

GOA UNIVERSITY
DEPARTMENT OF MARINE SCIENCES

Syllabus of M.Sc. Marine Science
Effective from 2010 – 2011
Course Structure

SEMESTER - I				
Paper Code	Paper Title	Credits	Contact hours	Marks
MS 101 (CORE)	Physical Oceanography	4	60	50 +50
MS 102 (CORE)	Marine Chemistry	4	60	50+50
MS 103 (CORE)	Marine Biology	4	60	50+50
MS 104 (OPTIONAL)	Geomorphology and Tectonics	2	30	25+25
MS 105 (OPTIONAL)	Physical Oceanography Practical	2	90	25+25
MS 106 (OPTIONAL)	Marine Chemistry Practical	2	90	25+25
MS 107 (OPTIONAL)	Marine Biology Practical I	2	90	25+25

SEMESTER - II				
Paper Code	Paper Title	Credits	Contact hours	Marks
MS 201 (CORE)	Marine Geology	4	60	50+50
MS 202 (CORE)	Computational Methods in Oceanography	4	60	50+50
MS 203 (OPTIONAL)	Remote Sensing and its application	4	60	50+50
MS 204 (OPTIONAL)	Analytical Chemistry of Sea water	4	60	50+50
MS 205 (OPTIONAL)	Aquaculture	4	60	50+50
MS 206 (OPTIONAL)	Marine Geology Practical	2	90	25+25
MS 207 (OPTIONAL)	Computational Methods in Oceanography Practical	2	90	25+25
MS 208 (OPTIONAL)	Remote sensing and its application Practical	2	90	25+25
MS 209 (OPTIONAL)	Analytical chemistry of sea water Practical	2	90	25+25
MS 210 (OPTIONAL)	Aquaculture Practical	2	90	25+25
MS 211 (OPTIONAL)	Marine Biology Practical II	2	90	25+25

SEMESTER - III (Physical Oceanography)				
Paper Code	Paper Title	Credits	Contact hours	Marks
MS 301 (CORE)	Geophysical Fluid Dynamics	4	60	50+50
MS 302 (CORE)	Ocean -Atmosphere coupling and Climate	4	60	50+50
MS 303 (CORE)	Marine Pollution	4	60	50+50
MS 304 (OPTIONAL)	Geophysical Fluid Mechanics Practical	2	90	25+25
MS 305 (OPTIONAL)	Ocean Atmosphere coupling and Climate Practical	2	90	25+25
MS 306 (OPTIONAL)	Marine Pollution Practical	2	90	25+25
MS 314 (OPTIONAL)	Cruise participation /Training	1	15	25
MS 315 (OPTIONAL)	Departmental Seminar	1	15	25

SEMESTER - III (Marine Chemistry)				
Paper Code	Paper Title	Credits	Contact hours	Marks
MS 302 (CORE)	Ocean -Atmosphere coupling and Climate	4	60	50+50
MS 303 (CORE)	Marine Pollution	4	60	50+50
MS 305 (OPTIONAL)	Ocean Atmosphere coupling and climate Practical	2	90	25+25
MS 306 (OPTIONAL)	Marine Pollution Practical	2	90	25+25
MS 307 (CORE)	Marine Geochemistry I	2	30	25+25
MS 308 (CORE)	Marine Geochemistry II	2	30	25+25
MS 309 (OPTIONAL)	Marine Geochemistry Practical	2	90	25+25
MS 314 (OPTIONAL)	Cruise participation / Training	1	15	25
MS 315 (OPTIONAL)	Departmental Seminar	1	15	25

SEMESTER - III (Marine Biology)				
Paper Code	Paper Title	Credits	Contact hours	Marks
MS 302 (CORE)	Ocean -Atmosphere coupling and Climate	4	60	50+50
MS 303 (CORE)	Marine Pollution	4	60	50+50
MS 305 (OPTIONAL)	Ocean Atmosphere coupling and Climate Practical	2	90	25+25
MS 306 (OPTIONAL)	Marine Pollution Practical	2	90	25+25
MS 310 (CORE)	Marine Ecology	4	60	50+50
MS 311 (OPTIONAL)	Marine Ecology Practical	2	90	25+25
MS 314 (OPTIONAL)	Cruise participation /Training	1	15	25
MS 315 (OPTIONAL)	Departmental Seminar	1	15	25

SEMESTER - III (Marine Geology)				
Paper Code	Paper Title	Credits	Contact hours	Marks
MS 303 (CORE)	Marine Pollution	4	60	50+50
MS 306 (OPTIONAL)	Marine Pollution practical	2	90	25+25
MS 307 (CORE)	Marine Geochemistry I	2	30	25+25
MS 308 (CORE))	Marine Geochemistry II	2	30	25+25
MS 309 (OPTIONAL)	Marine Geochemistry Practical	2	90	25+25
MS 312 (CORE)	Sedimentology	4	60	50+50
MS 313 (OPTIONAL)	Sedimentology Practical	2	90	25+25
MS 314 (OPTIONAL)	Cruise participation /Training	1	15	25
MS 315 (OPTIONAL)	Departmental Seminar	1	15	25

SEMESTER - IV (Physical Oceanography)				
Paper Code	Paper Title	Credits	Contact hours	Marks
MS 401 (CORE)	Estuarine and Coastal Physical Oceanography.	2	30	25+25
MS 402 (CORE)	Estuarine Chemistry	2	30	25+25
MS 403 (CORE)	Estuarine Biology	2	30	25+25
MS 404 (CORE)	Estuarine and Coastal Geology	2	30	25+25
MS 405 (OPTIONAL)	Dynamic Oceanography	4	60	50+50
MS 409 (OPTIONAL)	Dissertation	8	120	100+100

SEMESTER - IV (Marine Chemistry)				
Paper Code	Paper Title	Credits	Contact hours	Marks
MS 401 (CORE)	Estuarine and Coastal Physical Oceanography	2	30	25+25
MS 402 (CORE)	Estuarine Chemistry	2	30	25+25
MS 403 (CORE)	Estuarine Biology	2	30	25+25
MS 404 (CORE)	Estuarine and Coastal Geology	2	30	25+25
MS 406 (OPTIONAL)	Physical and Inorganic Chemistry of seawater	4	60	50+50
MS 409 (OPTIONAL)	Dissertation	8	120	100+100

SEMESTER - IV (Marine Biology)				
Paper Code	Paper Title	Credits	Contact hours	Marks
MS 401 (CORE)	Estuarine and Coastal Physical Oceanography	2	30	25+25
MS 402 (CORE)	Estuarine Chemistry	2	30	25+25
MS 403 (CORE)	Estuarine Biology	2	30	25+25
MS 404 (CORE)	Estuarine and Coastal Geology	2	30	25+25
MS 407 (OPTIONAL)	Marine Biodiversity, Conservation and practices.	4	60	50+50
MS 409 (OPTIONAL)	Dissertation	8	120	100+100

SEMESTER - IV (Marine Geology)				
Paper Code	Paper Title	Credits	Contact hours	Marks
MS 401 (CORE)	Estuarine and Coastal Physical Oceanography	2	30	25+25
MS 402 (CORE)	Estuarine Chemistry	2	30	25+25
MS 403 (CORE)	Estuarine Biology	2	30	25+25
MS 404 (CORE)	Estuarine and Coastal Geology	2	30	25+25
MS 408 (OPTIONAL)	Marine Geophysics	4	60	50+50
MS 409 (OPTIONAL)	Dissertation	8	120	100+100

NOTE:

- 1 credit (theory) shall be equivalent to 15 clock hours of contact teaching. 15 clock hours are inclusive of tutorial/discussion/interactive session.
- 1 credit (practical) shall be equivalent to 45 clock hours of contact teaching, ie. 15 practical of 3 clock hours duration each.
- The students will be eligible for the Master's degree on the successful completion of courses equivalent to 80 credits, average 20 credits per semester.
- Courses equivalent to 60 credits shall be opted for by the student from the parent Department in which the student is registered.
- The remaining 20 credits may be earned by the student by opting for courses either from the parent Department or from any other Department of the University.
- The assessment of the courses shall be fully internal. The evaluation of the courses shall be by continuous assessment. For this purpose, there shall be tests preferably on Saturday, corresponding to the prior 3 weeks of teaching of the given course. There shall be minimum 3 tests conducted for 2 credit courses and 5 tests for 4 credits courses of which the best 2/best 4, respectively, would be considered for computing the internal assessment performance. All tests/examination question papers for the continuous assessment shall have no internal choice in a question paper.
- Internal assessment for practical would be based on one test.

- The weightage of marks for internal and semester-end examinations in both theory and practical courses shall be 50:50.
- The Semester End Assessment (SEA), for the theory of 50 marks and for practical of 25 marks, will be for a duration of 2 hrs and 4 – 6 hrs respectively. The pattern of questions for a theory paper of 4 credits will be as follows: Qn.no.1 will be compulsory and will comprise 7 short notes of 5 marks each. Among the 7 short notes, 4 questions have to be answered. From the remaining 4 essay type questions of 15 marks each, 2 questions need to be answered. For a paper of 2 credits theory, there will be 4 short notes of 5 marks each. Among these, 2 questions have to be answered. From the remaining 2 essay type questions of 15 marks each, 1 question needs to be answered.
- Marks distribution for the practical of ISA/SEA will be as follows: 20 marks for experiment, 5 marks for journal.
- Dissertation is optional. Topics will be assigned at the end of 2nd semester and the study will begin from 3rd semester. There will be a continuous internal assessment by the guiding/supervising teacher in addition to assessment by the faculty members of the Department.

SYLLABUS

MS 101 : Physical Oceanography

Model – I

Oceanographic explorations - Evolution of theoretical ideas – Units used in Oceanography- The role of observations in Oceanography –Ocean and seas - Dimensions of the ocean- Physical properties of water- Influence of dissolved salts- Physical properties of seawater-Salinity – Temperature-Density- Distribution of temperature - salinity and density in space and time- Oceanic mixed layer and thermocline – Measurement of temperature and salinity - Sound in the sea. Propagation of sound in the sea- Light in the sea – The Oceanic heat budget.

