics: R.J. Goldston and P.H. Rutherford.

MPE-302: LASERS AND LASER APPLICATIONS   Credits: 3

Basic Principle and Different Lasers:
Principle and Working of CO_2 laser and Qualitative Description of Longitudinal and TE laser systems. Threshold condition for Oscillation in Semiconductor Laser. Homostructure and Heterostructure p–n junction lasers, Nd-YAG lasers. Principle of Excimer Laser. Principle and Working of Dye Laser. Free Electron Laser.

Non Linear Processes:
Propagation of Electromagnetic Waves in Nonlinear medium, Self Focusing, Phase matching condition, Fiber Lasers, Stimulated Raman Scattering and Raman Lasers, CARS, Saturation and Two photon Absorptions.

Novel Applications of Laser:
Cooling and Trapping of Atoms, Principles of Doppler and Polarization Gradient Cooling, Qualitative Description of Ion Traps, Optical Traps and Magneto-Optical Traps, Evaporative Cooling and Bose Condensation.

Reference Books:
1. Laser Spectroscopy and Instrumentation : W. Demtroder.
2. Principles of Lasers : O. Svelto.
3. Laser Cooling and Trapping : P.N. Ghosh.
4. Frontiers in Atomic, Molecular and Optical Physics : S.P. Sengupta.

MPE-303: CHARACTERIZATION OF SOLIDS   Credits: 3

Structural Characterization:
Intense X-ray Sources : Synchrotron Radiation, General theory of X-ray scattering and diffraction, Reciprocal space of perfect and imperfect crystals, X-ray diffraction characterization of imperfections in crystals, Basic concepts of small angle X-ray scattering and its application in evaluation of shape and size of surface particles. Neutron scattering and diffraction with reference to light elements and magnetic structures.

Electronic Characterization:
LEED (Low Energy Electron Diffraction) for Surface Structure, Surface Topography, Elementary Concepts of Scanning and Scanning Tunneling Microscopic Techniques (SEM, STM) X-ray Photoelectron Spectroscopy (XPS/ESCA) for chemical analysis. Methods.RBS (Rutherford Back Scattering) and SIMS (Secondary Ion Mass Spectroscopy). Defect related electronic states characterization by C-V characteristics of electronic junction devices, Temperature stimulated current and capacitance (TSC/TSCAP), Deep Level Transient Spectroscopy (DLTS), Electronic Beam Induced Current (EBIC) and Light Beam Induced Current (LBIC).

Spectroscopic Characterization:
Double Beam IR Spectrometers, Basic Concepts of Raman Spectroscopy in Solids, Sensitive Detectors such as CCD Camera, Concept of Space Group and Point Group, Identification and Analysis of Optic and Acoustic Modes in Solids. Electronic Absorption Study for Band Gap Determination.

Reference Books:
1. Analytical Techniques for Thin Film - Treatise on Material Science and Technology, Vol. 27: K.N. Tu and R. Rosenberg (ed.).
2. Electron Microprobe Analysis: S.J. B. Reed.
3. Topics in Applied Physics, Vol. 4: R. Gomer (ed.).
4. Analysis of High Temperature Materials: O. Van Der Biest (ed.).

MPE-304: MOLECULAR BIOPHYSICS **Credits: 3**

Basic Concepts in Biophysics:

Elementary ideas about the DNA structure, sugar-phosphate backbone, nucleosides and nucleotides, three-dimensional DNA structure, RNA. Proteins: primary, secondary, tertiary and quaternary structures, enzymes and their catalytic activity, DNA and protein folding, DNA denaturation, replication, mutation, intercalation, neurotransmitters, membranes.

DNA and its Role:

Forces stabilizing DNA and protein structure, Theoretical quantum chemical and molecular mechanical methods, Treatment of intermolecular interactions, conformations, hydrogen bonding, stacking and hydrophobic interactions, importance of electrostatic interactions, biomolecular recognition, drug design.

Experimental Techniques:

Application of experimental techniques of light scattering, absorption and fluorescence spectroscopy, Nuclear magnetic resonance, Interaction of UV radiation with DNA, Photodimerization, Photodynamic action.

Reference Books:
1. Essentials of Biophysics: P. Narayanan.
2. Basic Molecular Biology: Price.
3. Quantum Mechanics of Molecular Conformations: Pullman (Ed.).
4. Non-linear Physics of DNA: Yakushevich.
5. Biological Physics: Nelson.

MPE-305:   METHODS IN THEORETICAL PHYSICS **Credits: 3**

Path-integral Formalism:
Path-integral formalism in Quantum mechanics, applications to free particle and linear harmonic oscillator; Connection with statistical mechanics.

Foundations in Quantum Mechanics:
Statistical interpretation of Schrodinger's wave functions, Hidden variable and Copenhagen interpretation; EPR paradox and Bell's theorem; Geometrical phase and Aharanov-Bohm effect; Quantum measurement, No-clone theorem, schrodinger's Cat and Quantum Zeno paradox.

General theory of Relativity and Cosmology:
Tensors, metrics and geodesics, dyadics, covariant and contravariant derivatives, Christoffel's symbol and Levi-civita symbol; Einstein's equation and Schwarzchild's solution; Applications in cosmology, Black-holes.

Constraints and Gauge Theory:
Hamilton Method, Constraints (first class and second class); Gauge theory, gauge invariance and related physics.

Reference Books:
1. Techniques and Applications of Path Integration: L.S. Schulman.
2. Introduction to Quantum Mechanics: D.J. Griffiths.
3. Gravitation and Cosmology: S. Weinberg.
4. Classical Dynamics: E.C.G. Sudarshan and N. Mukunda.
5. Lectures on Quantum Mechanics: P.A.M. Dirac.

MPE-306: INSTRUMENTATION IN NUCLEAR AND PARTICLE PHYSICS Credits: 3

Standard Radioactive Sources:
Units, Fast Electron, Heavy Charged Particle, Radiation, Neutron Sources, Biological effects of Radiation, Quantification of Dose Type of Exposure, maximum permissible dose rate.

General Properties of Radiation Detectors:

Simplified detector model, Current and pulse modes of operation, pulse heigh spectra, counting curves and plateaus, energy resolution, detection efficiency, dead time. Device impedances, coaxial cables, Pulse shaping. General characteristics of single & multi-channel methods, spectrum stabilization and computerized spectrum analysis.

Linear and Logic Pulse Functions:
Fast and slow pulses, Linear and logic pulses, instrument standards, Function of pulse processing units, components common to many applications, pulse counting systems, pulse height analysis systems, systems involving pulse timing and pulse shape discrimination.

Background and Detector Shielding:
Sources of background, Background in Gamma ray spectra, Active methods of background reduction, shielding consideration against radiation from an accelerator and radioactive sources.

Counting Statistics and Error Estimation:
Characterization of data, statistical models and applications, error propagation, optimization of counting experiments, and distribution of time intervals.

Reference Books:
1. Radiation Detection and Measurement: G.F. Knoll.
2. Nuclear Physics Techniques: W.R. Leo.
3. Introduction to Nuclear and Particle Physics(2nd Edition): A Das and T. Ferbel.

MPE-307: SCIENCE AND TECHNOLOGY OF SOLAR ENERGY, HYDROGEN AND OTHER RENEWABLE ENERGIES   Credits: 3

Solar Energy: Fundamental and Material Aspects:
Fundamentals of photovoltaic Energy Conversion Physics and Material Properties, Basic to Photovoltaic Energy Conversion: Optical properties of Solids. Direct and indirect transition semiconductors, interrelationship between absorption coefficients and band gap recombination of carriers.

Solar Energy: Different Types of Solar Cells:
Types of Solar Cells, p-n junction solar cell, Transport Equation, Current Density, Open circuit voltage and short circuit current, Brief description of single crystal silicon and organic and Polymer Solar Cells, Elementary Ideas of Advanced Solar Cells e.g. Tandem Solar cells, Solid Liquid Junction Solar Cells, Nature of Semiconductor, Principles of Photo-electrochemical Solar Cells.

Hydrogen Energy: Fundamentals, Production and Storage:
Relevance in relation to depletion of fossil fuels and environmental considerations. Solar Hydrogen through Photoelectrolysis, Physics of material characteristics for production of Solar Hydrogen. Brief discussion of various storage processes, special features of solid hydrogen storage materials, Structural and electronic characteristics of storage materials. New Storage Modes.

Hydrogen Energy: Safety and Utilization:
Various factors relevant to safety, use of Hydrogen as Fuel, Use in Vehicular transport, Hydrogen for Electricity Generation, Fuel Cells, Various type of Fuel Cells, Applications of Fuel Cell, Elementary concepts of other Hydrogen- Based devices such as Hydride Batteries.

Reference Books:
1. Solar Cell Devices-Physics :Fonash
2. Fundamentals of Solar Cells Photovoltaic Solar Energy :Fahrenbruch & Bube
3. Phoptoelectrochemical Solar Cells: Chandra
4. Hydrogen as an Energy Carrier Technologies Systems Economy : Winter & Nitch (Eds.)
5. Hydrogen as a Future Engery Carrier : Andreas Zuttel, Andreas Borgschulte and Louis Schlapbach

MPL-301(A): Electronics Laboratory   Credits: 6

Students will be required to perform six (06) experiments of the following:

1. Microwave characteristics and measurements

2. Nonlinear applications of Op amplifier
3. PLL characteristics and its applications
4. PAM, PWM and PPM Modulation and demodulation.
5. PCM / delta modulation and demodulation
6. Fiber optic communication
7. Experiments on MUX, DEMUX, Decoder and shift register
8. Arithmetic operations using microprocessors 8085 / 8086
9. D/A converter interfacing and frequency / temperature measurement with microprocessor 8085 / 8086
10. A/D converter interfacing and AC/DC voltage / current measurement using microprocessor 8085/8086
11. PPI 8251 interfacing with microprocessor for serial communication.
12. Assembly language program on P.C

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-301(B): Nuclear Physics Laboratory   *Credits: 6*

Students will be required to perform seven (07) experiments of the following:

1. Gamma - Ray Spectroscopy Using NaI (Tl) detector
2. Alpha Sepctroscopy with Surface Barrier Detector
3. Determination of the range and energy of alpha particles using spark counter
4. Study of gamma ray absorption process
5. X-Ray Fluorescence
6. Neutron Activation Analysis Measurement of the Thermal Neutron Flux
7. To Study the Solid State Nuclear Track Detector
8. Fission Fragment Energy Loss Measurements from Cf^{252}
9. Gamma - Gamma Coicidence studies
10. Compton Scattering: Energy Determination
11. Compton Scattering: Cross-Section Determination
12. Determination of energy of mu-mesons in pi-decay using Nuclear Emulsion Technique
13. Identification of particles by visual range in Nuclear Emulsion
14. Study of Rutherford Scattering

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-301(C): SPECTROSCOPY LABORATORY   *Credits: 6*

Students will be required to perform six (06) experiments of the following:

1. Verification of Hartmann formula for prism spectrogram
2. Measurement of optical spectrum of an alkali atom
3. Determination of metallic component of an inorganic salt
4. Emitter of electric discharge through air in a tube with minute leak
5. Emitter of electric discharge through air in an evacuated tube
6. Measurement of optical spectrum of alkaline earth atoms
7. Measurement of Band positions and determination of vibrational constants of AlO molecule
8. Measurement of Band positions and determination of vibrational constants of N_2 molecule
9. Measurement of Band positions and determination of vibrational constants of CN molecule
10. Measurement and analysis of fluorescence spectrum of I_2 vapour
11. Determination of characteristic parameters of an optical fiber
12. Measurement of Raman spectrum of CCl_4.

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-301(D): SOLID STATE PHYSICS LABORATORY   **Credits: 6**

Students will be required to perform five (05) experiments of the following:

1. Measurement of lattice parameter and indexing of powder photograph
2. Identification of unknown sample using powder diffraction method.
3. To study the ferroelectric transition in TGS crystal and measurement of Curie temperature
4. To measure the superconductivity transition temperature and transition width of a high temperature superconductor
5. Rotation / oscillation photograph and their interpretation
6. To study the modulus of rigidity and internal friction in a metal as a functioning temperature
7. To measure the Cleavage step height of a crystal by multiple Fizeau Fringes
8. To determine magnetoresistance of a Bismrith crystal as a function of magnetic field
9. Synthesis/Fabrication of Cabon Nanotubes by Spray Pysolysis method and its verification through x-ray diffraction.

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

SEMESTER – IV

MPC-401: STATISTICAL MECHANICS – II   **Credits: 3**

Critical Phenomena and Phase Transition:
Phase transitions and thermodynamic functions. Thermodynamic limit and its importance. Mean field theory, Landau theory. Correlation functions, Ornstein-Zernike theory, Critical behaviour, Critical exponents, Scaling and Universality, Upper and lower critical dimensions. Renormalization group: basic idea, flows, fixed points, Application to 2-d Ising and Potts models.

Time Dependent Phenomena:

Dynamic correlation and response functions. Example of damped harmonic oscillator. Diffusion. Brownian motion and Langevin equations.Correlation and response of damped Brownian oscillator. General properties of correlation and response functions, Linear response theory. Dissipation: The fluctuation-dissipation theorem, The Kubo formula, Fokker-Planck Equation.

Reference Books:
1. Statistical Mechanics: Patheria.
2. Statistical Physics I and II: Kubo, Toda and Ashitsume.
3. Modern Theory of Critical Phenomena: Ma.
4. Statistical Mechanics: Landau and Lifshitz.
5. Lectures on Phase Transitions and Rnormalization Group: Goldenfeild.

MPS-401(A): DIGITAL COMMUNICATION SYSTEMS   **Credits: 4**

Signals, Systems and Noise:
Elements of communication systems, Fourier representation of periodic and non-periodic signals, Power spectral density, Impulse and step response of systems, Time and frequency domain analysis of systems, Ideal and Real filters, Noise in communication systems, Representation of narrow band noise, Signal to noise ratio, Noise equivalent band width and noise figure.

Information Theory and Coding:
Introduction, Amount of information, Average information, Shannon's encoding algorithm, Communication channels, Rate of information and capacity of discrete memoryless channels, Shanon-Hartley theorem. Linear block codes, Binary cyclic codes and Convolutions codes.

Digital Signal (Data) Transmission:

Introduction, Base band and pass band data transmission. Base band binary PAM system, Optimum receiver for binary digital modulation schemes, Binary ASK, FSK PSK and differential PSK signaling schemes. Brief idea about M-ary signaling schemes, Serial data communication in computers, USART 8251, MODEM.

Fiber Optic Communication:
Basic optical communication system, wave propagation in optical fiber media, step and graded index fiber, material dispersion and mode propagation, losses in fiber, optical fiber source and detector, optical joints and coupler. Digital optical fiber communication system, First/Second generation system, Data communication network.

Reference Books:
1. Digital and Analog Communication Systems: K. San Shanmugam.
2. Communication Systems: Simon Haykin.
3. Optical Fibre Communication: Kaiser.

MPS-401(B):   PARTICLE PHYSICS   Credits: 4

Particle Phenomenology:
Invariance and conservation laws in relation to particle reactions and decays. Elementary ideas of C, P and T symmetries. Pion-nucleon scattering, isospin analysis and phase shifts, resonances and their quantum numbers, Production and formation experiments, Relativistic kinematics & invariants, Mandelstam variables, Phase space, Decay of one particle into three particles, Dalitz Plot.

Strong Interactions and Symmetries:
Uses of symmetry, space time and internal symmetries, Lie groups generators and Lie algebra, Casimir operators, SU(2) irreducible representation, weight diagram, diagonal generators,   SU(3) generators, U and V spin, Raising and Lowering operators, Root diagram, Weight diagram, Dimensionality multiplets of SU(n), Baryons and meson multiplets, Symmetry   breaking   and Gell-Mann-Okubo mass formula, Decays in terms of Quark Model.

Physics of Quarks and Gluons:
Charm, bottom and top quarks and higher symmetry. Quark-Gluon interaction, Experimental tests of Quantum Chromodynamics. Particle Physics and Thermodynamics in the early Universe. Quark-Gluon Plasma. Stellar evolution and Element Synthesis.

Reference Books:
1. Nuclear and Particle Physics: W. Burcham and M. Jobes.
2. Quarks and Leptons: Halzen and Martin.
3. Unitary symmetry and Elementary Particles: D.B.Lichtenberg.
4. Symmetry Principles in particle Physics: Emmerson.
5. Introduction to High Energy Physics: Perkins.
6. Particles and Nuclei: B. Povh, K. Rith, C. Scholz and F. Zetsche.

MPS-401(C): MOLECULAR ORBITAL THEORY AND ELECTRONIC SPECTRA OF MOLECULES   Credits: 4

Atomic and Molecular Orbital Theories:
Elementary idea of Atomic Orbitals in Hartree-Fock Theory, Qualitative description of ab-initio methods, LCAO treatment of H_2^+ and H_2 molecules. Molecular charge distribution and Dipole moment. Molecular Electrostatic Potential. Hellman-Feynman Theorem and concept of force. Hybrid Atomic Orbitals in H_2O, CH_4, C_2H_2, and C_2H_4. Concept of lone pairs. Huckel method and its application to Ethylene, Butadiene and Benzene. Changes in molecular geometry on electronic excitation.

Spectroscopy of Diatomic and Poluatomic Molecules:
Coupling of Electrtonic and Rotational motion in Diatomioc Molecules and Rotational structure of $^1\pi$ - $^1\Sigma$ and $^1\Sigma$-$^1\Sigma$ transitions. Vibronic interaction and Herzberg Teller theory for absorption spectrum of benzene vapour.

Single vibronic level spectroscopy and lifetime of vibronic levels in benzene, Quantum yield, Kasha Rule and the concept of nonradiative transitions in molecules. Jablanski diagram and qualitative treatment of small molecule and large molecule limit for nonradiative transitions.

Reference Books:
1. Molecular Orbital Theory: A. Streitweiser.
2. Valence : C.A. Coulson.
3. High Resolution Spectroscopy: J.M. Hollas
4. Laser Spectroscopy and Instrumentation: W. Demtroder.

MPS – 401(D): SOLID STATE PHYSICS: SPECIAL SOLIDS, SURFACES AND PROPERTIES   Credits: 4

Aperiodic and Semiperiodic Systems:
Structure and symmetries of liquids, Liquid crystals and amorphous solids. Aperiodic solids and quasicrystals; Fibonaccy sequence, Penrose lattices and their extension to 3-dimensions.

Films and Surface:
Electrical conductivity of thin films, Difference of behaviour of thin films from bulk, Boltzmann Transport equation for a thin film (for diffused scattering), Expression for electrical conductivity.
Elementary concepts of surface crystallography, scanning tunneling and atomic force microcopy.

Magnetic Properties:
Weiss theory of ferromagnetism, Heisenberg model and molecular field theory, Spin waves and magnons, Curie-Weiss law for susceptibility, Ferri and antiferro-magnetic order, Domains and Bloch-wall energy.

Photonic Solids: Fabrication and properties.

Reference Books:
1. Solid State Physics: Kittel.
2. Thin Films: Heavens.
3. Physics of Thin Films: Chopra.
4. Solid State Physics : N.W. Aschroft and N.D. Mermiu

MPS -402(A): MICROPROCESSORS AND INTERFACING   **Credits: 4**

Intel 8085:
Internal operation of Intel 8085. Instructions, Opcodes, operands and mnemonics. Constructing machine language codes for instructions, Instruction execution timing diagram. Instruction word size and addressing modes, Instruction set. Stacks subroutines and Interrupts, Machine and assembly language programming.

Intel 8086:
Architecture, Pin description for minimum and maximum modes, Internal operation, Instruction execution timing diagram, Addressing modes. Instruction format for constructing machine language codes for different instructions. Introduction to assembly language. Instruction set and directives, Stacks, Procedures, Macros and interrupts. Flow chart of standard programming structures. I/O interfacing and data transfer scheme.

Advanced Microprosessors:
Multitasking, Architecture and memory management of microprocessor 80286, Brief idea about architecture of microprocessor 80386, 80486 and Pentium, Introduction to Microcontroller.

Microprocessor based Measurement/Control Circuits:
Transducers, D/A and A/D Converters, PPI 8255 Data acquisition and storage, Microprocessor based traffic light controller, Temperature and water label indicator/ controller. DC and steper motor speed measurements, Waveform generation and frequency measurement.

Reference Books:
1. Fundamentals of Microprocessors and Microcomputers: B. Ram.
2. Microprocessor System the 8086 /8088 Family: Liu and Gibson.
3. Microprocessor, Architecture, Programming and Application: R.S. Goonkar.
4. Introduction to Microprocessor: A.P. Mathur.
5. Microprosessor and Interfacing: D.V. Hall.

MPS-402(B): WEAK INTERACTIONS AND ELECTROWEAK UNIFICATION   Credits: 4

Weak Interactions:
 Leptonic, semileptonic and nonleptonic weak decays. Selection rules, Nuclear Beta decay and form of current-current interaction, Feynman Diagrams, V-A theory, Fermi and G-T selection rules, Parity violation in weak interaction, (Cobalt Sixty Experiment) Neutrino Oscillation and Mixing, Detection of Neutrinos, Decay of Pions and Muons, Calculation of Lifetime for Pions and Muons, Universal Fermi Interaction, Strangeness Oscillations, Regeneration and CP-Violation in Kaon Decay.

Unification of Interactions:
General idea of electro-weak unification, Experimental Evidence of Electro-Weak Unification, Non-Abelian Gauge Field Theory, Spontaneous Symmetry Breaking, Higgs Mechanism, Goldstone Theorem, A Brief Review of Salam-Weinberg-Glashow Model.

Reference Books:
1. Nuclear and Particle Physics: W.E. Burcham and M.Jobes.
2. Introduction to Elementary Particles: Griffths.
3. Quarks and Leptons: Halzen and Martin.
4. Gauge Theory of weak Interactions: Greiner and Muller.

MPS-402 (C): PRINCIPLES AND INSTRUMENTATION IN CONVENTIONAL AND LASER SPECTROSCOPY

                                                                          Credits: 4

Light Sources, Detectors and Spectroscopic Techniques:
Synchrotron Radiation Source, Dye Laser as a versatile spectroscopic light source, Grating spectrographs and spectrometers based on Czerry-Turner and Ebert mountings. Thermal Detector, Photodiode, Photomultiplier Tube, Channel Electron Multiplier, Charge coupled detector. Principle and Working of a Double Beam infrared spectrophotometer, Raman Spectrometer. Principle and Working of Fourier Transform Spectrometers. Photoacoustic Spectroscopy, Matrix Isolation Spectroscopy.

Non-Conventional Spectroscopic Techniques:
Two-photon spectroscopy, Saturation Spectroscopy, CARS, Experimental techniques of MPI spectroscopy, Optogalvanic spectroscopy and Supersonic Beam Spectroscopy with emphasis on measurement of molecular parameters.

Reference Books:
1. Laser Spectroscopy : W. Demtroder.
2. High Resolution Spectroscopy : J. M. Hollas.
3. Spectrophysics : A. Thorpe.

MPS-402 (D): SOLID STATE PHYSICS: MANY PARTICLE SYSTEMS   **Credits: 4**

Interacting Electron Gas:
Hartree and Hartree-Fock Methods, Correlation Energy, Screening, Plasma Oscillations, Dielectric Functions and its Properties, Friedel Oscillations.

Electron-Phonon Interactions:
Interaction of Electron with Acoustic and Optical Phonons, Long Wavelength Limit of Optical Phonons and Crystal Polarization, Polarons, Cooper Pairing due to Phonon, BCS Theory of Superconductivity, Ginzberg-Landau Theory of Superconductivity and Application to type II superconductors, Vortices and Abrikosov Phase.

Optical Properties:
Interactions of Electrons and Phonons with Photons, Direct and Indirect Transitions, Polaritons.

Electron Localiztion in Disordered System:
Electron Localization, Density of States, Mobility Edge, Anderson Model and Mott's Localization, Hopping Conductivity.

Reference Books:
1. Introduction to Solid State Physics: Madelung.
2. Quantum Theory of Solid State: Callaway.
3. Quantum Theory of Solid State: Kittel.

MPE-401: EXPERIMENTAL TECHNIQUES AND INSTRUMENTATION IN ATOMIC, MOLECULAR AND OPTICAL PHYSICS   **Credits: 3**

Experimental Techniques:

AES (Auger electron spectroscopy), PES (Photo electron spectroscopy), EELS (Electron energy loss spectroscopy), PIXE (Particle induced x-ray emission), BFS (Beam-foil spectroscopy), TOF (Time-of-flight) spectroscopy, SRS (Synchrootron radiation spectroscopy), technique of coincidence detection, High vacuum generation, Ultra-fast pulse generation and detection.

Instrumentation:
Principle and working of CEM (Channel electron multiplier), MCP (one-and two-dimensional micro-channel plates), PMT (Photo-multiplier tubes), SBD (Surface barrier detectors), Si(Li), HPGe, NaI photon detectors, electrostatic and magnetic charged particle energy analyzers (45°-parallel plate, and cylindrical mirror analyzer (CMA), TOF-spectrometer, MCA (multi-channel analyzer), TAC (Time-to amplitude converter), CFD (Constant fraction discriminator), ionization pressure gauges (Pirani and Penning).

Reference Books:
1. Electron Spectroscopy: Theory, Techniques and Applications: CR Brundle and AD Baker.
2. Synchrotron Radiation : Techniques and Applications: C. Kunz.
3. Low Energy Electron Spectroscopy: KD Sevier.
4. Radiation Detectors: WH Tait.
5. Advances in Image Pickup and Display, Vol. 1: P. Schagen.

MPE-402:   NANO SCIENCE AND TECHNOLOGY   **Credits: 3**

Nanoparticles: Synthesis and Properties:
Method of Synthesis: RF Plasma Chemical Methods, Thermolysis, Pulsed Laser Methods, Biological Methods: Synthesis using micro-organisms, Synthesis using Plant Extract, Metal Nanoclusters, Magic Numbers, Modeling of Nanoparticles, Bulk to Nano Transitions.

Carbon Nanostructures:
Nature of Carbon Clusters, Discovery of C_{60}, Structure of C_{60} and its Crystal, Superconductivity in C_{60}, Carbon Nanotubes: Synthesis, Structure, Electrical and Mechanical Properties. Graphene: Discovery, Synthesis and Structural Characterization through TEM, Elementary Concept of its applications.

Quantum Wells, Wires and Dots:
Preparation of Quantum Nanostructures, Size Effects, Conduction Electrons and Dimensionality, Properties Dependent on Density of States.

Analysis Techniques for Nano Structures/ Particles:
Scanning Probe Microscopes (SPM), Diffraction Techniques, Spectroscopic Techniques, Magnetic Measurements

Bulk Nanostructure Materials:
Methods of Synthesis, Solid Disorders Nanostructures, Mechanical Properties, Nanostructure Multilayers, Metal Nanocluster, Composite Glasses, Porous Silicon.

Reference Books:
1. Introduction to Nanotechnology: Poole and Owners
2. Quantum Dots : Jacak, Hawrylak and Wojs
3. Handbook of Nanostructured Materials and Nanotechnology : Nalva (editor)
4. Nano Technology/ Principles and Practices**:** S.K. Kulkarni
5. Carbon Nanotubes: Silvana Fiorito
6. Nanotechlongy: Richard Booker and Earl Boysen

MPE-403:   PHYSICS OF ELECTRONIC MATERIALS AND DEVICES   **Credits: 3**

Physical Mechanisms:
Crystal structures of Electronic materials (Elemental, III-IV and VI semiconductors), Energy Band consideration in solids in relation to semiconductors, Direct and Indirect bands in semiconductor, Electron/Hole concentration and Fermi energy in intrinsic/Extrinsic semiconductor continuity equation, Carrier mobility in semiconductors, Electron and Hole conductivity in semiconductors, Shallow impurities in semiconductors (Ionization Energies), Deep Impurity states in semiconductors, Carrier Trapping and recombination/generation in semiconductors, Schokley Read theory of recombination, Switching in Electronic Devices.

Devices:
(i)   Metal/Semiconductor Junction or (Abrupt P-N Junction), Current-voltage characteristics, C-V measurements, Estimation of Barrier Height and carrier concentration from C-V characteristics, Surface/Interface States, Role of interface States in Junction Diodes.

       Field Effect devices, C-V characteristic of MIS diodes (Frequency dependence), Estimation of Interface Trapped charges by capacitance conductance, method CCD (Charge Coupled Devices), MESFET, MOSFET.

(ii)   **Microwave Devices:** Tunnel Diode, MIS Tunnel Diode, Degenerate and Non-degenerate semiconductor, MIS Switch Diode, MIM Tunnel diode.
       IMPATT Diode.
       Characteristics, breakdown Voltage, Avalanche Region and Drift Region, Transferred Electron devices.

(iii)   **Photonic Devices:** LED and LASER, Photo detectors, Solar-cells.

Reference Books:
1.   Physics of Semiconductor Devices: S.M. Sze.
2.   Semiconductor Devices Basic Principles: Jaspreet Singh.
3.   Physics and Technology of Semiconductor Devices: A.S. Grove.
4.   Metal/Semiconductor Schottky Barrier Junction and their Applications: B.L. Sharma.
5.   Metal/Semiconductor Contact: Rhoderick.

MPE-404:   SATELLITE COMMUNICATION AND REMOTE SENSING   Credits: 3

Principle of Satellite Communication:
General and Technical characteristics, Active and Passive satellites, Modem and Codec.

Communication Satellite Link Design:
General link design equation, Atmospheric and Ionospheric effect on link design, Earth station parameters.

Satellite Analog Communication:
Baseband analog signal, FDM techniques, S/N and C/N ratio in FM in satellite link.

Digital Satellite Transmission:
Advantages, Elements of digital satellite communication, Digital base band signal, Digital modulation Techniques, Digital link Design, TDM, TDMA, some applications of satellite communications.

Concept and Foundations of Remote Sensing:
Electromagnetic Radiation (EMR), interaction of EMR with atmosphere and earth surface, Application area of Remote Sensing.

Characteristics of Remote Sensing Platform & Sensors:
Ground, Air & Space platforms, Return Beam Vidicon, Multi-spectral Scanner, Brief idea of Digital Image Processing.

Microwave Remote Sensing Tools:
Radar Remote Sensing, Microwave Sensing, Lidar (Single and double ended system), (Radar & Lidar): Data Characteristics.

Earth Resource Satellites:
Brief description of Landsat and Indian remote sensing satellites (IRS) Satellites.

Reference Books:
1. Satellite Communication : D.C. Agrawal andA. K. Maini.
2. Satellite Communication: T. Pratt and C. W. Bostiern.
3. Satellite Communication System: M. Richharia.
4. Introduction of Remote Sensing: J.B. Campbell.
5. Manual of Remote Sensing Vol I & II: (Ed. R.N. Colwell).

MPE-405: Quantum Field Theory: Path Integral Approach   Credits: 3

Path integral quantization and Feynman rules: Scalar and Spinor Fields:
Introduction to Path Integrals, Generating functional for scalar fields, Functional integral, Free particle Green's function, Generating functional for interacting fields: φ^4 theory. Effective action for φ^4 theory. Two point functions, Four point functions, Grassman variable, Fermionic functional integrals and generating functional.

Path Integral Quantization: Gauge Fields:
Propagator and gauge condition in QED. Photon propagator, Propagator for transverse photon. Scattering cross section for some elementary process in QED.

Renormalization:
Divergence in φ^4 theory, Dimensional regularization. Renormalization of φ^4 theory. Divergence in QED. Electron self-energy, Vacuum polarization. WT identities. Anomalous magnetic moment of electron. Renormalization group equations.

Reference Books:
1. An introduction of QFT: M. peskin and D. Schroeder.
2. Quantum Filed Theory: L.H. Ryder.
3. Quantum Field Theory: C. Itzykson and J.B. Zuber.
4. Field Theory: Modern Primer: P. Ramond.
5. Relativistic Quantum Field: J.D. Brojken and S.D. Drell.
6. Introduction to QFT: F. Mandle and G. Shaw.

MPE-406: LIQUID CRYSTALS   Credits: 3

Introduction:
States of matter, Liquid crystals, Symmetry, structure and order, Mesogenic molecules, Liquid crystals of achiral and chiral molecules, calamitic, disc shape and polymer liquid crystals.

Physical Properties:
Order parameters, measurement by magnetic resonance spectroscopy, Optical anisotropy, refractive index, Dielectric anisotropy, dielectric permittivity, Diamagnetic anisotropy, magnetic susceptibility;, Transport properties, Elastic constants, continuum description.

Statistical Theories of Nematic Order:
Landau-de-Gennes theory, hard particle, Maier saupe- and van der Walls type theories.

Nematic-Smectic A transition:
Phenomenological description, McMillan theory, polymorphism in smectic A Phase.

Chiral liquid crystals:
Chirality in liquid crystals: chiral nematic phase, optical properties, field induced nematic-cholesteric phase change, distortion of structure by magnetic field; Blue phase. Chiral smectic phases, origin of ferroelectricity: Structure, symmetry and ferroelectric ordering in chiral smectic C phase; Antiferroelectric and ferroelectric chiral smectic C phase.

Application of Liquid Crystals.

Reference Books:
1. Liquid Crystals: S. Chandrasekhar.

2.   The Physics of Liquid Crystals: P.G. de Gennes and J Prost.
3.   Liquid Crystals, Fundamentals: S Singh.

MPE-407: Computational Physics   **Credits: 3**

Stochastic Processes
Theory of random walks and simulation of random walks in one, two and three dimensions. Elementary ideas and simulations of self-avoiding walks, additive and multiplicative stochastic processes, Brownian motion and fractional Brownian motion

Percolation theory
Percolation theory and simulation by Hoshen-Kopelman algorithm; Application to simple lattice models in Physics

Simulations of physical models
Elementary ideas of: (a) Time-average and Molecular dynamics: Dynamical equations and physical potentials; Verlet algorithm (b) Ensemble average and Monte Carlo methods; Metropolis algorithm. Introduction to the simulations of: (a) Ising model in magnetism (b) Bak-Tang-Wiesenfeld model in studies of self-organized criticality

Combinatorial optimization problems
Classification of problems; examples of optimization problems: traveling salesman problem (TSP) and satisfiability (k-SAT) problem; heuristic methods of solutions and simulated annealing technique.

References
1.   Understanding Molecular Simulation (Academic Press), D. Frenkel & B. Smit
2.   Introduction to Percolation Theory (Taylor-Francis), D. Stauffer
3.   Equilibrium Statistical Physics (World Scientific), M. Plischke & B. Bergersen
4.   Numerical Recipes in C: The Art of Scientific Computing (Cambridge University Press), W.H. Press, B.P. Flannery, S.A. Teukolsky and W.T. Vetterling

MPL-401(A): ELECTRONICS LABORATORY   **Credits: 6**

Students will be required to perform six (06) experiments of the following, other than those performed in Semester-III:

1.   Microwave characteristics and measurements
2. Nonlinear applications of Op amplifier
3. PLL characteristics and its applications
4. PAM, PWM and PPM Modulation and demodulation.
5. PCM / delta modulation and demodulation
6. Fiber optic communication
7. Experiments on MUX, DEMUX, Decoder and shift register
8. Arithmetic operations using microprocessors 8085 / 8086
9.   D/A converter interfacing and frequency / temperature measurement with microprocessor 8085 / 8086
10.   A/D converter interfacing and AC/DC voltage / current measurement using microprocessor 8085/8086
11.   PPI 8251 interfacing with microprocessor for serial communication.
12.   Assembly language program on P.C

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-401(B): NUCLEAR PHYSICS   **Credits: 6**

Students will be required to perform seven (07) experiments of the following, other than those performed in Semester III:

1.   Gamma - Ray Spectroscopy Using NaI (Tl) detector.
2.   Alpha Spectroscopy with Surface Barrier Detector.
3.   Determination of the range and energy of alpha partcles using spark counter.
4.   Study of gamma ray absorption process.

5. X-Ray Fluorescence.
6. Neutron Activation Analysis Measurement of the Thermal Neutron Flux.
7. To Study the Solid State Nuclear Track Detector.
8. Fission Fragment Energy Loss Measurements from Cf^{252}.
9. Gamma - Gamma Coicidence studies.
10. Compton Scattering: Energy Determination.
11. Compton Scattering: Cross-Section Determination.
12. Determination of energy of mu-mesons in pi-decay using Nuclear Emulsion Technique.
13. Identification of particles by visual range in Nuclear Emulsion.
14. Study of Rutherford Scattering.

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

PL-401(C): SPECTROSCOPY LABORATORY   **Credits: 6**

Students will be required to perform six (06) experiments of the following, other than those performed in Semester III:

1. Verification of Hartmann formula for prism spectrogram
2. Measurement of optical spectrum of an alkali atom
3. Determination of metallic component of an inorganic salt
4. Emmiter of electric discharge through air in a tube with minute leak
5. Emitter of electric discharge through air in an evacuated tube
6. Measurement of optical spectrum of alkaline earth atoms.
7. Measurement of Band positions and determination of vibrational constants of AlO molecule
8. Measurement of Band positions and determination of vibrational constants of N_2 molecule
9. Measurement of Band positions and determination of vibrational constants of CN molecule
10. Measurement and analysis of fluorescence spectrum of I_2 vapour
11. Determination of characteristic parameters of an optical fiber
12. Measurement of Raman spectrum of CCl_4.

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-401(D): SOLID STATE PHYSICS LABORATORY   **Credits: 6**

Students will be required to perform four (04) experiments of the following, other than those performed in Semester III:

1. Measurement of lattice parameter and indexing of powder photograph
2. Identification of unknown sample using powder diffraction method.
3. To study the ferroelectric transition in TGS crystal and measurement of Curie temperature.
4. To measure the superconductivity transition temperature and transition width of a high temperature superconductor.
5. Rotation / oscillation photograph and their interpretation.
6. To study the modulus of rigidity and internal friction in a metal as a functioning temperature.
7. To measure the Cleavage step height of a crystal by multiple Fizeau Fringes.
8. To determine magnetoresistance of a Bismrith crystal as a function of magnetic field.
9. Synthesis/ Fabrication of Carbon Nanotubes by spray paralysis method and its verification through X-ray diffraction.

