Department of Biotechnology and Medical Engineering

Curriculum of M. Tech. (Biotechnology)

FIRST SEMESTER

Sl.No	Sub. Code	Subjects	L-T- P	Credits
1	BM 663	Advanced Biochemical Engineering	3-1-0	4
2	BM 669	Advanced Bioseparation	3-1-0	4
3		Professional Elective – I	3-1-0	4
4		Professional Elective – II	3-1-0	4
5		Professional Elective – III	3-1-0	4
6	BM 671	Advanced Bioseparation Laboratory	0-0-3	2
7	BM 673	Advanced Biochemical Engineering Laboratory	0-0-3	2
8	BM 685	Seminar & Technical Writing – I	0-0-3	2
	TOTAL		15-5-9	**26**

SECOND SEMESTER

Sl.No	Sub. Code	Subjects	L-T- P	Credits
1	BM 651	Advanced Bioinformatics	3-1-0	4
2	BM 652	Biophysics & Structural Biology	3-1-0	4
3		Professional Elective – IV	3-1-0	4
4		Professional Elective – V	3-1-0	4
5		Professional Elective – VI	3-1-0	4
6	BM 672	Cell and Protein Processing Laboratory	0-0-3	2
7	BM 674	Bioinformatics Laboratory	0-0-3	2
8	BM 686	Seminar & Technical Writing – II	0-0-3	2
	TOTAL		15-5-9	**26**

THIRD SEMESTER

Sl.No	Sub. Code	Subjects	L-T- P	Credits
1	BM 687	Seminar & Technical Writing – III	0-0-3	2
2	BM 691	Summer Research/ Industrial Project		4
3	BM 693	Research Project Work – I		8
4	BM 695	Research Project Review – I		8
	TOTAL			**22**

FOURTH SEMESTER

Sl.No	Sub. Code	Subjects	L-T- P	Credits
1	BM 688	Seminar & Technical Writing – IV		2
2	BM 692	Comprehensive Viva Voce		4
3	BM 694	Research Project Work - II		8
4	BM 696	Research Project Review - II		4
5	BM 699	Dissertation		8
	TOTAL			**26**

LIST OF PROFESSIONAL ELECTIVES

Sl.No.	Sub. code	Subject	L-T-P	Credits
1.	BM 612	Advanced Biomedical Instrumentation	3-1-0	4
2.	BM 621	Advanced Biomaterials	3-1-0	4
3.	BM 625	Advanced Tissue Engineering	3-1-0	4
4.	BM 631	Diagnostic imaging and radiation biology	3-1-0	4
5.	BM 641	Immunotechnology	3-1-0	4
6.	BM 642	Advanced Cell & Molecular Biology	3-1-0	4
7.	BM 644	Molecular Biology of Cancer	3-1-0	4
8.	BM 645	Protein conformational diseases and therapy	3-1-0	4
9.	BM 646	Recombinant DNA Technology	3-1-0	4
10.	BM 647	Industrial Pharmacology	3-1-0	4
11.	BM 649	Nutritional Sciences and Plant Based Products	3-1-0	4
12.	BM 653	Protein Engineering	3-1-0	4
13.	BM 654	Cell and Protein Processing	3-1-0	4
14.	BM 663	Advanced Biochemical Engineering	3-1-0	4
15.	BM 664	Industrial Microbiology	3-1-0	4
16.	BM 665	Bioprocess and Plant Design	3-1-0	4
17.	BM 667	Biological Waste Treatment	3-1-0	4
18.	BM 681	Special Topics in Biotechnology & Medical Engineering – I		3/4
19.	BM 682	Special Topics in Biotechnology & Medical Engineering - II		3/4
20.	BM 683	Special Laboratory in Biotechnology & Medical Engineering - I	0-0-3	2
21.	BM 684	Special Laboratory in Biotechnology & Medical Engineering - II	0-0-3	2

Department of Biotechnology and Medical Engineering

Curriculum of M. Tech. (Biomedical Engineering)

FIRST SEMESTER

Sl.No	Sub. Code	Subjects	L-T- P	Credits
1	BM 621	Advanced Biomaterials	3-1-0	4
2	BM 611	Biomedical Signal Processing and Analysis	3-1-0	4
3		Professional Elective – I	3-1-0	4
4		Professional Elective – II	3-1-0	4
5		Professional Elective – III	3-1-0	4
6	BM 675	Biomedical Equipment Design Laboratory	0-0-3	2
7	BM 677	Biomedical Signal Processing Laboratory	0-0-3	2
8	BM 685	Seminar & Technical Writing – I	0-0-3	2
	TOTAL		15-5-9	**26**