Module – II

The earth in space – Atmospheric wind systems – Composition of atmosphere - Vertical extent of atmosphere -Planetary boundary layer – Measurement of wind – Calculations of wind stress - Coriolis force- General circulation of atmosphere- Atmospheric temperature -Temperature system and scales - Atmospheric humidity - Vapour pressure - Circulation – Wind- driven and thermohaline circulations – Importance of deep circulation – Theory for deep circulation

Module – III

Equatorial processes - El Nino – El Nino teleconnection - Southern Oscillation and Indian Ocean Dipole(IOD) - Indian ocean Circulation. T.S.V. diagram- T.S. diagram - Oceanic fronts -Upwelling - Water masses in the ocean - Bottom water - Deep water - Antarctic intermediate water - Central water - Lagrangian and Eulerian methods for measuring currents .

Module – IV

Equipment used for physical oceanographic studies: Mechanical bathythermograph, Expendable bathythermograph, Reversing thermometers, CTD, Current meter, Acoustic Doppler Current Profiler(ADCP), Autosal. Equipment used for atmospheric studies: Psychrometer, anemometer, radio sonde, sunphotometer, Radiation meter, Automatic Weather Station - Research vessels: O.R.V. Sagar Kanya, R.V. Sagar Sampada.

Reference Books:

1. The Ocean: Their Physics, Chemistry and biology, 1962 - Sverdrup, H.U., Johnson, M.W. and Flemming, R.H., Asia Publ. House, New Delhi.
2. Descriptive Physical Oceanography : An introduction, 1989 - Pickard, G.B. and Emery, W.J., pergamon press, U.K.
3. Principles of physical oceanography, 1966 - pierson, W.J. and Newmann, G.S., Prentice Hall, Inc., New Jersey, U.S.A.
4. Meteorology today: An introduction to weather, climatic and the environment (2nd ed), 1985 - Ahrens, St. Paul, West Publ. House, U.K.
5. Meteorology : Forecasting the weather, 1973 - Wachter, H., Collins Publ., U.K.
6. The atmosphere and ocean: A physical introduction, 1986 - Wells, N., Taylor and Francis Ltd., U.K.
7. General Climatology, 1960 - Critchfeild, H.J., Prentice Hall Inc., New Jersey, U.S.A.

MS 102 : Marine Chemistry

Module – I

Symbols and units used in chemical oceanography – Major and minor elements in seawater – Geochemical balance of the oceans, residence times, chemical speciation.

Module – II

Constancy of relative ionic composition of seawater, conditions under which major elements may not be conservative, factors affecting the distribution of trace elements in the sea, interaction of trace elements with marine organisms, enrichment factor, – Chlorinity and salinity: definition and significance, practical salinity scale – Radioactive nuclides in the sea.

Module – III

Dissolved gases (other than CO₂) in seawater – Basic concepts : solubility of gases in seawater, air – sea gas exchange, processes affecting their distribution, dissolved oxygen in the ocean – Dissolved gases (CO₂) in seawater – Carbon dioxide equilibria in seawater; pH, alkalinity and buffering capacity of oceans: components of CO₂ system in seawater – Percentage composition of inorganic carbon; calcium carbonate precipitation and dissolution phenomena – Lysocline and carbonate compensation depth.

Module – IV

Micro-nutrient elements (P,N and Si) in seawater – Forms in seawater, distribution and cycle, N:P ratios – Stoichiometry of the uptake and regeneration of the nutrient elements and of oxygen – Chemical oceanography of the seas around India – Instruments used in chemical oceanography.

Atmospheric chemistry and air-sea interactions – Composition of the atmosphere, steady state or equilibrium, sources of gases in the atmosphere, reactivity of trace gases in the atmosphere, acid rain, ozone hole; chemistry of sea surface microlayer – Origin, thickness and collection of surface material, properties of the sea surface microlayer.

Reference Books:

- 1, Introduction to marine chemistry, 1981 – Riley, J.P. and Chester, R.
2. Chemical oceanography (Vol.1,2, 3 & 8), 1975 – Riley, J.P. & Skirrow, G.
3. Marine Chemistry, 1969 – Horne, R.A.
4. Seawater: Its composition, properties & behaviour, 1989 – The Open University.
5. Marine Chemistry (Vol.2), 1970 – Martin, D.F.
6. Chemical oceanography, 1982 – Broecker and Peng.
7. Marine geochemistry 1990 – Chester.
8. Chemical oceanography, 1992 – Millero and Saha, M.L.
9. Dynamic processes in the chemistry of the upper ocean, 1986 - Burton et al., Plenum Press.
10. The chemistry of the atmosphere and oceans, 1978 – Holland, H.D.
11. An introduction to environmental chemistry, 1996 – Andrews et al., Blackwell science.
12. Environmental chemistry, 1994 - De, A.K., Wiley – Eastern Ltd.
13. Geosphere – Biosphere Interactions and climate, 2001 – L.O.Bengtsson and C.U.Hammer.
14. Oceanography of the Indian Ocean, 1992 – B.N.Dessai (Ed.)
15. Chemical Oceanography of the Indian Ocean, North of Equator. Deep Sea Res. 1984, 31A, 671-706.
16. Chemical Oceanography, 1996 – F.J.Millero
17. The Sea Surface and Global Change, 1997, 2005 – P.S. Liss and R. Duce.

MS 103 : Marine Biology

Module – I

Introduction to marine biology – history, classification, theories, expeditions, hypothesis testing; Origin and evolution of life – life processes, abiogenesis, theories of natural selection, organic evolution, primordial soup hypothesis, organic molecules, chemical evolution, iron sulfide and black smoker's theory, RNA world hypothesis, theory of evolution and panspermia.

Module – II

Marine and coastal environment – biological zonation, inter-tidal ecosystem (rocky - zonation pattern - physical and biological factors, sandy shores and protected sand flats – physical and biological factors, faunal composition and adaptations), sea as a biological environment – physiological changes, regulators and conformers, scope for growth, temperature and metabolic rates, comparison among marine and terrestrial environment.

Module - III

Primary productivity – mechanism, light and dark reaction, intermediate products, factor affecting primary productivity, role of pigments, methods of assessment, biological pump and transformation of organic matter, vertical profile of primary productivity and SCM, turbulence and MLD.

Module – IV

Secondary productivity - heterotrophic processes and pathways, herbivores and grazing, zooplankton sampling and constraints, biomass estimation, ontogenic and vertical migrations, mud bank formation, processes and fisheries.

Reference Books:

1. Biological oceanography 1999 – Lalli, C.M.
2. Oceanography: The past, 1980 – Sears, M and Merimann D. (Eds).
3. Elements of ecology (3rd edn) 1982 – Tail, R.V.
4. An introduction to marine sciences, 1988 – Meadows, P.S. & Campbell, J.J.
5. Textbook of marine ecology, 1989 – Nair, N.B. & Thampy, D.M.
6. Marine biology, 1984 Thurman, H.V. and Webber, H.H.
7. Methods in marine zooplankton ecology, 1984 Omori, W. and Ikeda, T.
8. Methods for the study of marine benthos, 1984 – Holme, N.A. & Melntyre, A.D.
9. The ecology of rocky coasts, 1964 – Lewis, J.R.
10. The shore environment, 1980 – Irvine, J.H., Price, D.E.C. and Farnham, W.F.
11. Life between tidemark on rocky shores, 1972 – Stephenson, T.A. & Stephenson, A.
12. The invertebrates (5th Edn.), 1986 – Barnes, R.D.
13. Zooplankton Methodology Manual, 2000 - Harris, R., Wiebe, P., Lenz, J., Skjoldal, H.R., Huntley, M. (Eds), ICES Academic Press, San Diego, pp. 684.

MS 104 : Geomorphology and Tectonics.

Module – I

The earth and the solar system – Size, shape, structure, origin and age of the earth – Geological time scale – Size and shape of the ocean basins: Pacific, Atlantic and Indian – Morphology and structure of

continental margins, mid oceanic ridges and deep sea floor – Origin of ocean basins – Continental drift sea floor spreading and plate tectonics – Evolution of the Indian ocean

Module - II

Earth Quakes - classification, magnitude, epicentre, recording - seismographs, shadow zone, important earth quakes, causes. Volcanoes - magma, lava, volcanic land forms, famous eruptions. Mountains and mountain chains

Reference Books:

1. Introductory oceanography (5th ed), 1988 Thurman, H.V., Merill Publ. Co, Ohio.
2. Oceanography (5th ed), 1990 – Grant Gross, M., Prentice Hall.
3. Coastal and estuarine sediment dynamics, 1986 – Dyer, K.R., John Wiley & Sons.
4. Earth resources. 1969 – Skinner, B.J., Prentice Hall
5. Marine geology and oceanography of the Arabian Sea and coastal Pakistan 1984 – Haq. B.U. and Milliman, J.D., Van Nostrand Reinhold Co.
6. Marine Geology, 1982 – James P. Kennet. Prentice Hall INC Englewood, Cliffs, N.J. 07632.
7. Earth Science, 1985 - Mamowitz and Spaulding

MS 105 : Physical Oceanography Practical

Module – I

Analysis of Physical properties of sea water in the world ocean – Preparation of vertical and horizontal sections of temperature, salinity and density - Interpretation of physical oceanographic data for identification of oceanographic processes – Estimation and analysis of heat content – T.S. diagram-sound speed in sea water.

Module – II

Analysis of dynamic topography – Computation of geostrophic currents – Measurements of atmospheric pressure, humidity, minimum and maximum temperature, computation of absolute humidity, specific humidity – Mixing ratio – Studies of diurnal and seasonal variability of the atmospheric properties using radio sonde data – Preparation of tephigram – Field observations of physical oceanographic parameters.

Reference Books:

1. Principles of physical oceanography, 1996 – Pierson, W.J. and Newmann, G.S., Prentice Hall Inc., New Jersey, U.S.A..
2. Meteorology today: An introduction to weather, climate and the environment (2nd edition), 1985 Ahrens, St. Paul, West Publ. House.
3. Introduction to dynamic oceanography, 1983-Pond, S. and pickard, G.H.Pergamon Press, U.K.