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPD-401: PROJECT AND DISSERTATION   **Credits: 2**

The dissertation topics will be based on special papers or elective papers and topics of current interest. A departmental committee will distribute the topics.

M.A. / M.Sc. PSYCHOLOGY
Department of Psychology
Banaras Hindu University

DISTRIBUTION OF DIFFERENT COURSES AND CREDITS IN VARIOUS SEMESTERS

Semester-I		
Course Code	**Title**	**Credits**
PSM 101	Attention and Perceptual Processes	4
PSM 102	Research Methods and Experimental Designs	4
PSM 103	Advanced Physiological Psychology	4
PSM 104	Applied Social Psychology	4
PSM 105	Practicals	3
PSM 106M #	Minor Elective: Basic Psychological Process (for the students of other PG Programmes) Minor Elective (for Psychology Students)	3
	Total	**22**

Semester-II		
PSM 201	Language, Memory and Thinking	4
PSM 202	Non-experimental & Correlational Methods	4
PSM 203	Psychobiology	4
PSM 204	Cross-cultural Psychology	4
PSM 205	Practicals	3
PSM 206 #	Minor Elective: Applications of Psychology in Human Life (for the students of other PG Programmes) Minor Elective (for Psychology Students)	3
	Total	**22**

Semester-III			
PSM 301	Applied Psychological Assessment	4	
PSM 302	Affective Processes	4	
PSM 303	Diagnostic Techniques/ Organisational Behaviour/ Child Development /Comparative Psychology	4	
PSM 304	Psychopathology/ Stress-Management/ Child Psychopathology/ Psychopharmacology	4	
PSM 305	(a)Practicals (b) Comprehensive Viva-Voce	2 1	3
PSM 306 #	Minor Elective: Stress Management (for the students of other PG Programmes) Minor Elective (for Psychology Students)	3	
	Total	**22**	

Semester-IV		
PSM 401	Therapeutic techniques/Human Resource Management/Psychology of Adolescence	4
PSM 402	Neuro-Psychology/Organisational Development & Change/Psychology of Adulthood & Ageing.	4
PSM 403	Psychology of Personality/ Psychology of Rehabilitation/Organisational Communication/Psychology of Sports	4
PSM 404	Health Psychology/Drugs and Behaviour/Counselling/Human Factors	4
PSM 405	Practicals	3
PSM 406	Comprehensive Viva-Voce	3
	Total	**22**
	Grand Total	**88**

M.A./M.Sc. Psychology students will opt 3 minor electives (of 3 credits each in Semester I, II, & III) offered by the Department of Psychology.

PSM 101   **Attention and Perceptual Processes**

1. Cognitive approach: Origin and current status of cognitive psychology
2. Attention: Concepts and mechanisms;
   Selective attention: Bottleneck theories, capacity model and automaticity.
   Sustained attention: Psychophysical factors and theories
3. Perception: Figure-ground organization, figure formation, and psychophysics of   form. Non-veridical perception
4. Space, time and movement perception: Theoretical perspectives
5. Perceptual development. Nature-nurture controversy: Pre-exposure, deprivation   and enrichment.
6. Cognitive and motivational influences on perception: Instruction, target   identification and perceptual defence, perception without awareness.

Books Recommended

Best, J. B. (1999). *Cognitive psychology* (5th ed), Belmont, CA: Brooks/Cole

Dember, W.N.& Warm, J. S. (1979). *Psychology of perception* (2nd ed). New York: Holt

Howard, D,B. (1983) *Cognitive psychology*. New York: McMillan.

Mattlin, M. W. (1995). *Cognition.* (3rd edition).Bangalore: Prism Books

Schiffman, H.R. (1996). *Sensation and perception: An integrated approach*. New York: John Wiley

Solso, R.L. (2001) *Cognitive psychology*. (6th ed). Singapore: Pearson Education

PSM 102   **Research Methods and Experimental Designs**

1. Scientific approach in psychology and theory building;
   Types of research: Experimental and ex-post facto;
   Ethical issues in psychological research.
2. Problem and hypothesis: Origin and sources, special features
   Variables: Operational definition, criterion and predictor variables ,
   selection, manipulation and control of independent and extraneous variables, measurement of dependent variables and threats to valid measurement.
3. Sampling: Meaning, purpose and types
   Factors influencing sampling decisions: Size, accessibility and cost.
4. Research design: Meaning, characteristics and purpose, criteria of good design. Between groups designs: Equivalent groups, randomized groups, multilevel, factorial (2x2) and multifactor designs,
   Within groups designs: Within subjects design, one-group repeated trial, randomized block design (within the same subject), N = I design, two-factors within subjects design.
5. Statistics: Testing of hypotheses, substantive and null hypothesis. Statistical inferences: -'t' test, Chi-square test, analysis of variance factorial ANOVA with two or more variables.
   Multiple range tests: Tukey, Duncan, and Newman-Keuls.

Books Recommended

Broota, K. D. (1989). *Experimental designs in behavioural research*. New Delhi; Wiley Eastern.

Edwards, A. L. (1968). *Experimental designs in psychological research* (3rd ed). New Delhi: Oxford and IBIL.

Heiman, G. W. (1995) *Research methods in psychology*. Bostol1: Houghton Miffin Co.

Kerlinger, F.N. (1973). *Foundation of behavioural research* (2nd ed) Delhi: Sanjeet Publications.

Kopala, M., & Suzuki L.A. (1999). *Using qualitative methods in Psychology* (2nd ed). Thousand Oaks: Sage.

Siegel, S., & Castellon (1988). *Non-paramatic statistics for the behavioural sciences* (2nd ed). New York: McGraw Hill.

Winer, B.J ., Brown D.R., & Michels, .K.M. (1991). *Statistical principles in experimental designs* (3rd ed). New York: McGraw Hill

PSM 103   **Advanced Physiological Psychology**

1. Organization and functions of the central nervous system: Spinal cord, hindbrain, midbrain and forebrain
2. Methods of physiological psychology: Invasive physiological methods; Methods of visualizing the living human brain; Recording human psychophysiological activity.
3. Neural conduction and transmission: Resting membrane potential; Action potential; Synaptic transmission; Neuromuscular transmission: Information processing.
4. Hemispheres of the neocortex: Role of corpus callosum and anterior commissure; Split-

brain; Hemispheric dominance; Capabilities of right hemisphere; Lateralization of language; Neuroplasticity.
5. Hormones and the brain: Endocrine communication and pheromone communication

Books Recommended:

Brodal P. (1992) .*The central nervous system: Structure and function*. New York: Oxford University Press

Carlson, N.R. (2000). *Physiology of behaviour*. Boston: Allyn & Bacon.

Ganong, W.F.(2002) *Review of medical physiology*. Norwalk, C.T: Appleton & Lange

Guyton, A. C. (2000). *Text book of medical physiology*. philadelphia: W.B. Saunders Comp.

KaIat, J. W. (2001) *Biological psychology*. C.A.: Wadsworth

Nicholls, J.G. , Martin, A.R.,Wallace, B.G. and Fuchs, P.A. (2000) *From neuron to brain*, Sunderland, MA: Sinauer

PSM 104   Applied Social Psychology

1. Present trends in social psychology: Approaches to the study of social behaviour. General framework of applied social psychology.
2. Social disadvantage and deprivation: Disadvantaged .groups, indicators and measurement, psychological consequences, remedial and intervention programmes.
3. Environmental issues: Noise, pollution and atmospheric conditions; Density and crowding; Response to environmental challenges; Intervention for environmental management.
4. Health and well-being: Conceptual issues, biomedical and psycho-social models of health, ealth impairing behaviours; Health promotion and invention programmes.
5. Aggression and violence: Conceptual issues and theoretical explanations; Determinants; Interpersonal and intergroup forms of aggression; Strategies for reducing aggression and violence.
6. Population and gender issues: Economic and psycho-social models of population; Population growth; Dynamics and consequences; Control strategies. Problems of women, perceptions and discriminations, women empowerment strategies.

Books Recommended:

Alcock, .J.E., et al. (1998). *A textbook of social psychology*. Scarborough, Canada:Prentice Hall.

Baron, R.A. & Byrne, D. (2000). *Social psychology*. New Delhi: Prentice Hall

Misra, G. (Ed.) (1990). *Applied social psychology in India*. New Delhi: Sage.

Mohanty, A. K., Misra, G. (2000). *Psychology of poverty and disadvantage*. New Delhi: Concept.

Oskamp, S. (1984) *Applied social psychology*. Englewood Cliffs, N.J. Prentice Hall

Semin, G., & Fiedler, K. (1996). *Applied social psychology*. London: Sage.

PSM 105   Practical

Any six of the following experiments:
1. Masking effects by noise inducements.
2. Geometric illusion- perspective theory study.
3. Absolute judgement of positions on a line.
4. Signal detectability.
5. Selective attention -response selection.
6. Sustained attention: temporal and spatial uncertainty.
7. Target recovery by backward masking.
8. Depth perception -pictorial cues.
9. Reversible perspective.
10. Perceptual defence -autonomic discrimination without awareness.
11. Chronometric analysis of perceptual vigilance.
12. Time perception.
13 Set in perception.
14. Effect of instruction on perception.
15. Perceptual differentiation.
16. Gender stereotype
17. Health beliefs.
18. Perception of environment.

PSM 106M: Basic Psychological Processes Credits: **3**
1. Psychology : Nature and scope
1. Perceptual processes: Sensation, perception and attention.
2. Learning: Principles and processes.
3. Memory and forgetting: Process and measurement. Forgetting.
4. Emotion and Motivation: Nature and types.
5. Intelligence: Concept and measurement; emotional intelligence.
6. Personality: Concept and measurement.
Books recommended:
1. Atkinson, R. L., Atkinson, R. C., & Hilgard, E. R. (1998). Introduction to psychology, (10th edition), New York: Harcourt Brace Jovanovich.
2. Baron, R. A. (2006). Psychology (5th edition). New Delhi: Pearson Education.
3. Ciccarelli, S. K., & Meyer, G. E. (2007). Psychology (1st edition). New Delhi: Pearson Education.
4. Feldman, R. (2004). Understanding Psychology (6th edition). New Delhi: McGraw Hill
5. Gerrig, R. J., & Zimbardo, P. G. (2006). Psychology and Life (17th edition). New Delhi: Pearson Education.
6. Morgan, C. T., King, R. A., Weisz, J. R., & Schopler, J. (1986). Introduction to psychology (7th edition) Bombay: Tata-McGraw Hill.
7. Singh, R. N. (2005). Adhunik samanya manovigyan. Agra: Vinod Pustak Mandir.
8. Singh, A.K. (1997). Uchchtar samanya manovigyan. Varanasi: Motilal Banarasi Das.

PSM 201 Language, Memory and Thinking
1. Language structure: Grammar and linguistics. Chomsky's theory: Empirical support for deep-surface-structure distinction, neurology and language structure.
2. Speech and language perception: Perceiving and comprehending speech. Reading.
3. Language acquisition and cognitive development: Stages in language development, conceptual basis of language and the theory of mind
4. Memory storage models: Sensory, short-term and long-term storages. Working memory : Levels of processing approach; Procedural, episodic and semantic memory. Flashbulb, autobiographical and eye-witness memory; Implicit and explicit memory.

5. Reasoning and decision making: Logical, formal and natural reasoning. Decision making: Heuristics and framing decisions
6. Problem solving: Typology of problems; Newell-Simon theory; Tactics for solving problems: Problem space, means-end analysis, analogy, operators, sub- goal analysis, and working backward
Books Recommended
Anderson, J. R. (1995). *Learning and memory: An integrated approach*. New York: John Wiley.
Baddeley, A.D. (1986). *Working memory*: Oxford: Oxford University Press.
Baddeley, A. D, (1990). *Human memory: Theory and practice*. Boston: Allyn & Bacon.
Best, J. B. (1999). *Cognitive psychology* (5th Ed), Belmont, CA: Brooks/Cole.
Mattlin, M. W. (1995). *Cognition*. (Third Edition).Bangalore: Prism Books
Solso, R.L. (2004). *Cognitive psychology* (6th ed). New Delhi: Pearson Education.

PSM 202 Non-Experimental and Correlational Methods
1: Quasi- experimental designs:
    One group designs, non-equivalent control group, and time series designs.
2. Correlational designs:
    Panel design, cross-sectional and longitudinal designs.
3. Qualitative methods:
    Qualitative and quantitative perspectives;
    Collecting qualitative data: Case study, interview, observation method.
    Discourse analysis, grand narrative analysis, ethnographic methodology.
4. Concept and application of Multiple Regression Analysis (linear and stepwise),
    Factor analysis: Techniques and implications.
    Discriminant function analysis: Techniques and interpretation.
    Non-parametric statistics: Median test, Wilcoxen test, Mann- Whitney U-test, Kolmogorov-Smirnov one and two sample tests, Kruskal- Wallis H test, Kendall's coefficient of concordance.
    Friedman two-way analysis of variance.
5. Introduction to statistical analysis through computers

Books Recommended

Breakwell, G.M., Hammond, S., & Fife-Schaw, C. (2000). *Research methods in psychology* (2nd ed.).London: Sage Publications.

Broota, K. D. (1989). *Experimental designs in behavioural research*. New Delhi: Wiley Eastern.

Edwards, A. L. (1968). *Experimental designs in psychological research* (3rd edition).New Delhi: Oxford and IBH

Flick, U. (2002). *An introduction to qualitative research*. Landon: Sage Publications

Kerlinger, F.N. (1973). *Foundation of behavioural research* (2nd edition). Delhi: Sanjeet Publications.

Kopala, M. & Suzuki, L.A. (1999). *Using qualitative methods in psychology* (2nd edition). Thousand Oaks: Sage.

Siegel, S. & Castellon (1988). *Non-paramatic statistics for the behavioural sciences* (2nd edition). New York: McGraw Hill

Smith, J.A. (Ed) (2003). *Qualitative psychology: A practical guide to research methods*.London: Sage Publication

Winer, B.J., Brown D.R. & Michels, K.M. (1991). *Statistical principles in experimental designs* (3rd edition). New York: McGraw Hill

PSM 203   Psychobiology

1. Emotion: Somatic and visceral feedback, ANS and emotion, endocrine and emotion, neural mechanisms of emotion. Stress and health
2. States of consciousness: Physiological and behavioral correlates of sleep, arousal and alertness; Disorders of arousal and sleep.
3. Learning and memory: Locus of the memory trace, changes at the synapse in learning, neural structures involved in learning and memory; Biochemical basis of memory
4. Neurophysiological diseases, causes of brain damage and effects
5. Drugs and behaviour: Principles of drug action. Characteristics of psychoactive drugs: Alcohol, barbiturates, marijuana, nicotine, caffeine, cocaine, amphetamine, opiates. Neural mechanism of addiction

Books recommended:

Bloom, F.L. & Lazeron, A: (1996). *Brain mind and behaviour*: New York: Freeman & Co.

Kolb, B. & Whishaw, I.Q. (1996). *Fundamentals of human neuropsychology*. New York: W.H.Freeman & Co.

Mana, (1999). *Biopsychology*. Boston:Allyn & Bacon

Pinel P.J. (2000). *Biopsychology*. Boston: Allyn & Bacon.

Zaidel, D.W. (1994) *Neuropsychology*, New York, Academic Press.

PSM 204   Cross- Cultural Psychology

1   Culture and behaviour: Nature of culture; Cultural relativety and universality of human behaviour; Mechanism of cultural transmission.
2. Methodology of cross-cultural psychology: Comparability and equivalence; Universals, emics and etics; Sampling and measurement issues; Back translation, decentring and subsystem validation.
3. Culture and cognition: Theoretical positions, contemporary issues, cultural influences on perception, cognition, learning, memory, problem solving, reasoning and creativity; Everyday cognition.
4. Culture and emotion: Basic emotions, dimensional and componential models, subjective experiences, appraisal, physiological reaction and emotional expressions.
5. Cultural change and adaptations: Processes of enculturation and acculturation in plural societies; Acculturation strategies; Acculturation and adaptation of tribal people and refugees; Behaviour shifts and acculturative stress.
6   Cross-cultural communication: Verbal and nonverbal interactions; Communication incongruence; Deceptions, cultural display rules; Promoting intercultural interaction.

Books Recommended:

Berry, J.W, Poortinga, Y.H., Segall, M. H., & Dasen, P. R. (2002). *Cross-cultural psychology: Research and application*. New York: Cambridge University Press.

Berry, J. W. et al, (Eds). (1997). *Handbook of' cross-cultural psychology* (2nd Edition) (Vol 1-3), Boston: Allyn & Bacon.

Brislin, R. (Ed.) (1990). *Applied cross-cultural psychology*. Newbury Park: Sage

Matsumoto, D. (2001). *The handbook of culture and psychology*. New York: Cambridge University Press.

Segall, M. H., Dasen, P. R., Berry, J. W., & Poortinga, Y. H. (1999), *Human behaviour in global perspective*, Boston: Allyn & Bacon.

Triandis H.C. et al. (Eds.) (1980). *Handbook of cross-cultural psychology*, (Vol.1-6). Boston: Allyn & Bacon,

PSM 205 Practical

Any six of the following:

I. Planning of a correlational study.
2. Semantic differential technique
3. Q-sort methodology.
4. Narrative analysis.
5. Preparation of all interview schedule.
6. Case study.
7. Short term memory
8. Levels of processing
9. Episodic Memory
10. Semantic memory.
11. Formal Reasoning.
12. Problem solving.
13. Translation and back translational of a scale.
14. Achievement construct in cultural/ ethnic groups.
15. Psychological differentiation.
16. Classification of objects! pictures.
17. Acculturative stress.
18. Syllogistic reasoning.

Minor Elective

PSM 207M: Applications of Psychology in Human Life Credits: **3**

1.   Applied psychology: Nature and scope
2.   Guidance and counseling: Nature and techniques.
3.   Psychology in education: Pedagogic techniques; creativity.
4.   Mental health and well-being: Concept and indicators; techniques for improving mental health and well-being.
5.   Psychopathological problems: Neurotic and psychotic disorders.
6.   Application of psychology in social life: Prejudice and stereotypes; socially deviant behaviour: Crime and delinquency; Drug addiction.

Books Recommended:
1.   Rastogi, G. D. (1992). Vyavaharik manovigyan. Agra: Har Prasad Bhargava.
2.   Singh, A. P. (1995). Vyavaharik monovigyan. Varanasi: Abhishek publications.
3.   Anastasi, A. (1979). Fields of applied psychology. New Delhi: McGraw Hill.
4.   Goldstein, A. P., & Krasner, B. (1987). Modern applied psychology. Elmford, New York: Pergmon Press.
5.   McCormick, E.J., & Ilgen, D. (1980). Industrial psychology. Englewood Cliffs, N.J.: Prentice Hall.

Semester III

PSM 301(Compulsory) Applied Psychological Assessment

1.   Meaning and Purpose of Psychological Assessment: Principles of assessment; Ethical considerations.
2.   Developing interview schedules, questionnaires, rating scales and surveys for assessment of specific problems related to clinical, organizational and educational settings with practical exercises: Main problems in developing instruments.
3.   Administration of Instruments: Categorization, coding and scoring of data; Reliability of categories, codes and scores.
4.   Analysis of Data: Qualitative data analysis, quantitative data analysis and social statistics.
5.   Interpretation of Data: Evaluation, judgment, and biases.
6.   Research Report: Stops involved in presenting research report.

Books Recommended:

Babbie, E. (2004). *The practice of social research*. Singapore: Thomson Asia.

Ciminaro, A. R. (1984). *Handbook of behavioral assessment*. New York: Wiley.

Fowler, F.J. Jr. (2002). *Suevey research methods*. Thousands Oaks: Sage.
Henry, G.T. (1995). *Graphing data.* Newbury Park: Sage.
Holstein, J.A. & Gubrium, .F.(1995) *Active interview*. London : Sage.
Leung, F.T.L. & Austin, J.T. (1996). *The psychological research handbook*. London: Sage.
Miller, D.C. (1991). *Handbook of research design and social instrument*. London: Sage.

PSM 302 (Compulsory)   Affective Processes

1. Affective Processes: Nature and properties; Origin, development and present status.   Ethologist's contribution.
2. Motivation: Conceptual issues; Response dimension. Homeostasis.
3. Theoretical Framework: Murray and Maslow systems, intrinsic and extrinsic framework. Techniques of assessment: Unobtrusive, self- report and projective.
4. Emotion: Conceptual and theoretical issues, Differences in emotional expression, genetics, culture and personality.
5. Biological and Neurophysiological Approaches to Emotion: Emotional network in the brain, psychophysiology of emotion.
6. Emotional Intelligence: Framework, assessment and application.

Books Recommended:

Cofer, C. N. & Appley, M. H. (1964). *Motivation: Theory and research*. Delhi: Wiley   Eastern.
Lewis, M., & Haviland-Jones, J. M. (2000). *Handbook of emotions*. NewYork: Guilford   Press.
Singh, D (2003). *Emotinal intelligence at work*. New Delhi: Sage
Weiner, B. (1998). *Human motivation*. Newbury Park: Sage.

PSM 303 (Optional): Diagnostic Techniques

1. Psychodiagnostics: Nature and scope. Sources of clinical data: The assessment interview; behavioural assessment, ratings and checklists; Psychological tests. Differential diagnosis.
2. Case Study: Levels of assessment in case study and case study guide.
3. Psychological Interviewing: Structured interviewing; Intake interviewing; Mental status examination and diagnostic interviewing; Crisis interviewing.
4. Intelligence Testing; Standford–Binet: fourth edition, WAIS- III/WAIS- R scales.
5. Personality Testing: Self-report inventories-MMPI-2 and NEO PI-R. Projective tests: TAT and Rorschach with specific indicators for neuroses and schizophrenia.
6. Neuropsychological Testing: Bender-Gestalt and Wechsler Memory Scale- Revised.

Books Recommended:

Cullari, S. (Ed.) (1998). *Foundations of clinical psycholollgy*. Boston: Allyn & Bacon.
Goldenberg, H. (1983). *Contemporary clinical psychology* (2nd Ed.) New York:Brooks & cole.
Kahn, T.C. & Giffen,(1960) M.B. *Psychological techniques in diagnosis and evalution.*Oxford: Pergmon Press.
Neitzel, M.T. , Bernstein, D.A., & Millich, R. (1998). *Introduction to clinical psychology*. (5th Ed.) Upper Saddle River, N.J. : Prentice Hall.
Wolman, B.B. (1978). *Clinical diagnosis of mental disorders: A handbook*. New   York: Plenum.

PSM 303   (Optional)   Organizational Behaviour

1. Nature and Scope of Organizational Behaviour: Historical background,   approaches   challenges   and opportunities, contributing disciplines
2. Organizational Structure and   Design: Nature, organizational designs, behavioural implications of different organizational designs
3. Interactive Conflict and Negotiation skills: Intra-individual, interpersonal, inter-group conflicts, organizational conflicts, negotiation skills.
4. Leadership: Trait, behaviour, contingency, and contemporary theories, leadership styles and skills, roles and activities.
5. Power and Politics in Organizations: Bases of Power, Power tactics, Politics: Power in action, factors contributing to political behaviour.
7. Organizational Culture : Nature and types, creating and maintaining culture.

Books Recommended:

*Luthans, F. (1998).*Organizational Behaviour (8th ed*.). New York: McGraw Hill.*

Riggio, R. E. (2003). *Introduction to Industrial/Organizational Psychology* (4th   ed.). Upper Saddle River, NJ: Prentice-Hall.

Robbins, S. (2004). *Organizational Behaviour*. New York: Pearson Education.

Wexley, K.N. & Yukl, G.A. (1977*). Organizational Behavior and Personnel Psychology*. Homewood, Illinois: Irwin.

PSM 303 (Optional) Child Development

1.   Concept of Development: Principles of growth, maturation and development. Developmental stages.
2.   Determinants of Development: Biological and socio-cultural.
3.   Prenatal Development: Stages and factors affecting it.
4.   The Neonate: Physical characteristics, reflexes, sensory and motor capacities.
5.   Development During Infancy: Physical and motor development; Sensory and perceptual development; Language, emotional and social development.
6.   Development During Childhood: Cognitive, social, emotional and moral emergence of self.

Books Recommended:

Berk, L.E. (2003), *Child development*. New Delhi: Prentice Hall.

Bhutt, G.(1990). *Vikasatmak manovigyan*, Delhi: Delhi University.

Dworetzky J.P. (1984). *Introduction to child development* (2nd ed.). St. Paul: West   Publishing Co.

Hurlock, J.B.(1997). *Child psychology*. (Hindi & English Versions).

Kaluger, G.S., & Kaluger, M.F.(1984). *Human development: The span of life*, (3rd Ed.). St.. Louis: Times mirror.

Santrock, J.W.(1999). *Life-span development*, New York: McGraw Hill.

Seifert K.L. & Hoffnung R.J. (1991) *Child and adolescent development*. New   York: Houghton Mifflin Co.

Shaffer, D.R. (1996). *Developmental psychology*. California: Brooks / Cole.

PSM 303: (Optional) Comparative Psychology

1.   Methods of Comparative Psychology : Paradigms for the assessment of species common behaviors, conditioning paradigms, seminatural animal learning paradigms.
2.   Assessing the Effects of Drugs: Pharmacological considerations; Behavioral considerations.
3.   Evolution of brain and behaviour.
4.   Life-span development of the brain and behavior.
5.   Animal models of anxiety, depression and aggression.

Books Recommended:

Alcock, J.A. (2001). *Animal behavior: An evolutionary approach* (7th ed.) Sunderland, M.A: Sinauer.

Dewsbury, D.A. (1990) *Contemporary issues in comparative psychology*. Sunderland, M.A: Sinauer

Drickamer, L.C., Vessey, S.H. & Miekle, D. (1995) *Animal behavior: Mechanisms, ecology ,evolution*. New York: Mc Graw Hill Higher Education.

Finger S.(1994) *Origins of neuroscience*. New York: Oxford University Press.

Futuyma, D.J. (1998), *Evolutionary biology* (3rd ed.) Sunderland, MA: Sinauer.

Krebs, J.R. and Davies, N.B. (Eds.) (1997) *Behavioral ecology*: *An evolutionary approach*. Cambridge, MA: Blackwell Science.

Maier, R. (1997).*Comparative animal behavior : An evolutionary and ecological approach*.New York: Allyn & Bacon.

Malin, T., Birch, A., & Hayward, S.(1996). *Comparative psychology.London: MacMillan*.

Mellgren, R.L. (1983) *Animal cognition and behavior*. Amsterdam: North-Holland   Publishing Co.

Plomin, R.(1990) *Nature and nurture : An introduction to human behavioral genetics*.
Pacific Grove, CA: Brooks /Cole.
Shettleworth, S.A. (1998), *Cognition, evolution and behaviour*. New York: Oxford   University
Press.
Trivers, R.L. (1985). *Social evolution*. New York :Benjamin Cummings Publishing Co.

PSM 304 (Optional) : Psychopathology

1. Classification Systems in Psychopathology: Early diagnostic classification systems. ICD 10, DSM -IV
2. Approaches to Psychopathology: Biological, psychodynamic, behavioral,
     cognitive, socio-cultural.
3. Anxiety Disorders: Approaches and etiology of generalized and anxiety disorder,   panic   disorder,
     phobia   obsessive-compulsive disorder and post-   traumatic stress disorders.
4. Somatoform Disorders: Approaches and etiology of somatization, hypochondriasis, pain disorder and
     conversion disorder.
5. Psychotic Disorders: Approaches and etiology of schizophrenia, paranoid and mood disorders.
6. Cognitive Impairments: Approaches and etiology of delirium, dementia and amnestic syndromes,
     Dementia of the Alzheimer's type, presenile dementia, Pick's disease, Huntington's chorea.

Books Recommended:

Barlow, D.H. & Durand, V.M. (1999). *Abnormal psychology: An integrative
approach(2nd Ed.)*. Pacific Grove: Brooks/Cole.
Buss. A.H. (1999). *Psychopathology*. New York :John Wiley.
Carson, R.C., Butcher, J.N., & Mineka, S.(2001) *Abnormal psychology in   modern life*
(11Ed). New York. Allyn and Bacon
Davison, G.C. & Neals J.M. (1996) *Abnormal psychology* (Revised Ed.). New   York: John
Wiley.
Kaplan, H.I., Saddock, B.J. & Gribb, J.A. (1994) *Synopsis of psychiatry*. New   Delhi. B.I
Waruly.
Lamm. A.(1997). *Introduction to psychopathology*. New York : Sage.
Sue, R., Sue., D., & Sue, S (1990). *Understanding abnormal behavior*. Boston: Houghton
Mifflin.

PSM 304 (Optional) Stress Management

1. Organizational Stress**:** Concept- different perspectives, symptoms, individual factors influencing job
    stress.

2. Causes of Job Stress**:** Personal characteristics, organizational structure and change, properties of work and
    work setting, job role, machine pacing and shift work.

3. Consequences of Job Stress**:** Job behaviour, job satisfaction, performance, absenteeism; health strains-
    physical illness, mental/ psychological symptoms.

4. Stress Management Interventions**:** Individual centred- cognitive, behavioural, physical. Organization
    centred-preventing, mitigating and moderating organizational stressors.

5. Coping with Stress**:** Types of coping strategies

6. Therapeutic Approaches to Stress Management **:** Hypnosuggestive, philosophical hypnosis, self talk,
    music therapy.

Books Recommended:

Mattson, M.T. & Ivanevich, J.M. (1987) *Controlling work stress- Effective resources   and   management
       strategies*.
Pestonjee, D.M. (1992) *Stress and coping*. New Delhi: Sage Publications,.

Ross, R. R. & Altmair, E.M. (1994). *Interventions in occupational stress*. New Delhi: Sage Publications
Srivastava, A.K. (1999) *Management of occupational stress: Theories and practice.*   New   Delhi: Gyan
     Publishing House

PSM 304 (Optional) Child Psychopathology

1.   Childhood Psychopathology: Historical overview. Models: Medical, behavioural, psychodynamic, cognitive, and developmental.
2.   Approaches to Classification: Descriptive-behavioural, descriptive-inferential, dynamic-etiological, DSM-IV.
3.   Specific Disorders in Children: Attention deficit hyperactivity disorder, learning disability and mental retardation: Symptoms and causes.
4.   Neurotic Disorders: Childhood compulsive, obsessive and phobic reactions.
5.   Childhood Psychosis: Autism and childhood schizophrenia: Symptoms and causes.
6.   Mood Disorders: Depression and mania: Symptoms and causes

Books Recommended:

Clarizio, H.F.& McCoy, G.F. (1983) *Behavior disorder in children*. New York: Harper &   Row.
Karkar, S. (1981) *The inner world: A psycho-analytic study of childhood and society in   India*. Delhi: Oxford
     University Press.
Mash, E.J. & Barkly, R.A. (Eds.) (1996) *Chlid psychology*. New York: Guilford Press.
Quay, H.L. & Werry, J.S. (Eds.) (1986) *Psychological disorders of childhood.* New   York: John Wiley.
Weiner, I.B. (1982) *Child and adolescent psychopathology*. New York: John Wiley.
Wenar, C. (1982) *Psychopathology from infancy through adolescence: A developmental   Approach*. New York: Random House.

PSM 304 (Optional) Psychopharmacology

1.   Determinants of Drug Effect: Absorption, distribution, and termination of drug effects
2.   Responsiveness to Drugs: Organismic variables, drug variables, environmental variables, and task variables.
3.   Classification of psychoactive drugs and their effects.
4.   Psychopharmacological methods of studying the nervous system.
5.   Biopsychological paradigms of animal and human behavior.
6.   Nature and functioning of neurotransmitters and neuropeptides in the brain.

Books Recommended:

Carlson, N.R.(2000*). Physiology of behavior* . Boston: Allyn and Bacon.
Cooper, J.R., Bloom,F.E. & Roth, R.H. (2002*). The biochemical basis of neuropharmacology*. London: Oxford
     University Press.
Julien, R.J. (2000). *A primer of drug action* (7th ed.) New York: Freeman
Leavitt, F.(1982). *Drugs and behavior*. New York : John Wiley & Sons.
Marangell, L.B., Martinez, J.M., Silver, J.M., & Yudofsky, S.C. (2002) *Conciseguide to psychopharmacology*
     New York: American Psychiatric Association.
McKim, W.A. (1986). *Drugs and behavior : An introduction to behavioral pharmacology* . Englewood Cliffs,
     N.J.: Prentice –Hall.
Pies, R.W. (1998). *Handbook of essential psychopharmacology*. New York: American Psychiatric Association.
Pinel, P.J. (2000) *Biopsychology*. Boston : Allyn and Bacon.
Seiden, L.S. & Blaster, R.L. (1985). *Behavior pharmacology: The current status*. New York : Arliss.
Zaidel, D.W. (1994). *Neuropsychology*. New York : Academic Press.

PSM 305 (a) Practicals

Applied Psychological Assessment
(Any two of the following)
1.   Construction of Interview schedules

2. Construction of Questionnaires
3. Construction of Rating Scales
4. Conduct of Surveys

Affective Processes
(Any two of the following)
1. Extrinsic motivation and performance
2. Intrinsic motivation and performance
3. Feedback and performance
4. Assessment of emotional intelligence

Diagnostic Testing
(Any one of the following)

1. Rorschach Test (1 normal and 1 psychopathological case)
2. T.A.T. (1 normal and 1 psychopathological case)
3. NEOPIR (1 normal and 1 psychopathological case)
4. Case studies (1 normal and 1 pathological case)

Organizational Behaviour
(Any one of the following)
1. Conflict resolution
2. Job involvement
3. Leadership/supervision
4. Functional Social Support

Child Development
(Any one of the following)
1. Raven's Progressive Matrices.
2. Psychomotor learning.
3. Emotional control.
4. Gessell's / Bailey's scale for assessment of growth in infants.

Comparative Psychology
(Any one of the following)
1. Maze- learning
2. Reasoning behaviour
3. Discrimination learning
4. Level of activity

Psychopathology
(Any one of the following)

1. Rorschach /T.A.T. / S.I.S (1 normal & 1 psychopathological case)
2. Measurement of Neuroticism (2 cases)
3. Measurement of Psychotic Traits (2 cases)
4. DSM IV Diagnostic Criteria (2 cases)

Stress Management
(Any one of the following)
1. Assessment of stress (questionnaire)
2. Coping strategies
3. Functional Job stress
4. Stress Resistant (Cognitive, Behavioural)

Child Psychopathology
(Any one of the following)
1. Study of ADHD (1 case)

2. DSM -IV Diagnostic criteria for children (2 cases)
3. Childhood depression (2 cases)
4. Assessment of Mental Retardation using Form Boards/ Bender- Gestalt test.

Psychopharmacology
(Any one of the following)

1. Effects of drugs on exploratory behaviour in albino rats.
2. Effects of drugs on simple learning in albino rats.
3. Effects of drugs in Staircase test.
4. Effects of drugs in elevated T-maze test.

PSM 305 (b) Comprehensive Viva- Voce

Minor Elective

PSM 306M: Stress Management   Credits: 3
1. Stress: Nature of stress, physiology of stress, stress affects on human conditions.
2. Physiological, somatic, psychological and behavioural effects of stress.
3. The factors contributing to stress reactions; environmental factors and living conditions; and job-related stress.
4. Coping strategies
5. Constructive stress management: Controlling stressors; proactivity; the importance of awareness (self-monitoring); interpretation and perception.
6. Stress management techniques: Somatic, behavioural and cognitive.

Books Recommended:
1. Gluch, P. (2005). Stress management (2nd edition). Costa Mesa, CA: Psynergy Publication.
2. Greenberg, J. S. (2006). Comprehensive stress management (10th edition). New York: McGraw Hill.
3. Olpin, M, & Hesson, M. (2007). Stress management for life: A research base experiential approach. Belmont, CA: Thomson Learning.
4. Pestonjee, D. M. (1992). Stress and coping. New Delhi: Sage Publications.
5. Ross, R. R., & Altmair, E. M. (1994). Interventions in occupational stress. New Delhi: Sage Publications.
6. Srivastava, A. K. (1999) Management of occupational stress: Theories and practice. New Delhi: Gyan Publishing House.

PSM 401 (Optional) Therapeutic Techniques

1. Nature and techniques of psychotherapy: The client- therapist relationship; Ethical issues.
2. Psychopharmacological therapy: Overview of major psychotropic drug classes.
3. Psychodynamic therapy: Freudian psychoanalysis
4. Behavior therapy: Guided exposure, systematic desensitization, eye movement desensitization and reprocessing, aversion therapy, assertion training, modelling, biofeedback.
5. Cognitive behaviour therapy: Beck's cognitive therapy, rational emotive behaviour therapy.
6. Humanistic-experiential therapy: Person-centred therapy, gestalt therapy, existential therapy, transactional analysis.
7. Interpersonal relationship therapy: Marital and family systems therapy.

Books Recommended:
Corey, G. (2001). *Theory and practice of counselling and psychotherapy*. (6th ed.) Belmont, C.A: Brooks/Cole.
Culari, S. (1998) (Ed.) *Foundations of clinical psychology*. New York: Allyn & Bacon.
Goldenberg, H. (1983) *Contemporary clinical psychology* (2nd ed.). New York: Brooks /Cole
Hersen, M, & Sledge, E. (2002) (Eds.). *Encyclopedia of psychotherapy*. (TwoVolumes). New York: Academic.
Neitzel, M.T., Bernstein, D.A. & Millich, R. (1998) *Introduction to clinical psychology* (5th ed.) Upper Saddle River, New Jersy: Prentice Hall.

PSM 401(Optional) Human Resource Management

1. Fundamentals of HRM: Foundation, nature, scope and importance. HRM in changing environment.
2. Acquisition of human resources: Planning, assessment, job analysis, recruiting, selection process.
3. Training and development: Socialization process, determining training needs, management development.
4. Performance appraisal: Performance management system, appraisal process, methods, creating effective personnel management system.
5. Motivation and reward management: Theoretical perspectives, job design, work scheduling, types of reward, establishing pay structure, compensation and benefits.
6. Labour relations: Labour-management relations, unionism, collective bargaining.