SECOND SEMESTER

Sl.No	Sub. Code	Subjects	L-T- P	Credits
1	BM 612	Advanced Biomedical Instrumentation	3-1-0	4
2	BM 614	Biomedical Image Processing	3-1-0	4
3		Professional Elective – IV	3-1-0	4
4		Professional Elective – V	3-1-0	4
5		Professional Elective – VI	3-1-0	4
6	BM 676	Advanced Biomedical Instrumentation Laboratory	0-0-3	2
7	BM 678	Biomedical Image Processing Laboratory	0-0-3	2
8	BM 686	Seminar & Technical Writing – II	0-0-3	2
	TOTAL		15-5-9	**26**

THIRD SEMESTER

Sl.No	Sub. Code	Subjects	L-T- P	Credits
1	BM 687	Seminar & Technical Writing – III	0-0-3	2
2	BM 691	Summer Research/ Industrial Project		4
3	BM 693	Research Project Work – I		8
4	BM 695	Research Project Review – I		8
	TOTAL			**22**

FOURTH SEMESTER

Sl.No	Sub. Code	Subjects	L-T- P	Credits
1	BM 688	Seminar & Technical Writing – IV		2
2	BM 692	Comprehensive Viva Voce		4
3	BM 694	Research Project Work - II		8
4	BM 696	Research Project Review - II		4
5	BM 699	Dissertation		8
	TOTAL			**26**

LIST OF PROFESSIONAL ELECTIVES

Sl.No.	Sub. code	Subject	L-T-P	Credits
1.	BM 610	Ergonomics	3-1-0	4
2.	BM 613	Biomedical Engineering	3-1-0	4
3.	BM 615	Mathematical Methods and Computer Applications in Biomedical Engineering	3-1-0	4
4.	BM 616	Pharmaceutical Technology	3-1-0	4
5.	BM 617	Electrodiagnosis, Therapy and Electrical Safety	3-1-0	4
6.	BM 618	BioMems and Biosensors	3-1-0	4
7.	BM 622	Nanotechnology in Medical Application	3-1-0	4
8.	BM 623	Cell Physiology and Biopotential	3-1-0	4
9.	BM 624	Surface Engineering of Surgical Tools and Medical Devices	3-1-0	4
10.	BM 625	Advanced Tissue Engineering	3-1-0	4
11.	BM 626	Advanced Biomechanics	3-1-0	4
12.	BM 627	Quantitative Physiology	3-1-0	4
13.	BM 628	Biomaterials Characterization	3-1-0	4
14.	BM 629	Bioceramics and Biocomposites	3-1-0	4
15.	BM 630	Advanced Bioelectricity	3-1-0	4
16.	BM 631	Diagnostic Imaging and Radiation Biology	3-1-0	4
17.	BM 632	Artificial organ and Rehabilitative Engineering	3-1-0	4
18.	BM 633	Introduction to Nanobiotechnology	3-1-0	4
19.	BM 642	Advanced Cell & Molecular Biology	3-1-0	4
20.	BM 647	Industrial Pharmacology	3-1-0	4
21.	BM 651	Advanced Bioinformatics	3 1 0	4
22.	BM 663	Advanced Biochemical Engineering	3-1-0	4
23.	BM 664	Industrial Microbiology	3-1-0	4
24.	BM 667	Biological Waste Treatment	3-1-0	4
25.	BM 681	Special Topics in Biotechnology & Medical Engineering – I		3/4
26.	BM 682	Special Topics in Biotechnology & Medical Engineering - II		3/4
27.	BM 683	Special Laboratory in Biotechnology & Medical	0-0-3	2

		Engineering - I		
28.	BM 684	Special Laboratory in Biotechnology & Medical Engineering - II	0-0-3	2