MS 106 : Marine Chemistry Practical

Module – I

Estimation of salinity of seawater by Mohr-Knudsen's method – Determination of dissolved oxygen of seawater – Determination of pH of seawater – Determination of total alkalinity of seawater – Verification of Beer's Law.

Module – II

Determination of phosphate in seawater – Determination of nitrite in seawater – Determination of nitrate in seawater – Determination of ammonia in seawater – Determination of dissolved silicate in seawater.

Reference Books:

1. Methods of seawater analysis, 1983, 1995 – Grasshoff, K., Ehrhardt, M and Kremling, K.
2. A practical hand book of seawater analysis, 1972 Strickland, J.D. and Parsons, T.R

MS 107 : Marine Biology Practical I

Module – I

Sampling devices and instruments used in marine biology field work, general guidelines for identification of phytoplankton and zooplankton, identification of seaweeds and mangrove, identification of corals.

Module – II

Identification of finfish, crustaceans, mollusk and echinoderms, camera lucida drawings.

Reference Books:

1. Guides to the identification on marine and estuarine invertebrates, 1971-Grossner, K.L.
2. An introduction to the study of tropical plankton, 1965 – Wickstead, J.H.
3. Fishes of India, 1967 – Day, F.
4. Methods in marine zooplankton ecology, 1984 – Omori, W. and Ikeda, T.
5. Methods for the study of marine benthos, 1984 – Holme, N.A. and Melntyre, A.D.
6. Quantitative ecology and marine biology, 1990 Bakus, G.J.
7. Zooplankton Methodology Manual, 2000 - Harris, R., Wiebe, P., Lenz, J., Skjoldal, H.R., Huntley, M. (Eds), ICES Academic Press, San Diego, pp. 684.

MS 201 : Marine Geology

Module – I

Sediment, sediment grade scale and analysis – Classification, composition, distribution and source of sediments with emphasis on nearshore areas – Surveying, sampling and laboratory techniques for the study of coastal and estuarine sediments – Analysis of sedimentological data and interpretation – Instruments used in marine geology. Beach and beach profile, variations in beach morphology and its significance – Nearshore geological processes: erosion, transportation and deposition

Module – II

Sea bed minerals with emphasis on Indian ocean – Polymetallic nodules, phosphorites, carbonates, placer deposits and petroleum resources, gas hydrates – Fossilization process – Types of microfossils and classification, technique for paleoclimate reconstruction with respect to oxygen isotope studies, role of microfossils in paleo – oceanography, paleoclimate, marine archaeology petroleum exploration and monitoring marine pollution

Module – III

Structural Geology - Folds - parts of fold, nomenclature, types, causes; Faults - nomenclature, types; Joints. Minerals and their physical properties, Rocks - classification and properties. Ground water and saline water intrusion on the coastal plain and ground water.

Module – IV

Principles of geophysical methods: Gravity, magnetic and seismic – Elucidation of the structure of the earth using seismic model -- Instruments used in marine geophysics. Hydrography – position fixing, depth measurement and sea bed mapping technique, side scan sonar, hydrographic chart.

Reference Books:

1. Introductory oceanography (5th ed), 1988 Thurman, H.V., Merill Publ. Co, Ohio.
2. Oceanography (5th ed), 1990 – Grant Gross, M., Prentice Hall.
3. Coastal and estuarine sediment dynamics, 1986 – Dyer, K.R., John Wiley & Sons.
4. Beach processes and sedimentation, 1976 – Komar, P.D., Prentice Hall
5. Beaches and Coasts (2nd ed), 1972 – King, C.A.M., Edward Arnold
6. Introduction to marine micropaleontology, 1978 – Haq, B.U. and Boersma, A. (Eds.), Elsevier Publ.
7. Introduction to geophysical prospecting, 1976 – Dobrin, M.B., McGraw-Hill.
8. Gravity and magnetics in oil prospecting , 1976 – Nettleton, L.L., McGraw-Hill
9. The mineral sources of the sea, 1965 – Mcro, J.L., Elsevier, Amsterdam.
10. Earth resources. 1969 – Skinner, B.J., Prentice Hall
11. Structural Geology, 1972 - M.P. Billings, Third Edition
12. Marine minerals: advances in research and resource assessment, 1987 – Teleki, P.G. et al. D. Reidel Dordrecht.
13. The micropaleontology of oceans, 1971 – Funnell, B.M. and Reidel, W.R., Cambridge Univ. Press., U.K.
14. Marine geology and oceanography of the Arabian Sea and coastal Pakistan 1984 – Haq. B.U. and Milliman, J.D., Van Norstrand Reinhold Co.
15. Marine Geology, 1982 – James P. Kennet. Prentice Hall INC Englewood, Cliffs, N.J. 07632.

MS 202 : Computational Methods in Oceanography

Module – I

Programming FORTRAN (90/95) : constants, variables, arithmetic operations, arithmetic expressions – assignment statements – input – output statement - library functions – Hierarchy of operation – mixmode operations- relational operators, precedence of operators. IF-THEN - ELSE statement – ELSEIF structures – NESTED IF blocks – DO LOOP – NESTED DO LOOP – Intrinsic DO LOOP.

Module – II

Applications of basic Mathematics to oceanography : Indices, Logarithms, linear and parabolic functions – Permutation and combinations – Arithmetic and geometric progression – Differentiation, application of differentiation – Velocity, acceleration, related rates. Application of integration to growth and decay problems - Matrices: addition, subtraction, multiplication, inverse by adjoint method.

Module – III

Descriptive statistics: population sample – measures of central tendency - measures of dispersion – skewness kurtosis – simple correlation, Karl pearson’s coefficient of correlation, concurrent deviation method, method of least squares (regression) – regression equation – introductory probability.

Module – IV

Normal and binomial distribution – Inferential statistics: standard error – significance level – hypothesis testing : students t-test: test of significance for attributes, large samples and small samples, Z test, Ψ^2 (chi square) test, F test, analysis of variance

Reference Books:

1. A biologist’s basic mathematics, 1983 – Causton,D.R., Edward Arnold, London.
2. Introduction to mathematics for life scientists, 1971 – Batchelet, E.
3. Mathematics for biological sciences,1980 – Newby J.C., Oxford University Press, U.K.
4. College algebra, 1966-Bardell, R.H. and spitzbart, A., Addison-Wesley, Massachusetts, U.S.A.
5. Introduction to algebra, 1966 – Perlis S., Blaisdell Publ. Co., London.
6. Differential equations, 1985 Wylic, C.R., Mc Graw Hill Publ., Singapore.
7. Statistics: Theory methods and applications, 1988 – Samchetr, D.C. and Kapoor, V.K., Sultan Chand and Sons, New Delhi.
8. Biometry, 1981 – Sokal, R.R. and Rohlf, F.J. Freeman & Co. San Fransisco.
9. Statistical methods, 1967 – snedecore, G.W. and Cochran, W.G.,Allied Pacific Pvt. Ltd., Mumbai.
10. Multivariate statistical methods, 1990 – Morrison, D.F., Mc.Graw-Hill Publ., Singapore.
11. Fundamental computer concepts, 1986 - Davis, W.S. Mc.Graw Hill Publ., Singapore.
12. Theory and problems of data processing, 1982 – Lipschutz, M.M. and Lipschutz, S., McGraw Hill Book Co., Singapore.
13. Fortran 77 and numerical methods, 1994 Xavier, C., Wiley-Eastern Ltd., New Age International Ltd., New Delhi.
14. Computer Programming in FORTRAN 90/95, 1997. I.V. Rajaraman, Prentice Hall of India, New Delhi.
15. FORTRAN 90/95 for Scientists & Engineers. S.J. Chapman, 1998 Mc-Graw Hill.

MS 203 : Remote sensing and its applications

Module - I

Principles of Electromagnetic radiation– Energy matter interactions – Rayleigh scattering – Mie scattering – Non selective scattering - Radiative transfer in the atmosphere – Stefan’s and Wien’s displacement laws –Zenith and azimuth angles

Module - II

Optical remote sensing – bio-optical properties of sea water - Inherent and apparent optical properties - scattering - absorption-attenuation - diffuse attenuation – Remote sensing reflectance - Case I and Case II waters - radiative transfer in the water column .

Module – III

Sun photometry - Beer-lambert’s law - spectral variation of aerosol optical thickness - atmospheric correction - interpretation of ocean colour - spectral response of water as a function of organic and inorganic constituents - Analysis of suspended minerals, chlorophyll_a and dissolved organic matter through OCM/MODIS data.

Module – IV

Thermal infrared remote sensing- Thermal infrared properties - Atmospheric windows - Thermal radiation laws - Emissivity - sea surface temperature retrieval through IR sensors - Active and passive microwave remote sensing - Satellite altimetry of sea surface topography. Sensor characteristics – MSS, GOES, AVHRR, CZCS, SeaWiFS, IKONOS, MODIS, OCM I and OCM -II, LISS -1, LISS-II, WIFS and PAN – Fundamentals of digital image processing – Image rectification – Image enhancement – linear stretching – supervised and unsupervised classification - Introduction to Geographic Information system.

Reference Books:

1. Physical principles of remote sensing, 1990 – Rees, W.G., Cambridge Univ. Press, U.K.
2. Remote sensing optics and optical systems, 1980 – Slater, P.N., Addison Wesley Publ. Co.
3. Remote sensing and image interpretation (2nd edn), 1987 – Lillesand, T.M. and Kiefer, R.W., John Wiley and sons.
4. Remote sensing: Principles and interpretations (2nd edn), 1987 – Floyd and F. Sabnis Jr. W.H. Freeman and Co., New York.
5. Theory and application of optical remote sensing, 1989 – Asrar G., John wiley & Sons.
6. Introduction to satellite oceanography, 1985 – Maul, G.A., Martinus Nijhoff Publ.
7. Advanced remote sensing from theory to applications (vol.1,2 & 3), 1981 – Chlamys, F.T., Addison wisley Publ. Co. Inc., Canada.
8. Oceanography from space, 1987- Gover, J.A.R., Plenum Press, New York.
9. Remote sensing of atmospheres and oceans, 1980 Deepak A., Academic press.
10. Satellite oceanography, 1985 Robinson, I.S., John Wiley & Sons

MS 204 : Analytical Chemistry of Sea water and Instrumental Techniques

Module - I

Sampling – Collection and preservation of water, sediment and biological samples. General Errors, Accuracy and Precision.