Books Recommended:

Beardwell, I & Holden, L. (1996). *Human resource management: A contemporaryperspective.* New Delhi: Macmillan India Ltd.

Bhatia, S.K., & Singh, N. (2000). *Principal techniques of personnel management/ human resource management*(2nd ed). New Delhi: Deep & Deep Publications Pvt. .Ltd.

DeCenzo, D.A., & Robbins, S.P.(1999) *Human resource management*(6th ed.). New York: John Wiley.

Dwivedi, R.S. (1997) *Managing human resources: Personnel management in Indian enterprises*. New Delhi: Galgotia Publishing Company.

Hersey, P. Blanchard, K.H. & Johnson, D.E. (1996) *Management of organizational behavior*: *Utilizing human resource* (7th ed.). New Delhi: Prentice Hall of India Pvt.Ltd.

PSM 401 (Optional) : Psychology of Adolescence

1. Concepts of puberty and adolescence; Developmental tasks during adolescence.
2. Physical changes during early, mid and late adolescence. Perception and reaction to physical changes.
3. Cognitive and moral development: Piaget's, Kohlberg's and Loevinger's models.
4. Social development: Achieving independence from parents. Parent- peer conflicts and development of relationships.
5. Personality development: Identity formation and emotional characteristics.
6. Stressors and problems of adolescence: Suicidal behaviour, drug abuse, teenage parenthood, juvenile delinquency.

Books Recommended:

Berk, L.E. (2003*). Child development*. New Delhi: Prentice Hall.

Berzonsky, M. D. (1981). *Adolescent development*. New York: Macmillan.

Chauhan, S.S. (1983). *Psychology of adolescence*. New Delhi: Allied.

Dworetzky, J.P. (1984). *Introduction to child development.*St. Paul: West Publishing Company.

Kaluger, G., & Kaluger, M.F. (1984). *Human development: The span of life*. St. Louis: Times Mirror.

Rice, F.P. (1993). *The adolescent: Development relationships and culture* (7th ed.). Boston: Allyn and Bacon.

Seifert, K.L., & Hoffnung, R.J. (1991). *Child and adolescent development* (2nd ed.). NewYark: Houghton & Mifflin Co.

Shaffer, D.R. (1996). *Developmental psychology and adolescence* (4thed.). California: Brooks & Cole.

Verma, S. & Saraswati, T.S. (2002). *Adolescence in India: An annotated bibliography*. Jaipur: Rawat Publication.

PSM 402 (Optional) Neuropsychology

1. Assumptions, Methods; Functional modularity, anatomical, functional architecture, and substractivity.
2. Organization of the Brain: Cerebral cortex and its lobes; Hemispheres and related structures.
3. Cognitive Neuropsychology: Neurological basis of attention and consciousness; vigilance and cortical arousal.
4. Measurement of Brain Activity: EEG, QEEG, ERP; CT Scan, MRI, PET, fMRI; Neurological assessment (Luria Nebraska Neurological Battery, Halstead-Reitan Test).

5. Neurological Disorders: Vascular disorders; traumatic head injury; epilepsies; tumors; degenerative disorders; Prion Disease.
6. Abnormal Lobular Functions: Frontal lobe syndrome; Temporal lobe syndrome; Parietal and Occipital lobe syndrome.

Books Recommended:

Beatty, J. (2001). *The human brain: Essentials of behavioral neuroscience.*Thousand Oaks: Sage Publication, Inc.

Boller, F., & Grafman, J. (1998). *Handbook of neuropsychology.* New York: Elsevier.

Chalupa, L.M. & Werner, J.S. (2004). *The visual neurosciences.* London: MIT Press

Gazzaniga, M.S. (2002). *Cognitive neuroscience: The biology of mind* (2nd Ed.). New York: W.W. Norton and Company.

Kolb, B., Whisaw, I.Q. (1990). *Fundamentals of neuropsychology.* New York: Freeman, W.H.

Naatanen, R. (1992). *Attention and brain function.* Hillsdale: LEA

Parsuraman, R. (1998). *Attentive brain.* London: MIT Press.

Rapp, B. (Ed.) (2001). *The handbook of cognitive neuropsychology.* Chestnut Street: Psychology Press.

Paper S4:02(Optional) Organizational Development and Change

1. Introduction to organizational development: Nature and characteristics, historical development; Process of management of change.
2. Management of organizational development: Foundations, process and action research.
3. Organizational development interventions: Team, third-party, comprehensive, structural interventions, and training experiences.
4. Management of change: Organizational structure, organizational culture, employee relations and involvement strategies.
5. Evaluating change and future of organizational development.

Books Recommended:

Bennis, W.C. (1969) *Organization development: Its nature, origins, and prospects.* Reading, MA: Addison-Wesley

Colenso, M. (2001) *Successful organizational change: Evolution and revolution in the organization.* New York: Prentice Hall.

French, W. L. & Bell, C. H. (1995). *Organization development.* New York: Prentice Hall. McGill, M. E. *Organization development for operating managers.*

Nilakant, V. & Ramanarayan, S. (1998). *Change management.* New Delhi: Response Books.

Ramnarayan, S., Rao, T.V. and Singh, K. (1998). *Organization development: Interventions and strategies.* New Delhi: Response Books.

Thornhill, A., Lewis, P. Millmore, M., & Saunders, M. (2000), *Managing Change: A human resource strategy approach.* New York: Pearson Education.

S4:02 (Optional) Psychology of Adulthood and Aging

1. Concept, characteristic features and developmental tasks of adulthood and aging; Aging in India.
2. Theoretical approaches: Biological: Genetic, cellular and physiological; Psychological: Erikson and Peck; Social: Role theory, activity vs. disengagement theory; Indian theory of Ashramas.
3. Changes and coping with changes in adulthood and aging: Physical aspects, cognitive functions, personality and concept of self, social aspects.
4. Significant concerns in adulthood: Choosing a career, marriage, family, successful parenting, coping with midlife crisis, work and pre-retirement planning.
5. Significant concerns for aging persons: Retirement, living arrangement, grand parenting, coping with bereavement and death, and loneliness.

6. Factors leading to positive mental health in adulthood, longevity and successful aging.

Books Recommended:
Birren, J.E. (1996). *Encyclopedia of gerontology (Vol I & II)*. California: Academic Press
Botwinick, J. (1973). *Aging and behaviour*. New York: Springer Publication Co.
Hurlock, J.B. (1997). *Developmental psychology-The life span perspective* . New York: McGraw Hill Co.
Kaluger, G., & Kaluger, M.F. (1984). *Human development-The span of life*. St. Louis: Times Mirror.
Palmore, B.E. (1993). *Developments and research on aging: An international handbook*. Westport: Greenwood Press.
Rao, V.A. (1989). *Psychology of old age in India*. Madras: MacMillan India Press.

PSM 403 (Optional) Psychology of Personality

1. Personality: Concept and scope; Basic issues related to study of personality.
2. Trait and type approaches : Allport, Cattell, Eysenck and five factors model.
3. Psychodynamic and psychosocial approaches : Freud and Erikson
4. Behaviouristic and social learning approaches: Skinner, Bandura and Mischel.
5. Humanistic and phenomenological approaches: Rogers and Kelly.
6. Determinants of Personality: Biological-physiological and genetic; Environmental –socialization, society and culture.

Books Recommended:
Friedman, H.S. & Schustack, M.W. (2003). *Personality: Classic theory and modern research* (2nd ed.) Singapore: Pearson Education.
Hall, G.C., Lindzey, G., & Campbell, J.C. (1998). *Theories of personality*, (4th ed.). New York: Wiley.
Hjelle, L.A. & Zeigler, D.J. (1991). *Personality theories: Basic assumptions, research and applications*. (2nd ed.) New York: McGraw Hill.
Mischel, W. (1976). *Introduction to personality*. New York: Holt Reinhart & Winston.
Pervin, A. (1984). *Personality:Theory and research*. New York: John Wiley & Sons.

PSM 403(Optional) Psychology of Rehabilitation
1. Introduction : Definition, nature and rationale of rehabilitation.
2. Impairment and disability. Incidence and prevalence of various disabilities..
3. Assessment of Disabilities: Basic principles of assessment and evaluation. Types of assessment- norm based, criterion based and function based, Psychological tests as screening and assessment tools.
4. Rehabilitation Techniques: Basic principles of intervention, types of intervention-individual, group and family based. Vocational counselling, behavioural therapeutic approaches in rehabilitation.
5. Perspectives of rehabilitation services: Settings and agencies involved in rehabilitation services.
6. Government schemes and policies for rehabilitation: The role of NGOs. Legislation and legal aspects, policies and acts. Ethical issues in rehabilitation.

Books Recommended:
Advani, S.L., Ghate, P. Goel, H.C., & Reddy, V.R.L. (2002). *Foundation course on education of children with disability*. Hyderabad: G.Guru Publications
Kundu, C.L. (2000). *Status of disability in India*. New Delhi: Rehabilitation Council of India.
Narain, J & Kutty, A.C. T (1990). Skill *training for M R persons*. Hyderabad:J.S. Graphics.
Peshawaria, R. (1994). *Moving forward*. Hyderabad: J.S. Graphics.
Stromer, D.C.& Prout (1995) (Eds.). *Counselling and psychotherapy for persons with mental retardation and borderline intelligence*. Vermont: Clinical Psychology Publishing Co.
Verma, L. (1990). *The management of children with emotional and behavioural   difficulties*. London: Routledge.

PSM 403 (Optional) Organizational Communication

1. Conceptual framework: Meaning and process of communication, models and perspectives of communication in organizations. ethical Issues.

2. Communication within oganizational structures: Structural issues, direction of communication flow, communication barriers, communication networks, external communication.
3. Interpersonal communication: Interpersonal communication in formal relationships- needs perspective, transactional analysis, johari window; Role of symbols, media and information technology, choosing among media.
4. Non-verbal communication: Dimensions and functions of non-verbal communication, cultural differences in nonverbal communication.
5. Communication in groups: Group structure and communication networks, developing effective work groups, models of communication in group decision making.
6. Communication for organizational effectiveness: Persuasion and influence, counselling, listening, orientation and feedback, conducting effective interviews, effective oral presentations, forms of written communication.

Books Recommended:

Andrews, P.H. & Herschel, R.T. (1997) *Organizational communication*. (1st ed.). New Delhi: A.I.T.B.S. Publishers
Fisher, D. (2003*) Communication in organizations*(2nd ed.). Bombay: Jaico Books
Lesikar, R.V. & Pettit, J.D. (1998) *Business communication: Theory and applications. (6th ed.)*. IIinois: Richard D. Irwin Inc:

PSM 403 (Optional) Psychology of Sports

1. History and current status of Sports Psychology.
2. Growth and Development of Sports Persons – Concept of growth and development. Critical periods. Stages of psychomotor development of the athlete.
3. Cognitive Processes in Sports: Attention, perception, decision making.
4. Motivation in Sports: Motivational techniques. Emotions and Sports performance: Stress, anxiety and arousal and aggression in sports.
5. Personality and Sports – Personality traits of outstanding sports persons.
6. Psychosocial Dimensions of Sports: Sports as a social experience. Concept of team cohesiveness. Leadership and communication in Sports team. The role of sports psychologist. Spectators & Sports – Kinds and roles of spectators.

Books Recommeded:

Arnold, D.L.U. & Nation, J.R. (1989) *Sports psychology*. Chicago: Nalson-Hall
Cratty, B.J. (1989), *Psychology in contemporary sports*. N. J. Prentice Hall.
Horn, T.S. (Ed) (1992), *Advances in sports psychology*, Canada: Herman Kinetics.
Mohan, J. (1996), *Recent advances in sports psychology*: New Delhi: Friends.
Murphy, E. (1995), *Advances in sports psychology*, Illinois: Human Kinetics.
Murphy, S.M. (1995) *Sports psychological interventions*. Champaign: Herman   Kinetics.
Sandhu, G.S. (1992) *Psychology in sports: A contemporary perspective*, New   Delhi: Friends.
Sahani, S.P. (2001) *Handbook of sports psychology*.

PSM 404 (Optional) Health Psychology

1. Concept of health: Indicators; Medical and bio-psycho-social models of health; Cross–cultural perspectives on health; Main issues of health psychology and its social concerns.
2. Social environment and health: Global health trends; Health care systems, socio-economic factors in health; Gender and health.
3. Images of health: General and chronic health problems; Causal explanations and oral discourse; Health belief systems and models; Western and non-western perspectives on health.
4. Stress and coping: Stress as stimulus and response; Interaction model of stress; Stress born health problems.
5. Factors in health: Food, alcohol and drug consumption, smoking and sexual behaviours.
6. Management of health problems; Preventive, promotive and curative aspects of health; Choice of medicinal systems and patient-doctor relationship. Changing health behaviour.

Books Recommended:

Baum, A., Gatchel, R.J., & Krantz, D.S. (1997). *An introduction to health psychology*. New York: McGraw Hill.

Baum, A., Revenson, T.A., & Singer, J.E. (2001). *Handbook of health psychology*. Mahwah, N.J.: Lawrence Erlbaum.

Dimatteo, M.R. & Martin, L.R. (2002). *Health psychology*. Boston: Allyn & Bacon.

Marks, D., Murray, M., Evans, B., & Willig, C. (2000). *Health psychology : Theory,research and practice*. New Delhi: Sage.

Radley , M. (1994). *Health psychology: Bio-psycho-social interaction* . New York: John Wiley

Taylor, S.E. (1994). *Health psychology*. New York: Random House.

PSM 404 (Optional): Drugs and Behaviour

1. Pharmacology of learning & memory: The neurotransmitter systems, memory molecules and drug effects.
2. Aggression: Animal models of aggression. Influence of hormones and drugs in animals and human.
3. Sleep disorder and pharmacological treatment: Insomnia, hypersomnia and parasomnia.
4. Human and Nonhuman Sexual and reproductive functioning: Hormones and drugs effects.
5. Psychopharmacotherapy: Drug treatment of schizophrenia, depression, mania, anxiety and hyperkinetic behaviour.

Books Recommended:

Bloom, F.E. and Kupfer, D.(eds.). (1995) *Psychopharmacology: The fourth generation of progress*.New York : Raven.

Cooper, J.R., Bloom, F.E. and Roth, R.H. (1996). *The biochemical basis of neuropharmacology* (7th ed.) New York : Oxford University Press.

Feldman, R.S., Meyer, J.S. and Quenzer, L.F. (1997). *Principles of neuropsychopharmacology*. Sunderland, MA : Sinauer.

Gazzaniga, M.S. (2000). *The new cognitive neurosciences*.

Gorman, J.M. (1995). *The essential guide to psychiatric drugs*. St. Martin's Press.

Julien, R.J. (2000). *A primer of drug action* (9th ed.) New York: Freeman.

Kolb, B. and Whishaw, I.Q. (1996). *Fundamentals of human neuropsychology*. New York: W.H. Freeman & Co.

Rosenzweig, M.R., Breedlove, S.M., & Leiman, A.L. (2002). *Biological psychology*. Sunderland, MS: Sinauer Associates.

Spinella, M.(2001) *The psychopharmacology of herbal medicine: Plant drugs that alter mind, brain and behavior*. MIT Press.

Stahl, S.M. and Munter, N. (2000) *Essential psychopharmacology*: *Neuroscientific basis and practical applications*. Cambridge, England: Cambridge University Press.

PSM 404 (Optional): Counselling

1. Counselling: Historical perspective; Definitional models: Educational developmental and preventive; Ethical issues in counselling.
2. Expectations and goals of counselling: Characteristics of counselee and counselors; Role and functions of the counselors.
3. Counselling approaches: Affectively oriented approaches: psychoanalytic, person-centred and existential; Cognitively oriented approaches: Eclectic and behavioural.
4. Counselling process: External conditions and preparation; Structuring the counselling relationship; Counselling interview and degrees of lead by the counsellor, nonverbal behaviour; Group counselling approaches.
5. Areas of counselling: Educational, career, family and marital, gerontological and weaker sections; Stress management oriented counselling.
6. Evaluation of counselling: Nature and purpose, steps in evaluation, and outcome research.

Books Recommended:

Gelso, C.J., & Fretz, B.R. (1995) *Counselling psychology*. Bangalore: Prism Books Pvt. Ltd.

Locke, D.C.,Myers, J.E., & Herr, E.L.(eds.) (2001) *The handbook of Counselling*. Thousands Oaks, CA: Sage Publication Inc.

Patri, V.R. (2001) *Conselling psychology*. New Delhi: Authors Press.

Rao, S.N. (1991). *Counselling and guidance* (2nd ed.). New Delhi: McGraw Hill.

Shertzer, B. & Stone, S.C. (1968). *Fundamentals of counselling*. New York: Houghton Mifflin.

Woolfe, R., Dryden, W., & Strawbridge, S.(eds.) (2003) *Handbook of counselling psychology* (2nd ed.) London: Sage Publication Ltd.

PSM 404 (Optional) Human Factors

1. Human Factors: Definition, historical overview, models of human information processing, person-computer interface; video display terminal, interface design, and on-line help.
2. Human interaction with automation in various contexts: Automation definition, aircraft piloting, air-traffic control, automobiles and highway systems.
3. Human error: The man-machine interface: Approaches to human error, errors and accidents, error proneness and accident liability.
4. Human factors and health care: The promise of human factors in the medical devices, designing of WWW for older adults.
5. Human Performance in relation to automation: Monitoring performance, trust, situation awareness, mental workload.

Books Recommended :
Matthews, G., Davies, D.R., Westerman, S. J., &. Stammers, R. B.(2000). *Human performance.* Sussex, UK: Psychology Press.

Nickerson, R.S. (1992). *Looking ahead: Human factors challenges in a changing world*.   Hillsdale: LEA.

Senders, J. W., & Moray, N. P. (1991). *Human error: cause, prediction, and reduction*.   Hillsdale: LEA.

Sheridan, T. B. (2002). *Humans and automation*. CA: John Wiley

Singh, I.L., & Parasuraman, R. (1998) *Human cognition*. New Delhi: Sage Publications

PSM 405 (a) Practicals
Therapeutic Techniques
(Any one of the following)
1. Preparing hierarchy for systematic desensitization (1 case)
2. Biofeedback   (1 case)
3. Transactional analysis –Script analysis
4. Geslalt therapy- Role playing

Human Resource Management
(Any one of the following)
1. Performance appraisal
2. Job analysis/Job evalution
3. Work motivation
4. Unionism

Psychology of Adolescence
(Any one of the following)
1. Self esteem
2. Moral development
3. Assessment of stress
4. Emotional maturity

Neuropsychology
(Any one of the following)
1. Cortical arousal and vigilance performance
2. Heart rate variability (HRV) and performance
3. Hemispheric specialization and performance
4. Assessment of brain activity by Luria Nebraska

Organizational Development and Change
(Any one of the following)
1. Organizational climate
2. Psychological participation

3.   Personal efficacy scale
4.   Organizational culture

Psychology of Adulthood and Ageing

(Any one of the following)
1.   Parenting style among adults
2.   Self concept among adults.
3.   Adjustment / life satisfaction among elderly
4.   STM vs LTM process among elderly.

Personality

(Any one of the following)
1.   Personality assessment using any projective test
2.   Semantic differential
3.   NEO P I –R test
4.   T.P.P.S/16 P.F

Psychology of Rehabilitation

(Any one of the following)
1.   Assessment of social anxiety in orthopedically challenged persons. (1 case)
2.   Assessment of self-esteem in visually challenged (1 case)
3.   Assessment of paranoid thought content in hearing impaired (1 case)
4.   Family based intervention (1 case)

Organizational Communication

(Any one of the following)
1.   Transactional analysis
2.   Interviewing
3.   Communication patterns in public/ private sector
4.   Listening orientation

Psychology of Sports

(Any one of the following)
1.   Sports competitive anxiety test
2.   Biofeedback
3.   Reaction time/design making time
4.   Personality test

Health Psychology

(Any one of the following)
1.   Socio-economic factors and health
2.   Gender and health
3.   Psychological correlates of health
4.   Drug/ smoking and health problems/Pathogenic health habits

Drugs and Behaviour

(Any one of the following)
1.   Effects of drugs on elevated plus-maze test in albino rats.
2.   Effects of drugs on discrimination learning in albino rats.
3.   Effects of drugs on anxiety in albino rats.
4.   Effects of drugs on acquired-fear in albino rats.

Counselling

(Any one of the following)
1.   Conducting counselling interviews (2 cases)
2.   Educational counselling at secondary level (1 case)
3.   Assessment of career related stress (2 cases)
4.   Group counselling in school setting.

Human Factors

(Any one of the following)
1.   Vigilance and monitoring performance
2.   Workload and human performance
3.   Automation reliability and performance
4.   Person- computer interface

S4:05 (b) Comprehensive Viva- Voce

M.Sc. STATISTICS
Department of Statistics
Banaras Hindu University

FOUR SEMESTER POST - GRADUATE COURSE

STATISTICS

1. The Post Graduate Course in STATISTICS shall be Two – Year Degree Course comprising of FOUR SEMESTERS (Two Semesters in each year). The total credits including all the four semesters will be 90 including Minor Elective Papers.

2. There shall be sessionals / tutorials / class tests / seminars in class / group discussions in each theory and practical paper (Core Courses, Major and Minor Elective papers) except Paper No. STM - 417 : Project Work – II in Semester – IV.

3. Each theory paper, irrespective of their nature and credits shall be of 100 marks out of which 70 marks shall be assigned to the end semester theory examination and 30 marks to the sessionals / tutorials / class tests / seminars in class / group discussions.

4. The Theory papers shall be of THREE HOURS duration consisting of Eight full length questions in all out of which a student will be required to answer any five questions.

5. Each Practical paper will be of 100 marks out of which 30 marks will be assigned on sessionals / tutorials / class tests / seminars in class / group discussions and 70 marks will be assigned on the end semester examination out of which 50 marks will be on the performance in practical examination and 10 marks will be assigned each on practical record book and viva – voce .

6. All the practical papers shall be of FOUR HOURS duration.

7. In the paper " Research Methodology and Project Work – I" (Paper No. STM - 303) in Semester – III, there will be a theory paper of 70 marks and the rest 30 marks will be assigned to the preparation of project proposal, discussion and its presentation.

8. In semester – IV, the Project Work – II (Paper No. STM - 417) will be spread over the whole semester. A project may be undertaken by a group of students. However, the project report shall be submitted by each member of the group separately. A project report shall clearly state the problem addressed, the methodology adopted, the assumptions and the hypotheses formulated, any previous reference to the study undertaken, statistical analyses performed and the broad conclusion drawn. There shall be an external examiner and an internal examiner (preferably the supervisor of the student) for the evaluation of the project work. Out of total 100 marks assigned to the project, 60 marks will be assigned on the evaluation of the project work separately by both the examiners and 40 marks will be assigned jointly by the examiners on the oral presentation and viva – voce.

9. If a student offers four major elective papers from the same module, he/she will be certified to have specialized in that module.

10. The three MINOR ELECTIVE THEORY papers (one in each of the semesters – I , II and III) will be offered by the students of other departments of the faculty, who are not pursuing Post – Graduation in Statistics.

Semesterwise distribution of Courses and Credits

SEMESTER - I

Course Code	Title	Credit
STM – 101	Real Analysis, Complex Analysis and Linear Algebra	3
STM – 102	Distribution Theory	4
STM – 103	Statistical Inference - I	4
STM – 104	Statistical Computing	4
STM – 105	Practical Paper based on the contents of Papers STM – 103 and STM - 104	3
STM106M	Statistical Methods (Minor Elective for students of other programmes) *	3
	Total	**21**

SEMESTER - II

STM – 201	Survey Sampling	3
STM – 202	Linear Models and Regression Analysis	3
STM – 203	Statistical Inference – II	3
STM – 204	Stochastic Processes	3
STM – 205	Probability	3
STM – 206	Practical Paper based on the contents of Papers STM – 201 and STM - 203	2
STM – 207	Practical Paper based on the contents of Papers STM – 202 and STM - 204	2
STM 208M	Sampling Theory, Design of Experiments and Data Analysis Using Softwares (Minor Elective for students of other programmes) *	3
	Total	**22**

SEMESTER - III

STM– 301	Multivariate Analysis	3
STM – 302	Design and Analysis of Experiments	3
STM – 303	Research Methodology and Project Work – I	2
Any THREE papers out of the Paper Nos. STM – 304 to STM - 308		
STM – 304	Statistical Decision Theory	3
STM – 305	Advanced Operations Research - I	3
STM – 306	Survival Analysis	3
STM – 307	Computer Intensive Statistical Methods - I	3
STM – 308	Time Series Analysis	3
STM – 309	Practical Paper based on the contents of Papers STM – 301, STM – 302 and selected Major Elective Papers	4
STM308M	Data Analysis Using Regression Models (Minor Elective for students of other programmes) *	3
	Total	**24**

   * Students of Statistics shall offer Minor Electives from other programmes.

SEMESTER - IV

Course Code	Title	Credit
Any SIX papers out of the Paper Nos. STM – 401 to STM – 415		
STM – 401	Bayesian Inference	3
STM – 402	Non – Parametric and Semi – Parametric Methods	3
STM – 403	Applied Regression Analysis	3
STM – 404	Reliability Theory	3
STM – 405	Advanced Operations Research – II	3
STM – 406	Statistical Processes and Quality Control	3
STM – 407	Demography	3
STM – 408	Quantitative Epidemiology	3
STM – 409	Clinical Trials	3
STM – 410	Computer Intensive Statistical Methods – II	3
STM – 411	Computer Programming	3
STM – 412	Statistical Pattern Recognition	3
STM – 413	Econometrics	3
STM – 414	Actuarial Statistics	3

STM – 415	Official Statistics	3
STM – 416	Practical Paper based on the contents of selected Elective papers	3
STM – 417	Project Work – II	2
	Total	**23**
	GRAND TOTAL	**90**

The optional Papers of III and IV Semesters are divided into following five groups :
GROUP A : ADVANCED STATISTICAL ANALYSIS

Major Electives
Paper No.   Title of the Paper
STM - 304   : Statistical Decision Theory
STM – 401   : Bayesian Inference
STM – 402   : Non - Parametric and Semi - Parametric Methods
STM – 403   : Applied Regression Analysis

GROUP B : INDUSTRIAL STATISTICS AND OPERATIONS RESEARCH

Major Electives
STM – 305   : Advanced Operations Research – I
STM – 404   : Reliability Theory
STM – 405   : Advanced Operations Research – II
STM – 406   : Statistical Process and Quality Control

GROUP C : BIOSTATISTICS

Major Electives
STM – 306   : Survival analysis
STM – 407   : Demography
STM – 408   : Quantitative Epidemiology
STM – 409   : Clinical Trials

GROUP D : COMPUTATIONAL STATISTICS

Major Electives
STM – 307   : Computer Intensive Statistical Methods – I
STM – 410   : Computer Intensive Statistical Methods – II
STM – 411   : Computer Programming
STM – 412   : Statistical Pattern Recognition

GROUP E : ECONOMIC AND FINANCIAL STATISTICS

Major Electives
STM – 308   : Time Series Analysis
STM – 413   : Econometrics
STM – 414   : Actuarial Statistics
STM – 415   : Official statistics

Note : If a student offers FOUR major Elective Papers from the same Group, he / she will be certified to have specialized in that Module.

There shall be sessionals / tutorials / class tests / seminars in class / group discussions in each theory and practical paper except Paper No. STM – 417 : Project Work – II in Semester – IV.
Each theory paper, irrespective of their nature and credits shall be of 100 marks out of which 70 marks shall be assigned to the end semester theory examination and 30 marks to the sessionals / tutorials / class tests / seminars in class / group discussions. The Theory papers shall be of THREE HOURS duration consisting of Eight full length questions in all out of which a student will be required to answer any five questions
Each Practical paper will be of 100 marks out of which 30 marks will be assigned on sessionals / tutorials / class tests / seminars in class / group discussions and 70 marks will be assigned on the end semester examination out

of which 50 marks will be on the performance in practical examination and 10 marks will be assigned each on practical record book and viva – voce . The duration of the paper shall be FOUR HOURS).

.Semester I

STM – 101 : REAL ANALYSIS, COMPLEX ANALYSIS AND LINEAR ALGEBRA   Credits : 3

Recap of elements of set theory, introductions to real numbers, open and closed intervals (rectangles), compact sets, Bolzano-Weirstrass theorem.

Sequence and series, their convergence, real valued function, continuous functions, Uniform continuity, sequences of functions, Uniform convergence.

Differentiation, maxima-minima of functions, functions of several variables, multiple integrals, change of variables in multiple integration, uniform convergence in improper integral.

Complex numbers, Analytic function, Cauchy fundamental theorem, Cauchy integral theorem, Contour integrations.

Vector spaces, sub-spaces, linear dependence and independence, orthogonalization process, orthonormal basis

References :
1.   Apostol, T.M. (1985): Mathematical Analysis, Narosa Indian Edn.
2.   Miller, K.S. (1957): Advanced Real Calculus, Harper, New York.
3.   Ruddin, Walter (1976): Principles of Mathematical Analysis, McGraw Hill.
4.   Shanti Narain: A Course in Mathematical Analysis, S. Chand and Company (Pvt.) Ltd.
5.   Graybill, F.A. (1983): Matrices With Applications in Statistics, 2nd Ed. Wadsworth.
6.   Searl, S.R. (1982): Matrix Algebra for Statistical, John Wiley and Sons inc.,
7.   Rao, C.R. and Mitra, S.K. (1971): Generalized Inverse of Matrices and its Application, John Wiley and Sons Inc.
8.   Halmos, P.R. (1958): Finite Dimensional Vector Speces, 2nd ed. Van. Nortrand Company Inc.
9.   Shanti Narain: A text book of matrices, S. Chand and Company (Pvt.) Ltd.

STM – 102 : DISTRIBUTION THEORY   Credits : 4

Brief review of basic distribution theory, joint, marginal conditional p.m.f.'s and p.d.f's, standard discrete and continuous distributions, bivariate normal, bivariate exponential, multivariate normal and multinomial distributions, functions of random variables and their distributions using Jacobian of transformation and other tools.

Compound, truncated and mixture distributions, conditional expectation, multiple and partial correlations, linear and multiple regressions. Markov, Holder, Jensen, Liapunov inequalities.

Sampling distributions, non-central chi-square, t and F distributions and their properties. distributions of quadratic forms under normality and related distribution theory.

Order statistics, their distributions and properties, joint and marginal distributions of order statistics, extreme values and their asymptotic distributions (statement only) with applications. approximating distributions Delta method and its applications, approximating distributions of sample moments, transformations of statistics.

References :
1. Dudewicz, E.J. and Mishra, S.N. (1988): Modern Mathematics Statistics, Wiley
   International students edition.
2. Rohatagi, V.K. (1984): An introduction to Probability Theory and Mathematical Statistics, Wiley Eastern.
3. Rao, C.R. (1973); Linear Statistical Inference and its Applications, Wiley Eastern.
4. Pitman, J. (1993): Probability, Narosa Publishing House.
5. Jonson, S. and Kotz, S. (1972): Distribution in Statistics Vol. I-II & III, Houghton and Mifflin.

STM – 103 :   STATISTICAL INFERENCE – I   Credits : 4
Extension of Cramer-Rao inequality for multi-parameter case, Bhattacharya bounds, information in data about the parameters as variation in likelihood function.

Ideas of sufficient and minimal complete-sufficient statistics, sufficiency when the range of variate depends on parameter, minimum variance unbiased estimators, Rao-Blackwell and Lehman-Scheffe theorems, examples based on some standard distributions.

Asymptotic properties of maximum likelihood estimators, solution of likelihood equations, method of scoring, Newton-Raphson method.

General decision problems, loss function, risk function, estimation and testing viewed as general decision problems, minimax decision, Bayes decision, least favourable prior, Bayes estimation under squared error loss, some simple illustrations based on binomial, Poisson, and normal distributions, procedure for obtaining minimax estimators from Bayes estimators.

References :

1. Kale, B.K. (1999): A First Course on Parametric Inference, Narosa Publishing House.
2. Rohatgi, V.K. (1988): An Introduction to Probability and Mathematical Statistics, Wiley Eastern, New Delhi.
3. Lehmann, E.L. (1986): Theory of Point Estimation, Student Edition.
4. Lehmann, E.L.(1986): Testing Statistical Hypotheses, Student Editions.
5. Rao, C.R. (1973): Linear Statistical Inference and its Applications, Wiley Eastern.
6. Ferguson, T.S. (1967): Mathematical Statistics, Academic Press.
7. Zacks, S. (1971): Theory of Statistical Inference, Wiley, New York.

STM – 104 : STATISTICAL COMPUTING   Credits : 4
Programming in a high level such as C (preferred) or FORTRAN. The purpose of this unit is to introduce programming with the eventual aim of developing skills required to write statistical software.   Topics should include simple syntax, loops, pointers and arrays, functions, input/output, and linking to databases.

Numerical analysis and statistical applications. The purpose of this unit is to apply programming skills in methods and alogrithms useful in probability, statistics, and data analysis. Topics should include numerical integration, root extraction, random number generation, Monte Carlo integration, and matrix computations.

A statistical package such as SAS, or SPSS. The purpose of this unit is to use a statistical package to carry out statistical procedures already known to students. No 'new' statistical methods should be presented but interesting data can be analyzed using known methods on the package. Topics should include graphics, descriptive statistics, representation of multivariate data, simple hypothesis tests, analysis of variance.

References :

1. B.W. Kernighan and D.M. Ritchie (1988): The C Programming Language, Second edition, Prentice Hall.
2. W.H. Press, S.A. Teukolsky, W.T. Vellering, and B.P. Flannery (1993): Numerical Recipes in C, Second edition, Cambridge University Press.
3. B. Ryan and B.L. Joiner (2001). MINITAB Handbook, Fourth edition, Duxbury.
4. R.A. Thisted (1988): Elements of Statistical Computing, Chapman and Hall.

STM– 105 : Practical paper based on the contents of Papers Statistical Inference – I   Credits : 3
(STM - 103) and Statistical Computing (STM – 104)
Practical paper will be of 100 marks out of which 30 marks will be assigned on sessionals / tutorials / class tests / seminars in class / group discussions and 70 marks will be assigned on the end semester examination out of which 50 marks will be on the performance in practical examination and 10 marks will be assigned each on practical record book and viva – voce . The duration of the paper shall be FOUR HOURS).

STM106M : STATISTICAL METHODS   Credits : 3
Descriptive Statistics : Measures of central tendency, dispersion, skewness and kurtosis for the study of nature of data.

Idea of correlation and regression for two and three variables; correlation coefficient, correlation ratio, multiple and partial correlations.

Important statistical distributions : Binomial, Poisson, hypergeometric, negative binomial, normal, uniform, exponential and multinomial distributions.

Statistical Inference : concepts of point estimation, interval estimation and testing.

References :

1. Bhat, B. R., Srivenkataramana, T. and Rao Madhava, K. S. (1996) : "Statistics : A Beginner's Text" Vol. I & II, New Age International (P) Ltd.
2. Snedecors, G.W. and Cochran, W.G. (1967) : "Statistical Methods", Iowa State university Press.

3. Goon, A.M., Gupta, .K. and Dasgupta, B. (1991) : "Fundamentals of Statistics" Vol. I, World Press, Calcutta.
4. Parzen, E. (1960) : "Modern Probability Theory and Its Applications", Wiley Eastern.
5. Mukhopadhyay, P. (1996) : "Mathematical Statistics", New Central Book Agency.
6. Hogg, R.V. and Craig, A.T. (1972) : "Introduction to Mathematical Statistics", Amerind Publishing Co.
7. Spiegel, M.R. (1967) : "Theory and Problem of Statistics", Schaum's Publishing Series.
8. Freund, J.E. (2001) : "Mathematical Statistics", Prentice Hall of India.

Semester II

STM – 201 : SURVEY SAMPLING   **Credits : 3**

Fixed population and super-population approaches. Distinct featues of finite population sampling, Probability sampling design and estimators along with basic statistical properties. Review of some important results in SRSWOR and SRSWR. Estimation of population mean/Total in stratified population, Allocation problem in stratified random sampling in case of fixed cost and also for specified precision. Expression for variance of stratified sample mean in case of fixed cost, Post stratification, Double sampling with post stratification, Deep stratification, Controlled sampling.

Unequal probability sampling: PPSWR/WOR methods (including Lahiri's scheme) and Des Raj estimator, Murthy estimator (n=2). Horvitz Thompson Estimator of a finite population total/mean, Expression for V (HTE) and its unbiased estimator, Issue in non-negative variance estimation.

IIPS Scheme of sampling due to Midzuno-Sen, Double sampling scheme, Some double sampling estimators for mean using auxiliary character (Ratio, regression and product) method of estimation, Some unbiased ratio type estimators for population mean, Concept of cluster sampling, two stage sampling, interpenetrating sub-sampling, Two phase sampling.

Non-sampling error with special reference to non-response problems, Some well-known randomised response techniques for sensitive characteristics.

References :

1. Cassel, C.M., Sarndal, C.E. and Wretman (1977): Foundation of Inference in Survey Sampling, Wiley Inter Science, New York.

2. Choudhari A. and Vos, J.W.E. (1988): Unified Theory of Strategies of Survey Sampling, North Holland, Amsterdam.

3. Hedayat, A.S. and Sinha, B.K. (1991): Design and Inference in Finite Population Sampling, Wiley.

4. Murthy, M.N. (1977): Sampling Theory and Methods. Statistical Publication Society, Calcutta.

5. Mukhopadhyay, P. (1996): Inferential Problems in Survey Sampling, New Age International (P).

6. Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Asok, C. (1984): Sampling Theory of Surveys with Applications, Iowa State University Press and Indian Society of Agricultural Statistics.