LIST OF PROFESSIONAL ELECTIVES OFFERED BY OTHER DEPARTMENTS

1.	CH 646	Nano Science & Technology	3-1-0	4
2.	CR 626	Advanced Composites	3-1-0	4
3.	CR 646	Advances in Bio-ceramics	3-1-0	4
4.	CR 652	Computer Aided Designing and Modeling of Ceramic Systems	3-1-0	4
5.	CS 638	Pattern Recognition	3-1-0	4
6.	CS 643	Embedded Systems	3-1-0	4
7.	EC 600	Architecture of DSP	3-1-0	4
8.	EC 628	VLSI Signal Processing	3-1-0	4
9.	EC 642	Advanced Techniques in Digital Signal Processing	3-1-0	4
10.	EC 644	Soft Computing	3-1-0	4
11.	EC 646	Adaptive Signal Processing	3-1-0	4
12.	EE 634	Robotics & Automation	3-1-0	4
13.	EE 636	Intelligent Control	3-1-0	4
14.	EE 637	Soft Computing Techniques	3-1-0	4
15.	EE 644	Digital Image Processing	3-1-0	4
16.	EE 668	Instrumentation and Sensors	3-1-0	4

DEPARTMENT OF BIOTECHNOLOGY AND MEDICAL ENGINEERING

SUMMARY OF COURSES

Subdiscipline: Instrumentation and Computation

BM 610	Ergonomics	3-1-0	4
BM 611	Biomedical Signal Processing and Analysis	3-1-0	4
BM 612	Advanced Biomedical Instrumentation	3-1-0	4
BM 613	Biomedical Engineering	3-1-0	4
BM 614	Biomedical Image Processing	3-1-0	4
BM 615	Mathematical methods and Computer Applications in Biomedical Engineering	3-1-0	4
BM 616	Pharmaceutical Technology	3-1-0	4
BM 617	Electrodiagnosis, Therapy and Electrical Safety	3-1-0	4
BM 618	BioMems and Biosensors	3-1-0	4

Subdiscipline: Bioscience and Biomaterials

BM 621	Advanced Biomaterials	3-1-0	4
BM 622	Nanotechnology in Medical Application	3-1-0	4
BM 623	Cell Physiology and Biopotential	3-1-0	4
BM 624	Surface Engineering of Surgical Tools and Medical Devices	3-1-0	
BM 625	Advanced Tissue Engineering	3-1-0	4
BM 626	Advanced Biomechanics	3-1-0	4
BM 627	Quantitative Physiology	3-1-0	4
BM 628	Biomaterials Characterization	3-1-0	4
BM 629	Bioceramics and Biocomposites	3-1-0	4
BM 630	Advanced Bioelectricity	3-1-0	4
BM 631	Diagnostic Imaging and Radiation Biology	3-1-0	4
BM 632	Artificial organ and Rehabilitative Engineering	3-1-0	4
BM 633	Introduction to Nanobiotechnology	3-1-0	4

Subdiscipline: Cell and Molecular Biology

BM 641	Immunotechnology	3-1-0	4
BM 642	Advanced Cell & Molecular Biology	3-1-0	4
BM 644	Molecular Biology of Cancer	3-1-0	4
BM 645	Protein conformational diseases and therapy	3-1-0	4
BM 646	Recombinant DNA Technology	3-1-0	4
BM 647	Industrial Pharmacology	3-1-0	4
BM 649	Nutritional Sciences and Plant Based Products	3-1-0	4

Subdiscipline: Topics in Modern Biology

BM 651	Advanced Bioinformatics	3-1-0	4
BM 652	Biophysics & Structural Biology	3-1-0	4
BM 653	Protein Engineering	3-1-0	4
BM 654	Cell and Protein Processing	3-1-0	4

Sub-Discipline: Biochemical Engineering

BM 663	Advanced Biochemical Engineering	3-1-0	4
BM 664	Industrial Microbiology	3-1-0	4
BM 665	Bioprocess and Plant Design	3-1-0	4
BM 667	Biological Waste Treatment	3-1-0	4
BM 669	Advanced Bioseparation	3-1-0	4

Sub-discipline: Laboratory Courses

BM 671	Advanced Bioseparation Laboratory	0-0-3	2
BM 672	Cell and Protein Processing Laboratory	0-0-3	2
BM 673	Advanced Biochemical Engineering Laboratory	0-0-3	2
BM 674	Bioinformatics Laboratory	0-0-3	2
BM 675	Biomedical Equipment Design Laboratory	0-0-3	2
BM 676	Advanced Biomedical Instrumentation Laboratory	0-0-3	2
BM 677	Biomedical Signal Processing Laboratory	0-0-3	2
BM 678	Biomedical Image Processing Laboratory	0-0-3	2