Filtration and Storage- Criteria of an ideal filtering medium- Glass fibre, membrane and Nucleopore filters. Storage for analysis of water for major elements, nutrients, dissolved phosphate, total phosphorous, nitrogen compounds silicates, and trace metals.

Chemical separation methods: Matrix effects, Interference effects, Pre-concentration methods: Co-precipitation, Co-crystallization, ion exchange and solvent extraction methods, their principles and applications.

Module - II

Fresh water recovery by various methods of desalination, Low temperature thermal desalination, Distillation, solar evaporation, Membrane process, scale formation and its prevention.

Chemical recovery process- Chemistry of salt manufacture, Different grades of salt, washing of sea salt, salt for industries, up-gradation of sea salt, solar evaporation, forced evaporation of brine, Grainer process, Alberger process, Open pan evaporation and vaccum pan evaporation methods.

Recovery of bromine from salt bittern, Dow process, Steaming out process for the manufacture of bromine.

Recovery of magnesium, magnesium metal from sea water, Dow process and IG-MEL process for the production of magnesium.

Recovery of potassium from sea water, Balard and Niccoli Processes for the production of potassium from sea water.

Module - III

Extraction of Agar, Alginates and Carrageenan from seaweeds - their structures, production, uses and toxicology.

Extraction of marine drugs: Chemical and Pharmacological Aspects- Prostaglandins, Steroids, Terpenes and Nitrogenous compounds, Antibiotic compounds from sponges, Cephalosporins and Fish and Shellfish toxins.

Module - IV

Electro-analytical methods: Polarography: Basic principles and application in chemical speciation studies.

Chromatographic methods: Paper thin layer gas liquid and high performance liquid chromatograph Basic principles and application to marine samples.

Spectroanalytical methods: Photometry and Spectrophotometry, Fluorimetry, Flame photometry, Atomic absorption spectrophotometry, Flameless AAS and Inductively coupled plasma emission spectrometry (ES and MS)- Basic principles, instrumentation and applications in the analyses of marine samples.

Reference Books :

1. A text book of qualitative Inorganic Analysis including Elementary Instrumental analysis by Vogel (1978). Published by the English Language book society.
- 2.. APHA. Standard methods for the examination of water and waste water analysis(1998).20th edition, Washington DC.
3. Methods of seawater analysis by Grosshoff (1983) .Verlag Chemie, Weinheim.
4. Manual for geochemical analysis of marine sediments and suspended particulate matter by Loring and Rantala(1992). Earth Science Review.
5. Chemical Oceanography J.P. Riley and G. Skirrow, Vol. 3. (1975). Academic Press, London.
6. Environmental Chemistry by Anil Kumar De(1995). Published by Wiley Eastern Limited and New age international limited, New Delhi.
7. Marine drugs: chemical and Pharmaceutical aspects by H.W. Young Y. Shimizu. In chemical Oceanography, volume 4 J.P. Riley and chester (eds.) Chapter 23.
8. Seaweeds in industry by E. Booth In Chemical Oceanography, volume 4 J.P. Riley and R. Chester (eds.) Chapters 20,21 and 22. 1975.
9. Marine natural products, Chemical and biological prospectives 1-5, P.j. Scheuer (ed) 1978-83.
10. Marine natural products by P.J. scheuer, Acaemic Press 1973.
11. Quantitative analysis by R. A. day and A.L. Underwood. Prentice-Hall of India, New Delhi, 2001.
12. Instrumental methods of Chemical analysis by G. W. Ewing (1976)

MS 205 : Aquaculture

Module - I

Principles of aquaculture, global scenario, status and prospects of coastal aquaculture in India, traditional aquaculture practices.

Module – II

Basic considerations, site selection, water quality management, species selection, feasibility and technique applied for mussel, pearl oyster, fish, lobster and seaweed culture practices.

Module – III

Shrimp aquaculture, types of culture practices, traditional, modified traditional, extensive, modified extensive, semi intensive and intensive, critical requirements, site selection and pond preparation, selection of candidate species, brood stock procurement, hatchery production and management, nutrition, live feed culture and formulated feed preparation, water quality management in hatchery and lessons learned from Global and local scenario.

Module – IV

Reproduction, induced maturation by eye stalk ablation, role of X organ, sinus gland system, status and prospects of brood stock, domestication and genetic improvement, shrimp diseases, pathology and parasitological, prophylactic and therapeutic measures, shrimp health management, need and advantages of integrated aquaculture practices, Brackish water aquaculture, environmental issues and management strategies, Coastal aquaculture Act, 2005.

Reference Books:

1. Aquaculture, 1989 – Pillai, T.V.R.
2. Fish and fisheries of India, 1982 – Jhingran, V.G.
3. Fish diseases – Marine ecology (Vol 4), 1983 – Kinne, O.
4. Crustacean aquaculture, 1983 McKey, J.P. CRC series.
5. Aquaculture, 1972 – Bardach.
6. Prawn and prawn fisheries of India, 1976 – Kurian, C.V. & Sebastian, V.O.
7. Environmental management for aquaculture, 1998 – Midlen.
8. Nutrition and feeding of fish, 1999 – Lovell.
9. Pond aquaculture water quality management, 1998 – Tucker.

MS 206 : Marine Geology Practical

Module -I

Beach profile survey and sediment sample collection-Water sample collection and separation of suspended sediments- Sample collection using grab and corer and sample preservation- Beach profile plotting and volume computation- Pretreatment of sediment- Grain size analysis (sand grade) - Grain size data computation, graphical representation and interpretation

Module -II

Depositional environment studies using a data set of river, dune and beach- Techniques for heavy mineral separation - Computation of gravity data- Computation of magnetic data- Computation of

Seismic data- Graphical representation and interpretation of bathymetry data set- Study of bathymetry maps - Study of seismic profiles

Reference Books:

1. Exercises in sedimentology, 1982 – Friedman, G.M. & Johnson, K.G., John Wiley & Sons.
2. Rutley's elements of mineralogy (26th edn), 1984 – Read, H.H., C.B.S. publ. & Distri.
3. Beach processes and sedimentation 1976 – Komar, P.D., Prentice Hall.

MS 207 : Computational Methods in Oceanography Practical

Module – I

Programming in FORTRAN for computations of oceanographic parameters – use of IF features of FORTRAN, use of DO LOOPS. Application of nested DO LOOPS, relational operators, IF-ELSEIF – ELSE – ENDIF constructs in Oceanography.

Module – II

Analysis of oceanographic data. Applications of Internet. Use of software for estimation of statistics / parameter of sample / population. Development of FORTRAN programs for computation of statistical parameters – Eigen values.

Reference Books:

1. Fundamental algorithms, 1985 – Knuth, D.E., Narosa Publ. House, New Delhi.
2. Theory and practice of programming, with FORTRAN, 1986 – Lipschutz, S & Poe, A., Mc.Graw Hill Book Co., Singapore.
3. Fortran 77 and numerical methods, 1994 – Xavier, C., Wiley Eastern Ltd., New Age International Ltd., New Delhi.
4. Internet bible, 1997 Bremmer, L.M. & Al sernati, A.F.J., Golgotia Publ. (Pvt.) Ltd., New Delhi.
5. Computer Programming in FORTRAN 90/95, 1997. I.V. Rajaraman, Prentice Hall of India, New Delhi.
6. FORTRAN 90/95 for Scientists & Engineers. S.J. Chapman, 1998 Mc-Graw Hill.

MS 208 : Remote Sensing and its applications Practical

Module - I

Generation of inherent and apparent optical properties of case II water – computation of remote sensing reflectance and water leaving radiance from case II waters-

Module – II

Analysis of aerosol optical thickness – computation of aerosol radiance- atmospheric correction to ocean colour monitor data – use of different algorithms to map chlorophyll_a, sediment and dissolved organic matter through ERDAS IMAGINE.

Reference Books:

1. Physical principles of remote sensing, 1990 – Rees, W.G., Cambridge Univ. press, U.K.
2. Remote sensing optics and optical systems, 1980 – Slater P.N., Addison – Wesley Publ.Co.

3. Remote sensing and image interpretation (2nd ed.), 1987 Lillesand, T.M. and Kiefer, R.W., John Wiley & Sons.
4. Remote sensing: Principles and interpretations (2nd edn), 1987 – Floyd and F. Sabnis Jr, W.H. Freeman & Co., New York.
5. Theory and applications of optical remote sensing, 1989 – Asrar, G., John Wiley & Sons.
6. Introduction to satellite oceanography, 1985 – Maul, G.A., Martinus Nijhoff Publ.
7. Advanced remote sensing from theory to applications (Vol.1, 2 & 3), 1981, chlamys, F.T., Addison – Wesley Publ. Co. Inc., Canada.
8. Oceanography from space, 1987 – Grover, J.A.R., Plenum Press, New York .
9. Remote sensing of atmospheres and oceans, 1980 – Deepak, A., Academic Press.
10. Satellite oceanography, 1985 – Robinson I.S., John wiley & sons.
11. Some marine applications of satellite and airborne remote sensing, 1989 – 1st computer – based learning modules, UNESCO publications, Paris.
12. Applications of marine image data, 1991 – 2nd Computer – based learning modules, UNESCO Publications, Paris.
13. Applications of marine and coastal image data, 1992, 1993, 1995 – 3rd, 4th and 5th computer-based learning modules, UNESCO Publications, Paris.
14. Remote sensing of Environment, 2000. John. R. Jensen, Prentice hall series in Geographic Information science.

MS 209 : Analytical Chemistry of Sea water and Instrumental Techniques Practical

Module – I

Estimation of Cu, Co and Pb in seawater by Flame AAS method.- Estimation of Cu, Co and Pb in sediment samples by Flame AAS method - Estimation of Cu, Co and Pb in seaweeds by Flame AAS method - Estimation of Hg by using Hydride generator AAS.

Module - II

Speciation of metals in sediments (Sequential extraction procedure) - Speciation of Mn, Fe in sediments - Estimation of Cu and in water by Polarography method - Speciation of Chromium in waters by Polarography method.