7. Chaudhuri, A. and R. Mukherjee (1988): Randomised response: theory and techniques, New York, Marcel Deckker Inc.

8. Cochran, W.G.: Sampling Techniques (3rd edition. 1977), Wiley.

9. Singh D. and Chaudhary, F.S. (1986): Theory and Analysis of Sample Survey Designs, New Age International Publishers.

STM – 202 : LINEAR MODELS AND REGRESSION ANALYSIS   **Credits : 3**

Grauss-Markov linear models, estimable functions, error and estimation space, normal equations and least square estimators, estimation of error variance, estimation with correlated observations, properties of least square estimators, generalized inverse of a matrix and solution of normal equations, variances and covariances of least square estimators.

One way and two-way classifications, fixed, random and mixed effects models. Analysis of variance (two-way classification only), Multiple comparison tests due to Tukey, Scheffe and Student-Newmann-Karl.

Simple linear regression, multiple, regression, fit of polynomials and use of orthogonal polynomials. Residuals and their plots as tests for departure from assumptions such as fitness of the model, normality, homogeneity of variances and detection of outliers. Remedies.

Multi co-linearity, ridge regression, sub-set selection of explanatory variables, Mallows C_p Statistics.

References :

1. Goon, A.M., Gupta, M.K. and Das Gupta, B. (1967): An Outline of Statistical Theory, Vol. 2, The World Press Pvt. Ltd., Calcutta.

2. Rao, C.R. (1973); Linear Statistical Inference and its Application, Wiley Eastern.

3. Graybill, I.A. (1961): An Introduction to Linear Statistical Models, Vol. 1, McGraw Hill Book Co. Inc.

4. Draper, N.R. and Smith H. (1998); Applied Regression Analysis, 3rd Ed. Wiley.

5. Weisberg, S. (1985): Applied Linear Regression, Wiley.

6. Cook, R.D. and Weisherg, S. (1982): Residuals and Inference in Regression, Chapman and Hall.

STM – 203 : STATISTICAL INFERENCE – II   **Credits : 3**

Consistent Asymptotic normal estimators and their properties, CAN estimators obtained by ML method in one parameter exponential case, Invariant estimators, location and scale invariant estimators, Pitman's method for obtaining location and scale invariant estimators.

Interval estimation by confidence sets, Neyman theory, general method for constructing confidence intervals, shortest confidence intervals, uniformly most accurate intervals, Bayes intervals, example based on normal distribution.

Neyman-Pearson lemma, generalized Neyman-Pearson lemma, monotone likelihood ratio families, UMP tests for one and two sided alternatives, admissibility and unbiasedness of tests, type A and type A_1 tests, similar tests, tests having Neyman structure, likelihood ratio test (LRT) asymptotic distribution of LRT statistic.

Wald's sequential probability ratio test and its properties, OC and ASN function, derivation of OC and ASN functions.

References :

1. Kale, B.K. (1999): A First Course on Parametric Inference, Narosa Publishing House.
2. Rohatgi, V.K. (1988): An Introduction to Probability and Mathematical Statistics, Wiley Eastern, New Delhi.
3. Lehmann, E.L.(1986): Testing Statistical Hypotheses, Student Editions.
4. Rao, C.R. (1973): Linear Statistical Inference and its Applications, Wiley Eastern.
5. Ferguson, T.S. (1967): Mathematical Statistics, Academic Press.
6. Zacks, S. (1971): Theory of Statistical Inference, Wiley, New York.
7. Dudewicz, E.J. and Mishra, S.N. (1988): Modern Mathematics Statistics, Wiley International students' edition.

TM – 204 : STOCHASTIC PROCESSES   **Credits : 3**

Introduction to stochastic processes (SPs): Classification of SPs according to state space and time domain. Countable state Markov chains (MC's), Chapman-Kolmogorov equations; calculation of n-step transition probability and its limit. Stationary distribution, classification of states; transient MC; random walk and gambler's ruin problem; Applications from social, biological and physical sciences.

Discrete state space continuous time MC: Kolmogorov – Feller differential equations; Poisson process, birth and death process; Wiener process as a limit of random walk; first-passage time and other problems.

Renewal theory: Elementary renewal theorem and applications. Statement and uses of key renewal theorem; study of residual life time process. Stationary process; weakly stationary and strongly stationary processes; Branching process: Galton-Watson branching process, probability of ultimate extinction, distribution of population size. Martingale in discrete time, inequality, convergence and smoothing properties. Statistical inference in MC and Markov processes.

References :

1. Adke, S.R. and Manjunath, S.M. (1984): An Introduction to Finite Markov Processes, Willey Eastern.

2. Bharat, B.R. (2000): Stochastic Models: Analysis and Applications, new Age International, India.
3. Cinlar, E. (1975): Introduction to Stochastic Processes, Prentice Hall.
4. Feller, W. (1968): Introduction to Probability and its Applications, Vol. 1, Wiley Eastern.
5. Harris, T.E. (1963): The Theory of Branching Processes, Springer-Verlag.
6. Hoel, P.G., Port, S.C. and Stone, C.J. (1972): Introduction to Stochastic Processes, Houghton Miffin & Co.
7. Jagers, P. (1974): Branching Processes with Biological Applications, Wiley.
8. Karlin, S. and Taylor, H.M. (1975): A First Course in Stochastic Processes, Vol. 1, Academic Press.
9. Medhi, J. (1982): Stochastic Processes, Wiley Eastern.
10. Parzen, E. (1962): Stochastic Processes, Holden-Day.

STM – 205 :   PROBABILITY   **Credits : 3**

Classes of sets, fields, sigma fields, minimal sigma field, Borel sigma field, sequence of sets, lim sup and lim inf of a sequence of sets, measure, probability measure, properties of measure, Caratheodory extension theorem (statement only), Lebesgue and Lebesgue - Steiltzes measures.

Measurable functions, random variables, sequence of random variables, almost sure convergence, convergence in probability (and in measure). Integration of a measurable function with respect to a measure, monotone convergence theorem, Fatou's lemma, dominated convergence theorem.

Borel-Cantelli lemma, independence, weak law and strong law of large numbers for independently and identically distributed sequences.

Convergence in distribution, characteristic function, uniqueness theorem, Levy's continuity theorem (statement only). CLT for a sequence of independent random variables under Lindeberg's condition, CLT for independently and identically distributed random variables.

References :

1. Robert, A. (1972): Real Analysis and Probability, Academic press.

2. Billingsley, P. (1989): Probability and Measure, Wiley.

3. Dudley, R.M. (1989): Real Analysis and Probability, Wadsworth and Books.

4. Kingman, J.F.C. and Taylor, S.J. (1966): Introduction to Measure and Probability, Cambridge University Press.

STM – 206 :   Practical paper based on the contents of Papers Survey Sampling(STM – 201) and Statistical Inference – II (STM – 203)   **Credits : 2**

STM – 207 :   Practical paper based on the contents of Papers Linear Models and Regression Analysis (STM - 202) and Stochastic Processes (STM - 204)   **Credits : 2**

STM208M : SAMPLING THEORY, DESIGN OF EXPERIMENTS AND DATA ANALYSIS USING SOFTWARES   **Credits : 3**

(The course will involve only the concepts and uses of theories rather than rigorous derivations of the results.)
Basic concepts of sampling from a finite population; sampling versus complete enumeration; simple random sampling; sample size determination; stratified random sampling; systematic sampling; cluster sampling and multi – stage sampling (all sampling schemes without proof of expressions).

Analysis of variance techniques : One way and two way classified data.

Design of experiments : Randomization, replication, local control; completely randomized design; randomized block design and Latin square design; factorial experiments.

Data analysis : The students will be trained to use SPSS and SYSTAT softwares for data analysis. The main focus of the training will also include the use of parametric and non – parametric tests and the interpretation of the results.

References :
1. Cochran, W.G. (1977) : Sampling Techniques, 3rd Edition, Wiley.

2. DesRaj (2000) : Sample Survey Theory, Narosa Publishing House
3. Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Asok, C. (1984): Sampling Theory of Surveys with Applications, Iowa State University Press and Indian Society of Agricultural Statistics.
4. Das, M.N. and Giri, N (1986) : Design and Analysis of Experiments, Springer Verlag.
5. Goon, A.M., Gupta, M.K. and Das Gupta, B. (1991) : Fundamentals of Statistics, Vol. II, World Press, Calcutta
6. Gibbons, J.D. (1985) : Non – Parametric Statistical Inference, 2nd Edition, Marcel Dekkar, Inc.
7. Rohatgi, V.K. (1988) : An Introduction to Probability and Mathematical Statistics, Wiley Eastern, New Delhi.
8. Siegel, S. : Non – Parametric Statistics for the Behavioural Sciences,
9. Mood, A.M., Greybill, F.A. and Boes, D.C. (1974) : Introduction to the Theory of Statistics, McGraw Hill

Semester III

STM - 301 :   MULTIVARIATE ANALYSIS

Credits : 3

Multivariate normal distribution and its properties. Random sampling from multivariate normal distribution. Maximum likelihood estimators of parameters, distribution of sample mean vector.

Wishart matrix – its distribution and properties, distribution of sample generalized variance, null and non-null distribution of multiple correlation coefficient.

Hotelling's T^2 and its sampling distribution, application in test on mean vector for one and more multivariate normal population and also on equality of components of a mean vector in multivariate normal population.

Classification problem: Standards of good classification, procedure of classification based on multivariate normal distributions.

Principal components, dimension reduction, canonical variates and canonical correlation—definition, use, estimation and computation.

References :
1. Anderson, T.W. (1983): An Introduction to Multivariate Statistical Analysis, 2nd Ed., Willey.
2. Giri, N.C. (1977): Multivariate Statistical Inference, Academic Press.
3. Kshirsagar, A.M. (1972): Multivariate Analysis, Marcel Dekker.
4. Morrison, D.F. (1976): Multivariate Statistical Methods, 2nd Ed. McGraw Hill.
5. Muirhead, R.J. (1982): Aspects of Multivariate Statistical Theory, J. Wiley.
6. Rao, C.R. (1973): Linear Statistical Inference and its Applications, 2nd Ed. Wiley.
7. Seber, G.A.F. (1984): Multivariate Observations, Wiley.
8. Sharma, S. (1996); Applied Multivariate Techniques, Wiley.
9. Srivastava, M.S. and Khatri, C.G. (1979): An introduction to multivariate statistics, North Holland.
10. Johnson, R. and Wychern (1992): Applied Multivariate Statistical Analysis, Prentice Hall, 3rd Edition.

STM – 302 :   DESIGN AND ANALYSIS OF EXPERIMENTS

Credits : 3

Review of linear estimation and basic designs, missing plot technique:- General theory and applications, Analysis of Co-variance for CRD and RBD.

Incomplete block design: Balanced incomplete block designs, simple lattice designs, Two-associate partially balanced incomplete block designs: association scheme and intra block analysis, group divisible designs.

General factorial experiments, factorial effects; best estimates and testing the significance of factorial effects; study of 2^n and 3^r factorial experiments in randomized blocks; complete and partial confounding, construction of symmetrical confounded factorial experiments, fractional replications for symmetrical factorials, split plot and strip-plot experiments.

Application areas: Response surface experiments; first order designs, and orthogonal designs; clinical trials, treatment-control designs; model variation and use of transformation; Tukey's test for additivity.

References :
1. Alok Dey (1986): Theory of Block Designs, Wiley Eastern.
2. Angela Dean and Daniel Voss (1999): Design and Analysis of Experiment, Springer.
3. Das, M. and Giri, N. (1979): Design and Analysis of Experiments, Wiley Eastern.
4. Joshi, D.D. (1987): Linear Estimation and Design of Experiments, Wiley Eastern.

5. Montgomery, C.D. (1976): Design and Analysis of Experiment, Wiley, New York.
6. Mysers, R.H. (1971): Response Surface Methodology, Allyn and Bacon.
7. Giri (1986): Analysis of Variance, South Asian Publishers.

STM – 303 : RESEARCH METHODOLOGY AND PROJECT WORK – I   Credits : 2

(In this paper there will be a theory paper of 70 marks and the rest 30 marks will be assigned to the preparation of project proposal, discussion and its presentation).

Concept and definitions, variables and hypotheses, theory and facts, formulation of research problems, development of research methodology and research methods-collection of data, statistical techniques used, evaluation and accuracy of results, developments of knowledge-approaches, rationalistic mode, scientific mode. Identification of problem, formulation of hypotheses, imagination in the formulation of scientific law, recognition of a problem area and identifying the relative questions.

Steps in research process-

A. Conceptual phase-formulation of the research problem, literature review, developing the hypothesis.

B. Empirical phase- preparing the research design, determination of sample size, collection of data.

C. Analytical phase- analysis of data, hypothesis testing, generalization and interpretations, writing up, conclusions.

Types of variables- independent, dependent and control variables.

Measurements - concept and level of measurement, scaling technique, validity and reliability of a measurement.

Types of data and methods of collection of data, pre-testing, pilot survey, longitudinal survey, prospective and retrospective surveys, sampling and non-sampling errors, sampling unit and sampling frame, population and sample, scrutinizing of data, estimation of coverage and errors in data collection, revisits.

References :
1. Kothari, C.R. (1985): Research Methodology: Methods and Techniques, Wiley Eastern.
2. Dominowski, R.L. (1980): Research Methods, Prentice Hall Inc., New Jersey.
3. Mishra, R.P. (1980): Research Methodology, Handbook Concept Publishing Company, New Delhi.
4. IIPS (1996): Research Methodology, IIPS, Mumbai.

STM – 304 : STATISTICAL DECISION THEORY   Credits : 3

Decision problem and 2-person game, utility theory, loss functions, expected loss, decision rules (non-randomized and randomized), decision principles (conditional Bayes, frequentist), inference problems as decision problems, optimal decision rules.

Concept of admissibility and completeness, Bayes rules, admissibility of Bayes rules.

Supporting and separating hyperplane theorems, minimax theorem of for finite parameter s pace, minimax estimators of Normal and Poisson means, admissibility of minimax rules.

Invariant decision rules – location parameter problems, invariance and minimaxity , admissibility of invariant rules, complete class theorem, complete and essentially complete classes in simple estimation and testing situations, estimation of a distribution function.

Sufficient statistics, essentially complete classes of rules based on sufficient statistics, complete sufficient statistics.

Sequential decision rules, Bayes and minimax sequential decision rules, invariant sequential decision problems.

References :
1. Berger, J.O. (1985): Statistical Decision Theory and Bayesian Analysis, 2nd Edition. SpringerVerlag.
2. Ferguson, T.S. (1967): Mathematical Statistics – A Decision Theoretic Approach, Academic Pres.
3. Rohatgi, V.K. (1988): An Introduction to Probability and Mathematical Statistics, Wiley Eastern, New Delhi.
4. Rao, C.R. (1973): Linear Statistical Inference and its Applications, Wiley Eastern.
5. Bernando, J.M. and Smith, A.F.M. Bayesian Theory, John Wiley and Sons.
6. Robert, C.P.: The Bayesian Choice: A Decision Theoretic Motivation, Springer.

STM – 305 : ADVANCED OPERATIONS RESEARCH – I   **Credits : 3**

Decision Theory: Introduction; decision making under uncertainty; decision making under risk; uses of different criteria.

Decision making in the face of competition.

Two-person games; pure and mixed strategies; existence of solution and uniqueness of value in zero-sum games; finding solution in 2×2, 2×m and m×n games; reduction of game problem to a linear programming problem.

Review of linear programming problems (LPP); revised simplex method; duality theorem; bounded variable problems.

Allocation Problems: transportation problem (TP); degeneracy in TP; unbalanced TP.

Dynamic Programming: Bellman's principle of optimality; general formulation of dynamic programming; computational methods and applications of dynamic programming.

Queuing Models: specifications and effectiveness measures; steady-state solutions of (M/M/I) and (M/M/C) models with associated distributions of queue length and waiting time; M/G/1 queue and Pollazcek – Khinchine result; steady-state solutions of $M/E_K/1$ and $E_K/M/1$ queues; machine interference problem.

Non-Linear Programming: Kuhn-Tucker conditions; Wolfe's and Beale's algorithms for solving quadratic programming problems.

Analytical structure of inventory problems; EOQ formula of Harris; its sensitivity analysis and extensions allowing quantity discounts and shortages; Multi-item inventory subject to constraints.

Inventory models with random demand; the static risk model; P and Q – systems with constant and random lead times.

References:
1. Saaty, T.L. (1961): Elements of Queuing Theory with Applications; McGraw Hill.
2. Gross, D. and Harris, C.M. (1974): Fundamentals of Queuing Theory, John Wiley.
3. Hadley, G. (1964): Non-Linear and Dynamic Programming; Addison Wesley.
4. Taha, H.A. (1982): Operations Research: An Introduction; MacMillan Publishing Company, New York.
5. Kanti Swaroop, Gupta, P.K. and Singh, M.M. (1985): Operations Research, Sultan Chand and Sons.
6. Philips, D.T., Ravindran, A. and Solberg, J.: Operations Research, Principles and Practice.
7. Mckinsey, J.C.C. (1952): Introduction to the Theory of Games; McGraw Hill.
8. Hadley, G. and Whitin, T.M. (1963): Analysis of Inventory Systems; Prentice Hall.

STM – 306 :   SURVIVAL ANALYSIS   **Credits : 3**

Concept of time, order and random censoring, likelihood in the distributions – exponential, gamma, Weibull, lognormal, Pareto, Linear failure rate, inference for these distribution.

Life tables, failure rate, mean residual life and their elementary classes and their properties.

Estimation of survival function – actuarial estimator, Kaplan – Meier estimator, estimation under the assumption of IFR/DFR, tests of exponentiality against non-parametric classes, total time on test.

Two sample problem – Gehan test, log rank test.

Semi-parametric regression for failure rate – Cox's proportional hazards model with one and several covariates. rank test for the regression coefficient.

Competing risk model, parametric and non-parametric inference for this model.

 Multiple decrement life table.

References:
1. Cox, D. R. and Oakes, D. (1984): Analysis of Survival Data, Chapman and Hall, New York.
2. Gross A. j. and Clark, V.A. (1975): Survival Distribution: Reliability applications in the Biomedical Sciences, John Wiley and Sons.
3. Elandt – Johnson, R.E. Johnson N. L.: Survival Models and Data Analysis, John Wiley and Sons.
4. Miller, R. G. (1981): Survival Analysis (John Wiley).
5. Kalbfleisch J. D. and Prentice R. (1980): The Statistical Analysis of failure Time data, John Wiley.

STM – 307 : COMPUTER - INTENSIVE STATISTICAL METHODS – I   **Credits : 3**

Exploratory data analysis: transforming data, graphical methods of clustering, outliers.

Linear regression**:** Influential observations and diagnostics robust methods, collinearity, variable selection.

Generalized linear models: exponential families and ML estimation, analysis of deviance and variable selection, logistic regression.

Nonlinear regression: estimation, hypothesis testing, goodness of fit.

EM algorithm: applications to missing and incomplete data problems, mixture models.

Smoothing with kernels, density estimation, simple non-parametric regression.

Note on practicals: Each practical session should correspond to two teaching hours. Practical work should be done on statistical packages or using high level languages as taught in the core course on Statistical Computing.

References :
1.   R. Gnandesikan (1997): Methods for Statistical Data Analysis of Multivariate Observations, Second edition, Wiley.
2.   D.A. Belsley, E. Kuh, and R.E. Welsch (1980): Regression Diagnostics, Wiley.
3.   P. McCullagh and J.A. Nelder (1999): Generalized Linear Models, Third edition, Chapman and Hall.
4.   G.E.F. Seber and C.J. Wild (1989): Nonlinear Regression, Wiley.
5.   G.J. McLachlan and T. Krishnan (1997): The EM Algorithms and Extensions, Wiley.
6.   J.S. Simonoff (1996): Smoothing Methods in Statistics, Springer.

STM – 308 : TIME SERIES ANALYSIS   **Credits : 3**

Time-series as discrete parameter stochastic process, auto covariance and autocorrelation functions and their properties.

Exploratory time Series analysis, tests for trend and seasonality, exponential and moving average smoothing. Holt and Winters smoothing, forecasting based on smoothing.

Detailed study of the stationary processes: (1) moving average (MA), (2) auto regressive (AR), (3) ARMA and (4) AR integrated MA (ARIMA) models. Box-Jenkins models, choice of AR and MA periods.

Discussion (without proof) of estimation of mean, auto covariance and autocorrelation functions under large sample theory, estimation of ARIMA model parameters.

Spectral analysis of weakly stationary process, peridogram and correlogram analyses, computations based on Fourier transform.

References:
1.   Box, G.E.P. and Jenkins, G.M. (1976): Time series analysis—Forecasting and Control, Holden-day, San Francisco.
2.   Anderson, T.W. (1971): The Statistical Analysis of Time Series, Wiley, N.Y.
3.   Montgemory, D.C. and Johnson, L.A. (1977): Forecasting and Time Series Analysis, McGraw Hill.
4.   Kendall, Sir Maurice and Ord, J.K. (1990): Time Series (Third Edition), Edward Arnold.
5.   Brockwell, P.J. and Davis, R.A.: Time Series: Theory and Methods (Second Edition), Springer-Verlag.
6.   Fuller, W.A. (1976): Introduction to Statistical Time Series, John Wiley, N.Y.
7.   Granger, C.W.J. and Newbold (1984): Forecasting Econometric Time Series, Third Edition, Academic Press.
8.   Priestley, M.B. (1981): Spectral Analysis & Time Series, Griffin, London.
9.   Kendall, M.G. and Stuart A. (1966): The Advanced Theory of Statistics, Volume 3, Charles Griffin, London.
10. Bloomfield, P. (1976): Fourier Analysis of Time Series—An Introduction, Wiley.
11. Granger, C.W.J. and Hatanka, M. (1964): Spectral Analysis of Economic Time Series, Princeton Univ. Press, N.J.
12. Koopmans, L.H. (1974). The spectral Analysis of Time Series, Academic Press.
13. Nelson, C.R. (1973): Applied Time Series for Managerial Forecasting, Holden-Day.
14. Findley, D.F. (Ed.) (1981): Applied Time Series Analysis II, Academic Press.

Major Elective Papers   **Credits : 4**

STM - 309 : Practical paper based on the contents of Papers Multivariate Analysis (STM - 301), Design and Analysis of Experiments (STM – 302) and selected

STM308M : DATA ANALYSIS USING REGRESSION MODELS   Credits : 3
(The course will involve a substantial amount of computing and the emphasis will be on applications and interpretations, rather than equations and derivations. Illustrations will be done using R language)

Basics of linear regression with one predictor and multiple predictors, interactions, statistical inference, graphical display of data and fitted models.

Linear regression before and after fitting the model: linear transformations, centering and standardizing, logarithmic and other transformations.

Logistic regression with single predictor, interpreting the regression coefficients, logistic regression with interactions.

Generalized linear model : Poisson regression, logistic – binomial model, regression (normally distributed latent data), ordered and unordered catagorical regression, robust regression.

Simulation of probability models and statistical inferences, simulation for checking model fits.

References :
1. Weisberg, S. (1985) : Applied Linear Regression, 2nd Edition
2. Draper, N.R. and Smith, H. (1998) : Applied Regression Analysis, Wiley
3. Rawlings, John, O. (2001) : Applied Regression Analysis, Springer Verlag.

Semester IV

STM - 401 : BAYESIAN INFERENCE   Credits : 3

Subjective probability, its existence and interpretation. Prior distribution, subjective determination of prior distribution. Improper priors, non-informative (default) priors, invariant priors. Conjugate prior families, construction of conjugate families using sufficient statistics of fixed dimension, mixtures of conjugate priors, hierarchical priors and partial exchangeability. Parametric Empirical Bayes.

Bayesian inference : Bayes sufficiency, summary through posterior, predictive inference.

Bayesian decision theory : Bayes solutions for practical decision problems. Point estimation, credible sets, testing of hypotheses. Comparison with classical procedures. Admissibility and minimaxity of Bayes and generalized Bayes procedures.

Ideas on Bayesian robustness. Asymptotic expansion for the posterior density. Bayesian calculation, Monte-Carlo Integration and Markov chain Monte Carlo techniques (without proof).

References:
1. Berger, J.O. : Statistical Decision Theory and Bayesian Analysis, Springer Verlag.
2. Robert, C.P. and Casella, G. : Monte Carlo Statistical Methods, Springer Verlag.
3. Leonard, T. and Hsu, J.S.J. : Bayesian Methods, Cambridge University Press.
4. Bernando, J.M. and Smith, A.F.M. : Bayesian Theory, John Wiley and Sons.
5. Robert, C.P. : The Bayesian Choice: A Decision Theoretic Motivation, Springer.
6. Gemerman, D. : Markov Chain Monte Carlo: Stochastic Simulation for Bayesian Inference, Chapman Hall.
7. Box, G.P. and Tiao, G.C.: Bayesian Inference in Statistical Analysis, Addison-Wesley.

STM - 402 : NON - PARAMETRIC AND SEMI - PARAMETRIC METHODS   Credits : 3

Empirical distribution function, Gilvenko Cantelli Theorem, Kolmogorov Goodness of fit test.

One sample U-statistics, kernel and symmetric kernel, two sample U-statistics, asymptotic distribution of U-statistics. UMVUE property of U-statistics, asymptotic distribution of linear function of order statistics.

Rank tests, locally most powerful rank tests, linear rank statistics and their distributional properties under null hypothesis, Pitman's asymptotic relative efficiency.

One sample location problem, sign test and signed rank test, two sample Kolmogorov Smirnov tests, two simple location and scale problems. Wilcoxon-Mann-Whitney test, normal score test, ARE of various tests based on linear rank statistics. Kruskal-Wallis K sample test.

Cox's proportional hazards model, rank test (partial likelihood) for regression coefficients, Concepts of jackknifing method of Queenouille for reducing bias, Bootstrap methods.

References:

1. Davison, A.C. and Hinkley, D.V. (1997): Bootstrap Methods and Their Application, Cambridge University Press.
2. Gibbons, J.D. (1985): Non-Parametric Statistical Inference, 2nd ed. Marcel Dekker, Inc.
3. Randles, R.H. and Woffe, D.A. (1979): Introduction to the Theory of Non-Parametric Statistics, John Wiley & Sons, Inc.
4. Fraser. D.A.S. (1957): Nonparametric Methods in Statistics, John Wiley & Sons, Inc.
5. Hajek, J. and Sodal. Z. (1967): Theory of Rank Tests, Academic Pess.
6. Puri, M.L. and Sen, P.K. (1971): Nonparametric Methods of Multivariate Analysis, John Wiley & Sons, Inc.
7. Cox, D.R. and Oakes, D. (1983): Survival Analysis, Chapman and Hall.

STM – 403 : APPLIED REGRESSION ANALYSIS   **Credits : 3**

Residuals and their analysis, influential observations, power transformations for dependent and independent variables.

Robust and L-1 regression, estimation of prediction error by cross-validation and boot-strap.

Non-linear regression models, different methods of estimation (Least squares, Maximum Likelihood), Asymptotic properties of estimators

Generalized linear models, analysis of binary and grouped data by using logistic models, log-linear models.

Bayes analysis of linear and generalized linear models.

References:

1. Bates, D.M. and Watts, D.G. (1988): Nonlinear Regression, Analysis and its Application, Wiley, New York.
2. Cook, R.D. and Weisberg, S. (1982): Residuals and Inference in Regression, Chapman and Hall, London.
3. Draper, N.R. and Smith, H. (1998): Applied Regression Analysis, 3rd Ed., Willey, New York.
4. Efron, B. and Tibsirani, J.R. (1993): An Introduction to the Bootstrap, Chapman and Hall, New York.
5. Kashirsagar, A.M. (1995): Growth Curves, Marcel and Dekker, New York.
6. McCullagh, P. and Nelder, J.A. (1989): Generalized Linear Models, 2nd Ed., Chapman and Hall, London.
7. Searle, S.R. (1987): Linear Models for Unbalanced Data, Wiley, New York.
8. Seber, G.A. and Wild, G.J. (1989): Nonlinear Regression, Wiley, New York.
9. Robert, C.P.: The Bayesian Choice: A Decision Theoretic Motivation, Springer.

STM – 404 : RELIABILITY THEORY   **Credits : 3**

Reliability concepts and measures; components and systems; coherent systems; Reliability of coherent system; cuts and paths; modular decomposition; bounds on system reliability; structural and reliability importance of components.

Life distributions; reliability function; hazard rate; common life distributions – exponential, Weibull, gamma, normal, etc.; Estimation of parameters and tests in these models.

Notions of aging; IFR; IFRA; NBU; DMRL and NBUE classes and their duals; lo of memory property of the exponential distribution; closures of these classes under formation of coherent systems; convolution and mixtures.

Basic ideas of accelerated life testing.

Univariate shock models and life distribution arising out of them; bivariate shock models; common bivariate exponential distributions and their properties.

Maintenance and replacement policies; availability of reparable systems; modelling of a repairable system by a non-homogeneous Poisson process.

Reliability estimation based on failure times in variously censored life tests and in tests with replacement of failed items; stress-strength reliability and its estimation.

Reliability growth models; Probability plotting techniques; Hollander – Proschan and Deshpande tests for exponentiality; tests for HPP vs. NHPP with repairable systems.

References:
1. Barlow, R.E. and Proschan, F. (1985): Statistical Theory of Reliability and Life Testing; Holt, Rinehart and Winston.
2. Lawless, J.F. (1982): Statistical Models and Methods of Life Time Data; John Wiley.
3. Nelson, W. (1982): Applied life Data Analysis; John Wiley.
4. Zacks, S.: Reliability Theory; Springer
5. Bain, L. J. and Engelhardt (1991): Statistical Analysis of Reliability and Life Testing Models; Marcel Dekker.

STM – 405 : ADVANCED OPERATIONS RESEARCH – II   Credits : 3

Integer Programming: Branch and bound algorithm and cutting plane algorithm. Multi-criterion and goal programming.

Stochastic Programming; quantile rules.

Two-stage programming; use of fractional programming.

Sequencing and scheduling problems: 2 machine n-job and 3–machines n-job problems with identical machine sequence for all jobs; 2-job n-machine problem with different routings; branch and bound method for solving travelling-salesman problem.

Sensitivity analysis. parametric programming.

Project management: CPM and PERT; probability of project completion; PERT-crashing.

Replacement problems: block and age replacement policies; dynamic programming approach for maintenance problems; replacement of items with long life.

Transient solution of M/M/1 queue; bulk queues (bulk arrival and bulk service); finite queues; queues in tandem; GI/G/1 queue and its solution; simulation of queues.

References:
1. Taha, H.A. (1982): Operations Research: An Introduction; MacMillan Publishing Company, New York.
2. Hillier, F.S. and Leiberman, G.J. (1962): Introduction to Operations Research; Holden Day.
3. Kanti Swaroop, Gupta, P.K. and Singh, M. M. (1985): Operations Research; Sultan Chand and Sons.
4. Churchman, C.W.; Ackoff, R.L. and Arnoff, E.L. (1957): Introduction to Operations Research; John Wiley.
5. Mckuisey, J.C.C. (1952): Introduction to the Theory of Games, McGraw Hill.
6. Kleinrock, L. (1975): Queuing Systems, Vol. I; John Wiley.
7. Hadley G. and Whitin, T.M. (1963): Analysis of Inventory Systems; Prentice Hall.
8. Starr, M. K. and Miller, D.W. (1962): Inventory Control – Theory and Practice; Prentice Hall.
9. Shamblin, J.E. and Stevens, G.T. (1974): Operations Research: A Fundamental Approach; McGraw Hill.

STM – 406 : STATISTICAL PROCESSES AND QUALITY CONTROL   Credits : 3

Basic concepts of process monitoring ad control; process capability and process optimization.

General theory and review of control charts for attribute and variable data; O.C. and A.R.L. of control charts; control by gauging; moving average and exponentially weighted moving average charts; Cu-Sum charts using V-masks and decision intervals; Economic design of X-bar chart.

Acceptance sampling plans for attributes inspection; single and double sampling plans and their properties; plans for inspection by variables for one-sided and two sided specification.

Mil Std. and IS plans; continuous sampling plans of Dodge type and Wald-Wolfiwitz type and then properties.

Sequential sampling plan and its properties; Bayesian sampling plans.

Capability indices Cp, Cpk and Cpm; estimation, confidence intervals and tests of hypotheses relating to capability indices for normally distributed characteristics.

Use of design of experiments in SPC; factorial experiments, fractional factorial designs; construction of such designs and analysis of data.

Multivariate quality control; use of control ellipsoid and of utility functions.

References
1. Montgomery, D.C. (1985): Introduction to Statistical Quality Control; Wiley.
2. Montgomery, D.C. (1985): Design and Analysis of Experiments; Wiley.
3. Ott, E.R. (1975): Process Quality Control; McGraw Hill
4. Phadke, M.S. (1989): Quality Engineering Through Robust Design; Prentice Hall.
5. Wetherill, G.B. (1977): Sampling Inspection and Quality Control; Halsted Press.
6. Wetherill, G.B. and Brown, D.W.: Statistical Process Control: Theory and Practice.

STM – 407 : DEMOGRAPHY   Credits : 3

Coverage and content errors in demographic data, Chandrasekharan—Deming formula to check completeness of registration data, adjustment of age data- use of Whipple, Myer and UN indices. population transition theory.

Measures of fertility; stochastic models for reproduction, distributions of time of birth, inter-live birth intervals and of number of births (for both homogeneous and homogeneous groups of women), estimation of parameters; estimation of parity progression from open birth interval data.

Measures of Mortality; construction of abridged life tables, infant mortality rate and its adjustments, model life table.

Stable and quasi-stable populations, intrinsic growth rate. Models of population growth and their filling to population data.

Internal migration and its measurement, migration models, concept of international migration.

Methods for population projection, component method of population projection, Nuptiality and its measurements.

References:
1. Kumar, R. (1986): Technical Demography, Wiley Eastern Ltd.
2. Benjamin, B. (1969): Demographic Analysis, George, Allen and Unwin.
3. Chiang, C.L. (1968): Introduction to Stochastic Progression.
4. Cox, P.R. (1970): Demography, Cambridge University Press.
5. Keyfitz, N. (1977): Introduction to the Mathematics of Population-with Revisions, Addison-Wesley, London.
6. Spiegelman, M. (1969): Introduction to Demographic Analysis, Harvard University Press.
7. Wolfenden, H.H. (1954): Population Statistics and Their Compilation, Am Actuarial Society.

STM – 408 : QUANTITATIVE EPIDEMIOLOGY   Credits : 3

Introduction to modern epidemiology, principles of epidemiologic investigation, surveillance and disease monitoring in populations.

Epidemiologic measures: organizing and presenting epidemiologic data, measure disease frequency, measures of effect association, causation and causal inference.

Design and analysis of epidemiologic studies: types of studies, case-control studies, cohort studies, quantitative methods in screening.

Special Topics: epidemiology of infections and chronic disease, Cancer and cancer prevention, environmental epidemiology.

References:
1. K. J. Rothman and S. Geenland (ed.) (1988). Modern Epidemiology, Lippincott-Raven.
2. S. Selvin (1996). Statistical Analysis of Epidemiologic Data, Oxford University Press.
3. D. McNeil (1996). Epidemiological Research Methods. Wiley and Sons.
4. J. F. Jekel, J. G. Elmore, D.L. Katz (1996). Epidemiology, Biostatistics and Preventive Medicine. WB Saunders Co.

STM – 409 : CLINICAL TRIALS   Credits : 3

Introduction to clinical trials: the need and ethics of clinical trials, bias and random error in clinical studies, conduct of clinical trials, overview of Phase I – IV trials, multicenter trials.

Data management: data definitions, case report forms, database design, data collection systems for good clinical practice.

Design of clinical trials: parallel vs. cross-over designs, cross-sectional vs. longitudinal designs, review of factorial designs, objectives and endpoints of clinical trials, design of Phase I trials, design of single-stage and multi-stage Phase II trials, design and monitoring of phase III trials with sequential stopping,

Reporting and analysis: analysis of categorical outcomes from Phase I – III trials, analysis of survival data from clinical trials.

Introduction to Meta-analysis of clinical trials.

References:
1. S. Piantadosi (1997): Clinical Trials: A Methodologic Perspective. Wiley and Sons.
2. C. Jennison and B. W. Turnbull (1999): Group Sequential Methods with Applications to Clinical Trials, CRC Press.
3. L. M. Friedman, C. Furburg, D. L. Demets (1998): Fundamentals of Clinical Trials Springer Verlag.
4. J. L. Fleiss (1989): The Design and Analysis of Clinical Experiments. Wiley and Son.
5. E. Marubeni and M. G. Valsecchi (1994): Analyzing Survival Data from Clinical Trials and Observational Studies, Wiley and Sons.

STM – 410 : COMPUTER - INTENSIVE STATISTICAL METHODS – II   Credits : 3

Stochastic simulation: generating random variables, simulating standard univariate and multivariate distributions.

Variance reduction: importance sampling for integration, control variates and antithetic variables.

Markov Chain Monte Carlo Methods: Gibbs sampling for standard distributions.

Simulation based testing: simulating test statistics and power functions, permutation tests.

Bootstrap methods: re sampling paradigms, bias and standard errors, confidence intervals, bootstrapping in regression.

Jackknife and cross validation: Jacknife in sample surveys, cross-validation for tuning parameters.

Note on practicals: Each practical session should correspond to two teaching hours. Practical work should be done on statistical packages or using high level languages as taught in the core course on Statistical Computing.

References:
1. G.S. Fishman (1996): Monte Carlo: Concepts, Algorithms, and Applications, Springer.
2. R.Y. Rubinstein (1981): Simulation and the Monte Carlo Method, Wiley.
3. M.A. Tanner (1996): Tools for Statistical Interference, Third edition, Springer.
4. B. Efron and R.J. Tibshirani (1993): An introduction to the Bootstrap, Chapman and Hall.
5. J. Shao and D. Tu (1995): Jackknife and the Bootstrap, Springer Verlag.

STM – 411 : COMPUTER PROGRAMMING   Credits : 3

This course is intended to introduce object-oriented computer programming. It assumes prior exposure to programming in languages in such as C and/or Fortran. The language of choice here is C_{++}.

Introduction to object-oriented programming concepts and design.