Sub-discipline: Project, Seminar and Special Courses

BM 681	Special Topic in Biotechnology & Medical Engineering - I		03/04
BM 682	Special Topic in Biotechnology & Medical Engineering – II		03/04
BM 683	Special Laboratory in Biotechnology & Medical Engineering - I	0-0-3	2
BM 684	Special Laboratory in Biotechnology & Medical Engineering - II	0-0-3	2
BM 685	Seminar & Technical Writing - I	0-0-3	2
BM 686	Seminar & Technical Writing - II	0-0-3	2
BM 687	Seminar & Technical Writing - III	0-0-3	2
BM 688	Seminar & Technical Writing - IV	0-0-3	2
BM 691	Summer Research/ Industrial Project		4
BM 692	Comprehensive Viva Voce		4
BM 693	Research Project – I		8
BM 694	Research Project – II		8
BM 695	Research Project Review-I		8
BM 696	Research Project Review-II		4
BM 699	Dissertation		8

DETAILED SYLLABI OF COURSES

BM 610	Ergonomics	3-1-0	4
BM 611	Biomedical Signal Processing and Analysis	3-1-0	4
BM 612	Advanced Biomedical Instrumentation	3-1-0	4
BM 613	Biomedical Engineering	3-1-0	4
BM 614	Biomedical Image Processing	3-1-0	4
BM 615	Mathematical methods and Computer Applications in Biomedical Engineering	3-1-0	4
BM 616	Pharmaceutical Technology	3-1-0	4
BM 617	Electrodiagnosis, Therapy and Electrical Safety	3-1-0	4
BM 618	BioMems and Biosensors	3-1-0	4
BM 621	Advanced Biomaterials	3-1-0	4
BM 622	Nanotechnology in Medical Application	3-1-0	4
BM 623	Cell Physiology and Biopotential	3-1-0	4
BM 624	Surface Engineering of Surgical Tools and Medical Devices	3-1-0	4
BM 625	Advanced Tissue Engineering	3-1-0	4
BM 626	Advanced Biomechanics	3-1-0	4
BM 627	Quantitative physiology	3-1-0	4
BM 628	Biomaterials Characterization	3-1-0	4
BM 629	Bioceramics and Biocomposites	3-1-0	4
BM 630	Advanced Bioelectricity	3-1-0	4
BM 631	Diagnostic Imaging and Radiation Biology	3-1-0	4
BM 632	Artificial organ and Rehabilitative Engineering	3-1-0	4
BM 633	Introduction to Nanobiotechnology	3-1-0	4
BM 641	Immunotechnology	3-1-0	4
BM 642	Advanced Cell & Molecular Biology	3-1-0	4
BM 644	Molecular Biology of Cancer	3-1-0	4
BM 645	Protein conformational diseases and therapy	3-1-0	4
BM 646	Recombinant DNA Technology	3-1-0	4
BM 647	Industrial Pharmacology	3-1-0	4
BM 649	Nutritional Sciences and Plant Based Products	3-1-0	4
BM 651	Advanced Bioinformatics	3-1-0	4
BM 652	Biophysics & Structural Biology	3-1-0	4
BM 653	Protein Engineering	3-1-0	4
BM 654	Cell and Protein Processing	3-1-0	4
BM 663	Advanced Biochemical Engineering	3-1-0	4
BM 664	Industrial Microbiology	3-1-0	4
BM 665	Bioprocess and Plant Design	3-1-0	4
BM 667	Biological Waste Treatment	3-1-0	4
BM 669	Advanced Bioseparation	3-1-0	4
BM 671	Advanced Bioseparation Laboratory	0-0-3	2
BM 672	Cell and Protein Processing Laboratory	0-0-3	2
BM 673	Advanced Biochemical Engineering Laboratory	0-0-3	2

BM 674	Bioinformatics Laboratory	0-0-3	2
BM 675	Biomedical Equipment Design Laboratory	0-0-3	2
BM 676	Advanced Biomedical Instrumentation Laboratory	0-0-3	2
BM 677	Biomedical Signal Processing Laboratory	0-0-3	2
BM 678	Biomedical Image Processing Laboratory	0-0-3	2
BM 681	Special Topic in Biotechnology & Medical Engineering - I		03/04
BM 682	Special Topic in Biotechnology & Medical Engineering – II		03/04
BM 683	Special Laboratory in Biotechnology & Medical Engineering - I	0-0-3	2
BM 684	Special Laboratory in Biotechnology & Medical Engineering - II	0-0-3	2
BM 685	Seminar & Technical Writing - I	0-0-3	2
BM 686	Seminar & Technical Writing - II	0-0-3	2
BM 687	Seminar & Technical Writing - III	0-0-3	2
BM 688	Seminar & Technical Writing - IV	0-0-3	2
BM 691	Summer Research/ Industrial Project		4
BM 692	Comprehensive Viva Voce		4
BM 693	Research Project – I		8
BM 694	Research Project – II		8
BM 695	Research Project Review-I		8
BM 696	Research Project Review-II		4
BM 699	Dissertation		8