Reference Books:

1. A text book of qualitative Inorganic Analysis including Elementary Instrumental analysis by Vogel (1978). Published by the English Language book society.
- 2.. APHA. Standard methods for the examination of water and waste water analysis(1998).20th edition, Washington DC.
3. Methods of seawater analysis by Grosshoff (1983) .Verlag Chemie, Weinheim.
4. Manual for geochemical analysis of marine sediments and suspended particulate matter by Loring and Rantala(1992). Earth Science Review.
5. Quantitative analysis by R. A. day and A.L. Underwood. Prentice-Hall of India, New Delhi, 2001.
6. Instrumental methods of Chemical analysis by G. W. Ewing (1976)

MS 210 : Aquaculture Practical

Module - I

Identification of cultivable fishes of shrimps, mussels, oysters, fish, crabs and sea weeds, reproductive system of shrimp, identification of larval stages of shrimp of commercial importance.

Module - II

Methods of estimation of dissolved oxygen, BOD, suspended solids, dissolved and particulate organic carbon and ammonia, visit to shrimp hatchery for demonstrations, visit to NIO laboratory for demonstration of biological filter and air lift aeration system, fabrication of raft, transplantation of spat for mussel culture.

Reference Books:

1. Crustacean aquaculture, 1983 – Mckey, J.P., C.R.C. series.
2. Training manual on recent advances in management of water quality parameters in for aquaculture, 1997 – C.I.F.E. Publication, Mumbai.
3. Training manual on advances in keeping and breeding ornamental fishes, 1997 C.I.F.E. Publication, Mumbai.
4. Training manual on culture of live food organisms for aqua hatcheries, 1998 – C.I.F.E. Publication, Mumbai.
5. Training manual on culture of live fish for aquaculture, 1998 – C.I.F.E. Publication, Mumbai.

MS 211 : Marine Biology Practical II

Module – I

Sterilization techniques, preparation of bacterial media, nutrient, broth & agar preparation of slants; method of sample collection (water) from marine environment, estimation of bacterial, fungal population. isolation & preservation of cultures, isolation of pure cultures microscopy : wet mounts.

Module – II

Isolation of pathogenic organisms from water and sediments, identification of unknown bacteria, separation of mixed culture, isolation, maintenance and preservation of pure culture, characterization, biochemical tests, staining of bacteria and cell morphology.

Reference Books :

1. Bergeys manual of systematic bacteriology, Vol.I (William & Willcens, Baltimore, MD), 1984, 518 pg
2. Marine and estuarine microbiology laboratory manual, 1975 – Rita R. Colwell – University Park Press, 1975. 96 pgs.
3. Marine microbiology, a monograph & hydrobacteriology , C.E. Zobell, 1946 – Chronica botarica Compare, 1946. 240 pgs.
4. Laboratory methods in microbiology, W.F. Harigan, M.E. Mc Cance, 1966, Academic press 1966, 362 pgs.
5. Manual of environmental microbiology, G. J. Hurst , G. R. Knudsen, 1997, AsM Press, 1997, 894 pgs.

MS 301: Geophysical Fluid Dynamics

Module – I

Basic concepts: fluid continuum, fluid properties, ideal fluid, actual fluids, types of flow; D' Alembert's Paradox; statics: pressure surface and body forces on a fluid element; fundamental equation of fluid statics: application to compressible and incompressible fluids, perfect gas equation, hydrostatic equation along the vertical, application to the atmosphere, Laplace's equation. Units of measurement – Newtonian and non – Newtonian fluids – Kinematics –

Module – II

Kinematics: Lagrangian and Eulerian methods of description of fluid flow- Lagrangian and Eulerian method- stream lines, streak lines and trajectories, Biot's equation, steady and non-steady flow, decomposition of the field of motion in the vicinity of a point, translation, rotation, divergence and deformation, Principles of Prandtl's mixing length theory, Taylor's statistical theory and Kolomogoroff's similarity theory physical interpretation, application to plane motion, typical flow patterns, stream function, divergence and vorticity in different co-ordinate systems, material, local and convective derivatives.

Module – III

Dynamics -I: equation of continuity and its applications, non-viscous incompressible flow, Eulerian equations of motion, inertial and rotational frames of reference, Coriolis force, irrotational flow, velocity potential, integration of the equations of motion, Bernoulli's theorem and its applications.

Module – IV

Dynamics – II: Circulation and vorticity, Stoke's theorem, Kelvin's theorem, Helmholtz theorem, barotropic and baroclinic fluids, absolute and relative circulation; V.Bjerknes circulation theorem and its interpretation, potential vorticity-conservation, application to air flow over mountain barriers. Navier-Stoke's equations of motion for a viscous Newtonian fluid; laminar flow of viscous incompressible fluids, Poiseuille flow, Couette flow, steady flow around a sphere, Stoke's formula, Reynold's number and dynamic similarity of flows, physical significance of Reynold's number, low and high Reynold's number.

Reference Books:

1. Hydraulics and fluid mechanics, 1985 – Modi, P.N.and Seth., Standard Book House, Delhi.
2. Foundation of fluid mechanics, 1969 – Yuan,S.W., Prentice Hall, New Delhi.
3. An introduction to fluid mechanics, 1967 – Batchelor, G.K., Cambridge Univ. Press, UK.
4. Hydrodynamics, 1975 – Lamb, H., Cambridge Univ. Press, U.K.
5. Introduction to fluid mechanics, 1976 – Rathy, R.K., Oxford and IBH Publ. Co., New Delhi.
6. The physics of marine atmosphere, 1965 – Roll, H.U., Academic Press, London.
7. Atmosphere – ocean Dynamics,1982 -- Gill, Adrian E, International Geophysics, 30 Academic press, New York.

MS 302: Ocean-Atmosphere coupling and Climate

Module – I

Wind generation, forces acting on wind, Geostrophic winds, thermal winds. Wind wave generation, scale of interaction, General character of sea surface as a lower boundary of air flow – Geometry of the sea surface – The wind field in the maritime frictional layer. Drag coefficient.

Module – II

General consideration of air sea interaction – Planetary boundary layer - Laminar boundary layer, surface layer and spiral layer. Variation of air sea fluxes with special reference to upwelling – Transfer of heat and water vapour – Determination of air – sea fluxes – Fronts and water masses interaction - Profile method and non profile methods

Module – III

Energy exchange and global climate – Radiation and its role on tropical circulation – Monsoons: cause, interseasonal and intraseasonal variability. El-nino & La – nina - Indian summer monsoon.

Module – IV

Tropical cyclones : Cyclone structure, Generation, growth and decay. Temperature, pressure field and wind speed and direction. Cyclones in North Indian Ocean, – Instruments used in marine meteorology – Concepts in climatology, fundamental oceanic processes influencing climate – climate change.

Reference Books:

1. The physics of marine atmosphere , 1965 Roll, H.U., Academic Press, London.
2. The sea: Ideas and observations (Vol.1) 1962 – Hill, M.N.(Ed.), John Wiley & sons, New York.
3. Oceanography for meteorologists, 1945 – Sverdrup, H.U., George Allen & Unwin, London.
4. Principles of physical oceanography, 1996 – pierson, W.J. and Newman, G., Prentice Hall Inc., new Jersey, U.S.A. .
5. Introduction to theoretical meteorology 1959 – Hess, H.L.,Holt, Rinehart & Winston, New York.
6. Tropical meteorology (Vol. 1 & 2), 1993 – Asnani, G.C., Asnani Publ., Pune, India.
7. The physics of monsoons, 1992 – Keshavmurthy and Rao, Allied Publ., New Delhi.
8. Climate change, 1995 – Houghton, J.T., Cambridge Univ. Press, U.K.
9. Climate of South Asia, 1997 – Pant and Kumar , John wiley.
10. Global environmental issues: Climatological approach, 1994 – Kemp, D., Routledge, D.

MS 303: Marine Pollution

Module – I

Marine Pollution: Definition, categories of additions, Pollutant and its classification.

Organic wastes: BOD, COD, dilution factor, Fluctuations in DO, Consequences of organic discharges to estuaries with examples; Thames and Mersey estuary; Consequences of sludge dumping at sea with reference to Thames and Firth of Clyde. Sewage treatment: Primary, Secondary and Tertiary treatment processes. Solid waste pollution: Classification and disposal of solid wastes.

Module II

Industrial pollution: sources, nature and their treatment processes with reference to wastes from paper and pulp and soap manufacturing industries.

Marine corrosion: Definition, corrosion reactions, classification of corrosion, factors affecting corrosion of metals in sea water and prevention of marine corrosion. The state of some seas in the world (pollution aspect); The North sea, The Mediterranean sea and the Baltic sea.

Module – III

Oil spills and cleanup: sources, major accidental spills, fate of spilled oil on the sea, consequences of oil spills and treatment of oil spills.

Pesticide pollution: inputs, fate in the sea, factors affecting the bioaccumulation of pesticides, DDT- the most wide spread molecule, Impact of pesticides on the Environment, Mode of poisoning of pesticides, Methods to minimize pesticide pollution.

Conservative pollutants: Measures of contamination, toxicity, measurement of toxicity, acute and chronic exposure, Detoxification. Metal pollution in coastal waters (Hg, Pb, Cd, Cu, Zn and Fe). The present status of coastal pollution in India and future strategies.

Radioactive Pollution: Sources, Classification and effects of radiation; Protection and control from radiation: Maximum permissible dose concept, dose limits, Disposal of radio active wastes; Beneficial aspects of radiation and food safety.

Module – IV

Indicator organisms: Criteria for selection of indicator organism: Quantitation of pollution load, basic pre-requisites, response to different pollution load and time integration capacity, Macro algae, crustaceans and mollusks as indicator organisms for monitoring of trace metal pollution; Red tides : distribution, types of poisoning, effects and methods to minimize red tides in the sea.

Monitoring strategies of marine pollution: Critical pathway approach and Mass balance approach. Standards in water quality: Assessment of pollution damage: The need, seriousness of damage, assessment of damage and problems of measuring impact.