Programming in C_{++}: data types and operations, functions and parameters, classes, constructors, input output, control statements such as if-else, switch, for, while and do-while, pointers and references, dynamic allocation, processing of linked lists, arrays and character strings, libraries.

Introduction to program analysis: simple testing and debugging.

Note on practicals/tutorials: As this is programming course, hand-on practical sessions are important and should be held in conjunction with lectures.

References:
1. R. Decker, and S. Hirshfield (1998): The Object Concept: An Introduction to Computer Programming using C_{++}, PWS Publishing.

2. S.B. Lippmann and J. Lajole (1998): C$_{++}$ Primer. Third edition, Addison-Wesley.
3. P. Naughton (1996): The Java Handbook. Tata McGraw-Hill.
4. W.J. Savitch (2001): Problem Solving with C$_{++}$: The Object of Programming Edition, Addison-Wesley Longman.
5. K. Fukunga (1990): Introduction to Statistical Pattern Recognition, Second Edition, Academic Pres s.
6. G.J. McLachlan (1992): Discriminant Analysis and Statistical Pattern Recognition, Wiley.
7. B.D. Ripley (1996): Pattern Recognition and Neural Networks. Cambridge University Press.

STM – 412 : STATISTICAL PATTERN RECOGNITION   Credits : 3

Linear classifiers: Linear discriminant function (LDF) for minimum squared error. LDF for binary outputs, perception learning algorithm.

Nearest neighbour decision rules: description, convergence, finite sample considerations, use of branch and bound methods.

Probability of errors: Two classes, normal distributions, equal covariance matrix assumptions, Chernolf bounds and Bhattacharya distance, estimation of probability of error.

Feature selection and extraction: Interclass distance measures, discriminant analysis, probabilistic distance measures, principal components.

Note on practicals: Each practical session should correspond to two teaching hours. Practical work should be done on statistical packages or using high level languages as taught in the core course on Statistical Computing.

References:

1. R.O. Duda and P.E. Hart (1973): Pattern Recognition and Scene Analysis, Wiley.
2. K. Fukunga (1990): Introduction to Statistical Pattern Recognition. Second Edition, Academic Press.
3. G.J. McLachlan (1992): Discriminant Analysis and Statistical Pattern Recognition, Wiley.
3. B.D. Ripley (1996): Pattern Recognition and Neural Networks. Cambridge University Press.

STM – 413 : ECONOMETRICS   Credits : 3

Nature of econometrics, the general linear model (GLM) and its extensions, ordinary least squares (OLS) estimation and prediction, generalized least squares (GLS) estimation and prediction, heteroscedastic disturbances, pure and mixed estimation.

Auto correlation, its consequences and tests. Theil BLUS procedure, estimation and prediction, multicollinearity problem, its implications and tools for handling the problem, ridge regression.

Linear regression and stochastic regression, instrumental variable estimation. errors in variables, autoregressive linear regression, lagged variables, distributed lag models, estimation of lags by OLS method, Koyck's geometric lag model.

Simultaneous linear equations model and its generalization, identification problem, restrictions on structural parameters, rank and order conditions.

Estimation in simultaneous equations model, recursive systems, 2 SLS estimators, limited information estimators, k-class estimators. 3 SLS estimator, full information maximum likelihood method, prediction and simultaneous confidence intervals.

References :

1. Apte, P.G. (1990): Text books of Econometrics, Tata McGraw Hill.
2. Cramer, J.S. (1971): Empirical Econometrics, North Holland.
3. Gujarathi, D. (1979): Basic Econometrics, McGraw Hill.
4. Intrulligator, M.D. (1980): Econometric models—Techniques and applications, Prentice Hall of India.
5. Johnston, J. (1984): Econometric methods. Third edition, McGraw Hill.
6. Klein, L.R. (1962): An introduction to Econometrics, Prentice Hall of India.
7. Koutsoyiannis, A. (1979): Theory of Econometrics, Macmillan Press.
8. Malinvaud, E. (1966): Statistical methods of Econometrics, North Holland.
9. Srivastava, V.K. and Giles D.A.E. (1987): Seemingly unrelated regression equations models, Maicel Dekker.
10. Theil, H. (1982): Introduction to the theory and practice of Econometrics, John Wiley.
11. Walters, A. (1970): An introduction to Econometrics, Macmillan & Co.
12. Wetherill, G.B. (1986): Regression analysis with applications, Chapman Hall.

STM – 414 : ACTUARIAL STATISTICS   Credits : 3

Utility theory, insurance and utility theory, models for individual claims and their sums, survival function, curtate future lifetime, force of mortality.

Life table and its relation with survival function, examples, assumptions for fractional ages, some analytical laws of mortality, select and ultimate tables.

Multiple life functions, joint life and last survivor status, insurance and annuity benefits through multiple life functions evaluation for special mortality laws.

Multiple decrement models, deterministic and random survivorship groups, associated single decrement tables, central rates of multiple decrement, net single premiums and their numerical evaluations.

Distribution of aggregate claims, compound Poisson distribution and its applications. Distribution of aggregate claims, compound Poisson distribution and its applications.

Principles of compound interest: Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, continuous compounding.

Life insurance: Insurance payable at the moment of death and at the end of the year of death-level benefit insurance, endowment insurance, deferred insurance and varying benefit insurance, recursions, commutation functions.

Life annuities: Single payment, continuous life annuities, discrete life annuities, life annuities with monthly payments, commutation functions, varying annuities, recursions, complete annuities.

Net premiums: Continuous and discrete premiums, true monthly payment premiums, apportionable premiums, commutation functions, accumulation type benefits.

A brief outline of payment premiums and net premiums

References:
1. N.L. Bowers, H.U. Gerber, J.C. Hickman, D.A. Jones and C.J. Nesbitt (1966), 'Actuarial Mathematics,' Society of Actuarials, Ithaca, Illinois, U.S.A., Second Edition (1997).
2. Spurgeon, E.T. (1972): Life Contingencies, Cambridge University Press.
3. Neill, A. (1977): Life Contingencies, Heinemann.

STM – 415 : OFFICIAL STATISTICS   Credits : 3

Introduction to Indian and International statistical systems. role, function and activities of central and state statistical organizations, organization of large scale sample surveys, role of national sample survey organization general and special data dissemination systems.

Population growth in developed and developing countries, evaluation and performance of family welfare programmes, projections of labour force and manpower, scope and content of population census of India.

System of collection of agricultural statistics, crop forecasting and estimation, productivity, fragmentation of holdings, support prices, buffer stocks, impact of irrigation projects.

Statistics related to industries, foreign trade, balance of payment, cost of living, inflation, educational and other social statistics.

References:
1. Basic Statistics Relating to the Indian Economy (CSO), 1990.
2. Guide to Official Statistics (CSO) 1999.
3. Statistical System in India (CSO), 1995.
4. Principles and accommodation of National Population Censuses, UNESCO.
5. Panse, V.G.: Estimation of Crop Yields (FAO).
6. Family Welfare Yearbook, Annual Publication of D/o Family Welfare.
7. Monthly Statistics of Foreign Trade in India, DGCIS, Calcutta and other Govt. Publications.

STM–416 : Practical paper based on the contents of selected Elective Papers　　　　　**Credits : 3**

STM–417 : Project Work - II　　　　　　　　　　　　　　　　　　　**Credits : 2**
　　The Project Work – II will be spread over the whole semester. A project may be undertaken by a group of students. However, the project report shall be submitted by each member of the group separately. A project report shall clearly state the problem addressed, the methodology adopted, the assumptions and the hypotheses formulated, any previous reference to the study undertaken, statistical analyses performed and the broad conclusion drawn. There shall be an external examiner and an internal examiner (preferably the supervisor of the student) for the evaluation of the project work. Out of total 100 marks assigned to the project, 60 marks will be assigned on the evaluation of the project work separately by both the examiners and 40 marks will be assigned jointly by the examiners on the oral presentation and viva – voce).

M.Sc. ZOOLOGY
Department of Zoology
Banaras Hindu University

Semesterwise distribution of Courses and Credits

Course Code	Title	Credits
Semester-I		
Course Code	**Title**	**Credits**
ZOM101	Non Chordata & Chordata (Credits 1.5+1.5)	3
ZOM102	Entomology & Fish Biology (Credits 1.5+1.5)	3
ZOM103	Vertebrate Endocrinology	4
ZOM104	Analytical and Molecular Techniques & Microscopy (Credits 3+1)	4
ZOM105	*Lab. exercises based on courses ZOM101 & ZOM102*	3
ZOM106	*Lab. exercises based on courses ZOM103 & ZOM104*	3
ZOM107M #	*Minor Elective:* Evolutionary Biology *(for students of other PG programmes)* *Minor Elective (for Zoology students)*	3
	Total	**23**
Semester-II		
ZOM201	Cytogenetics & Genetics (Credits 2+2)	4
ZOM202	Biochemistry & Cell Structure and Function (Credits 2+2)	4
ZOM203	Histology and Histochemistry & Bioinformatics (Credits 1.5 + 1.5)	3
ZOM204	Mammalian Physiology & Neurobiology (Credits 2.5+1.5)	4
ZOM205	*Lab. exercises based on course ZOM201*	2
ZOM206	*Lab. exercises based on course ZOM202*	2
ZOM207	*Lab. exercises based on courses ZOM203 & ZOM204*	3
ZOM208M #	*Minor Elective:* Hormones and Diseases *(for students of other PG programmes)* *Minor Elective (for Zoology students)*	3
	Total	**25**
Semester-III		
ZOM301	Developmental Biology & Immunology (Credits 2+1)	3
ZOM302(A-E)	Major Elective Course I	3
ZOM303(A-E)	Major Elective Course II	3
ZOM304(A-E)	Major Elective Course III	3
ZOM305	*Lab. exercises based on course ZOM301*	2
ZOM306(A-E)	*Lab. exercises based on courses ZOM302,303 & 304(A-E)*	3
#	*Minor Elective (for Zoology students)*	3
	Total	**20**
Semester-IV		
ZOM401	Animal Behaviour & Environmental Biology (Credits 1.5+1.5)	3
ZOM402	Evolution & Parasitology (Credits 2+1)	3
ZOM403(A-E)	Major Elective Course IV	3
ZOM404(A-E)	Major Elective Course V	3
ZOM405	*Lab. exercises based on courses ZOM401 & ZOM402*	3
ZOM406(A-E)	*Lab. exercises based on courses ZOM403 & 404 (A-E)*	2
ZOM407(A-E)	*Project work/ Dissertation*	4
ZOM408	*Seminar*	1
	Total	**22**
	Grand Total	**90**

M.Sc. Zoology students will opt 3 Minor Electives (3 credit each in semester I, II & III) offered by other PG Programmes of Faculty.

Note: 1. Each student will opt *one out of the five* Major Elective Groups (A-E). Each group will have a set of *five* theory courses and corresponding laboratory exercises, which will be spread over Semester III & IV. The *Project work/ Dissertation* will be carried out in the field of the respective Group (A-E).

2. Group-wise distribution of Major Elective courses are given on next page.

ZOM 101: NON CHORDATA & CHORDATA
(Credit 3)

Section A: Non Chordata (Credit 1.5)	Hours of teaching
1. Protozoa	3
1.1 Nucleus and reproduction	
1.2 Colonial protozoans and theories of the origin of metazoans	
2. Porifera: canal system	2
3. Cnidaria	2
3.1 Nematocysts	
3.2 Polymorphism in Siphonophora	
4. Annelida	3
4.1 Adaptive radiation in polychaetes	
4.2 Trochophore larva: structure and significance	
5. Mollusca	3
5.1 Nervous system	
5.2 Modifications of foot	
6. Arthropoda	3
6.1 Affinities of trilobites	
6.2 Crustacean larvae and their significance	
7. Echinodermata: larval forms and their significance	1
8. Salient features and affinities of	3
8.1 Placozoa	
8.2 Mesozoa	
8.3 Rotifera	
8.4 Phoronida	
8.5 Sipuncula	

Section B: Chordata (Credit 1.5)	Hours of teaching
1. Characteristic features and affinities of the following	4
1.1 Protochordata	
1.1.1 Hemichordata	
1.1.2 Urochordata	
1.1.3 Cephalochordata	
1.2 Cyclostomes	
2. Transition from agnatha to gnathostomata	1
3. Origin of the following	5
3.1 Fish	
3.2 Amphibia	
3.3 Reptile	
3.4 Bird	
3.5 Mammal	
4. Adaptive radiation in vertebrates	5
4.1 Aquatic	
4.2 Terrestrial	
4.3 Aerial	
4.4 Arboreal	
4.5 Fossorial	
5. Parental care in amphibians	1
6. Skull in reptiles	1
7. Venom in ophidians	1
8. Flightless birds	1

9. Modification of beak, feet and palate in birds   **1**

Books Recommended

1.   Barnes: Invertebrate Zoology (4th ed 1980, Holt-Saunders International)
2.   Barnes: The Invertebrates – A synthesis (3rd ed 2001, Blackwell)
3.   Hunter: Life of Invertebrates (1979, Collier Macmillan)
4.   Marshall: Parker & Haswell Text Book of Zoology, Vol. I (7th ed 1972, Macmillan)
5.   Moore: An Introduction to the Invertebrates (2001, Cambridge University Press)
6.   Harvey et al: The Vertebrate Life (2006)
7.   Colbert et al: Colbert's Evolution of the Vertebrates: A history of the backboned animals through time (5th ed 2002, Wiley - Liss)
8.   Hildebrand: Analysis of Vertebrate Structure (4th ed 1995, John Wiley)
9.   Jordan and Verma: Chordate Zoology (1998, S. Chand)
10. Kotpal: The Birds (4th ed 1999, Rastogi Publications)
11. McFarland et al: Vertebrate Life(1979, Macmillan Publishing)
12. Parker and Haswell: TextBook of Zoology, Vol. II (1978, ELBS)
13. Romer and Parsons: The Vertebrate Body (6th ed 1986, CBS Publishing Japan)
14. Sinha, Adhikari and Ganguli: Biology of Animals, Vol. II (1988, New Central Book Agency)
15. Young: The life of vertebrates (3rd ed 2006, ELBS/Oxford)

ZOM 102: ENTOMOLOGY & FISH BIOLOGY (Credit 3)

Section A: Entomology (Credit 1.5)   **Hours of teaching**
1. Importance and taxonomic richness of insects   **1**
2. External anatomy   **4**
    2.1 Segmentation and tagmosis
    2.2 Integument: structure and functions of cuticle, sclerotization and colouration
    2.3 Head: types of head and antennae
    2.4 Thorax: legs and wings
3. Internal anatomy and physiology   **9**
    3.1 Nervous system
    3.2 Endocrine system and function of hormones
    3.3 Circulatory system: heart and haemolymph
    3.4 Respiratory system
        3.4.1 Aerial respiration: spiracles, trachea and tracheoles
        3.4.2 Aquatic respiration
    3.5 Digestive system
        3.5.1 Structure of gut
        3.5.2 Digestion and absorption of food
    3.6 Excretory system and waste disposal
        3.6.1 Malpighian tubules
        3.6.2 Nitrogen excretion
    3.7 Reproduction
        3.7.1 Female and male systems
        3.7.2 Physiology of reproduction
4. Sensory system   **1**
    4.1 Tactile mechanoreceptor and position receptor
    4.2 Compound eye
5. Applied Entomology   **5**
    5.1 Insects as friends and foes
    5.2 Insect plant-interaction
    5.3 General methods of insect pest management
    5.4 Medical entomology: insects as vectors of diseases and their control

Section B: Fish Biology (Credit 1.5)   **Hours of teaching**

1. **Major groups of living fishes**   1
2. **Nutritional value and economic importance of fishes**   1
3. **Fins: origin, types and function**   3
4. **Respiratory organs**   3
   4.1 Water breathing
   4.2 Air-breathing
5. **Swim bladder**   2
6. **Electric organs**   2
7. **Poisonous and venomous fishes**   2
8. **Fish migration**   2
9. **Fisheries**
   9.1 Definition and classification   1
   9.2 Outlines of fish culture in ponds   2
10. **Ichthyology and its scope**   1

<u>**Books Recommended**</u>

Entomology
1. Atwal: Agricultural Pests of India and South East Asia (1986, Kalyani Publishers)
2. Chapman: The Insects: structure and function (4th ed, 1998, ELBS)
3. Gilbert et al: Comprehensive Molecular Insect Science Volume 1- 7 (2005, Elsevier)
4. Hill: Pest of stored foodstuffs and their control (2002, Springer)
5. Imms: A general text book of entomology, 2 vols (1997, Asia Publishing House)
6. Klowden: Physiological Systems in Insects (2002, Academic Press)
7. McGavin: Essential Entomology (2001, Oxford Univ Press)
8. Mullen and Durden: Medical and Veterinary Entomology (2002, Academic Press)
9. Resh and Carde: Encyclopedia of Insects (2003, Academic Press)
10. Srivastava: A text book of applied entomology, Vol I & II (1993, Kalyani Publishers)
11. Wigglesworth: Principles of Insect Physiology (1972, ELBS)

Fish Biology
1.   Brown: Physiology of fishes, Vols 1 and 2 (1957, Academic press)
2.   Gupta and Gupta: General and applied Ichthyology (Fish and Fisheries) (2006, S. Chand)
3.   Hoar and Randall: Fish Physiology, Volumes I-XV (1969-onwards, Academic Press)
4.   Khanna and Singh: A textbook of Fish Biology and Fisheries (2003, Narendra Publishing House)
5.   Lagler, Bardach, Miller and May Passino: Ichthyology (2003, Wiley)
6.   Mishra: Records of Indian Museum an aid to the identification of the common commercial fishes of India and Pakistan, Vol. 5 (Part I-IV) (1962)
7.   Norman and Greenwood: A History of Fishes (3rd ed 1975, Ernest Bvenn Limited)
8.   Pillay: Aquaculture: Principles and Practices Fishing News Books (2005, First Indian reprint)
9.   Srivastava: A Textbook of Fishery Science and Indian Fisheries (1985, Kitab Mahal)
10. Srivastava: Fishes of U.P. and Bihar (2002, Vishwavidyalaya Prakashan)
11. Parihar: Fish Biology and Indian fisheries (1999, Central publishing House Allahabad)
12. Singh: Advances in Fish Research, Vol. I, II and III (Fisheries and Fish Biology: Ed Datta   Munshi) (1993, 1997and 2004, Narendra Publishing House Delhi)

ZOM 103: VERTEBRATE ENDOCRINOLOGY
(Credit 4)

Section A: Comparative Endocrinology   (Credit 2)   **Hours of teaching**

1. **Vertebrate endocrine system**   1

2. **Hypothalamo-hypophysial system**   7
   2.1 Neurosecretion
   2.2 Hypothalamic neurosecretory centers
   2.3 Neurohypophysis

      2.3.1 General organization
      2.3.2 Median eminence: structure and function
      2.3.3 Octapeptide hormones
    2.4. Adenohypophysis
      2.4.1 General organization
      2.4.2 Distribution of pituitary cell types and functions (teleost model)

3. Urophysis: structure and function	**2**
4. Pineal organ: structure and function	**2**
5. Comparative anatomy of thyroid gland and its role in metamorphosis (amphibian model)	**3**
6. Comparative anatomy of adrenocortical and medullary homologues	**2**
7. Gonads	**5**

7.1 Structure of testis and ovary
7.2 Steroidogenic sites
7.3 Steroid hormones and their functions

8. Endocrine control of colour change with emphasis on pars intermedia function in amphibians	**2**
9. Endocrine control of osmoregulation in fish	**2**

Section B: Mammalian Endocrinology   *(Credit 2)*

Hours of teaching

1. Mechanism of hormone action	**3**

    1.1 Protein hormones
      1.1.1 Membrane receptors
      1.1.2 G-proteins
      1.1.3 Cyclic AMP signaling cascade
      1.1.4 PKC signaling pathway
    1.2 Steroid hormones (genomic and nongenomic pathways)

2. Hypothalamo-hypophysial System	**8**

    2.1 General organization
    2.2 Neurohypophysial octapeptides (oxytocin and vasopressin)
    2.3 Hypophysiotropic hormones: chemistry, localization and actions
    2.4 Adenohypophysial hormones: chemistry and physiological roles of
      2.4.1 Somatotropin and prolactin
      2.4.2 Glycoprotein hormones (FSH, LH and TSH)
      2.4.3 Pro-opiomelanocortin (ACTH, MSH, -LPH and -endorphin)
    2.5 Neural control of adenohypophysis

3. Thyroid hormones: biosynthesis, control of secretion and physiological roles	**2**
4. Steroid hormones: biosynthetic pathways	**1**
5. Testis: organization and physiological roles of androgens	**2**
6. Ovary: organization and physiological roles of estrogen, progesterone,relaxin and inhibin	**3**
7 Adrenal cortex	**2**

    7.1 Organization
    7.2 Control of mineralocorticoid and glucocorticoid hormones
    7.3 Physiological role of glucocorticoids and mineralocorticoids

8. Adrenal medulla: catecholamine biosynthesis, release and physiological role	**1**
9 Role of parathormone, calcitonin and vitamin D in calcium homeostasis	**1**
10. Endocrine pancreas: biosynthesis and physiological actions of insulin and glucagon	**2**
11. Gastrointestinal hormones (secretin, gastrin and cholecystokinin)	**1**

<div align="center">

Books Recommended

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1. Bentley: Comparative Vertebrate Endocrinology (1998, Cambridge University Press)

2. Chester-Jones et al: Fundamentals of Comparative Endocrinology (1987, Plenum Press)

3. Gorbman et al: Comparative Endocrinology (1983, John Wiley)

4. Norris: Vertebrate Endocrinology (4th ed 2007, Elsevier)

5. Schreibman & Pang: Vertebrate Endocrinology Vol I-IV, Fundamentals & Biomedical Implications (1985 & onwards, Academic Press)

6. Hadley: Endocrinology, Prentice Hall (2000, International Edition)

7. Brooks and Marshall: Essentials of Endocrinology (1995, Blackwell Science)

8. Turner and Bagnara: General Endocrinology (1984, Saunders)

9. Larson: Williams Textbook of Endocrinology (10th ed 2002, Saunders)

ZOM 104: ANALYTICAL AND MOLECULAR TECHNIQUES & MICROSCOPY
(Credit 4)

Section A: Analytical and Molecular Techniques   **(Credit 3)**

Hours of teaching

1. Buffers   **2**
     1.1 pH and its determination
     1.2 Preparation of buffer

2. Centrifugation   **3**
     2.1 Basic principles
     2.2 Types of rotors
     2.3 Clinical, high speed and ultracentrifuge

3. Spectrophotometry   **2**
     3.1 Types of spectrophotometer
     3.2 Beer-Lambert's law, molar extinction coefficient
     3.3 Absorption spectrum
     3.4 Principles of UV- Vis spectrophotometry

4. Electrophoresis   **4**
     4.1 Principles
     4.2 Agarose- and polyacrylamide gel
     4.3 Isoelectrofocussing
     4.4 Two-dimensional

5. Chromatography   **6**
     5.1 Principles
     5.2 Paper and thin layer chromatography
     5.3 Column chromatography
         5.3.1 Gel filtration
         5.3.2 Ion exchange
         5.3.3 Affinity
     5.4 Introduction to FPLC and HPLC
     5.5 Introduction to mass spectrometry: MALDI-TOF

6. Introduction to NMR and X-ray crystallography   **2**

7. Radio-tracer techniques   **4**
     7.1 Unit of radioactivity and half-life
     7.2 Measurement of radioactivity (and emission)
     7.3 Applications of radioisotopes
     7.4 Safety measures

8. Detection of proteins   **2**
     8.1 Western blotting
     8.2 ELISA

9. DNA-protein and protein-protein interactions   **6**
     9.1 South-Western
     9.2 DNA foot printing
     9.3 EMSA
     9.4 Yeast two-hybrid
     9.5 Phage display
     9.6 Far Western

10. Recombinant DNA techniques   **6**
     10.1 Restriction enzymes
     10.2 Cloning vectors

10.3 Preparation and screening of cDNA and genomic DNA libraries
10.4 Southern and Northern hybridizations
10.5 *In situ* hybridization
10.6 Polymerase chain reaction: principles and applications

11. Introduction to DNA sequencing　　　　　　　　　　　　　　　　　**2**

Books Recommended

1. Boyer: Modern Experimental Biochemistry and Molecular biology (2nd ed 1993, Benjamin/Cumin)

2. Freifelder: Physical Biochemistry (2nd ed 1982, Freeman)

3. Holme and Peck: Analytical Biochemistry (3rd ed 1998, Tata McGraw Hill)

4. Plummer: An Introduction to Practical Biochemistry (3rd ed 1990, Tata-McGraw Hill)

5. Switzer and Garrity: Experimental Biochemistry (92nd ed 1999, Freeman)

6. Wilson and Walker: Principles of Biochemical and Molecular Biological Techniques (6th ed 2006, Cambridge Univ Press)

Section B: Microscopy　　　　　　　　　　　　　　　　　　**(Credit 1)**
　　　　　　　　　　　　　　　　　　　　　　　　　　　Hours of teaching

1. Basic principles of microscopy　　　　　　　　　　　　　　　　　**2**
2. Types of microscopes and their biological applications　　　　　　**10**
   2.1 Bright-field microscope: numerical aperture, limit of resolution, types of objectives, ocular and stage micrometers
   2.2 Dark-field microscope
   2.3 Phase-contrast microscope
   2.4 Differential interference contrast microscope
   2.5 Fluorescence microscope
   2.6 Confocal microscope
   2.7 Atomic force microscopy
   2.8 Transmission and scanning electron microscopes
3. Photomicrography and image processing　　　　　　　　　　　　　**1**

Books recommended
1. Alberts et al: Molecular Biology of the Cell (2002, Garland)
2. Karp: Cell and Molecular Biology (2007, Wiley)
3. Lodish et al: Molecular Cell Biology (2007, Freeman)
4. Pollard & Earnshaw: Cell Biology (2002, Saunders)
5. Ruthman: Methods in Cell Research (1970, Bell & Sons)

LABORATRORY EXERCISES

ZOM 105: NONCHORDATA & CHORDATA AND ENTOMOLOGY & FISH BIOLOGY
(Credit 3)

Part A: Non Chordata & Chordata (Credit 1.5)

Non Chordata

1. Preparation of permanent slides
   1.1 Protozoa: *Paramecium* (whole mount) and demonstration of food vacuoles
   1.2 Cnidaria: *Bougainvillea, Sertularia*
   1.3 Arthropoda: *Cyclops*, Megalopa/Zoea, booklung of scorpion
   1.4 Mollusca: glochidium larva
   1.5 Echinodermata: pedicellaria, tubefeet

2. Dissections

2.1 Arthropoda: reproductive system of *Palamnaeus*

2.2 Mollusca: nervous system of *Mytilus* and *Aplysia/Sepia*

3. Study of museum specimens
   3.1 Porifera
   3.2 Cnidaria
   3.3 Annelida
   3.4 Arthropoda
   3.5 Mollusca
   3.6 Echinodermata

Chordata

1. Study of external features of *Branchiostoma* and permanent preparation of its oral hood, velum and pharyngeal wall

2. Study of whole mount preparations of following proto-chordates
   2.1 *Doliolum, Pyrosoma, Salpa* and *Oikopleura*
   2.2 T.S. through pharynx, gonad and post anal region of *Branchiostoma*
   2.3 T.S. and L.S. through proboscis of *Balanoglossus*

3. Permanent preparation of test and spicules of *Herdmania*

4. Dissections of air-sacs and urino-genital systems of pigeon

5. Study of museum specimens
   5.1 Amphibia
   5.2 Reptiles
   5.3 Birds
   5.4 Mammals

Part B: ENTOMOLOGY & FISH BIOLOGY
(Credit 1.5)

Entomology

1. Study of external morphology of cockroach

2. Internal anatomy of cockroach
   2.1 Alimentary canal
   2.2 Salivary apparatus: dissection and *in toto* stained preparation
   2.3 Permanent mounting of heart

3. Dissection of frontal ganglion, brain, corpora cardiaca, corpora allata and recurrent nerve

4. Dissection and mounting of prothoracic gland

5. Dissection of male and female reproductive systems of cockroach

6. Study of external morphology of honey bee and dissection of sting apparatus

7. Study of following using permanent slides/specimens: L. S. of teleotrophic and polytrophic ovarioles, T. S. of testis, and brain showing MNSC, whole mount of head of louse, CC & CA and chironomous larva

Fish Biology

1. Classification of the following locally available fishes using key
   1.1 Carps: *Catla catla; Labeo rohita, Cirrhina mrigala*
   1.2 Catfishes: *Heteropneustes fossilis, Clarias batrachus*

2. Dissection and display of accessory respiratory organs of
   2.1 *Clarias batrachus*
   2.2 *Channa sp*
   2.3 *Heteropneustes fossilis*

3. Dissection of carp showing interrelationship between the gas (swim or air) bladder and Weberian ossicles

4. Mounting of respiratory epithelium of accessory respiratory organs of *H. fossilis* and air bladder epithelium of carp

5. Study of museum specimens of fishes having electric organs, venomous organs and air breathing organs
6. Study of T.S. of gills, accessory respiratory organs and swim bladder from prepared slides
7. Visit to a local pond or fishing site

ZOM 106: VERTEBRATE ENDOCRINOLOGY AND ANALYTICAL AND MOLECULAR TECHNIQUES & MICROSCOPY

Part A: Vertebrate Endocrinology
(Credit 1.5)

1. Handling and maintenance of rat in laboratory
2. Survey of endocrine glands and reproductive organs in *Calotes* and rat
3. Surgical ablations of testis, ovary, adrenal and thyroid in *Calotes* and rat
4. Study of oestrous cycle of rat by vaginal smear preparation
5. Study of the following using permanent slides
   5.1 Endocrine glands and reproductive organs of rat
   5.2 Gonads (testis and ovary from fish to birds)
   5.3 Thyroid of fish (pharyngeal and ectopic) and reptile
   5.4 Adrenal homologues (interrenal and chromaffin tissues) in fish and reptile
   5.5 Cell types of fish pituitary
   5.6 Hypothalamo-neurohypophsial system of a catfish in *in situ* preparation
6. Immuocytochemical identification of pituitary cell types in fish and amphibians using permanent slides
7. Demonstration of ELISA-based hormone assay

Part B: Analytical and Molecular Techniques & Microscopy
(Credit 1.5)

Analytical and Molecular Techniques (Credit 1)
1. Preparation of buffer and measurement of pH using pH meter
2. Demonstration of separation of subcellular organelles by differential centrifugation
3. Verification of Beer's law and preparation of absorption spectrum of riboflavin
4. Demonstration of separation of protein by native and SDS-polyacrylamide gel electrophoresis
5. Separation of amino acids by paper chromatography
6. Demonstration of separation of blue dextran and riboflavin by gel filtration column chromatography
7. Demonstration of tracer techniques
8. Isolation of plasmid, restriction digestion and determination of size by agarose gel electrophoresis
9. Demonstration of DNA amplification by polymerase chain reaction

Microscopy
(Credit 0.5)
1. Study of different components of student's microscope and its assembly
2. Study of different components of stereobinocular microscope and its assembly
3. Study of different parts of binocular research microscope
4. Measurement of microscopic object using ocular and stage micrometers
5. Setting up of darkfield and phase contrast microscope
6. Demonstration of working of fluorescence, confocal and electron microscopes

ZOM107M: EVOLUTIONARY BIOLOGY

	Hours of teaching
1. Evolutionary time scale and geological eras	2
2. Origin and early history of life	
2.1 Theories about the origin of life	
2.2 Theories about the origin of cell	
3. Organic evolution: concept and evidences	4

(comparative anatomy, embryology, biogeography, palaeontology,
genetics, biochemistry and physiology)

4. Theories of evolution: Lamarckism, Darwinism and Modern theories   4

5. Population as unit of evolution   4
   5.1 Gene frequencies in Mendelian population
   5.2 Hardy-Weinberg Equilibrium
   5.3 Major evolutionary forces

6. Species and phylogenetic relationships   4
   6.1 Concepts of species
   6.2 Modes of speciation
   6.3 Phylogenetic relationships

7. Evolution at molecular level   4
   7.1 Genomic and proteomic changes
   7.2 Molecular clock
   7.3 Molecular phylogeny

8. Evolution of man   4
   8.1 Hominid evolution: anatomical, geographical and cultural
   8.2 Ancestry of *Homo sapiens*: molecular phylogenetic relationship
   8.3 Peopling of continents

9. Environmental contexts of evolutionary changes   3
   9.1 Environment and global climate patterns
   9.2 Responses to environmental variation
   9.3 History of biodiversity and extinction
   9.4 Adaptation to specific habitats with examples

10. Evolution of behaviour   4
   10.1 Behaviour as phenotypic traits
   10.2 Adaptive value of behaviour
   10.3 Role of behaviour in evolution
   10.4 Interactions among species (competition, predation, parasitism,
       mutualism and mimicry)

11. Evolution of reproductive mechanisms: asexual and sexual reproduction; evolution of cleidoic egg   2

12. Biochemical evolution: metabolic pattern changes (autotrophic, heterotrophic, anaerobic and aerobic)   2

Books Recommended
1. Coyne and Orr: Speciation(2004, Sinauer)
2. Dobzhansky et al: 1976 Evolution (2004, Surjeet Publ)
3. Dodson: Evolution: Process and Product (1964, Reinhold Publishing Corp)
4. Freeman and Herron: Evolutionary Analysis (1998, Prentice Hall)
5. Futuyma: Evolutionary Biology(1998, Sinauer)
6. Hartl and Clarke: Principles of Population Genetics (1989 & 1997, Sinauer)
7. Hochachha and Samero: Biochemical Adaptations(1984, Princeton University Press edition)
8. Jobling et al: Human Evolutionary Genetics: Origins, Peoples & Diseases (2004, Garland Science)
9. Kimura: The Neutral Theory of Molecular Evolution (1990, Cambridge)
10. Koonin and Galperin: Sequence-evolution-Function: Computational Approaches in comparative
    Genomics (Kluwer Academic Publishers)
11. Hsiung and Graur: Fundamentals of Molecular Evolution (1991, Sinauer)

12. Mader: Biology (2007, McGraw)
13. Mayr: Populations, Species and Evolution: An Abridgement of Animal Species and Evolution (1971, Belknap Press)
14. Moody (1978): Introduction to Evolution. Kalyani Publ.
15. Prosser (1986): Adaptational Biology: Molecules to organism . John Wiley
16. Purves et al. (2004): Life: The Science of Biology. Sinauer
17. Raven and Johnson (2002): Biology. Mc Graw Hill
18. Ridley (1993): Evolution. Blackwell.
19. Savage (1963): Evolution. Holt, Rinehart and Winston
20. Stearns (1999): The Evolution of Life Histories. Oxford.
21. Stebbins (1979): Processes of Organic Evolution. Prentice- Hall of India
22. Strickberger (2000): Evolution. Jones and Bartlett.
23. White (1978): Modes of Speciation. Freeman

SEMESTER II

ZOM 201: CYTOGENETICS & GENETICS
(Credit 4)

Section A: Cytogenetics (Credit 2)

	Hours of teaching
1. Eukaryotic chromatin structure and chromsome organization	**9**

   1.1 Classes of DNA
   1.2 Chromosomal proteins: histones and their modifications, non-histone proteins, scaffold/matrix proteins
   1.3 Levels of chromatin condensation at interphase and metaphase stages
   1.4 Nuclear matrix and organization of interphase nucleus
   1.5 Centromere, kinetochore and telomere
   1.6 Metaphase chromosome banding
   1.7 Chromosome and chromatid type aberrations

2. Giant chromosomes: models for studies on chromosome organization and gene expression   **4**

3. Cell division   **7**
   3.1 Mitosis
      3.1.1 Role of maturation promoting factor
      3.1.2 Chromosomal movement
      3.1.3 Exit from mitosis
      3.1.4 Cytokinesis
   3.2 Meiosis
      3.2.1 Chromosome pairing and recombination
      3.2.2 Genetic regulation of meiosis

4. Human cytogenetics   **6**
   4.1 Karyotype and nomenclature of metaphase chromosome bands
   4.2 Chromosome anomalies and disease
   4.3 Types of chromosomal anomalies
   4.4 Common syndromes caused by aneuploidy, mosaicism, deletion and duplication
   4.5 Chromosomal anomalies in malignancy (chronic myeloid leukemia, Burkitt lymphoma, retinoblastoma and Wilms' tumour)
   4.6 Fragile site and X-linked mental retardation

Section B: Genetics (Credit 2)

	Hours of teaching
1. Mendel's laws and their chromosomal basis	**1**
2. Extensions of Mendelism	**1**

   2.1 Dominance relationships
   2.2 Epistasis
   2.3 Pleiotropy

2.4 Expressivity and penetrance

3. Methods of gene mapping   **6**
    3.1 3-point test cross in *Drosophila*
    3.2 Gene mapping in human by linkage analysis in pedigrees
    3.3 Tetrad analysis in *Neurospora*
    3.4 Gene mapping in bacteria by conjugation, transformation and transduction

4. Gene mutation and DNA repair   **6**
    4.1 Types of gene mutations
    4.2 Methods for detection of induced mutations
    4.3 P-element insertional mutagenesis in *Drosophila*
    4.4 DNA damage and repair

5. Nature of the gene and its functions   **6**
    5.1 Evolution of the concept of gene
    5.2 Fine structure of gene (*rII* locus)
    5.3 Regulation of gene activity in *lac* and *trp* operons of *E.coli*
    5.4 Introduction to gene regulation in eukaryotes
        5.4.1 Organization of a typical eukaryotic gene
        5.4.2 Transcription factors, enhancers and silencers
        5.4.3 Transcriptional and post-transcriptional regulation
        5.4.4 Noncoding genes

6. Organization and function of mitochondrial DNA   **1**

7. Quantitative inheritance   **2**

8. Applications and implications of genetic engineering   **3**
    8.1 Genetic manipulations in plants and animals
    8.2 Detection of genetic disorders
    8.3 Gene therapy

Books Recommended:

1. Alberts et al: Essential Cell Biology (1998, Garland)
2. Alberts et al: Molecular Biology of the Cell (2002, Garland)
3. Bostock & Sumner: Eukaryotic Chromosome (1987, North-Holland)
4. Brooker: Genetics : Analysis and Principles (1999, Addison-Wesley)
5. DeRobertis & DeRobertis: Cell and Molecular Biology (1987, Lee & Febiger)
6. Gardner et al: Principles of Genetics (1991, John Wiley)
7. Griffith et al: Modern Genetic Analysis (2002, Freeman)
8. Hartl & Jones: Essential Genetics: A Genomic Perspective (2002, Jones & Bartlet)
9. Karp: Cell and Molecular Biology (2002, John Wiley & Sons)
10. Lewin, Genes VIII (2004, Wiley)
11. Lodish et al: Molecular Cell Biology (2000, Freeman)
12. Pollard & Earnshaw: Cell Biology (2002, Saunders)
13. Russell: Genetics (2002, Benjamin Cummings)
14. Snustad & Simmons: Principles of Genetics (2003, John Wiley)

ZOM 202: BIOCHEMISTRY & CELL STRUCTURE AND FUNCTION
(Credit 4)
Section A: Biochemistry (Credit 2)

                                             Hours of teaching

1. Laws of thermodynamics and their applications   **1**
    1.1 Concept of free energy and calculations based on free energy change

2. Protein structure   **6**
    2.1 Primary structure, peptide bond
    2.2 Secondary structure
        2.2.1 α-helix, β-pleated sheet and bends
        2.2.2 Prediction of secondary structure, Ramachandran plot

2.3 Tertiary structure
    2.3.1 Forces stabilizing tertiary structure
    2.3.2 Domains and motifs
2.4 Quaternary structure

3. Enzymes   **6**
3.1 Enzyme kinetics
    3.1.1 Lowering of activation energy
    3.1.2 Derivation of Michaelis-Menten equation, related calculations And Michaelis-Menten and Lineweaver-Burk plots
3.2 Mechanism of action
    3.2.1 Active site, substrate binding, transition state analogues and abzyme
    3.2.2 Acid-base and covalent catalysis (chymotrypsin, carboxypeptidase)
    3.2.3 Concepts of regulation of enzyme activity

4. Metabolism   **3**
4.1 Concept of metabolic pathways
4.2 Energy transduction: glucose and fatty-acids as energy source

5. Nucleic acids

5.1 Structure, folding motifs, conformational flexibility and supercoiling   **1**
5.2 Mechanism of DNA replication   **3**
    5.2.1 DNA polymerases
    5.2.2 Origin of replication and formation of primosome
    5.2.3 Replication fork and replisome
    5.2.4 Termination of replication

5.3 Transcription unit   **1**

5.4 Mechanism of transcription
    5.4.1 RNA polymerases
    5.4.2 Formation of pre-initiation complex at RNA pol II promoter

5.5 Processing of hnRNA   **2**
    5.5.1 Capping
    5.5.2 Poly(A) tailing
    5.5.3 Splicing

5.6 Genetic code   **1**

5.7 Mechanism of translation   **2**
    5.7.1 Role of ribosomes and tRNAs
    5.7.2 Formation of initiation complex
    5.7.3 Elongation and termination

Books Recommended

1. Berg et al: Biochemistry (5th ed 2001, Freeman)
2. Nelson et al: Lehninger Principles of Biochemistry (3rd ed 2004, Pearson)
3. Mathews et al: Biochemistry (3rd ed 1990, Benjamin/Cummings)
4. Segal Biochemical calculations (2nd ed 1976, John Wiley)
5. Watson et al: Molecular Biology of the Gene (2nd ed 1976, Benjamin/Cummings)
6. Zubay et al: Principles in Biochemistry (2nd ed 1995, WCB)
7. Rawn: Biochemistry (1989, Neil Patterson)
8. Primrose et al: Principals of gene manipulation (6th ed 2001, Blackwell Scientific)

Section- B: Cell Structure and Function (Credit 2)

      Hours of teaching
1. Prokaryotes
1.1 Viruses: structure and replication   **4**
    1.1.1 Bacteriophage (Lambda phage, phi x 174)
    1.1.2 Animal DNA virus (SV 40)
    1.1.3 Retroviruses (HIV)
1.2. Bacteria   **2**
    1.2.1 Structure and reproduction of *E. coli*
    1.2.2 Plasmid and their functions

2. Eukaryotes

2.1 Cell Membrane   **4**

    2.1.1 Lipid bi-layer and membrane proteins

    2.1.2 Transport across the cell membrane

        2.1.2.1 Channels and transporters

        2.1.2.2 Diffusion, osmosis and measurement of osmotic pressure

        2.1.2.3 Active transport: mechanism and related calculations

2.2 Targeting and sorting of proteins   **4**

    2.2.1 Signal peptide and SRP dependent targeting of translational complex

    2.2.2 Processing of proteins in RER

    2.2.3 Processing through Golgi complex: targeting to plasma membrane and lysosome

    2.2.4 Targeting of nuclear and mitochondrial proteins

2.3 Mitochondria   **4**

    2.3.1 Structure: assemblies of respiratory chain and $F_0 F_1$ - ATPase

    2.3.2 Oxidative phosphorylation: mechanism and chemiosmotic concept

    2.3.3 Bioenergetics of ATP and other high energy phosphate compounds.

2.4 Nucleolus: structure and biogenesis of ribosomes   **1**

2.5 Cytoskeleton: organization of microtubules, microfilaments and intermediary filaments   **1**

2.6 Cell signaling   **3**

    2.6.1 Cell-cell interaction

    2.6.2 Chemical mediators

    2.6.3 Signaling through cell surface and intracellular receptors

2.7 Apoptosis: mechanism and significance   **2**

2.8 Cell transformation and malignancy   **1**

Books Recommended

1. Alberts et al: Molecular Biology of the Cell (4th ed 2002, Garland)

2. Lodish et al: Molecular Cell Biology (6th ed 2007, Freeman)

3. Berg et al.: Biochemistry (5th ed 2002, Freeman)

4. Michael Jr: Microbiology (1993, Tata McGraw Hill)

ZOM 203: HISTOLOGY AND HISTOCHEMISTRY & BIOINFORMATICS
(Credit 3)
Section A: Histology and Histochemistry (Credit 1.5)

                            Hours of teaching

1. Fixation and tissue processing   **3**

    1.1 Types of fixatives

    1.2 Chemistry of fixation

    1.3 Choice of fixatives

    1.4 Dehydration

    1.5 Clearing and embedding

2. Microtomy   **1**

    2.1 Types of microtomes

    2.2 Sectioning of paraffin blocks

3. Staining of paraffin sections   **2**

    3.1 Principle and methods of staining

    3.2 Histological stains: haematoxylin and eosin

4. Principles and methods of histochemical localization and identification of the following

    4.1 Carbohydrate moieties   **2**

        4.1.1 Glycogen and glycoproteins with oxidizable vicinal diols by periodic acid Schiff method

        4.1.2 Glycoproteins with carboxyl groups and/or *O*-sulphate esters by alcian blue methods

        4.1.3. Role of lectin in carbohydrate histochemistry

    4.2 Protein end groups   **2**

        4.2.1 General protein localization by bromophenol blue method

4.2.2 –NH$_2$ groups by ninhydrin-Schiff method

4.2.3 – SS- groups by performic acid –Schiff and performic acid- alcian blue methods

4.3 Lipids moieties   **2**

    4.3.1 General lipids by Sudan black B method

    4.3.2 Neutral lipids by Sudan III and Sudan IV methods

    4.3.3 Differentiation of neutral lipids from acidic lipids by nile blue sulphate method

4.4 Nucleic acids   **1**

    4.4.1 Methyl green pyronin-Y for DNA and RNA

    4.4.2 Feulgen reaction for DNA

4.5 Enzymes   **3**

    4.5.1 Principles of enzyme histochemistry

    4.5.2 Acid and alkaline phosphatases by metal precipitation and azo dye methods

5. Basic principles of immunohistochemistry   **2**

6. Enzyme as histochemical reagent   **1**

Books recommended

1. Bancroft & Stevens: Theory and Practice of Histological techniques (2002, Churchill- Livingstone)

2. Casselman: Histochemical techniques (1959, John Wiley)

3. Pearse: Histochemistry: Theoretical and Applied (Vol. I, II & III) (4th ed 1980-1993, Churchill- Livingstones)

Section B: Bioinformatics
(Credit-1.5)

                                                 Hours of teaching

1. Introduction and scope of bioinformatics: a concept of digital laboratory   **1**

2. Basics of computers (CPU, I/O units), operating systems (Windows, UNIX), networks (LAN, WAN) and information technology   **3**

3. Concept of hypertext and internet protocol (HTTP, TCP/IP)   **1**

4. Basics of home-pages, web-pages and uniform resource locators (URL)   **1**

5. Introduction to data archiving systems (FASTA format, Accession, and GI-Number)   **1**

6. Basic features and management systems of following   **6**

6.1 Nucleic acid sequences databases

6.2 Genome databases

6.3 Protein sequence, structures and interacting proteins databases

6.4 Literature databases

6.5 Biodiversity and ecosystem based databases

7. Introduction to data retrieval systems   **2**

7.1 Search engines

7.2 Entrez, sequence retrieval system (SRS) and protein identification resource (PIR)

8. Introduction to molecular sequence analysis software packages and tools   **3**

8.1 Prediction of motifs, folds and domains

8.2 Sequence alignments (BLAST and Clustal W) and phylogenetic trees (PHYLIP)

9. Applications of bioinformatics   **2**

9.1 Clinical informatics

9.2 Cheminformatic resources and pharmacoinformatics

Bioinformatics

1. Barnes & Gray: Bioinformatics for geneticists (2003, Wiley)

2. Lesk: Bioinformatics (2nd ed 2006, Oxford)

3. Westhead et al: Bioinformatics Instant Notes (Indian ed 2003, Viva Books)

4. Mount, Bioinformatics (2nd ed 2006, CBS)

5. Hunt and Livesey: Functional Genomics (2006, Oxford)

6. Campbel: Discovering Genomics, Proteomics and Bioinformatics (2006, LPE)

ZOM 204: MAMMALIAN PHYSIOLOGY & NEUROBIOLOGY
(Credit 4)
Section A: Mammalian Physiology   (Credit 2.5)

	Hours of teaching
1. Circulation	**9**

1. Circulation — 9
 1.1 Blood
   1.1.1 Haemopoiesis
   1.1.2 Haemostasis
 1.2 Lymph: composition and dynamics
 1.3 Heart
   1.3.1 Origin and conduction of cardiac impulse
   1.3.2 ECG and cardiac cycle
   1.3.3 Myocardial infarction

2. Respiration — 7
 2.1 Pulmonary ventilation
   2.1.1 Respiratory centers: organization and function
   2.1.2 Surfactant
 2.2 Gaseous exchange
 2.3 Haemoglobin and gaseous transport
 2.4 Basal metabolic rate and its measurement
 2.5 Respiratory adjustments
   2.5.1 Hypoxia and oxygen therapy
   2.5.2 Dyspnea
   2.5.3 Respiratory buffering

3. Excretion — 6
 3.1 Urine formation and regulation
 3.2 Acid-base balance and homeostasis
 3.3 Renal function tests

4. Muscle — 5
 4.1 Types of contraction
 4.2 Muscle proteins
 4.3 Mechanism of contraction and energetics
 4.4 Muscular dystrophy

5. Digestion and nutrition — 4
 5.1 Digestion and absorption of macronutrients and their regulation
 5.2 Obesity and starvation

Section B: Neurobiology (Credit 1.5)

	Hours of teaching
1. Plasticity of brain and neurogenesis	**1**

2. Organization of nervous system
 2.1 Brain structure
 2.2 Neurons and glia
 2.3 Cerebrospinal fluid
 2.4 Neural network
 2.5 Blood brain barrier
 2.6 Autonomic nervous system

3. Axonal and synaptic transmission — 5
 3.1 Types of neurons
 3.2 Membrane potential and action potential
 3.3 Types of synapses
 3.4 Excitatory and inhibitory post-synaptic potential
 3.5 Chemical transmission, neurotransmitters (acetylcholine, catecholamines, serotonin and GABA), neuropeptides

4. Learning and memory: types and molecular basis — 2

5. Brain and behavior: motivation and sleep — 2

6. Brain imaging: CAT, PET and MRI — 2

7. Brain aging   **1**

8. Neuropathology   **4**
    8.1 Strokes
    8.2 Epilepsy
    8.3 Alzheimer disease
    8.4 Huntington disease
    8.5 Parkinson disease

Books Recommended

1. Ganong: Review of Medical Physiology (22nd ed 2005, Lang Medical Publications)
2. Guyton and Hall: Text Book of Medical Physiology (11th ed 2006, W.B. Saunders)
3. Keel et al: Samson Wright's Applied Physiology (13th ed1989, Oxford Press)
4. Murray et al: Harper's Illustrated Biochemistry (27th ed 1989, Appleton & Lange)
5. West: Best and Taylor's Physiological Basis of Medical Practice (11th ed 1981, Williams and Wilkins)
6. Longstaff: Neuroscience (2002, Viva Books)
7. Shepherd: Neurobiology(1994, Oxford Univ Press)
8. Squire et al: Fundamental Neuroscience(2003, Academic Press)
9. Eric Kandel: Principles of Neural Science (2000, Mc Graw Hill)

LABORATORY EXERSISES
ZOM 205: Cytogenetics & Genetics (Credit 2)

Part A: Cytogenetics

1. Study of meiosis in grasshopper testes by squashing method

2. Temporary squash preparation of polytene chromosomes from salivary glands of *Drosophila* larvae

3. Study of colchicinised metaphase chromosomes in bone marrow of rodent by air dry method

4. Preparation of human karyotype

5. Study of sex chromatin in human female from buccal epithelial and hair bud cells

6. Study of permanent slides for the following
    6.1 Dicentric bridge in the anaphase 1 chromosomes of grasshopper
    6.2 Inversion in polytene chromosomes
    6.3 Autoradiography detection of transcription in polytene chromosomes
    6.4 Lampbrush chromosomes of *Triturus* oocyte
    6.5 G-banded and C-banded metaphase chromosomes
    6.6 Chromatid exchanges and chromosomal anomalies
    6.7 Sister chromatid exchanges
    6.8 Replicon organization by DNA-fibre autoradiography
    6.9 Premature chromosome condensation

Part B: Genetics

1. Culturing of *E coli* on solid and liquid media

2. Demonstration of bacterial transformation using a suitable plasmid vector (with and without insert)

3. Handling of *Drosophila* and study of its life cycle

4. Examination of wild type (males and females) and mutants of *Drosophila*

5. Sex linked inheritance in *Drosophila melanogaster*
6. Linkage and crossing over in *Drosophila melanogaster*

ZOM 206: BIOCHEMISTRY & CELL STRUCTURE AND FUNCTION
(Credit 2)

Part A: Biochemistry

1. Preparation of extract for enzyme assay (alkaline phosphatase)

2. Study of alkaline phosphatase activity

    2.1 Standard curve preparation
    2.2 Effect of enzyme concentration and determination of total and specific activity
    2.3 Effect of pH on enzyme activity
    2.4 Effect of temperature on enzyme activity
    2.5 Effect of time on enzyme activity
    2.6 Effect of substrate concentration on enzyme activity
    2.7 Determination of Km and Vmax by Michaelis-Menten and Lineweaver-Burk Plot

3. Isolation of genomic DNA by spooling method and its characterization
    3.1 Determination of quality and quantity of DNA
    3.2 Determination of melting temperature (Tm)

Part B: Cell structure and Function

1. Study of bacterial growth curve

2. Study of types of testicular cells and striated muscle

3. Fractionation of macromolecules from rat/mouse tissues

4. Estimations of fractionated molecules through spectrophotometric methods

    4.1 Free phosphate by Amies method
    4.2 Protein by Biuret/Folins method
    4.3 DNA by diphenylamine method
    4.4 RNA by orcinol method

ZOM 207: HISTOLOGY AND HISTOCHEMISTRY & BIOINFORMATICS AND MAMMLIAN PHYSIOLOGY & NEUROBIOLOGY
(Credit 3)
Part A: Histology and Histochemistry & Bioinformatics (Credit 1.5)

Histology and Histochemistry

1. Paraffin sectioning
    1.1 Fixation of tissue blocks (e.g. intestine and stomach of rat or squirrel)
    1.2 Dehydration, clearing and embedding of tissue block in paraffin
    1.3 Sectioning of paraffin blocks, stretching and spreading of sections on slides

2. Histological staining of paraffin sections using haematoxylin and eosin method

3. Histochemical staining of paraffin sections for certain carbohydrate moieties using

    3.1 Periodic acid/Schiff's method for neutral glycoproteins
    3.2 Alcian blue pH 2.5 method for acidic glycoproteins

4. Histochemical staining for lipids using
    4.1 Sudan black B method
    4.2 Sudan III method
    4.3 Sudan IV method

Bioinformatics

1. Familiarization with computer operations and TCP/IP

2. Data archiving systems: FASTA format, WebIn, BankIT, Accession and GI numbers

3. Use of search engines (Google, Altavista, Dogpile, Meta-crawler)

4. Demonstration of web-pages related to biological information (NCBI, ExPasy)

5. Hands on practice to features of following databases
    GeneBank, PDB, DIP, PubMed, Toxnet, OMIM, Fly Base, AceDB, HGDB, MGDB, HGMD, LSD, MHCDB, KEGG, RNAdb

6. Hands on practice to features of following software packages/tools: BLAST, Clustal-W, PHYLIP, M-fold, GeneCards, NetChop

Part B: Mammalian Physiology & Neurobiology
(Credit 1.5)

1. Differential leucocytes counting in human blood

2. Determination of blood groups (ABO and Rh)

3. Estimation of ascorbic acid content in milk and lemon extract using titration method

4. Studies on frog skeletal muscle (gastrocnemius muscle preparation) contraction, and to observe the effects of increasing voltage, frequency of stimulus and load

5. Studies on frog heart beat *in situ,* and to observe the effects of acetylcholine and noradrenalin

6. Studies on action potential in isolated nerve fibers using cathode ray oscilloscope (CRO), and measurement of nerve impulse conduction

7. Studies on learning and memory in rat/mouse model by Morris-Water-Maze Test

8. a). Isolation of neurons and glia by differential centrifugation
   b). Characterization of isolated cells types using marker enzyme assay

MINOR ELECTIVES
(To be offered to students of other department in the Faculty)
ZOM 208M: HORMONES AND DISEASES
(Credit 3)

	Hours of teaching
1. Scope of endocrinology	**1**
2. Pituitary gland	**6**
2.1 General organization and hormones	
2.2 Diseases: dwarfism, gigantism, acromegaly, diabetes insipidus	
3. Thyroid	**5**
3.1 General organization and hormones	
3.2 Diseases: goiter, myxoedema, cretinism	
4. Parathyroid gland	**4**
4.1 General organization and hormones	
4.2 Diseases: osteoporosis and tetany	
5. Islets of Langerhans	**4**
5.1 General organization and hormones	
5.2 Disease: diabetes mellitus (type I and type II)	
6. Adrenal gland	**3**
6.1 General organization and hormones	
6.2 Diseases: Addison's disease, Cushing's syndrome	
7. Testis	**4**
7.1 General organization and hormones	
7.2 Male infertility	
7.3 Cryptorchidism	
8. Ovary	**4**
8.1 General organization and hormones	
8.2 Diseases: polycystic ovarian disease, hirsutism, and hyperandrogenism	
9. Hormones and cancer	**2**
10. Hormones and stress	**2**
11. Obesity, and eating disorders	**2**
12. Melatonin, sleep disorders, and jet lag	**2**

Books Recommended

1. Hadley, M.C.: Endocrinology, Prentice Hall, International Edition, 2000

2. Wilson and Foster, Williams Text Book of Endocrinology 10th edition, W.B. Saunders
   Company Philadelphia, 2005

SEMESTER III

ZOM 301: DEVELOPMENTAL BIOLOGY & IMMUNOLOGY
(Credit 3)
Section A: Developmental Biology (Credit 2)

	Hours of teaching
1. Fertilization in sea urchin and mammals	**3**

   1.1 Recognition of gametes and acrosomal reaction
   1.2 Prevention of polyspermy and gamete fusion
   1.3 Activation of egg metabolism

2. Early development	**14**

   2.1 Cleavage: patterns
   2.2 Formation of blastula in amphibians
   2.3 Gastrulation: fate maps, cell movement and formation of
      germ layers in echinoderms, ambhibians and birds
   2.4 General concept of potency, commitment, specification, induction,
      competence and determination
   2.5 Differentiation and pattern formation
        2.5.1 Stalk and fruiting body formation in *Dictyostellium*
        2.5.2 Origin of anterior-posterior and dorsal-ventral polarity in
           Drosophila: role of maternal, segmentation and homeotic genes
        2.5.3 Organization of HOX gene in vertebrates
        2.5.4 Axis formation in amphibians: Nieuwkoop Centre and primary
           organizer
        2.5.5 Axis formation in birds and mammals: role of pattern
           forming genes

3. Late embryonic development
4

   3.1 Vulva formation in *Caenorhabditis*
   3.2 Formation of neural tube in vertebrates
   3.3 Development of limb in vertebrates: role of HOX and other pattern
      forming genes

4. Hormonal regulation of metamorphosis in insects and amphibians	**1**
5. Regeneration of Salamander limbs: polar coordinate model	**1**
6. Senescence	**1**
7. Stem cells and their applications	**2**

Section B: Immunology (Credit 1)

	Hours of teaching
1. Immune system	**3**

   1.1 Innate and adaptive immunity
   1.2 Immune cells: types and production
   1.3 Immune tolerance
   1.4 Concept of clonal selection
   1.5 Complement system

2. Humoral immunity	**4**

   2.1 Antigen and haptens
   2.2 Primary and secondary response
   2.3 Antibody: types, structure and functions
   2.4 Generation of antibody diversity

2.5 Class switching

3. Cell mediated immunity   **5**

    3.1 T-cell receptors
    3.2 MHC complexes
    3.3 Antigen: processing and presentation
    3.4 T helper cell and lymphocyte activation
    3.5 Role of cytotoxic T-cell

4. Concept of vaccination   **1**

Books Recommended

1. Alberts et al: Molecular Biology of the Cell (4th ed 2002, Garland)
2. Balinsky: An introduction to Embryology (5th ed 1981, Saunders)
3. Gilbert: Developmental Biology (8th ed 2006, Sinauers)
4. Kalthoff: Analysis of Biological development (1996, McGraw)
5. Wolpert: Principles of Development (3rd ed 2007, Oxford)
6. Abbas et al: Cellular and Molecular Immunology (2000, Saunders)
7. Elgert: Immunology understanding the Immune System (1996, Wiley)
8. Kuby: Immunology (6th ed 2007, Freeman)
9. Roitt: Essential Immunology (10th ed 2006, Mosby)
10. Roitt et al: Immunology (7th ed 2006, Mosby)

MAJOR ELECTIVE

ZOM 302A: BIOCHEMISTRY AND MOLECULAR BIOLOGY
Course I: Nucleic Acids
(Credit 3)

    Hours of teaching

1. Eukaryotic genome   **6**
   1.1 Introduction to structural and functional genomics
   1.2 Denaturation and renaturation of DNA, unique and repetitive DNA
      sequences (LINEs, SINEs)
   1.3 Chromatin organization
      1.3.1 Nucleosomes and higher order structures
       1.3.2 Histones and non-histone chromosomal proteins
      1.3.3 Telomere
      1.3.4 Chromatin modifications

2. DNA replication   **3**
   2.1 DNA polymerases
   2.2 ARS and initiation in yeast
   2.3 Eukaryotic chromatin replication and regulation

3. DNA repair and recombination   **2**

4. Human genome: mapping, characteristics and implications   **2**

5. Transcription and its regulation   **8**
   5.1 RNA polymerases in eukaryotes
   5.2 Transcription factors: general and specific
   5.3 Assembly of pre-initiation complex and initiation
   5.4 Elongation and elongation factors
   5.5 Enhanceosomes
   5.6 Transcriptome
   5.7 Promoter analysis and characterization
      5.7.1 Expression system: transient and stable
      5.7.2 Deletion mapping
      5.7.3 S1/RNase mapping
      5.7.4 Chromatin immunoprecipitation (ChIP)
      5.7.5 Electrophoretic mobility shift assay

5.7.6 DNase I footprinting

6. Post transcriptional processing and regulation   **4**
    6.1 Introns: types and mechanisms of splicing
    6.2 RNA editing
    6.3 Post transcriptional gene silencing (RNA interference)

7. Catalytic RNA and its role   **1**

8. Genetic engineering
    8.1 Tools   **2**
        8.1.1 Restriction enzymes and other enzymes for DNA manipulation
        8.1.2 Vector types: cloning and expression
        8.1.3 Probes
    8.2 Cloning strategies   **2**
        8.2.1 cDNA and genomic libraries
        8.2.2 Positional cloning
    8.3 Screening of clones   **2**
        8.3.1 Preparation of probes
        8.3.2 Hybridization: Southern, Northern (colony/plaque), immuno-screening
    8.4 Characterization of clones   **2**
        8.4.1 Sequencing
        8.4.2 Microarray
    8.5 PCR and its applications   **1**
    8.6 Application: transgenic organisms and genetically modified organisms (GMOs), animal cloning,
        site-directed mutagenesis, generation of knock-out animals, gene therapy, DNA drugs   **3**
    8.7 Ethical and social issues   **1**

Books Recommended

1. Malacinski: Freifelder's Essentials of Molecular Biology (4th ed 2005, Narosa)
2. Lewin: Genes IX (2008, Jones and Bartlett)
3. Brown: Genomes (3rd ed 2006, Garland Science)
4. Brown: Gene Cloning and DNA Analysis (2001, Blackwell)
5. Sambrook & Russell: Molecular Cloning (2001, Cold spring Harbor)
6. Primrose: Principles of Gene Manipulation (2001, Blackwell)
7. Asubel et al: Current Protocol in Molecular Biology (1994, Wiley)
8. Lodish et al: Molecular Cell Biology (6th ed 2007, Freeman)
9. Goldsby et al: Kubey Biochemistry (2001, Freeman)
10. Gesteland et al: RNA World (2nd ed 1999, Cold Spring Harbor)

ZOM 303A: BIOCHEMISTRY AND MOLECULAR BIOLOGY
Course II: Proteins and Cell Signaling
(Credit 3)

                                                                            Hours of teaching
1. Purifications and characterization of proteins   **2**
2. Protein structure   **10**
    2.1 Determination of primary structure
        2.1.1 Amino acid composition
        2.1.2 N- and C- terminal determination
        2.1.3 Amino acid sequence determination
    2.2 Forces and interactions involved in structural organization of fibrous and
        globular proteins
    2.3 Structure function relationship
    2.4 Protein denaturation
    2.5 Molecular chaperones and protein folding
    2.6 Post translational processing

3. Synthesis of proteins   **4**
    3.1 Translation

3.2 Chemical synthesis
3.3 Recombinant proteins: expression and application

6. Proteins in immune system   12

6.1 B- and T- cells interaction in antibody synthesis
6.2 Immunoglobulin: genes and their diversity
6.3 Major histocompatibility complex, antigen processing
6.4 Complement proteins
6.5 Immunodeficiency diseases
6.6 Polyclonal and monoclonal antibody
6.7 Interferon
6.8 Immunotoxins

7. Cell signaling   11

7.1 Signaling through intracellular receptors: lipophilic hormones
7.2 Signaling through cell surface receptors
     7.2.1 G protein linked receptors: signaling via cAMP, PKA, IP3, Ca^{2+}/calmodulin, PKC, Ca-MK, ion channels (exemplified by vision)
     7.2.2 Enzyme linked receptors
         7.2.2.1 Receptor tyrosine kinase (RTK) signaling of growth factors
         7.2.2.2 Tyrosine kinase associated receptors, JAK-STAT signalling pathway
         7.2.2.3 Receptor protein tyrosine phosphatase (PTP)
         7.2.2.4 Receptor serine/threonine kinase
         7.2.2.5 Receptor guanyl cyclase, cGMP, PKG
         7.2.2.6 Histidine kinase associated receptors, bacterial chemotaxis
7.3 Signaling by nitric oxide and carbon monoxide

Books recommended

1. Nelson et al: Lehninger Principles of Biochemistry (3rd ed 2006, MacMillan Worth)

2. Berg et al: Biochemistry (6th ed 2007, Freeman)

3. Mathews et al.: Biochemistry (6th ed 2006, Pearson)

4. Zubay et al: Biochemistry (4th ed 1998, WCB)

5. Horton et al: Principles of Biochemistry (4th ed 2006, Prentice Hall)

6. Mahler & Cordes: Textbook of Biological Chemistry (1966, Harper)

7. Albert et al: Molecular Biology of the Cell (5th ed 2007, Garland Publishing Inc)

8. Lodish et al: Molecular Cell Biology (6th ed 2007, Freeman and Company)

9. Murray et al: Harper's Illustrated Biochemistry (27th ed 2006, Appleton & Lange)

10. Kindt et al: Kuby's Immunology (2007, Freeman)

11. Voet and Voet: Biochemistry (2004, John Wiley)

ZOM 304A: BIOCHEMISTRY AND MOLECULAR BIOLOGY
Course III: Enzymology
(Credit 3)

                 Hours of teaching

1. Nomenclature and classification   1

2. Mechanism of enzyme action   1
2.1 Enzyme substrate binding
2.2 Binding energy, entropy change

3. Active site structure and determination: irreversible inhibitors, affinity labeling and suicide inhibitors   2

4. Kinetics   6
4.1 Single substrate reactions: steady state and equilibrium kinetics
4.2 Michaelis-Menten equation and plot
4.3 Linear kinetic plots: Lineweaver-Burk, Edie-Hofstee, Cornish-Bowden
4.4 Calculations on enzyme kinetics

5. Multi-substrate reactions   2

5.1 Random sequential
5.2 Ordered
5.3 Theorel-Chance mechanism
5.4 Ping-pong (double reciprocal) mechanism

6. Enzyme inhibition   **3**
6.1 Competitive; non-competitive; un-competitive and mixed
6.2 Determination of nature of inhibition and Ki by L-B and Dixon plots

7. Regulation: allosterism and covalent modifications   **2**

8. Multi-enzyme complex and multifunctional enzymes   **2**

9. Enzyme distribution, diversity and evolution   **1**

10. Coenzymes and cofactors   **2**

11. Principles and techniques of enzyme assay: fixed time, continuous and coupled assays   **2**

12. Enzyme purification

12.1 Objective and strategy, choice of source   **1**
12.2 Methods of homogenization   **1**
12.3 Methods of separation on the basis of: solubility, size and mass, charge and specific binding   **3**
12.4 Crystallization   **1**
12.5 Evaluation of purification and selection of purification methods   **3**
    12.5.1 Recovery and fold of purification
    12.5.2 Homogeneity of the purified enzyme
    12.5.3 Determination of enzyme structure
12.6 Enzyme storage and stability *in vitro*

13. Enzyme technology

13.1 Enzyme immobilization: method and applications   **2**
13.2 Enzyme engineering   **2**
    13.2.1 Modifications in active-site and introducing silent mutations
    13.2.2 Application of enzyme engineering

Books Recommended

1. Nelson et al: Lehninger Principles of Biochemistry (3rd ed 2000, MacMillan Worth)
2. Berg et al: Biochemistry (5th ed 2002, Freeman)
3. Mathews et al.: Biochemistry (3rd ed 2004, Pearson)
4. Zubay et al: Principles in Biochemistry (2nd ed 1995, WCB)
5. Rawn: Biochemistry (1989, Neil Patterson)
6. Mahler & Cordes: Textbook of Biological Chemistry(1966, Harper)
7. Price & Stevens: Fundamentals of Enzymology (2nd ed 1988, Oxford University Press)
8. Engel: Enzyme kinetics: The steady state approach(1981, Chapman and Hall)
9. Segal: Biochemical calculations (2nd ed 1976, John Wiley)
10. Fersht: Enzyme Structure and Mechanisms (2nd ed 1985, Freeman)

MAJOR ELECTIVE

ZOM 302B: ENTOMOLOGY
Course I: Insect Physiology I

      Hours of teaching
1. Digestive system   **6**
1.1 Digestion
1.2 Absorption
1.3 Nutrition
    1.3.1 Nutritional requirements
    1.3.2 Ectosymbiotic fungi
    1.3.3 Endosymbionts

2. Fat body: physiology and biochemistry   **4**

3. Excretory system   **8**

3.1 Organs of excretion
3.2 Nitrogenous excretion
    3.2.1 Excretory products
    3.2.2 Storage excretion
3.3 Production of urine and its hormonal regulation
    3.3.1 Terrestrial and salt water insects
    3.3.2 Control of diuresis
    3.3.3 Water regulation
    3.3.4 Detoxification

4. Circulatory system   **13**
  4.1 Circulation
  4.2 Haemocytes
    4.2.1 Type
    4.2.2 Origin and longevity
    4.2.3 Haemopoietic organs
    4.2.4 Changes in haemocyte population
  4.3 Immunity
    4.3.1 Cell mediated immunity
    4.3.2 Humoral immunity
  4.4. Haemolymph proteins
    4.4.1 Methods of study: protein purification, sequence analysis, immunological techniques
    4.4.2 Storage proteins: synthesis, uptake and their role
    4.4.3 Vitellogenin and its receptor mediated uptake by ovary
    4.4.4 Antibacterial proteins
    4.4.5 Lectins
    4.4.6 Protease inhibitors
    4.4.7 Enzymes in haemolymph
    4.4.8 Peptides: neuropeptides and humoral factors
    4.4.9 Chromoproteins
    4.4.10 Specific transport proteins

5. Reproduction   **8**
  5.1 Anatomy of reproductive organs
  5.2 Spermatogenesis and oogenesis
  5.3 Mating, insemination, oviposition
  5.4 Special modes of reproduction

ZOM 303B: ENTOMOLOGY

Course II: Insect Pests and their Management

(Credit 3)

                                                   Hours of teaching

1. Insect pests   **2**
  1.1 Causes of success of insects
  1.2 Origin of insect pests
  1.3 Factors affecting the abundance of insects

2. Insect pest control   **4**
  2.1 Natural control
  2.2 Applied control
    2.2.1 Cultural control: agronomic practices (crop rotation, tillage practice, planting/harvesting date manipulation, sowing/planting density, inter cropping, trap cropping and irrigation)   **4**
    2.2.2 Chemical control   **4**
        2.2.2.1 Formulations and insecticide toxicity
        2.2.2.2 Botanical pesticide (pyrethrins, rotenone, sabadilla, nicotine and neem)
        2.2.2.3 Synthetic organic insecticides and their mode of action (organchlorines, organophosphates, carbamates, pyrethroids and neonicotinoids)
        2.2.2.4 Insect growth regulators (juvenoids, ecdysoids, antihormones and chitin inhibitors)
    2.2.3 Biological control   **5**

<pre>
        2.2.3.1 Parasites
        2.2.3.2 Parasitoids
        2.2.3.3 Predators
        2.2.3.4 Methods for using biocontrol agents
                2.2.3.4.1 Classical biological control
                2.2.3.4.2 Augmentation and inoculation techniques
                2.2.3.4.3 Conservation biological control
</pre>

2.2.4 Microbial control (virus, bacteria and fungi) — **5**

2.2.5 Behavioural control — **3**

      2.2.5.1 Types of pheromones

      2.2.5.2 Uses of pheromones in pest management (monitoring, mass trapping and mating disruption)

2.2.6 Genetic and biotechnological control — **3**

      2.2.6.1 Methods of genetic manipulation

      2.2.6.2 Transgenic plants with insecticidal genes

2.2.7 Insect attractants, repellents and antifeedants — **2**

2.2.8 Integrated and biointensive integrated pest management — **3**

      2.2.8.1 Concept of injury levels

      2.2.8.2 Integration of control tactics

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ZOM 304B: ENTOMOLOGY
Course III: Industrial and Medical Entomology
(Credit 3)

</div>

Hours of teaching

1. Sericulture

1.1 Mulberry sericulture — **7**

  1.1.1 Cultivation of food plants
  1.1.2 Rearing of silkworms
  1.1.3 Harvesting and processing of cocoons
  1.1.4 Reeling appliances
  1.1.5 Genetic improvement of silkworms
  1.1.6 Diseases of *Bombyx mori*
  1.1.7 Predators and parasitoids of silkworm and their management

1.2 Non-mulberry sericulture — **3**

  1.2.1 Tasar sericulture
    1.2.1.1 Cultivation of food plants
    1.2.1.2 Rearing of tasar silkworms
    1.2.1.3 Pupation and cocoon formation
    1.2.1.4 Stifling and reeling of cocoons
  1.2.2 Muga sericulture
    1.2.2.1 Cultivation of food plants
    1.2.2.2 Rearing of muga silkworms
    1.2.2.3 Pupation and cocoon formation
    1.2.2.4 Grainage technology
    1.2.2.5 Stifling and reeling of cocoons
  1.2.3 Eri sericulture
    1.2.3.1 Cultivation of food plants
    1.2.3.2 Rearing of eri silkworms
    1.2.3.3 Pupation and cocoon formation
    1.2.3.4 Stifling and reeling of cocoons

2. Apiculture — **6**

2.1 Types of honeybees
2.2 Organization of bee colony
2.3 Life history and behaviour of bees
2.4 Dance language of honeybees
2.5 Diseases of honeybees
2.6 Beekeeping methods
  2.6.1 Equipment and tools
  2.6.2 Apiary management
    2.6.2.1 Hiving a colony

2.6.2.2 Controlling swarming
        2.6.2.3 Handling of bees
        2.6.2.4 Extraction of honey and wax
    2.7 Bee products

3. Lac culture   **3**
    3.1 Lac insect and its life history
    3.2 Host plant management
    3.3 Strains of lac insects
    3.4 Propagation of lac insects
    3.5 Lac crop management
    3.6 Natural enemies of lac insects and their management
    3.7 Lac extraction