Reference Books:

1. Chemical Oceanography (Vol: 3) 1975- Riley J.P and Skirrow, G.
2. The health of the oceans. 1976 Goldberg, E.D
3. Marine Pollution. 1986 Clark, R.B.
4. Quantitative aquatic biological indicators. 1980 Phillips J.D.H.
5. Thermal and radioactive pollution. 1994. Sharma, B.K and Kaur, H.
6. Water Pollution. 1994. Sharma, B. K and Kaur, H.
7. Marine and offshore corrosion. 1985. Chandler, K.A.

MS 304: Geophysical Fluid Dynamics Practical

Module – I

Kinematics analysis of wind and ocean current – Isotach and isogen analysis and construction of streamline patterns – Construction of trajectories of air parcels from successive synoptic charts – Computation of divergence and vorticity in horizontal flow – Current meter measurements and analysis of estuarine dynamics

Module – II

Construction of stream lines for simple types of flow – Field observations and analysis of Physical Oceanographic parameters of estuarine waters using conductivity temperature and depth (CTD) instrument - Numerical techniques in ocean and atmospheric modeling – Analysis of aerosol trajectory using HYSPLIT (HYbrid Single – Particle Lagrangian Integrated Trajectory) model.

Reference Books:

1. Hydraulics and fluid mechanics, 1985 – Modi, P.N.and Seth., Standard Book House, Delhi.
2. Foundation of fluid mechanics, 1969 – Yuan,S.W., Prentice Hall, New Delhi.
3. An introduction to fluid mechanics, 1967 – Batchelor, G.K., Cambridge Univ. Press, UK.
4. Hydrodynamics, 1975 – Lamb, H., Cambridge Univ. Press, U.K.
5. Introduction to fluid mechanics, 1976 – Rathy, R.K., Oxford and IBH Publ. Co., New Delhi.
6. The physics of marine atmosphere, 1965 – Roll, H.U., Academic Press, London.

7. Atmosphere – ocean Dynamics, 1982 -- Gill, Adrian E, International Geophysics, 30 Academic press, New York.

MS 305: Ocean Atmosphere Interactions and Climate Change Practical

Module – I

Estimation and analysis of incoming short-wave radiation, outgoing long-wave radiation, sensible heat flux, latent heat flux and net heat flux. Analysis of seasonal variation in fluxes. Tropospheric temperature inversion.

Module – II

SST and its link with southwest monsoon. Cyclone movement analysis, track detection. T- number and cyclonic wind strength determination using satellite images.

Reference Books:

1. The Physics of marine atmosphere, 1965 – Roll, H.U., Academic Press, London.
2. Oceanography for meteorologists, 1945 – Sverdrup, H.U., George Allen & Unwin, London, U.K.
3. Climate change, 1995 – Houghton, J.T., Cambridge Univ. Press, U.K.

MS 306: Marine Pollution Practical

Module – I

Analysis of polluted water - Determination of dissolved oxygen- Determination of biochemical oxygen demand - Determination of chemical oxygen demand - Determination of hardness of water.

Module – II

Determination of fluoride- Determination of hydrogen sulphide - Pre-concentration of water by solvent extraction method - Estimation of toxic heavy metals Cd and Zn.

Reference Books:

1. A practical hand book of sea water analysis, 1972 strickland, J.D.H. and parsons, T.R.
2. Marine chemistry (vol.1), 1972 – Martin, D.F.
3. APHA – Standard methods of the examination of water and waste water, 1985 – American Public Health Association, American water works association, Water Pollution Control Federation, New York.
4. Methods of seawater analysis, 1983 – Grasshoff, K., Ehrhardt, M and kremling, K.
5. A manual of chemical and biological methods of seawater analysis, 1972 – Parsons T.R. Mritz, Y and Lalli, C.H.

MS 307: Marine Geochemistry I

Module-I

Geochemical classification of elements - distribution and abundance of elements in lithosphere – Principle geochemical cycle, Chemical weathering. Suspended matter – Methods of collection and analysis, spatial and temporal variation of total suspended particulate matter in the ocean – Component composition and settling rates of suspended matter – Particle flux in the ocean and

various techniques of measurement – Particulate organic matter in the sea: its origin, nature, composition and methods of measurements.

Module-II

Sedimentation – physicochemical factors in sedimentation – ionic potential, hydrogen ion concentration, redox potential and colloids – Behaviour of major and trace elements during sedimentation – Significance of organic content in sedimentation – Component composition and geochemistry of deep sea sediments – Application of major and minor elements in the reconstruction of marine paleo-environment.

Reference Books:

1. Introduction to geochemistry, 1967 Krauskopf, K.B., Mc.Graw-hill.
2. Geochemistry, 1962 – Goldschmidt, V.M., Clarendon press.
3. Principles of geochemistry 1956 – Mason, B. and Moore, B.
4. Chemical oceanography (Vol. 1 & 3), 1975 – Riley, J.P. and Skirrow, G.
5. Introduction to geochemistry, 1995 – Krauskopf, K.B. and Bird, Mc-Graw Hill.
6. The geochemistry of natural waters, 1982 – Drever, J.I.
7. Estuarine chemistry, 1976 – Burton, J.D. and Liss, P.S., Academic Press.
8. Ocean chemistry and deep sea sediments, 1989 – Open University Course Material.
9. Aquatic chemistry, 1996 – Stumm, W. and Morgan, J.J., Wiley- Interscience, New York.
10. Aquatic surface chemistry, 1987 – Stumm, W., Wiley – Interscience, New York.
11. Marine Chemistry, 1969 – Home, R.A.
12. Advanced physical chemistry, Glasstone, S.

MS 308: Marine Geochemistry II

Module – I

Chemical and biological aspects of dissolved organic matter in the sea – Sources of supply and processes of removal of dissolved organic matter.

Radioactivity – Classification – Primary, cosmogenic and artificial radio nuclides; distribution and occurrence of radionuclides, their properties in the marine environment and their decay series – Sampling and storage of radionuclides, radio chemical separation- Applications of radionuclides to the geochronology of marine sediments and rocks – Carbon dating methods in marine sediments, oceanic mixing and residence time.

Module – II

The solid-solution interface – Electrokinetic phenomena, The electrical double layer, the structure of water at the solid solution interface, surface chemistry of oxides, hydroxides and oxide minerals; the colloidal state, origin of surface charge, aggregation of colloids, the role of coagulation in natural waters – Surface phenomena – Langmuir and Freundlich Adsorption isotherms, trace metal partitioning on solid- solution phases, particle concentration effects.

Reference Books :

1. Introduction to geochemistry, 1967 Krauskopf, K.B., Mc.Graw-hill.
2. Geochemistry, 1962 – Goldschmidt, V.M., Clarendon press.
3. Principles of geochemistry 1956 – Mason, B. and Moore, B.
4. Chemical oceanography (Vol. 1 & 3), 1975 – Riley, J.P. and Skirrow, G.
5. Introduction to geochemistry, 1995 – Krauskopf, K.B. and Bird, Mc-Graw Hill.

6. The geochemistry of natural waters, 1982 – Drever, J.I.
7. Estuarine chemistry, 1976 – Burton, J.D. and Liss, P.S., Academic Press.
8. Ocean chemistry and deep sea sediments, 1989 – Open University Course Material.
9. Aquatic chemistry, 1996 – Stumm, W. and Morgan, J.J., Wiley- Interscience, New York.
10. Aquatic surface chemistry, 1987 – Stumm, W., Wiley – Interscience, New York.
11. Marine Chemistry, 1969 – Horne, R.A.
12. Advanced Physical Chemistry, Glasstone, S.

MS 309: Marine Geochemistry Practical

Module - I

Determination of dissolved and particulate organic N in seawater -Determination of dissolved and particulate organic P in seawater - Determination of particulate organic C in seawater - Determination of dissolved Fe in seawater - Determination of dissolved Mn in seawater. Determination of dissolved Al in seawater - Determination of dissolved B in seawater.

Module II

Sediment digestion procedure - Determination of Mn in sediments- Determination of Cr in sediment - Determination of Ni in sediments - Determination of organic carbon in sediments - Determination of nitrogen in sediment - Determination of phosphorous in sediments

Reference Books:

1. APHA – Standard methods for the examination of water and waste water, Water Pollution Control Federation, New York.
2. Methods of sea water analysis, 1983, 1995 – Grasshoff, K. Erhardt, M and Kremling, K.
3. A practical handbook of seawater analysis, 1972 – Strickland, J.D.H and Parsons, T.R.
4. Marine Chemistry, 1972 – Martin, D.F.
5. Practical manual of sedimentary petrology, 1987 Babu, S.K. and Sinha, D.K.

MS 310: Marine Ecology

Module - I

Marine ecosystems (pelagic and benthic ecosystem), coral reef, deep sea, polar seas and hydrothermal vents and its ecology, concept of food chain, food web, niche, trophic structure and ecological efficiency, community structure diversity and ecosystem function, factor regulating community structure. Symbiosis, plant - animal and animal - animal associations in the marine environment.

Module – II

Phytoplankton ecology – diatoms, dinoflagellates, coccolithophores, foraminifers, harmful algal blooms – foraminifers – causative species, bloom formation, propagation, decomposition and its impact on ecosystem function, cyst and dormant stages, shellfish poisoning and effect on fish.

Module - III

Zooplankton ecology – copepods, euphasids, chaetognaths and other major groups and their role in food chain and food web, microbial loop and its role in tertiary production, secondary production and fisheries, fouling communities and introduced species.

Module – IV

Macro, meio and micro benthic fauna and their ecology, aerobic and anaerobic environments, benthic autotrophic production, chemical composition of sediments, animal - sediment relations, benthic metabolism .

Reference Books:

1. Marine biology: An ecological approach (2nd ed), 1988 – Nybbakken, J.W.
2. Marine ecology, 1982 – Levinton, J.S.
3. Biological oceanographic processes, 1984 – Parsons, T.R.
4. Marine biological processes(2nd ed), 1995 Valiela, I., springer
5. Plankton and productivity in the oceans (Vol. 1 & 2), 1983 – Raymont, J.E.G.
6. Introduction to marine ecology, 1982 Barnes, R.S.K. and Hughes, R.N.
7. Population ecology: An unified study of plants & animals, 1986 Begon, M. & Mortimer, M.
8. Ecology: the experimental analysis od distribution and abundance, 1985 – Krebs, C.J.
9. Biological oceanography (2nd edn.), 1999 – Lalli, C.M.
10. Deep sea demersal fish and fisheries, 1997 – Merrett, N.R.
11. Reef fisheries, 1996 – Polunin, R.S.V.
12. Valiela Evans, 1995 – Marine Ecological Processes – Springer Verlag, New York, 686.