4. Medical entomology   **8**
    4.1 Pests of public importance and their control: mosquitoes, house flies,
        lice, bedbugs, fleas
    4.2 Insect borne diseases of man: typhus, yellow fever, dengue fever,
        encephalitis, plague, leishmaniasis, sleeping sickness, malaria, filaria,
    4.3 Venoms and allergens
        4.3.1 Insect venoms
        4.3.2 Blister and urtica-inducing insects
        4.3.3 Insect allergenicity

5. Household pests: cockroaches, ants, wasps, carpet beetles, furniture beetles and booklice   **2**

6. Pest of farm animals and their control   **3**
    6.1 Blood-sucking flies
    6.2. Myiasis flies
    6.3. Lice
    6.4. Fleas

7. Forensic entomology   **2**
    7.1 Arthropods of forensic importance
    7.2 Insects succession on corpse and its relationship to determining time of death

8. Biotechnological applications   **5**
    8.1 Transgenesis
    8.2 Insects as bioreactors
    8.3 Insect cell culture

Books Recommended
(see list at the end of Course V: Agricultural Entomology)

ZOM 302C: FISH BIOLOGY

Course I: Culture Fisheries, Fish Nutrition and Fish Pathology

(Credit 3)

                                                                          Hours of teaching
  1. Fish culture systems
    1.1 Ponds
        1.1.1 Fish farm: construction and lay out of different types of ponds   **4**
            1.1.1.1 Formulation and operation of different types of hatcheries
            1.1.1.2 Hatchery management
            1.1.1.3 Brood pond management for culturable indigenous and exotic carps
        1.1.2 Pond management   **9**
            1.1.2.1 Physico-chemical properties of pond water and soil and their maintenance
            1.1.2.2 Manuring (organic and inorganic) and liming
            1.1.2.3 Composite fish farming and polyculture
            1.1.2.4 Predatory and weed fishes and their eradication
            1.1.2.5 Aquatic vegetation and its control
            1.1.2.6 Biological means of increasing production
    1.2. Other systems: cage, raft, pens, raceways   **4**

2. Fish culture in paddy fields	**1**
3. Sewage-fed fisheries	**1**
4. Exotic fishes and their role in fish farming	**2**
5. Larvivorous fishes	**1**
6. Nutrition and feeds	**9**

6.1 Physiological roles of nutrients
    6.1.1 Food and feeding habits of freshwater fishes, prawn, mussel and oysters
    6.1.2 Nutrient requirement (proteins, lipids, carbohydrates, minerals and vitamins) for
        various growth stages of freshwater carps, prawns and mussels
    6.1.3 Nutritional bio-energetics
    6.1.4 Presence of anti nutritional factors and their removal procedures
6.2 Supplementary feed
    6.2.1 Kind of supplementary feeds
    6.2.2 Formulation and processing, storage and quality control of feeds

7. Fish pathology, prophylaxis and therapy	**8**

7.1 Protozoan diseases of fish
    7.1.1 Cyclochaetiasis, Costiasis, (sliminess of skin)
    7.1.2 Ichthyophthiriasis (white spot disease)
7.2 Helminth parasites of fish
    7.2.1 *Gyrodactylus*
    7.2.2 *Dactylogyrus*
    7.2.3. Nematodes
7.3 Crustacean parasites of fish
    7.3.1 Lernaea
    7.3.2 Ergasilus
7.4 Fungal diseases of fish
    7.4.1 Saprolegniasis
    7.4.2 Branchiomycosis (gill rot)
7.5 Bacterial diseases of fish
    7.5.1 Tail and fin rot
    7.5.2 Dropsy
    7.5.3 Furunculosis
7.6 Viral diseases of fish
    7.6.1 Papillomatosis (cauliflower disease)
    7.6.2 Pox disease
7.7 Nutritional diseases of fish
    7.7.1 Avitaminoses
    7.7.2 Intoxication

ZOM 303C: FISH BIOLOGY

Course II: Fish Physiology I (based on teleost)

(Credit 3)

	Hours of teaching
1. Integument	

1.1 Epidermis

1.1.1 Mucogenic	**2**
1.1.2 Keratinized	**2**

1.2 Dermis

1.2.1 General organization	**1**
1.2.2 Scales	**1**
1.2.3 Chromatophores	**2**

2. Respiration

2.1 Aquatic respiration

2.1.1 Gills	**3**

2.1.2   Mechanisms   of   respiration

3

        2.1.2.1 Counter current principle
        2.1.2.2 Water flow across the gills
        2.1.2.3 Respiratory pump
        2.1.2.4 Pump musculature and skeleton
        2.1.2.5 Gas exchange
  2.2. Air-breathing
    2.2.1 Accessory respiratory organs and respiratory   epithelium   **3**
    2.2.2   Physiological   adaptation   in   air-breathing   fishes

2

  2.3. Transport of respiratory gases
    2.3.1 Transport of oxygen

1
2.3.2   Transport   of   carbon   dioxide

1

3. Digestion
    3.1 Alimentary canal and its modifications in relation to food and feeding habits   **2**
    3.2 Digestive fluids and enzymes   **2**
    3.3 Digestion and absorption of lipid, protein and carbohydrate   **2**
    3.4 Gastrointestinal motility control

4. Swim bladder
    4.1 General organization and circulation   **1**
    4.2 Composition of swim bladder gas, its secretion and maintenance   **1**
    4.3 Removal of gas from swim bladder   **1**
    4.4 Functions of swim bladder   **1**

5. Circulation
    5.1 Heart and aortic arches   **1**
    5.2 Regulation of cardiac activity   **1**
    5.3 Hemodynamics   **1**
    5.4. Cardiac output   **1**
    5.5. Circulation time   **1**
    5.6. Blood pressure   **1**
    5.7. Fish haemoglobin   **1**

ZOM 304C: FISH BIOLOGY

Course III: Fish Reproduction, Breeding and Biotechnology
(Credit 3)

                                 Hours of teaching

1. Functional morphology of gonads of teleosts
  1.1 Gametogenesis   **2**
  1.2 Role of environmental factors (photoperiod, temperature, rainfall, salinity) on gonad maturation   **2**
  1.3 Gonadal steroidogenesis and its control   **2**

2. Role of hypothalamo-hypophyseal hormones in reproduction   **2**

3. Reproductive behavior and pheromones   **2**

4. Types and mode of reproduction   **1**

| **5. Secondary sexual characters** | **1** |

5. Secondary sexual characters   **1**

6. Sexuality: intersex, bisexuality, hermaphroditism   **2**

7. Parental care   **1**

8. Induced breeding   **7**
8.1 Factors responsible for induced breeding
8.2 Hypophysation
8.3 Use of different synthetic and natural hormones, their formulation and
     mechanism of action
8.4 Bundh breeding
8.5 Hapa breeding
8.6 Hatchery breeding

9. *In vitro* fertilization and incubation   **1**

10. Fish seed collection, transport of brood fishes and fish seed   **3**

11. Fundamentals of fish genetics   **2**

12. Fish biotechnology   **7**
12.1 Gynogenesis.
12.2 Androgenesis
12.3 Polyploidy
12.4 Production of monosex population
12.5 Hybridization
12.6 Cryo-preservation of gametes and embryo
12.7 Transgenic fish

13. Age and growth

13.1 Growth rate and aging   **2**
13.2 Length weight relationship   **1**
13.3 Gonadosomatic index

ZOM 302D: MOLECULAR ENDOCRINOLOGY AND MAMMALIAN REPRODUCTIVE PHYSIOLOGY

Course I: Neuroendocrinology and Non-classical Hormones
(Credit 3)

         Hours of teaching

1. Neuroendocrinology
1.1 Hypophysiotropic hormones: localization, secretion and mechanism of action   **12**
     1.1.1 TRH
     1.1.2 GnRH
     1.1.3 CRH
     1.1.4 GHRH and PACAP
     1.1.5 Somatostatin
     1.1.6 Monoamines
1.2 Adenohypophysis   **10**
     1.2.1 Role of transcription factors in pituitary differentiation
     1.2.2 Paracrine/autocrine secretions
     1.2.3 Neural control of ACTH, TSH, prolactin and growth hormone
1.3 Pineal gland   **4**
     1.3.1 Pineal, biological clock and calendar
     1.3.2 Melatonin and photoperiodic measurement

2. Non - classical hormones   **13**
2.1 Growth factors: cellular origin, secretion and functions
     2.1.1 Epidermal growth factor family (EGF and TGFα)
     2.1.2 Transforming growth factor β family (TGF β, anti-Mullerian hormone,
         inhibins and activins)
     2.1.3 Platelet-derived growth factor family
     2.1.4 Fibroblast growth factor family
     2.1.5 Insulin family (IGF-1 and IGF-II)

2.1.6 Nerve growth factor family
2.1.7 Hematopoietic growth factors (erythropoietin, thrombopoietin and colony stimulating factor)
2.1.8 Immunoinflammatory hormones (interleukines, TNFα and TNFβ)
2.2 Eicosanoids (prostaglandins, thromboxanes and leukotrines)
2.3 Leptin

Books recommended
1. Bolander: Molecular Endocrinology (3rd ed 2006, Elsevier)
2. DeGroot and Jameson: Endocrinology (5th ed 2006, Vol 1, Elsevier-Saunders)
3. Larson. Williams Textbook of Endocrinology (10th ed 2002, Saunders
4. Norman and Litwack. Hormones(2nd ed 1997, Academic press)
5. Henson and Castracane: Leptin and Reproduction (2003, Plenum,Publishers)

ZOM 303D: MOLECULAR ENDOCRINOLOGY AND MAMMALIAN REPRODUCTIVE PHYSIOLOGY

Course II: Male Reproduction
(Credit 3)

	Hours of teaching
1. Gonadotropins: structure, secretion and regulation	**4**
2. Testis	**16**

  2.1 Spermatogenesis and hormonal regulation
  2.2 Sertoli cell
  2.3 Leydig cell
  2.4 Cell – cell interactions

	Hours of teaching
3. Epididymis: organization and function	**6**
4. Male accessory sex glands	**4**

  4.1 Structural organization and endocrine regulation of prostate
  4.2 Functions of accessory sex glands

	Hours of teaching
5. Sexual differentiation and behaviour	**9**

  5.1 Gonadal differentiation
  5.2 Brain differentiation
  5.3 Copulatory patterns
  5.4 Hormones in sexual behaviour
  5.5 Sites of action of sex hormones

ZOM 304D: MOLECULAR ENDOCRINOLOGY AND MAMMALIAN REPRODUCTIVE PHYSIOLOGY

Course III: Female Reproduction
(Credit 3)

	Hours of teaching
1. Reproductive cycles	**3**

  1.1 Menstrual cycle
  1.2 Control of seasonal reproductive cycle
    1.2.1 Photoperiod and temperature
    1.2.2 Food supply

	Hours of teaching
2. Hormonal control of puberty and pregnancy	**4**
3. Regulation of ovarian function	**16**

  3.1 Follicular development and selection
  3.2 Regulation of steroidogenesis
  3.3 Oocyte maturation
  3.4 Mechanism of ovulation
    3.4.1 Hormonal and molecular changes during periovulatory period
    3.4.2 Factors involved in follicular rupture

       3.5 Follicular atresia

   4. Fertilization   **6**

       4.1 Hormonal control of gamete interaction

       4.2 Role of zona proteins

       4.3 Gamete activation

       4.4 Sperm-egg fusion

   5. Biology of implantation   **10**

       5.1 Cellular aspects

       5.2 Molecular aspects

       5.3 Markers of developing embryo

       5.4 Cross-talk between embryo and uterus

ZOM 302E: MOLECULAR AND HUMAN GENETICS

Course I: Human Genetics
(Credit 3)

Hours of teaching

1. History of human genetics   **1**

2. Patterns of inheritance   **10**

   2.1 Pedigree construction, inheritance patterns (autosomal, sex-linked, sex-limited and
      sex- influenced), and risk assessment

   2.2 Mitochondrial inheritance

   2.3 Complexities associated with inheritance (penetrance and expressivity, new mutations,
      anticipation, co-dominance, pseudo-dominance, genetic heterogeneity, imprinting, Lyonisation,
      mosaicism and chimerism)

   2.4 Consanguinity and its effects

3. Complex traits   **10**

   3.1 Oligogenic and polygenic traits

   3.2 Multifactorial traits: nature-nurture concept

      3.2.1 Family, twin and adoption studies

      3.2.2 Genetic susceptibility, heritability, and empiric risk

   3.2 Threshold trait

4. Mapping and identifying a disease gene   **15**

   4.1 Genetic mapping of the locus

      4.1.1 DNA markers: RFLP, microsatellites, SNPs

      4.1.2 LOD score analysis, linkage disequilibrium mapping (haplotype analysis)

   4.2 Genetic mapping of complex traits: affected sib-pair method, association studies

   4.3 Cloning the disease gene: functional, positional, and candidate gene approach

   4.4 Identifying and confirming the disease gene: mutation detection, validation in animal   model
      systems

5. Pharmacogenetics and ecogenetics   **3**

ZOM 303E: MOLECULAR AND HUMAN GENETICS

Course II: Genomics and Molecular Genetic Techniques
(Credit 3)

Hours of teaching

Section A: Genomics (Credit-2)

1. Diversity of genomes   **12**

   1.1 Overview of pro- and eukaryotic genomes

      1.1.1 Comparative genomics of pro- and eukaryotes

      1.1.2 Human genome mapping strategies (genetic and physical mapping)

1.2.3 Annotation of human genome
1.2.4 Integrated map and organization of human genome
1.2 Modes of genomic innovations
1.2.1 Mutations
1.2.2 Gene duplication: gene families, pseudogenes
1.2.3 Transposable elements: prokaryotes, yeast, *Drosophila*, human
1.2.4 Horizontal transfer among genomes

2. Genomic expression profiling   **12**
2.1Concepts of transcriptome and proteome
2.2 Microarray analysis, 2D-electrophoresis, protein sequencing, mass spectrometry
2.3 Prediction, diversity and multiplicity of protein functions
2.4 Sequence homology and predictions of gene functions
2.5 Applications in human disease

3. Metabolomics and global biochemical networks (human perspective)   **2**

Section B: Molecular Genetic Techniques (Credit 1)

1. DNA Techniques   **3**
1.1 Oligonucleotide synthesis
1.2 DNA sequencing
1.3 DNA fingerprinting
1.4 Expression of recombinant proteins

2. Gene function analysis
10
2.1 DNA-protein and protein-protein interactions: gel mobility shift assay, foot printing,   western and
    south-western blotting, Yeast 2-hybrid system
2.2 Random mutagenesis, mutation screens, complementation and suppression
2.3 Manipulation of genes, site-specific mutagenesis, transgenesis
2.4 Targetted mutagenesis, gene knockout and gene knock-in methods
2.5 Reporter genes and temporal/site specific expression
2.6 RNAi and specific gene silencing
2.7 Mitotic recombination and generation of somatic clones for developmental studies in *Drosophila*
2.8 Nomenclature of gene mutations and chromosome rearrangements in *Drosophila*;balancer
    chromosomes

ZOM 304E: MOLECULAR AND HUMAN GENETICS
Course III: Developmental Genetics and Gene Expression
(Credit 3)

Hours of teaching

Section A: Developmental Genetics (Credit 1.5)

1. Genetic control of embryonic development and pattern formation   **2**
2. Epigenetic modifications   **6**
2.1 Imprinting
2.2 Endoreplication and amplification
2.3 Chromatin diminution
2.4 Programmed DNA rearrangements

3. Sex determination and dosage compensation in *Caenorhabditis*, *Drosophila*
and mammals   **6**
4. Medical implications of developmental genetics   **5**
3.1 Infertility
3.2 Teratogenesis
3.3 Stem cells and tissue engineering

Section B: Gene Expression (Credit 1.5)

1. Regulation of transcription and gene expression

                                                                                        1

0

1.1 Chromatin remodelling and gene expression
1.2 Activators and repressors of transcription
1.3 Regulation of gene expression by steroid hormones, temperature shock
1.4 Regulation of lysogenic-lytic cycle in lambda phage

2. Post-transcriptional processing   **7**
2.1 RNA binding proteins and RNA motifs
2.2 Transcription attenuation
2.3 Splicing, alternative splicing and trans-splicing
2.4 Processing of pro- and eukaryotic rRNA and tRNAs
2.5 RNA editing
2.6 RNA targeting
2.7 mRNA stability
2.8 RNAi and RNA degradation

3. Post-translational processing   **3**
3.1 Codon usage and codon bias
3.2 Protein folding and molecular chaperons
3.3 Protein processing
3.4 Protein degradation

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LABORATORY EXERCISES
ZOM 305: DEVELOPMENTAL BIOLOGY & IMMUNOLOGY
(Credit 2)

</div>

Part A: Developmental Biology (Credit 1.5)
1. Collection of frog spawns and observation of different developmental stages
2. Study of embryonic developmental stages in frog through models
3. Study of spiral cleavage in eggs of snail
4. Study of effect of thyroxine and antithyroid drug on metamorphosis
5. Effect of vitamin A in tadpole tail regeneration
6. Study of embryonic development in chick through slides
7. Window preparation to study chick embryo development
8. Whole mount preparation of chick embryos at various stages of development
9. Cuticular preparation of *Drosophila* embryos and studying segmentation defects in developmental mutants
10. Study of expression of the developmental genes in larval imaginal discs and pharate adults
11. Observation and mounting of aristapedia and bithorax mutants of *Drosophila*
12. Study of role of ecdysone in metamorphosis by ligature experiments using maggots/*Drosophila* larvae

Part B: Immunology (Credit 0.5)
1. Separation of macrophages from mice and their identification on the basis of non specific esterase staining
2. Immunization of rabbit and collection of antisera
3. Demonstration of antigen-antibody reaction by immunodiffusion
4. Demonstration of direct ELISA
5. Demonstration of western blotting

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MAJOR ELECTIVE LABORATORY EXERCISES
ZOM 306A: BIOCHEMISTRY AND MOLECULAR BIOLOGY
Course I (Credit 3)

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Part A: Nucleic acids
1. Sterilization techniques, media preparation and agar plate preparation
2. Measurement of growth curve of *E.coli*., calculation of its generation time and viable cell counting
3. Induction of β-galactosidase in *E.coli*
4. Rapid isolation of plasmid DNA (mini prep. alkaline lysis method)

5. Restriction digestion of plasmid and analysis by agarose gel electrophoresis, determination of insert size
6. Cloning of a DNA fragment
7. Preparation of competent cells, transformation and screening of colonies (blue-white selection)
8. Demonstration
   8.1 Southern hybridization
   8.2 PCR

Part B: Proteins and Cell Signaling
1. Purification of nuclei from mouse/rat tissues, quantitation and characterization
2. Isolation of total histones
3. Fractionation of core histones and histone H1
4. Electrophoretic analysis of total histones and histone H1
5. Isolation of non-histone chromosomal proteins (high mobility group proteins) and electrophoretic analysis
6. Studies on the expression of protein by western blotting
7. Studies on quantitation of proteins by various methods : Biuret, Lowry, Bradford, Bromcresol and UV spectrophotometry
8. Studies of effects of interfering agents such as salts, detergents, reducing agent (β-mercaptoethanol/dithiotheritol), urea, etc on the protein estimation methods
9. Measurement of nitric oxide in normal and pathological conditions using rat/mouse model
10. Spectrophotometric and ELISA based assay of nitric oxide synthase in normal and pathological conditions using rat/mouse model
11. Analysis of expression of cMyc/cFos in normal and pathological conditions using rat/mouse model

Part C: Enzymology
1. Tissue collection, storage and processing and preparation of enzyme extract
2. Standardization of the assay procedure
3. Determination of total activity and specific activity
4. Tissue distribution and sub-cellular distribution of enzyme activity.
5. Development and standardization of purification protocol
6. Enzyme purification and determination of fold of purification and percent recovery.
7. Kinetic studies

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ZOM 306B: ENTOMOLOGY
Course I (Credit 3)

</div>

Part A: Insect physiology I
1. Study of internal anatomy of different stages of hemi and holometabolous insects
2. Preparation of stained histological slides of
   2.1 Alimentary canal of cockroach (fore gut, mid gut and hind gut).
   2.2 Salivary apparatus of cockroach and *Dysdercus*.
   2.3 Malpighian tubules of cockroach
   2.4. Blood cells of cockroach.
   2.5 Reproductive organs of hemi and holometabolous insects
   2.6 L.S. telotrophic and polytrophic ovarioles
   2.7 Testis of cockroach and *Dysdercus*.
3. Demonstration of amylase and proteinase activities of salivary gland of cockroach.
4. Study of morphology of eggs of *Drosophila*, cockroach and *Dysdercus*.
5. Protein profiling of hemolymph during development

Part B: Insect Pests and their Management
1. Collection and preservation of insects by
   1.1 Dry preservation methods (direct pinning, carding and pointing)
   1.2 Liquid preservation and processesed mounting methods
2. Study of key features of insects belonging to economically important insect orders (Orthoptera, Hemiptera, Lepidoptera, Hymenoptera, Diptera)
3. Measurement of oxygen consumption in lindane-treated cockroach
4. Study of repellent effect of oil of citronella on mosquito

5. Study of antifeedant effect of neem extract on grasshoppers
6. Determination of LC$_{50}$ of Rogor using *Drosophila melanogaster* larvae or *Tribolium* sp.
7. Comparison of toxicity effects of lindane and malathion on *Tribolium* sp.

Part C: Industrial and Medical Entomology
1. Study of food utilization by silkworm *Bombyx mori*
2. Rearing of silkworm
3. Study of silk glands and their proteins in different larval stages of *B. mori*
4. Study of pre- and post-cocooning characteristics of *B. mori*
5. Study of fecundity of silk moth *B. mori* reared on different varieties of mulberry leaves
6. Study of silkworm diseases using permanent slides/specimen
7. Visit to a local silkworm rearing centre
8. Study of external morphology of different castes of honey bee and preparation of a permanent mount of sting apparatus
9. Visit to a local apiculture centre to study bee keeping and apiary management
10. Study of life cycle of mosquitoes/house flies and their habitats
11. Visit to a local diary farm to study farm animal pests and their control

ZOM 306C: FISH BIOLOGY
Course I (Credit 3)

Part A: Culture Fisheries, Fish Nutrition and Fish Pathology
1. Seasonal analyses of pond water by measuring the following physico-chemical properties:
   1.1 Dissolved CO_2 content
   1.2 O_2 content
   1.3 Alkalinity
   1.4 pH
2. Identification of common aquatic vegetation of ponds
3. Study of locally available weed and predatory fishes
4. Study of locally available larvivorous fishes
5. Collection, mounting and study of helminth parasites infecting locally available fishes
6. Identification of locally available fishes of economic importance
7. Determination of feeding habit of important edible fishes by morphological analyses of their buccopharyngeal region
8. Determination of feeding habit of carps and catfishes by analyses of their gut contents

Part B: Fish Physiology I (based on teleost)

1. Dissection and display of afferent and efferent branchial vessels of a carp and a catfish
2. Preparation of permanent stained slides of skin, gills, spleen, digestive tract (stomach and intestine), liver, gonads of *Heteropneustes fossilis* or *Clarias batrachus*
3. Determination and comparison of hemoglobin content of water-breathing and air breathing fish
4. Study of ventilation rate and surfacing activity of a air-breathing fish under different experimental conditions

Part C: Fish Reproduction, Breeding and Biotechnology
1. Determination of fecundity in major carp and catfish
2. Determination of fertilization rate of carp
3. Determination of final oocyte maturation by scoring germinal vesicle breakdown
4. Study of functional morphology of testes and ovary by preparing permanent stained slides belonging to different reproductive phases
5. Determination of gonosomatic index and hepatosomatic index and their relations with regard to gonadal and body growth
6. Demonstration of induced breeding at a seed production centre
7. Visit to a fish farm and hatchery
8. Study of length weight relationship of major carp and catfish

ZOM 306D: MOLECULAR ENDOCRINOLOGY AND MAMMALIAN REPRODUCTIVE PHYSIOLOGY
Course I (Credit 3)

Part A: Neuroendocrinology and Non-classical Hormones
1. Study of pituitary and pineal cell types through prepared slides
2. *In situ* study of pituitary gland
3. Transplantation of pituitary in kidney capsule
4. *In situ* study of pineal gland and associated epithalamic complex
5. Demonstration of pinealectomy
6. Demonstration of pituitary cell dispersal and separation by percoll density gradient
7. Anatomical mapping of hypothalamic centres (SON, PVN, AR, VMO, mammillary nucleus, median eminence)
8. Deaffarentation of MBH
9. Demonstration of hypothalamic monoamines/neuropeptides by HPLC
10. Ascorbic acid depletion bioassay for LH
11. Pigeon crop-sac bioassay for prolactin
12. ELISA/RIA of TSH or gonadotropins
13. Demonstration of growth factors in ovary/testis by ICC

Part B: Male Reproduction
1. Preparation of permanent slides of reproductive organs: testis, epididymis (caput, corpus, and cauda), seminal vesicle and prostate
2. Study of stages of spermatogenesis and spermiogenesis using histological slides of testis
3. Biochemical estimation of fructose and alkaline and acid phosphatases in seminal vesicle and prostate
4. Study of effect of epididymal ligation on microscopic features of epididymis
5. Study of the following using permanent slides: testis, epididymis, seminal vesicle, prostate and Cowper′s gland
6. Androgen bioassay by sialic acid assay
7. Biochemical estimation of 3β-hydroxyl steroid dehydogenase
8. Demonstration of lordosis in androgenized female rat

Part C: Female Reproduction
1. Study of rat oestrous cycle using vaginal smear preparations
2. Studies on follicular development using sections of rat ovary
3. Studies on permanent slides of female reproductive organs (ovary, uterus, oviduct and vagina)
5. Ovariectomy and hormone replacement therapy in rat
6. Isolation of large antral follicle and corpus luteum
7. Isolation of egg, granulosa and theca cells
8. Induction of pseudopregnancy and pregnancy and comparison of progesterone levels
9. Demonstration of different stages of preimplantation embryos in mouse
10. Demonstration of implantation sites by pontamine blue (blue dye reaction) in mouse
11. Induction of decidualization in rat
12. *In vitro* culture of ovarian follicles
13. Effect of anti-histamines/anti-prostaglandins on ovulation
14. SDS-PAGE analysis of ovarian proteins
15. Biochemical estimation of protein, cholesterol and total lipids

ZOM 306E: MOLECULAR AND HUMAN GENETICS
Course I (Credit 3)

Part A: Human Genetics
1. Estimation of frequency of common genetic traits in local human population
2. Construction of pedigrees for selected traits and analysis of inheritance patterns
3. Calculation of Mendelian risk from the prepared pedigrees
4. Study of multifactorial trait (analysis of fingerprint patterns of random individuals)
5. Study of threshold trait (cleft-lip/palate)
6. Dysmorphology and dermatoglyphic studies in Down and Turner syndromes

7. Extraction of DNA from lymphocytes
8. Southern hybridization of a non-radioactive labelled probe with the extracted genomic   DNA
9. Demonstration of inheritance patterns using microsatellite markers and SNPs

Part B : Genomics and Molecular Genetic Techniques
1. Familiarity with laboratory instruments and usage of micropipettes; preparation of laboratory reagents
2. Cleaning and autoclaving of glasswares, preparation of culture media and plates for bacterial work
3. Ligation of an insert in a suitable cloning vector
4. Preparation of competent cells and transformation using recombinant plasmid
5. Minipreparation of plasmid DNA
6. DNA extraction from *Drosophila*
7. Quantitation of DNA on agarose gel using spectrophotometer
8. DNA sequencing (demonstration)
9. Sequence homology search and prediction of gene function
10. Zoo-blot to study sequence conservation
11. Study of DNA methylation in human genome
12. Extraction of mitochondrial DNA and its restriction mapping

Part C: Developmental Genetics and Gene Expression
1. Differentiation in *Dictyostellium*
2. Development of *Caenorhabditis*
3. RNA:RNA *in situ* hybridisation to study tissue specific expression of genes
4. RT-PCR based study of gene expression during mouse development
5. Restriction enzyme based detection of methylated DNA
6. Identification of different embryonic stages of *Drosophila*
7. Study of conditionally driven gene expression using UAS-GAL4 system by GFP fluorescence and/or lacZ staining
8. SDS-PAGE analysis of protein profiles in mouse or heat shocked *Drosophila* larvae
9. Analysis of cellular proteins from mouse/*Calotes* by 2D-gel electrophoresis
10. Induction of enhancer/protein-trap mutations in *Drosophila* by P-transposon mobilization
11. Preparation of polytene chromosomes from salivary glands of *Drosophila melanogaster* larvae and identification of different arms
12. Localization of P-transposon insertion on polytene chromosomes of *Drosophila melanogaster* by *in situ* hybridization
13. Heat shock response in *Drosophila*
14. Quantitative comparison of gene expression using Real-Time PCR

SEMESTER IV

ZOM 401: ANIMAL BEHAVIOUR & ENVIRONMENTAL BIOLOGY
(Credit 3)
Section A: Animal Behaviour
(Credits 1.5)

	Hours of teaching
1. Introduction to behaviour	**1**
2. Patterns of behaviour	**1**
3. Genetic and neural basis of behaviour	**5**
3.1 Genetic basis	
3.2 Bird song development	
3.3 Biological rhythms	
4. Habitat selection and foraging behaviour	**3**
5. Animal signals and communication	**3**
5.1 Evolution of animal signals	
5.2 Honesty and deceit in communication	
6. Sexual conflict	**3**
6.1 Parental care	
6.2 Sexual selection	

7. Social organization   **3**
    7.1 Theories of social behaviour
    7.2 Altruism in eusocial animals

Section B: Environmental Biology
(Credit 1.5)

                                Hours of teaching

1. Introduction to environmental biology   **1**

2. Ecological principles   **2**
    2.1 Concept of ecosystem
    2.2 Energy flow

3. Population ecology   **6**
    3.1 Population dynamics
       3.1.1 Population growth form
       3.1.2 r- and k-selections and carrying capacity
    3.2 Biological communities and species interactions
       3.2.1 Types of interactions between two species
       3.2.2 Interspecific competition

4. Environmental health and toxicology   **4**
    4.1 Types of environmental health hazards
    4.2 Pollution: air, water, solid waste and radioactive
    4.3 Bioaccumulation and biomagnification

5. Conservation and management of natural resources   **7**
    5.1 Soil and mineral resources
    5.2 Biodiversity: benefits and threats
    5.3 Endangered species management and biodiversity protection

Books Recommended

Animal Behaviour:

1. Alcock : Animal Behaviour: An Evolutionary Approach (7th ed 2005, Sinaur)
2. Bolhuis & Giraldeau: The Behavior of Animals: mechanisms, function, and evolution (2005, Blackwell)
3. Drickamer & Vessey: Animal Behaviour –Concepts, Processes and Methods (2nd ed 1986, Wadsworth)
4. Drickamer, Vessey & Jakob: Animal Behavior: Mechanisms, Ecology, Evolution (2007, McGraw-Hill)
5. Gadagkar: Survival Strategies: Cooperation and Conflict in Animal Societies. (1998, Universities Press)
6. Goodenough et al: Perspectives on Animal Behaviour (1993, Wiley)
7. Grier: Biology of Animal Behaviour (1984, Mosby)
8. Krebs & Davis: Behavioural Ecology. (3rd ed 1993, Blackwell)
9. Lehner: Hand Book of Ethological Methods.(2nd ed 1996, Garland)
10. Manning & Dawkins: An introduction to Animal Behaviour (5th ed 1998, Cambridge Univ. Press)
11. Slater & Halliday: Behaviour and Evolution (1st ed 1994, Cambridge Univ. Press)

Environmental Biology:

1. Cunningham and Saigo: Environmental Science (5th Ed., McGraw Hill, 1999).
2. Odum : Fundamentals of Ecology (Saunders, 1971).
3. Odum and Barett: Fundamentals of Ecology (EWP, 2005).
4. Primark : A Primer of Conservation Biology (2nd Ed., Sinauer, 2004).
5. Raven, Berg, Johnson: Environment (Saunders. 1993).
6. Sharma: Ecology and Environment (7th Ed., Rastogi, 2000).
7. Turk and Turk: Environmental Science (4th Ed., Saunders, 1993).

8. Wright and Nebel: Environmental Science (8th Ed., Prentice Hall, 2002).

ZOM 402: EVOLUTION & PARASITOLOGY
(Credit 3)
Section A: Evolution
(Credit 2)

	Hours of teaching
1. An overview of evolutionary thoughts, development and the concept of synthetic theory.	**2**
2. Population genetics	**3**
2.1 Gene frequencies in Mendelian population	
2.2 Hardy-Weinberg equilibrium	
2.3 Conditions for the maintenance of genetic equilibrium	
3. Elemental forces of evolution	**5**
3.1 Mutation	
3.2 Selection (types of selection, selection coefficient, selection in natural populations)	
3.3 Random genetic drift	
3.4 Migration	
4. Chromosomal, allozyme and DNA polymorphisms	**6**
4.1 Adaptive genetic polymorphism	
4.2 Balanced polymorphism and heterosis	
4.3 Genetic coadaptation and linkage disequilibrium	
5. Isolating mechanisms	**2**
6. Concepts of species and models of speciation:allopatric, sympatric and stasipatric	**3**
7. Phylogenetic relationships	**5**
7.1 Chromosome phylogeny in *Drosophila* (based on inversion polymorphism)	
7.2 Molecular phylogenies	
7.3 Neutral theory	
7.4 Molecular clock	

Section B: Parasitology
(Credit1)

	Hours of teaching
1. Parasites and parasitism	**1**
1.1 General consideration	
1.2 Type of parasites	
1.3 Type of hosts	
1.4 Symbiosis and commensalisms	
2. Molecular interaction between host and parasite and evasion of immunity	**2**
3. Protozoan parasites	**3**
3.1 Distribution, habit and habitat, structure, life cycle and diseases caused by	
3.1.1 *Entamoeba histolytica*	
3.1.2 *Leishmania donovani*	
4. Helminth parasites	**7**
4.1 General characters, organization and larval forms of Platyhelminthes and Nemathelminthes	
4.2 Distribution, habit and habitat, structure, life cycle and diseases caused by	
4.2.1 *Echinococcus granulosus*	
4.2.2 *Schistosoma haematobium*	
4.2.3 *Wuchereria bancroft*	

Books Recommended

Evolution

1. Dobzhansky: Genetics and the Origin of Species (1964, Columbia)

2. Dobzhansky: Evolution (1976, Surjeet Publ.

3. Freeman and Herron: Evolutionary Analysis (1998, Prentice Hall)

4. Futuyma: Evolutionary Biology (1998, Sinauer)

5. Hedrick: Genetics of populations (2005, Jones and Bartlett Publ Inc)

6. Hartl and Clark: Principles of Population Genetics (1989 & 1997, Sinauer)

7. Kimura: The Neutral Theory of Molecular Evolution (1984, Cambridge)

8. Li Wen-Hsiung and Dan Graur: Fundamentals of Molecular Evolution (1991, Sinauer)

9. Mayr: Animal Species and Evolution (1966, Belknap Press)

10. Ridley: Evolution (1993, Blackwell)

11. Strickberger: Evolution (2000, Jones and Bartlett)

12. White: Modes of Speciation (1978, Freeman)

Parasitology

1. Chatterjee: Parasitology(1981, Chatterjee Medical Publishers)

2. Chandler & Read: Introduction to Parasitology (1970, Wiley)

3. Marr *et al*: Molecular Medical Parasitology (2003, Elsevier)

4. Noble & Noble: Parasitology (1973, Lea & Febiger)

5. Smith: Animal Parasitology (1996, Cambridge University Press)

MAJOR ELECTIVES

ZOM 403A: BIOCHEMISTRY AND MOLECULAR BIOLOGY

Course IV: Regulation of Intermediary Metabolism
(Credit 3)

	Hours of teaching
1. Intermediary metabolism and metabolic pathways	**2**
2. Carbohydrate metabolic pathways, their integration and regulation	**10**
2.1 Glycogenesis and glycogenolysis	
2.2 Glycolysis and gluconeogenesis	
2.3 Krebs cycle	
2.4 Pentose phosphate pathway	
2.5 Glyoxylate pathway	
3. Lipids	**11**
3.1 Fattyacid: biosynthesis and degradation	
3.2 Cholesterol: biosynthesis and degradation	
3.3 Lipid transport and storage	
3.4 Eicosanoids: classification, biosynthesis and functions	
4. Amino acids	**10**
4.1 Amino acids as source for nitrogen	
4.2 Synthesis and significane of polyamines	
4.3 Amino acid catabolism	
4.3.1 Transamination	
4.3.2 Deamination: transdeamination and oxidative deamination	
4.3.3 Toxicity of ammonia	
4.3.4 Ammonia detoxification	
4.3.5 Urea cycle	
4.3.5.1 Reactions and their regulation	
4.3.5.2 Evolution of urea cycle	
5. Nucleotides	**6**
5.1 Biosynthesis and regulation of purine and pyrimidine nucleotides	
5.2 Catabolism of purines and pyrimidines	

Books Recommended

1. Nelson et al: Lehninger Principles of Biochemistry (3rd ed 2000, MacMillan Worth)

2. Berg et al: Biochemistry (5th ed2002, Freeman)

3. Mathews et al: Biochemistry (3rd ed 2004, Pearson)

4. Zubay et al: Principles in Biochemistry (2nd ed 1995, WCB)

5. Rawn: Biochemistry (1989, Neil Patterson)

6. Bender: Amino acid metabolism (1985, John Wiley)

7. Grisolia et al: The Urea Cycle (1976, John Wiley)

8. Voet & Voet: Biochemistry Vol I & II (3rd ed 2004, Wiley

ZOM 404A: BIOCHEMISTRY AND MOLECULAR BIOLOGY
Course V: Medical Biochemistry
(Credit-3)

Hours of teaching

1. Biochemical basis of diseases/disorders, diagnosis and treatment — 2

2. Molecular deficiency disorders — 7
2.1 Enzyme deficiency: inborn errors of metabolism
    2.1.1 Alkaptonuria
    2.1.2 Phenylketonuria
    2.1.3 Lesh-Nyhan syndrome
2.2 Protein defects/ deficiency
    2.2.1 Cystic fibrosis
    2.2.2 Sickel cell anaemia
    2.2.3 Thalassemia

3. Transport/storage associated disorders — 5
3.1 Hypercholesterolemia and atherosclerosis
3.2 A-Beta-lipoproteinemia
3.3 Tay-Sachs disease
3.4 Gout

4. Apoptosis and its implications in health and disease — 8
4.1 Process of apoptosis
    4.1.1 Induction and biochemical changes
    4.1.2 Execution: cytochrome C release, caspase action
    4.1.3 Phagocytosis of apoptotic bodies
4.2 Regulation of apoptosis: extra- and intra-cellular
4.3 Implications
    4.3.1 Programmed cell death and development
    4.3.2 Development of immunological tolerance
    4..3.3 Neurological disorders

5. Cancer — 4
5.1. Biochemical aberrations
5.2. Therapeutic srategies: TNF-alfa induced, immunological cytotoxicity,
    chemotherapy and radiotherapy

6. Drug action, abuse and catabolism — 5
6.1 Mechanisms
6.2 Drug addiction, alcohol toxicity
6.3 Catabolism of drugs

7. Recent trends in therapy — 6
7.1 Biomolecules as diagnostic markers and therapeutic agents
7.2 Gene technology and gene therapy
7.3 Drug delivery and targeting

8. Medical gerontology — 2

Books Recommended

1. Murray et al: Harper's Illustrated Biochemistry (27th ed 2006, McGraw Hill)

2. Ganong: Review of Medical Physiology (21st ed 2003, Lange Medical Publications)

3. Alberts et al: Molecular Biology of the Cell (4th ed 2002, Garland)

4. Goldsby et al: Immunology (5th ed 2003, Freeman)

5. Bhagvan: Medical Biochemistry (4th ed 2004, Hap)

6. Goodman et al: The Pharmacological Basis of Therapeutics (7th ed 1991, Macmillan Publishers)

7. Smith & Marks: Basic Medical Biochemistry (2nd ed 2005, LWW Lippincott's)

8. Chatterjea & Shinde: Medical Biochemistry (6th ed 2005, Jaypee brothers)

9. Bennett & Brown: Clinical Pharmacology (9th ed 2005, Elsevier)

10. Saini & Kaur: Clinical Biochemistry (1st ed 2001, CBS Publ)

11. Kanungo: Biochemistry of Aging (1980, Academic Press)

12. Kanungo: Genes and Aging (1994, Cambridge University Press)

ZOM 403B: ENTOMOLOGY
Course IV: Insect Physiology II
(Credit 3)

	Hours of teaching
1. Endocrine organs and hormones	**12**

    1.1 Historical perspective
    1.2 Endocrine glands and concept of neurosecretion
    1.3 Biosynthesis and degradation of hormones
    1.4 Function of JH and ecdysteroids
    1.5 Mechanism of action of JH and ecdysteroids
    1.6 Vertebrate hormones in insects
    1.7 Eicosanoids and their functions

2. Nervous system: basic components and their function   **2**

3. Neurotransmitters and neuromodulator system   **8**
    3.1 Cholinergic systems
    3.2 Biogenic amines
        3.2.1 Synthesis and metabolism
        3.2.2 Catecholamines
        3.2.3 Indolamines
    3.3 Amino acids
        3.3.1 Glutamatergic system
        3.3.2 GABAergic system
    3.4 Neuropeptides
        3.4.1 FMRFamide-related peptides
        3.4.2 Cholecystokinin-related peptides
        3.4.3 Proctolin

4. Mechanisms for cuticular sclerotization   **8**
    4.1 Components of sclerotized cuticle (structural proteins,
        chitin, catechols, enzymes)
    4.2 Dityrosine crosslinks
    4.3 Quinone tanning
    4.4 β-sclerotization
    4.5 Differential mechanism of tanning
    4.6 Combined pathway and cross linking mechanisms
    4.7 Free radical formation

5. Visual system   **2**
    5.1 Compound eye
    5.2 Image formation
    5.3 Light and dark adaptation

6. Mechanism and significance of sound production   **2**

7. Aerodynamics and the origin of insect flight   **3**

8. Bioluminescence   **3**
    8.1 Light producing organs
    8.2 Mechanism of light production
    8.3 Control and significance of light production

ZOM 404B: ENTOMOLOGY
Course V: Agricultural Entomology
(Credit 3)

	Hours of teaching
1. Insect – plant interactions	**13**

    1.1 Herbivory
        1.1.1 Leaf chewing

1.1.2 Plant mining and boring

1.1.3 Sap sucking

1.1.4 Gall formation

1.1.5 Seed predation

1.2 Insect feeding preference and host-plant selection

1.2.1 Role of plant chemicals in stimulation of feeding and oviposition

1.2.2 Role of plant chemicals as feeding deterrents

1.3 Plant toxins and their effect on insects

1.4 Insects and plant reproductive biology

1.4.1 Pollination

1.4.2 Myrmecochory

1.5 Host-plant resistance

2. Ground-dwelling insects   **4**

2.1 Insects as scavengers

2.2 Insect-fungal interactions

2.2.1 Fungivorous insect

2.2.2 Fungus farming by leaf-cutter ants

2.2.3 Fungus cultivation by termites

3. Environmental monitoring using aquatic insects   **1**

4. Insect pests of crops   **17**

4.1 Major pests of the following crops, their life cycles, nature of damage caused and pest management: paddy, wheat, sugarcane, pulses, fibre crops, vegetables, fruits and stored grain

4.2 Polyphagous insect pest: locusts, termites, cutworms, gram pod borer, aphids

5. Environmental impact of insecticides   **3**

5.1 Insect resistance to insecticides and resurgence

5.2 Effect on non-target animals

6. Forest entomology (insects damaging forest trees and their control)   **1**

Books Recommended

1. Advances in Insect Physiology (vols. 1-28), Academic Press, 1986-2001

2. Alford: A textbook of Agricultural Entomology, Blackwell 1999

3. Atwal: Agricultural pests of India and South-East Asia, Kalyani Publishers, 1986

4. Blomquist et al.: Insect Pheromone Biochemistry and Molecular Biology: the synthesis and detection of pheromones and plant volatiles, Elsevier Acad. Press, 2003

5. Busvine: Insects and Hygiene (3rd ed.), Chapman and Hall, 1980

6. Byrd and Castner: Forensic Entomology, CRC Press, 2001

7. Chandler & Read: Introduction to Parasitology, Wiley International, 1970

8. Chapman: The Insects: Structure and Function (4th ed.), ELBS, 1998

9. Dhaliwal and Arora: Principals of Insect pest management, National Agricultural Technology Information Centre, Ludhiana, 1996

10. Dhaliwal and Arora: Trends in Agricultural Insect pest Management, Commonwealth Publ.,1994

11. Gilbert et al.: Comprehensive Molecular Insect Science (Volume 1- 7), Elsevier, 2005

12. Gillot: Entomology (2nd ed.) Plenum Press,1995

13. Gullan & Cranston: The Insects: An Outline of Entomology (2nd ed.) Blackwell, 2000

14. Gupta: Insect Hemocytes, Cambridge University Press, 1979

15. Harborne: Introduction to Ecological Biochemistry (4th ed.), 1993

16. Hill: Pest of stored foodstuffs and their control, Springer, 2002

17. Imms: A General Text Book of Entomology (2 vols.), Asia Publishing House, 1997

18. Kerkut and Gilbert: Comprehensive Insect Physiology, biochemistry and pharmacology (vols 1-13), Pergamon, 1985

19. Klowden: Physiological Systems in Insects, Academic Press, 2002

20. McGavin: Essential Entomology, Oxford Univ. Press, 2001

21. Metcalf and Flint: Destructive and useful insects and their control, McGraw Hill, 1962

22. Mullen and Durden: Medical and Veterinary Entomology, Academic Press, 2002

23. Norris et al: Concepts in Integrated Pest Management, Prentice-Hall, 2002

24. Pedigo: Entomology and Pest Management (4th ed.), Prentice Hall, 2002

25. Pruthi: A Text Book of Agricultural Entomology, ICAR, New Delhi, 1969

26. Purohit: Agricultural Biotechnology (2nd ed.) Agrobios (India), 2003

27. Racheigl and Racheigl: Biological and biotechnological control of insect pests, CRC Press, 1998

28. Rockstein: Biochemistry of Insects, Academic Press, 1978

29. Schoonhoven et al.: Insect-plant Biology- from physiology to evolution (1st ed.) Chapman & Hall, 1998

30. Srivastava: A Text Book of Applied Entomology (Vol. I & II, 2nd ed.) Kalyani Publ.,   2001

31. Wigglesworth: Principles of Insect Physiology, ELBS, 1972

ZOM 403C: FISH BIOLOGY
Course IV: Capture Fishery

(Credit 3)

	Hours of teaching
1. The inland capture fishery resources of India	
1.1 Riverine fisheries	
1.1.1 Riverine fisheries resources	**1**
1.1.2 Regulation and exploitation	**1**
1.1.3 Improvement of fish stocks	**2**
1.1.4 River pollution	**2**
1.1.5 Dams and their effect on fish migration and remedial measures	**2**
1.2 Lacustrine fishery: management, development and exploitation	**3**
1.3 Cold water fishery: management, development and exploitation	**3**
2. Estuarine fisheries: management, development and exploitation	**3**
3. Marine fishery: exploitation of marine fishery resources of India	**4**
4. Chemical composition and nutritional value of fish	**4**
5. Fishery by-products, their production and utilization	**7**
5.1 Liver oils	
5.2 Body oils	
5.3 Fish meal	
5.4 Fish flour	
5.5 Fish silage	
5.6 Fish solubles	
5.7 Fish protein	
5.8 Fish guano	
5.9 Bone meal	
5.10 Shark fins and fin rays	
5.11 Fish roes	
5.12 Fish glue	
5.13 Isinglass	
5.14 Fish skin	
5.15 Chitin	
5.16 Chitosan	
5.17 Surgical suture from fish gut	
5.18 Pearl essence	
5.19 Surimi	
5.20 Ambergris	
6. Inland fishing gears and fishing methods	**3**

6.1 Biological factors in fishing
6.2 Types of fishing gears
6.3 Natural and synthetic fibres
6.4 Preparation and maintenance of fishing nets

7. Importance and methods of fish preservation   **4**
   7.1 Refrigeration and freezing
   7.2 Drying
   7.3 Salting
   7.4 Smoking
   7.5 Canning
   7.6 Pickling, pasting and spicing
   7.7 Fermentation
   7.8 Marinating

ZOM 404C: FISH BIOLOGY
Course V: Fish Physiology II (based on teleosts)
(Credit 3)

	Hours of teaching

1. Nervous system
  1.1 Brain and cranial nerves   **2**
  1.2 Receptors
     1.2.1 Eye   **4**
        1.2.1.1 Structure
        1.2.1.2 Photoreceptive functions
        1.2.1.3 Formation of image
        1.2.1.4 Photoreception
        1.2.1.5 Functional adaptations
     1.2.2 Acoustico-lateralis system   **3**
        1.2.2.1 Labyrinth
        1.2.2.2 Lateral line organs
     1.2.3 Chemoreceptors   **3**
        1.2.3.1 Gustatory
        1.2.3.2 Olfactory
        1.2.4.3 Electroreceptors

2. Excretion and osmoregulation   **7**
  2.1 Glomerular and aglomerular kidneys
  2.2 Excretion of nitrogenous wastes, water and ion balance
     2.2.1 Urea cycle
     2.2.2 Stenohaline teleosts
     2.2.3 Euryhaline teleosts
     2.2.4 Migratory teleosts

3. Endocrinology
  3.1 Hypothalamo-hypophyseal system   **4**
     3.1.1 Neurosecretory system and neuro-hypophyseal hormones
  3.2 Functional morphology of pituitary   **3**
  3.3 Hypothalamic control of pituitary   **3**
  3.4 Structure and functions of the following   **8**
     3.4.1 Thyroid
     3.4.2 Ultimobranchials
     3.4.3 Pancreas
     3.4.4 Adrenal
     3.4.5 Corpuscles of Stannius
     3.4.6 Urophysis
     3.4.7 Pineal

    Books Recommended

  1. Bentley: Comparative Vertebrate Endocrinology (2000, Cambridge University Press)
  2. Bond: Biology of Fishes (1979, Saunders)
  3. Brown: The Physiology of Fishes Vol I, II (1953 & 1957, Academic Press)

4. C.I.F.R.I.: Prawn Fisheries (Bulletin No. 10, 1977)
5. Chakroff: Freshwater Fish Pond Culture and Management (1987, Scientific Publishers)
6. Datta-Munshi & Hughes: Air-breathing fishes of India (1992, Oxford and IBH)
7. Davis: Culture and Diseases of Game Fishes (1956, University of California Press)
8. Duijn: Diseases of Fishes (1967, London Iliffe Books)
9. Evans: The Physiology of Fishes(1998, CRC Press)
10. Gopakumar, Singh and Chitranshi: Fifty Years of Fisheries Research in India (2000, Fisheries Division Indian Council of Agricultural Research)
11. Gorbman et al: Comparative Endocrinology (John Wiley)
12. Hadley: Endocrinology Prentice Hall (2000, International Editions)
13. Hall: Ponds and Fish Culture (1994, Agro Botanical Publishers)
14. Hoar & Randall: Fish Physiology, Series Vol. I – XIV (Academic Press)
15. Hora and Pillay: Handbook on Fish Culture in the Indo-Pacific Region (1962, Fisheries Division, Biology Branch,,FAO)
16. Howard & Churchill Canning technology (London)
17. Huet: Textbook of Fish Culture, Breeding and Cultivation of Fish, Fishing News (1989, Books)
18. Hughes: Comparative Physiology of Vertebrate Respiration, Heinemann Educational (1967, Books)
19. Jhingran: Fish and Fisheries of India (1985, Hindustan Publishing Corporation)
20. Khanna and Singh: Textbook of Fish Biology and Fisheries (2003, Narendra Publishing House)
21. Kreuzer: Fishery products, FAO, Fishing News (1974, Books)
22. Kurian and Sebastian: Prawns and Prawn Fisheries of India (1976, Hindustan Publ)
23. Lagler: Studies in fresh water fishery biology (1950)
24. Lagler, Bardach, Miller and May Passino, Ichthyology (2003, John Wiley)
25. Mishra: Records of Indian Museum: an aid to the identification of the common commercial fishes of India and Pakistan Vol 5 (Part I-IV) (1962)
26. Nilsson & Holmgren: Fish Physiology Recent Advances (1986, Croom Helm)
27. Norman and Greenwood: A History of Fishes (3rd ed 1975, Ernest Benn)
28. Norris: Vertebrate Endocrinology (2nd ed 2007, Academic Press)
29. Proceedings of International Symposium on Reproductive Physioloy of fishes (1982, 1987, 1991, 1995, 1999.2003, 2007)
30. Ribelin & Migaki:The Pathology of Fishes(1975, The Univ. of Wisconsin Press)
31. Rounsfell and Everhart: Fishery Science: It's Methods and Applications (1985, John Wiley)
32. Santhanam: Fisheries Science (1990, Daya Publishing House)
33. Singh: Advances in Fish Research, Vol. I and II (1993 and 1997, Narendra Publishing House)
34. Srivastava: A Textbook of Fishery Science and Indian Fisheries (1985, Kitab Mahal)
35. Srivastava, Gopalji: Fishes of U.P. and Bihar (2002, Vishwavidyalaya Prakashan)
36. The Wealth of India, Raw Materials Vol IV Fish and Fisheries (1962, CSIR)
37. Pillay: Aquaculture: Principles and Practices: Fishing News Books: (2005, First Indian reprint)
38 .Gupta and Gupta: General and applied Ichthyology (Fish and Fisheries) (2006, Chand)

ZOM 403D: MOLECULAR ENDOCRINOLOGY AND REPRODUCTIVE PHYSIOLOGY
Course IV: Hormone Receptors, and Signaling Mechanisms
(Credit 3)

	Hours of teaching
1. Control of hormone secretion	**7**

    1.1 Synthesis, processing, and sorting of preprohormone precursor
    1.2 Sequential stages of the regulated secretory pathway
    1.3 Dense-cored granule exocytosis
    1.4 Regulation of exocytosis by calcium and protein kinase C

2. Receptors   **7**
    2.1 Nuclear receptors
        2.1.1 Structure
        2.1.2 Families (glucocorticoid, thyroid and estrogen)
        2.1.3 Metabolism
        2.1.4 Activation and recycling
    2.2 Membrane receptors

        2.2.1 Enzyme-linked receptors
        2.2.2 Cytokine receptors
        2.2.3 G-Protein coupled receptors
        2.2.4 Ligand-gated ion channels

   2.3 Hormone signaling   **12**
        2.3.1 Receptor tyrosine kinase pathway
        2.3.2 Cytokine receptors pathway
        2.3.3 Cyclic AMP pathway
        2.3.4 Phospholipid/calcium- protein kinase C pathway
        2.3.5 Nitric oxide signaling pathway
        2.3.6 MAP kinase pathway

   2.4. Hormonal control of gene expression   **4**

  3. Molecular basis of hormone synergism and antagonism   **4**
   3.1 Glycogen metabolism
   3.2 Smooth muscle contraction

  4. Termination of hormone action   **1**

  5. Pathophysiology of hormone receptors, hormone analogues as drug and xeno-estrogens   **4**

Books recommended

1. Bolander: Molecular Endocrinology (3rd ed 2006, Elsevier)

2. DeGroot and Jameson: Endocrinology, Vol 1 (5th ed 2006 Saunders)

3. Larson: Williams Textbook of Endocrinology, 10th ed 2002, Saunders)

4. Alberts et al: Molecular Biology of the Cell(4th ed 2002, Garland)

5. Squires: Applied Animal Endocrinology (2003, CABI publications)

ZOM 404D: MOLECULAR ENDOCRINOLOGY AND REPRODUCTIVE PHYSIOLOGY
Course V: Fertility and Sterility
(Credit-3)

                                            Hours of teaching

1. Control of male fertility   **9**
  1.1 Chemical interference
    1.1.1 Suppression of spermatogenesis
      1.1.1.1 Suppression of hypophysial activity by steroid hormones
      1.1.1.2 Chemicals acting directly on the testis
    1.1.2 Prevention of sperm maturation in epididymis
  1.2 Immunological interference
  1.3 Surgical interference with reference to vasectomy

2. Control of female fertility   **9**
  2.1 Inhibition of ovulation with reference to oral contraceptives
  2.2 Mechanical methods with reference to intrauterine devices
  2.3 Immunological approaches

3. Male sterility   **5**
  3.1 Parameters of male sterility
  3.2 Origin and cause of male sterility
    3.2.1 Azoospermia
    3.2.2 Oligozoospermia
    3.2.3 Varicocoele
    3.2.4 Cryptorchidism

4. Female sterility   **5**
  4.1 Tubal factors
  4.2 Premature ovarian failure
  4.3 Polycystic ovarian syndrome
  4.4 Luteal insufficiency
  4.5 Endometriosis

5. Assisted reproductive techniques (ART)   **5**
  5.1 Principles of ART and protocols

5.2 Types of ART
    5.3 Cryopreservation of gametes

6. Primer pheromones   6
    6.1 Estrous cycle disruption
    6.2 Male induction of estrus (Whitten effect)
    6.3 Male induced pregnancy block (Bruce effect)
    6.4 Pheromones and puberty
    6.5 Human reproductive pheromones

Books Recommended (Courses II, III and V)

1. Leung and Adashi: The Ovary (2004, Raven Press)

2. Adashi et al: Reproductive Endocrinology, Surgery and Technology (1996, Lippincott- Raven publishers)

3. Findlay: Molecular Biology of the Female Reproductive System (1994, Academic Press)

4. Knobil & Neill: The Physiology of Reproduction, Vol. I & II (1994 Raven Press)

5. Knobil & Neill: Encyclopedia of reproduction, Vol. 1-4, Academic Press, 1998.

6. Lamming: Marshall's Physiology of Reproduction (1984, Longman)

7. Mann & Lutwak-Mann: The Male Reproductive Function and Semen (1998, Springer)

8. Paulson et al: Andrology: Male Fertility and Sterility (1986, Academic Press)

9. Setchell: The Mammalian Testis (1992, Cornell University Press)

10. Yen et al: Reproductive Endocrinology (1999, Saunders)

ZOM 403E: MOLECULAR AND HUMAN GENETICS
Course IV: Clinical Genetics
(Credit 3)

                                                                    Hours of teaching

1. History, nature and frequency of genetic diseases

2. Molecular and biochemical basis of genetic diseases   14
    2.1 Monogenic disorders
        2.1.1 Autosomal (cystic fibrosis, thalassaemias, Charcot-Marie-Tooth syndrome)
        2.1.2 X-linked (hemophilia A, Duchenne muscular dystrophy, color blindness)
    2.2 Metabolic disorders (phenylketonuria, polysaccharidosis)
    2.3 Genomic disorders (neurofibromatosis-1)
    2.4 Dynamic mutations (Huntington disease)
    2.5 Late onset disorders (Alzheimer disease)
    2.6 Imprinting disorders (Prader-Willi syndrome, Angelman syndrome)
    2.7 Mitochondrial diseases (MELAS)

3. Multifactorial diseases: atherosclerosis, diabetes mellitus

4. Clinical cytogenetics   9
    4.1 Cytogenetic techniques in disease detection
    4.2 Chromosomal anomaly and clinical phenotypes
    4.3 Aneuploidy in human disease: autosomal, sex-chromosomal, aneuploidy and parental   age
    4.4 Chromosomal deletions
    4.5 Microdeletion syndromes
    4.6 Structural rearrangements in chromosomes
    4.7 Fetal wastage and chromosomal anomalies

5. Management of genetic disorders   5
    5.1 Treatment of metabolic disorders
    5.2 Replacement therapy
    5.3 Gene therapy
        5.3.1 Somatic versus germ line
        5.3.2 *Ex vivo* and *in vivo* gene therapy
        5.3.3 Gene therapy strategies and gene delivery vehicles
        5.3.4 Clinical applications
        5.3.5 DNA vaccines

5.4 Stem cell therapy
6. Genetic counseling
6
    6.1 Concept and purpose
    6.2 Risk evaluation
    6.3 Diagnostics (chromosomal, post-natal, pre-natal, pre-implantation, pre-fertilization)
    6.4 Population screening
    6.5 Legal and ethical considerations

ZOM 404E: MOLECULAR AND HUMAN GENETICS
Course V: DNA Repair and Recombination, Cancer Genetics and Immunogenetics
(Credit 3)

	Hours of teaching
Section A: DNA repair and recombination (Credit 1)	
1. DNA damage and repair	**6**
1.1 Endogenous and exogenous sources, types of DNA damage	
1.2 Repair pathways in pro- and eukaryotes, damage specificity	
1.3 Damage signaling and checkpoints	
1.4 DNA repair-associated disorders	
2. Recombination	**7**
2.1 Homologous recombination	
2.2 Mechanism of recombination in bacteria and mammals	
2.3 Gene conversion	
2.4 Site-specific recombination	
2.5 Transpositional recombination	
2.6 Mitotic recombination	
2.7 Recombination and genomic instability	
2.8 Application in genetic engineering	
Section B: Cancer Genetics (Credit 1)	
1. Genetic regulation of cell cycle and apoptosis	**2**
2. Cell transformation and tumorigenesis	**8**
2.1 Oncogenes	
2.2 Tumour suppressor genes	
2.3 DNA repair genes and genomic instability	
2.4 Epigenetic modifications, telomerase activity, centrosome malfunction	
2.5 Genetic heterogeneity and clonal evolution	
3. Genetic models for familial cancer: retinoblastoma, colorectal cancer, breast cancer	**1**
4. Tumor progression: angiogenesis, metastasis	**1**
5. Tumor-specific chromosome rearrangements, tumor specific markers	**1**
Section C: Immunogenetics (Credit 1)	
1. Immune response proteins: genetic basis of structure and diversity	**1**
2. Immunoglobulin gene superfamily	**9**
2.1 Organization of Ig gene loci	
2.2 Genetic basis of antibody diversity	
2.2.1 Somatic recombination: V(D)J recombination and junctional diversity	
2.2.2 Somatic hypermutation	
2.2.3 Allelic exclusion	
2.2.4 Class switching	
2.3 Organization of TCR gene loci and genetic basis of TCR diversity	
2.4 Organization of HLA locus: genetic polymorphism and HLA haplotypes	
3. Immune disorders	**3**
3.1 Primary and secondary immunodeficiency disorders	
3.2 HLA and disease association	

Books Recommended

1. Alberts et al, Molecular Biology of the Cell (4th ed 2002, Garland)
2. Baker et al: A Guide to Genetic Counseling(1998, Wiley)
3. Bate & Arias: The Development of *Drosophila melanogaster*, vols 1-2 (1993 CSHL Press)
4. Brooker: Genetics- Analysis and Principles, Benjamin
5. Brown, Gene Cloning (3rd ed 1995, Stanley)
6. Brown, Genomes (3rd ed 2007, Bios)
7. Connors & Smith: Essentials of Medical Genetics (3rd ed, Blackwell)
8. Cowell, Molecular Genetics of Cancer (2nd ed, Eaton)
9. Cox & Sinclair: Molecular Biology in Medicine (1996, Blackwell)
10. Davies: Human Genetic Disease Analysis (Saunders)
11. Ehrlich, DNA Alterations in Cancer (Eaton)
12. Emery & Mueller: Elements of Medical Genetics (ELBS)
13. Fairbanks et al: Genetics: The Continuity of Life
14. Gersen & Keagle: Principles of Clinical Cytogenetics (Humana)
15. Gibson & Muse: A Primer of Genome Science (2002, Sinauer)
16. Gilbert: Developmental Biology (8th ed 2006, Sinauer)
18. Glick & Pasternak: Molecular Biotechnology (2nd ed ,ASM Press)
19. Goldsby et al: Kuby Immunology (Mosby)
20. Gregory (ed): The Evolution of the Genome (2006, Elsevier)
21. Hartl & Jones: Genetics: Principles & Analysis of Genes & Genomes(2001, Jones & Bartlett)
22. Hartl: Essential Genetics: A Genomic Perspective (3rd ed, Jones Blackett)
23. Hawley & Walker: Advanced Genetic Analysis (Blackwell)
24. Howley & Mori: The Human Genome (AP)
25. Jorde et al: Medical Genetics (3rd ed, Elsevier)
26. Korf: Human Genetics: A Problem Based Approach (1997, Blackwell)
27. Lindahl & West: DNA repair & Recombination (Chapman)
28. Lewin: Genes IX (2008, Jones & Barlett)
29. Lewis: Human Genetics (3rd ed, WCB McGraw)
30 Lodish et al: Molecular Cell Biology (4th ed 2008, Freeman)
31. Mange and Mange: Basic Human Genetics (1999 Sinauer)
32. Nickoloff & Hoekstra (ed): DNA Damage and Repair, vol II (2001, Humana)
33. Nussbaum et al: Genetics in Medicine (Saunders)
34. Passarge: Colour Atlas of Genetics (2nd ed, Thieme)
35. Pasternak: An Introduction to Human Molecular Genetics (2005, Wiley
36. Primrose & Twyman: Principles of Genome Analysis and Genomics (Fritzgerald)
37. Rimoin et al: Principles & Practice of Medical Genetics, vols I-III (5th ed 2007, Churchill Livingstone)
38. Robinson & Linden: Clinical Genetics handbook (Blackwell)
39. Roit et al: Immunology (Mosby)
40. Rooney: Human Cytogenetics (3rd ed, Oxford)
41. Sambrook et al: Molecular Cloning, vols 1-3 (3rd ed, CSHL Press)
42. Snustad and Simmons: Principles of Genetics (4th ed 2006, Wiley)
43. Stillman: Molecular Genetics of Cancer (CSHL Press)
44. Strachan & Read: Human Molecular Genetics (2004, Wiley)
45. Sudbery: Human Molecular Genetics (2nd ed 2002, Prentice Hall)
46. Vogel & Motulsky: Human Genetics (3rd ed, Springer)
47. Watson et al: Molecular Biology of the Gene (5th ed 2004, Pearson Education)
48. Wilson: Clinical Genetics: A Short Course (Wiley)
49. Wolpert: Principles of development (2nd ed 2002, Oxford)
50. Young: Introduction to Risk Calculation in Genetic Counseling (2nd ed, Oxford)
51. Phadke: Genetics for Clinicians (2007, Prism)
52. Kumar: Genetic Disorders in Indian Subcontinent (2004, Kluwer)

LABORATORY EXERCISES

ZOM 405: ANIMAL BEHAVIOUR & ENVIRONMENTAL BIOLOGY AND EVOLUTION & PARASITOLOGY

Part A: Animal Behaviour and Environmental Biology
(Credit 1.5)

Animal Behaviour

1. Study of dominant-subordinate relationships in male mice

2. Study of courtship behaviour in *Drosophila melanogaster*

3. Study of habitat selection in spiders or larvae of *Drosophila melanogaster* or woodlice

4. Study of learning behaviour in mice by using a zigzag or T-shaped maze

5. Study of wall-seeking behaviour in mice

6. A field study of play behaviour or parent-young interactions in a troop of rhesus   monkeys,*Macaca mulatta*

7. A field study of foraging or trail making behaviour in a seed harvester or predatory ant species

8. A field study of flower choice or colour perception in bees

Environmental Biology

1. Determination of standing crop energy status in a grassland area and construction of 'number'and 'biomass (wet weight) pyramids

2. Study of biotic components of a terrestrial ecosystem and description of the morphological   adaptations of the collected organisms

3. Study of biotic components of a pond ecosystem and description of morphological adaptations of the collected organisms

4. Estimation of autotrophs in a terrestrial ecosystem
   4.1 Frequency of different species
   4.2 Abundance of species in the community
   4.3 Density of different species in the community by quadrat method

5. Estimation of heterotrophs in a terrestrial ecosystem
   5.1 Frequencies of different species
   5.2 Abundance of species in the community
   5.3 Density of different species in the community by quadrat method

6. Determination of texture, pH, carbonate, nitrate and base deficiency in different
   soil samples

7. Measurement of chlorophyll content per unit area of a grass field

8. Estimation of grasshopper population density of an area by capture-recapture method

9. Measurement of oxygen change and productivity differences in a pond ecosystem
   by Winkler's method

Part B: Evolution & Parasitology
(Credit 1.5)

Evolution

1. Study of quantitative inheritance in *Drosophila*: sternopleural bristle phenotypes in *D. melanogaster*

2. Demonstration of natural selection under laboratory conditions by making competition
   between red-eyed and white-eyed *D. melanogaster*

3. Demonstration of Hardy-Weinberg equilibrium in human populations by taking examples
   of MN and ABO blood group systems

4. Study of inversion polymorphism in *Drosophila*

5. Study of sexual isolation between two closely related and sympatric species of *Drosophila*
    : *D. bipectinata* and *D. malerkotliana*

Parasitology

1. Collection, fixation and permanent stained preparation of rectal ciliates

2. Study of different protozoan parasites using permanent slides

3. Collection, fixation and permanent stained preparation of helminth parasites of goat rumen

4. Study of various larval stages in the life cycle of digenetic trematodes

5. Study of the following using permanent slides
   5.1 Trematode
   5.2 Cestode

5.3 Nematode

MAJOR ELECTIVE LABORATORY EXERCISES
ZOM 406A: BIOCHEMISTRY AND MOLECULAR BIOLOGY
Course II (Credit 2)

Part A: Regulation of Intermediary Metabolism (Credit 1)

1. Effect of starvation on liver glycogen content in rat/mouse
2. Estimation of blood glucose level using glucose oxidase method
3. Estimation of total cholesterol, HDL-cholesterol and triacyl glycerol
4. Estimation of amino acid concentration
5. Assay of adenine deaminase (ADA) in rat/mouse tissues

Part B: Medical Biochemistry (Credit 1)

1. Study of pathological condition in rat/mouse model: liver cirrhosis, diabetes
   and ascites tumor
2. Analysis of enzymatic/biochemical markers from serum/tissues
   of rat/mouse model
   2.1 Studies on the anti-oxidant enzymes (SOD, catalase and GPx) in normal and
       diseased rats
   2.2 Native-PAGE analysis of LDH isoforms
   2.3 Spectrophotometric assay of SGOT (AST) and SGPT (ALT)
   2.4 Estimation of bilirubin concentration
   2.5 Electrophoretic analysis of lipoproteins
3. Study of apoptosis in liver cirrhotic/tumor model
   3.1 Analysis of DNA-degradation pattern using agarose gel electrophoresis
   3.2 Western blot analysis of release of cytochromeC from mitochondria
   3.3 Expression analysis of Bcl2 and pro-apoptotic factors (Caspase3 and 9)
4. Demonstration of expression of a gene/protein during aging

ZOM 406B: ENTOMOLOGY
Course II (Credit 2)
Part A: Insect Physiology II

1. Dissection of CNS of *Dysdercus* and cockroach.
2. Whole mount stained preparation of
   2.1 Brain
   2.2 Corpora cardiaca
   2.3 Corpora allata
   2.4 Prothoracic gland
3. Preparation of histological slides of brain, corpus cardiacum, corpus allatum and CNS   ganglia
4. Preparation of permanent AF stained slide to demonstrate presence of MNSCs in brain of cockroach/
   Dysdercus
5. To observe the effect of insect hormones (JH, 20-E, etc.) on the growth and development of
   Dysdercus/silkworm
6. Demonstration of presence of chitin in the cuticle of cockroach
7. Dissection of lamina medulla lobula complex in live cockroach/cricket
8. Ligation experiment to demonstrate effect of brain hormones on development
9. Lipids detection by TLC in hemolymph

PART B: Agricultural Entomology
1. Identification of insects belonging to economically important insect orders (Orthoptera, Hemiptera,
   Lepidoptera, Hymenoptera, Diptera) using couplet keys
2. Dissection and permanent whole mount preparation of
   2.1 Mouthparts of cockroach and *Dysdercus*
   2.2 Mouth parts and legs of honey bee
3. Study of insect pests of stored grains
4. Study of food preference of grasshoppers and *Tribolium* sp. / *Callosobruches* sp.
5. Study of repellents on stored grain pests using an olfactometer

6. A field study of the insect pests of pulses or vegetables
7. A field study of aquatic insects
8. Culture of *Dysdercus*
9. Study of systemic effect of Rogor on *Dysdercus*

ZOM 406C: FISH BIOLOGY
Course II (Credit 2)
Part A: Capture Fishery

1. Study of efficacy of different methods (freezing, drying, salting, and salting and drying simultaneously) of fish preservation
2. Determination of protein and lipid contents in fresh and preserved fishes (carp and catfish)
3. Periodic survey of fish market to collect gonads and data related to length weight relationship
4. Visit to a fishing site to study the variety of fish catches at different seasons
5. Study of fishing nets being used at different seasons

Part B: Fish Physiology II (based on teleosts)
1. Preparation of permanent stained slides of different endocrine glands and kidney of *Heteropneustes fossilis* or *Clarias batrachus*
2. Survey of different endocrine glands
3. Dissection and display of cranial nerves of Mystus
4. Surgical ablation of pineal gland and gonads in a live fish

ZOM 406D: MOLECULAR ENDOCRINOLOGY AND REPRODUCTIVE PHYSIOLOSY
Course II (Credits 2)

Part A: Hormone Receptors and Signaling Mechanisms
1. Demonstration of exocytotic cycle by electronmicrographs
2. Demonstration of gonadotropin receptors/ growth factors in the ovary by western blot
3. Demonstration of receptor assay
4. Estrogen bioassay in female rat
5. Demonstration of estrogenic activity in certain plant products
6. Biochemical estimation of nitric oxide by nitrate/nitrite assay
7. Effect of glucagon and insulin on liver glucose
8. Effect of hormones on lipid metabolism

Part B: Fertility and Sterility
1. Operations in rat
   1.1 Induction of cryptorchidism
   1.2 Vasectomy
   1.3 Tubectomy
   1.4 Hysterectomy
2. Study of sperm motility, sperm morphology, and sperm count in rat
3. Effect of cadmium chloride treatment on testis
4. Effect of anti-androgens on sperm storage in epididymis
5. Induction of superovulation in mouse/rat
6. Induction of PCOS condition in rat
7. Demonstration of *in vitro* sperm-egg interaction
8. Demonstration of GVBD in oocyte
9. Demonstration of the Whitten and Lee-Boot effects in cycling mice
10. Biochemical estimation of succinate dehydrogenase and catalase activity
11. Kymographic demonstration of uterine contraction under different experimental conditions (Dale′s apparatus recording)

ZOM 406E: MOLECULAR AND HUMAN GENETICS
Course II (Credit 2)
Part A: Clinical Genetics
1. Chromosome preparations from cultured human lymphocytes
2. Preparation of karyotype and idiogram from G-banded metaphases and annotations of the bands
3. Familiarity with characteristic features of human chromosomal disorders

4. Detection of Downs syndrome by analysis of chromosomes
5. ARMS test for detection of thalassaemia
6. Multiplex based detection of DMD
7. Detection of microdeletion of Y-chromosome in cases of male infertility
8. Detection of trisomy 21 by fluorescence *in situ* hybridization

Part B: DNA Repair and Recombination, Cancer Genetics and Immunogenetics
1. Study of sister chromatid exchanges (basal and induced) in cultured human lymphocytes
2. Study of chromosomal aberrations
3. Study of micronuclei in cultured human lymphocytes (control and induced)
4. Estimation of DNA damage by comet assay (demonstration)
5. Induction of mutation in *Drosophila* and detection by attached-X or Muller-5 method
6. Detection of Philadelphia chromosome in CML cells
7. Detection of human papilloma virus in cervix cancer
8. Immunostaining
9. Raising antibodies in rabbit/mouse using a suitable antigen

ZOM 407(A-E): Project work/ Dissertation
(Credit 4)

Topic will be based on Major elective opted by the students. Project will include laboratory based work. Project report to be submitted and presented including viva voce.

ZOM 408: Seminar
(Credit 1)

On a current topic within 45 minutes to be evaluated by a panel of examiners.