MS 311: Marine Ecology Practical

Module – I

Estimation of chlorophyll and other pigments, analysis of phytoplankton sample, group level identification comparative analysis and interpretations, analysis of zooplankton sample, group level identification comparative analysis and interpretations, ecology of few economically important species and estimation of oxygen uptake by fish in the laboratory.

Module – II

Population studies, species diversity indices, species evenness and species richness, Morista's index, mark – capture – recapture method, conventional and diagrammatical life tables.

Reference Books:

1. International biological programme methodology handbook No. 12, 1974 – Vollen Weider, R.A. (Ed).
2. Methods in marine zooplankton ecology, 1984 – Omori, M and Ikeda, T.
3. Guides to the identification on marine and estuarine invertebrates, 1971 – Gossner K.L.
4. Methods for the study of marine benthos, 1984 – Holme, N.A. and McIntyre, A.D.
5. An introduction to numerical classification, 1975 – Clifford, H.T. and Stephenson, W.
6. Quantitative ecology and marine biology, 1990 – Bakus, G.J.
7. Fishes of India, 1967 – Day, F.
8. Feeding, digestion and growth quantitative consideration, 1982 – Pullin, R.S.V. and Lowe McConnell, R.M. (Eds.) ICLARM.
9. The ecology and ethology of fishes, 1981 – Noakes, G.V.
10. Ecology of teleost fishes 1999 – Wootton.
11. Zooplankton Methodology Manual, 2000 - Harris, R., Wiebe, P., Lenz, J., Skjoldal, H.R., Huntley, M. (Eds), ICES Academic Press, San Diego, pp. 684.

MS 312: Sedimentology

Module – I

Distribution and genesis of terrigenous, biogenous, chemogenous, volcanogenic, authigenic and extra terrestrial (cosmogenous) sediments in the world ocean – Rate of sedimentation in the oceans.

Module - II

Concepts of sedimentary facies, facies construction and interpretation, factors controlling the nature and distribution of facies – Provenance – Heavy minerals, rock particles and clay minerals – Mineral stability – Goldich stability series, sediment maturity, heavy mineral zones - X ray diffraction technique and its use in mineral and sediment study.

Module - III

Sedimentary depositional environments – Aeolian, lacustrine, glacial desert, fluvial, coastal shallow marine and deep sea – Sedimentary and faunal markers of paleoenvironmental conditions

Module - IV

Sedimentary rocks – Classification, properties, origin and importance – Sandstone, limestone, mudstones and evaporites – Sedimentary structures formed by unidirectional water flows, water waves, airflows, liquefaction and current drag, diapirism and differential loading, desiccation and shrinkage structure – Diagenesis: general considerations, terrigenous clastic sediments, carbonate sediments, evaporates and hydrocarbons, Diagenesis of silica, iron and Manganese .

Reference Books:

1. Sedimentation in the world ocean, 1972 – Lisitzin, A.P., Soc. Of E.C. Paleontologists.
2. Sedimentology, 1982 – Leeder, M.R., George Allen & Unwin.
3. Sedimentary rocks (3rd edn.), 1984 – Pettijohn, E.J., C.B.S. Publ. And Distrib.
4. Stratigraphy and sedimentation, 1963 – Krumbein, W.C. and Sloss, L.L., W.H.Freeman & Co.
5. Sedimentary environments and facies (2nd edn), 1986 – Reading, H.G. Blackwell Sci Publ.
6. Depositional sedimentary environments, 1986- Reineck, H.E. and Singh, I.B., Springer Verlag.
7. Origin of sedimentary rocks, 1972 – Blatt, H., Middleton, G. and Englewood, M.R., Cliff, New Jersey.
8. Principles of sedimentology, 1978 – Friedman, G.M. and Sanders, J. E., John Wiley & Sons.
9. Procedures in sedimentary petrology, 1971 – Carver, R.F., Wiley Interscience.
10. Sedimentary structures: their character and physical basis (Vol.1 & 2), 1982 – Allen, J.R.I., Elsevier.
11. Physical processes of sedimentation: An introduction, 1970 Allen, J.R., George Allen & Unwin.
12. Ancient sedimentary environments: A brief survey, 1970 – Selley, R.C., Chapman & Hall.
13. Atlas and glossary of primary sedimentary structures, 1964 – Pettijohn, F.J. and Potter, P.E. Springer Verlag.
14. Sand and sandstone, 1972 – Pettijohn, F.J., Potter, P.E. and Siever, R., Springer Verlag.

MS 313: Sedimentology Practical

Module-I

Grain size analysis: sand, silt, clay and their estimation and interpretation -Heavy mineral mounting techniques and identification - Heavy mineral counting and determination of number percentage - Study of stratigraphic correlation - Study of paleocurrent analysis - Facies identification of sediments.

Module-II

Measurement of sphericity and roundness of sediment grains - Identification of minerals Identification of sedimentary structures and rocks - Preparation of samples, X-ray diffraction technique -Identification of clay and carbonate minerals - Semiquantitative analysis of minerals.

Reference Books:

1. Exercises in sedimentology, 1982, - Friedman, G.M. and Johnson, K.G., John Wiley & Sons.
2. A practical approach to sedimentology, 1987 – Lindholm, R., C.B.S. Publ. And Distr.
3. The study of rocks in thin sections, 1985 – Moorhouse, W.W., C.B.S. Publ & Distr.
4. Rutley's elements of mineralogy, 1984 – Read, H.H., C.B.S. Publ. & Distrib.
5. Scientific method of analysis of sediments, 1967 – Griffiths, J.C., McGraw- Hill.
6. Text book of sedimentary petrology, 1981 – Varma, V.K. and Prasad, C., Intl. Book Distrib.
7. Practical manual of sedimentary petrology, 1987 – Babu, S.K. and Sinha, D.K., C.B.S. Publ. & Distrib.

MS 401: Estuarine and Coastal Physical Oceanography

Module-I

Physical characteristics of estuaries – Classification based on physical characteristics – Tides and tidal currents in estuaries – Tide producing forces -tidal theorem, tidal analysis and prediction- tides at the coast - salinity intrusion - gravity driven freshwater flow – estuarine circulation and mixing – stratification and entrainment – Measurement of tides.

Module-II

Breakers and surf – Littoral currents – Rip currents – Factors influencing coastal processes – River-estuary-near shore systems - Generation of waves by wind- their growth- propagation and decay- wave reflection- refraction and diffraction –Tsunamis -Theories of wave generation- general characteristic of waves - boundary conditions- small amplitude waves – phase speed- particle velocity and displacement -group velocity- wave energy- internal waves - Measurement of waves.

References Books:

1. Physical processes in Estuaries, 1988 – John Dronkers and Wim Van Leussen., Springer Verlag.
2. Physical Oceanography, Vol 2, 1960 – A. Defant., Pergamon press.
3. Waves, Tides and Shallow water processes, 1989 – The Open University, Walton Hill, Pergamon press.
4. Coastal oceanography, 1982 – H. G. Gade, A.Edward and H. Svendsen, plenum press.
5. Estuaries – a physical introduction – K.R. Dyer, 2nd edition , 1997 – John Wiley and sons.

MS 402: Estuarine Chemistry

Module – I

Salinity distribution in estuaries – a chemical perspective, flushing time, mixing and diffusion dispersal of pollutants in estuaries and nearshore areas – Conservative and non – conservative properties of dissolved constituents during estuarine mixing – Behaviour of dissolved oxygen, pH and major elements in estuarine water.

Module – II

Biogeochemistry of P, N, Si, minor and trace metals and dissolved organic matter in estuaries – Sources, sinks and general biogeochemistry; Simple flux calculations.

Reference Books:

1. Estuarine chemistry, 1976 - Burton, J.D. and Liss, P.S.
2. Practical estuarine chemistry, 1985 – Head, P.C.
3. Chemistry and biogeochemistry of estuaries, 1980 – Olausson, E. and Cato, I.
4. Chemical oceanography (Vol.7), 1978 Riley, J.P. and Chester, R.
5. Waves, tides and shallow-water processes, 1991 – The Open University.
6. Coastal and estuarine sediment dynamics, 1986 – Dyer, K.R., John Wiley & Sons.
7. Estuarine hydrography and sedimentation, 1986 – Dyer, K.R., John Wiley & Sons.
8. Biogeochemistry of Marine Dissolved Organic Matter, 2002 – D. A. Hansell and C. A. Carlson.
9. Biogeochemistry of Estuaries, 2007 – Thomas S. Bianchi

MS 403: Estuarine Biology

Module – I

Productivity in coastal waters, salt marsh ecosystem – species composition, distribution, nutrient dynamics, primary productivity and ecological processes and fate of salt marsh plant, mangrove ecosystem – species composition, distribution, adaptations, primary productivity, heterotrophic production, secondary communities and energy flow.

Module – II

Plankton, nekton and benthic communities, adaptations (buoyancy, locomotion and defense) in coastal and estuarine plankton and nekton population, major pelagic and demersal fish resources, Horse-shoe crab, Fish migrations and spawning.

Reference Books:

1. Elements of ecology -3rd edn., 1982 – Tait, R.V.
2. An introduction to Marine Sciences, 1988 – Meadows, P.S. and Campbell, J.J.
3. Textbook of Marine Ecology, 1989 – Nair, N.B. and Thampy, D.M.
4. Advances in marine biology, Vol. 20, 1982- Academic Press Ltd. New York.
5. Advances in marine biology, Vol. 36 ,1999- Press, New York.
6. Text book of marine ecology, 1989 – Nair N.B. and Thampy, D.M
7. Marine Biology – An ecological approach 2nd ed 1988 – Nybbakken.

MS 404: Estuarine and Coastal Geology

Module - I

Estuaries: Classification based on tide - geological classification and evolution – sub- environments in estuaries: mudflats, salt marsh, mangrove, salt pans - sediment source, transportation and deposition – bed and suspended sediment sampling and analysis – mineralogy and geochemistry of estuarine sediments - seasonal variation in geochemistry - metal variation with time in the sub-environments and their application in paleomonsoon, sea level changes and paleoenvironment, bioavailability of metals from sediments in estuaries.

Module - II

Coasts: classification, types of coast with reference to Indian coast line – evolution of the Indian coast -global sea level changes: eustatic, tectonic and isostatic. Coastal signature of sea level changes, coastal resources and coastal zone management, CRZ regulations and ICZM. Impact of floods, tsunamis and anthropogenic interferences in coastal processes, coastal erosion, preparedness and precaution measures.

Reference Books:

1. Estuarine chemistry, 1976 - Burton, J.D. and Liss, P.S.
2. Practical estuarine chemistry, 1985 – Head, P.C.
3. Chemistry and biogeochemistry of estuaries, 1980 – Olausson, E. and Cato, I.
4. Chemical oceanography (Vol.7), 1978 Riley, J.P. and Chester, R.
5. Waves, tides and shallow-water processes, 1991 – The Open University.
6. Coastal and estuarine sediment dynamics, 1986 – Dyer, K.R., John Wiley & Sons.
7. Estuarine hydrography and sedimentation, 1986 – Dyer, K.R., John Wiley & Sons.
8. Beach processes and sedimentation, 1976 – Komar, P.D., Prentice Hall.
9. Sea-level rise and coastal subsidence: causes, consequences and strategies, 1966 – Milliman, J.D. and Haq, B.U., Kluwer Academic.
10. Introduction to geochemistry, 1967 – Krauskopf, K.B., McGraw-Hill.
11. Elements of ecology (3rd edn.), 1982 – Tait, R.V.
12. An introduction to Marine Sciences, 1988 – Meadows, P.S. and Campbell, J.J.
13. Textbook of Marine Ecology, 1989 – Nair, N.B. and Thampy, D.M.

MS 405: Dynamic Oceanography

Module – I

Basic physical laws used in oceanography – Classification of forces and motion – Equation of continuity – static stability – double diffusion – Equation for the mean or average motion – Non-linear terms in the equation of motion – Eddy viscosity

Module – II

Currents without friction – Vorticity: relative vorticity, planetary vorticity, absolute vorticity, potential vorticity- Geostrophic flow – Hydrostatic equilibrium – Geopotential – Geopotential surfaces and isobaric surfaces – Geostrophic methods for calculating relative velocity – Thermal wind equation – Relation between isobaric and isopycnal surfaces

Module – III

Currents with friction – The equation of motion with friction: Transport and upwelling – Bottom friction and shallow water effects – Ekman's solution to the equations of motion with friction .Limitation to Ekman's theory – Sverdrup's solution for the wind driven circulation – Stommel's contribution – The planetary wind field, upwelling and sinking with special reference to the Indian ocean — Westward intensification – equatorial current system – Munk's equation - Boundary layer approach to obtain a solution to Munk's equation – The mixed layer of the ocean

Module – IV

Co-ordinate system – Governing equations – Boundary conditions layer averaged equations – Staggered grid systems – Finite difference method- Model spin up time- Model stability condition.

Reference Books:

1. Introductory dynamical oceanography, 1983 – Pond, S and Pickard, G.H., Pergamon Press, U.K.
2. Principles of physical oceanography, 1966 – Newman, G. and Pierson, W.J., Prentice Hall, Inc., New Jersey, U.S.A.
3. Physical oceanography (Vol.1) 1961 – Defant, A., Oxford pergamon press, U.K.
4. The dynamics of the upper ocean (2nd edn) 1977 – phillips, O.M., Cambridge Univ. Press, U.K.
5. Modeling and prediction of the upper layers of the ocean, 1977 – Krous, E.B. (Ed.).
6. Modeling of marine systems, 1986 – Nihoul, J.C.J., Elsevier Scientific Publ.Co., Oxford, U.K.
7. Atmosphere – ocean Dynamics,1982 -- Gill, Adrian E, International Geophysics, 30 Academic press, New York.

MS 406: Physical and Inorganic Chemistry of Seawater

Module – I

The structure of liquid water – Theories of water structure, colligative properties of seawater with the thermodynamic derivations of expressions for boiling point elevation and freezing point depression, electrostriction – The Thermodynamics of seawater – Ideal and real solutions.

Module – II

Equation of state for pure water and seawater, thermodynamics of PVT changes in seawater, activities, activity coefficients; Debye-Huckel theory and the Debye-Huckel limiting law; heats of solution, dilution and mixing.

Module – III

Acids and bases – basic concepts, proton condition and the electroneutrality of solutions; pH as a master variable – log C – pH diagram for monoprotic and diprotic acid – base system; buffer pH, buffer intensity – Oxidation and Reduction Reactions – Redox equilibria, electron activity and pE – Peters-Nernst equation; pE-pH diagram for the aqueous chlorine system, pE – pc diagram for Fe (II) - Fe (III) system, Kinetics of redox processes (Oxidation of Fe (II) and Mn (II) only).

Module – IV

Metal Ions in Aqueous solutions – hydrolysis of metal ions, formulation of stability constants, the stability of hydrolysis species, chelates and the chelate effect; Precipitation and dissolution – Heterogeneous equilibria, solubility product and saturation; the solubility of oxides and hydroxides – carbonate system closed to atmosphere and in equilibrium with CO₂(g); the stability of hydroxides and carbonates; crystal formation – The initiation and production of the solid phase – Solubility of silicates, gibbsite and iron (oxy) hydroxides.

Reference Books:

1. Marine chemistry, 1969 – Horne, R.A., Wiley – Interscience, London.
2. Aquatic chemistry, 1981, 1996 – Stumm, W. and Morgan, J.J., Wiley-Interscience, New York.
3. Water chemistry, 1980 – Snocink, V.L. and Jenkins, D., John Wiley & Sons, New York.
4. Principles of aquatic chemistry, 1983 – Moral, E.M.M.
5. Chemical Kinetics and process dynamics in aquatic systems, 1994 – Brezonik, P.L., Lewis Publ., London.
6. Aquatic chemistry, 1995 – Huang, C.P., O'Melia, C.R. and Morgan, J.J. American Chemical Society, Washington, DC.
7. Aquatic surface chemistry, 1987 – stumm, W., Wiley Interscience, New York.
8. Chemical oceanography (vol. 1), 1975 – Riley, J.P. and Chester G.
9. Physical chemistry, 1980 Glasstone, S.
10. The geochemistry of natural waters, 1982 Drever, J.I.
11. Introduction to geochemistry, 1995 – Krauskopf, K.B. and Bird, Mc.Graw Hill.

MS407: Marine Biodiversity, Conservation and practices

Module - I

Biodiversity, definition, taxic, phylo-genetic and molecular measurements, intellectual property rights and bio-piracy, life patenting, impact of GATT on farmer's right, indigenous and traditional knowledge.

Module - II

Coastal biodiversity, wild and domesticated, Indian fisheries & status, ecosystem based management traditional and mechanized crafts and gears, fishing fleets, fishing through food webs.

Module - III

Semi-intensive shrimp culture and mangroves, environmental costs, problems associated with conservation of mangroves and shrimp culture, reef related fisheries and banned fishing practices. Coastal tourism, implications and management.

Module – IV

Biodiversity conservation - corals, turtles, dugong, holothurians and shark, environmental laws and protection of coastal ecosystems, marine parks and protected areas, sanctuaries and marine biosphere reserves of India - Bhitarkanika wildlife sanctuary, Gulf of Kachch Marine National Park and Sanctuary, Gulf of Mannar biosphere reserve, Wandoor Marine National Park.

Reference Books:

1. Marine Biodiversity - Pattern and Processes, edited by Rupert F.G. Ormond, John.D.Gage and Martin.V.Angel, Cambridge University press (1997): pp449.
2. Biodiversity and Environment by Arvind Kumar, Published by S.B.Nangia, A.P.H. Publication Corporation (2004), New Delhi, 110 002: pp659.
3. Biodiversity Conservation, edited by Vandana Shiva, Publication of Indian National Trust for Art and Cultural Heritage, New Delhi, 110 002 (1994); pp 315.

MS 408: Marine Geophysics

Module – I

Fundamentals of Geophysical prospecting, sound transmission in water and sediments, Acoustic properties of water and sediments – Marine instrumentation – Techniques of echosounding, side scan sonar, sparker and pneumatic pulser profiling.

Module – II

Marine geophysical instrumentation and various methods employed in oceans – Single channel and multi-channel seismic reflection source – Airguns, sleeve guns, water guns – Array configuration and advantages. Seismic reflection receivers - Geophones – hydrophones; streamers, wide angle reflection – Seismic reflection – sonobuoys, ocean bottom seismometers OBS – Data acquisition and quality control.

Module – III

Seismic data processing, signal processing – Spectral analysis in geophysics – Analysis of geophysical signals – frequency and spectral analysis, spectra vs time domain analysis – Fourier series and Fourier transforms – Theoretical development and Fourier series and applications – Identification of reflectors, their correlation and interpretation.

Module – IV

Gravity and magnetic surveys over the ocean – Reduction of observations, identification of anomalies and interpretation of the data set – integrated interpretation of geophysical data – Continental margin studies of India – Application of geophysical methods in offshore exploration for oil, natural gas and other minerals.

Reference Books:

1. Principles of geophysical prospecting, 1976 – Dobrin, M.B., Mc.Graw Hill.
2. Geophysical prospecting for oil, 1976 – Nettleton, L.L., McGraw Hill.
3. Exploration seismology (Vol. 1 and 2) 1982, 1983 – Sheriff, R. E. and Geldant, L.P., Cambridge Univ. Press, U.K.
4. Developments in solid earth geophysics (Vol.5) Spectral analysis in geophysics, 1974 – Bath Markens.
5. Seismic prospecting instruments (Vol.1) 1972 – Evenden, B.S., Stone, D.R. and Anstey,