BM 610 ERGONOMICS 4 Credits [3-1-0]

Introduction to Ergonomics, Why Ergonomics makes Good Business Sense ,Principles of Ergonomics Basic Cognitive ,Capabilities and Limitations of the workers ,Environmental Situation and Limitations Conducting an Ergonomic Assessment ,Developing an Ergonomic Program ,Ergonomic Issues Related to Posture ,Ergonomic Issues Related to Materials Handling/Lifting ,Using the NIOSH Lifting Formula Ergonomic Issues Related to the Use of Hand Tools ,Frequent Types of Injuries Related to Workplace Design, Repetitive Motion, and Cumulative Trauma Disorders ,Preventing Ergonomically Related Injuries by Redesigning the Workplace ,Designing Displays for Workers, Auditory Displays ,Transfer and Design of Information ,Controls and Control arrangements, Keyboards and Input Devices for Computers ,Occupational and Human Stress.

Essential Reading :

1. G. Salvendy, *Handbook of Human Factors and Ergonomics***,** Wiley, 3 edition 2006.
2. K. H.E. Kroemer ,E. Grandjean, *Fitting The Task To The Human*, Fifth Edition:
3. *A Textbook Of Occupational Ergonomics***,** CRC; 5 edition 1997.

Supplementary Reading :

1. The Eastman Kodak Company, *Kodak's Ergonomic Design for People at Work*, Wiley; -13: 2 edition 2003;
2. Robert Bridger; *Introduction to Ergonomics*, 2nd Edition ;CRC; 2 edition 2003

3. J Dul and B Weerdmeester, *Ergonomics For Beginners: A Quick Reference Guide*, CRC; 2 edition 2001.

BM 611 BIOMEDICAL SIGNAL PROCESSING AND ANALYSIS 4 Credits [3-1-0]

Short introduction -Discrete time systems and signals; Z-transform, Difference equation. Filter design by transformation - Impulse and step Invariant, Bi-linear Z-transform, matched Z-transform. Signal Model-AR, MA, ARMA, State Variable model, Lattice structures. FIR filter design, Frequency windowing technique, Equi ripple Chebyshev and Butterworth criterion. Filter performance and design in presence of noise, FIR filters banks-subband decomposition. Inverse filtering-Deconvolution and equalization techniques-Weiner, Linear prediction etc., Signal reconstruction. Time frequency Analysis - STFT, WT, DSP hardware - Design methodologies, Popular architectures and overview of programming Application notes. Filter implementation: Topology, Scaling, Coefficient quantization, Signal quantization, Sensitivity analysis.

Essential Reading :

1. Oppenheim & Ronald W Schafer, *Digital Signal Processing*, Prentice Hall India, 2005
2. Wills J. Tompkins, *Biomedical digital signal processing*, Prentice Hall of India Pvt. Ltd. 1993
3. D.C.Reddy, *Biomedical Signal Processing – Principles and Technique*, Tata McGraw-Hill.,2005

Supplementary Reading :

1. Andreas Antoniou , *Digital Signal Processing*, McGraw Hill, 2005
2. Iefeachor, *Digital Signal Processing*, Prentice Hall, 2002
3. J.G. Prokis & D.G. Manolakis, *Digital Signal Processing: Principles, Algorithm and Applications*, PHI/Pearson Education, 1996

BM 612 ADVANCED BIOMEDICAL INSTRUMENTATION 4 Credits [3-1-0]

Evolution of medical instrument, components of a medical instrumentation system, Problems encountered in a measuring system, Biofeedback instrumentation. Measurement system-specification of instruments, static & dynamic characteristics of medical instruments. Biosignal, characteristics, classification of errors, statistical analysis. reliability, accuracy, fidelity, speed of response, linearization of technique, data acquisition system ,Detection of physiological parameters using impedance techniques: Impedance and current distribution, bipolar and tetra polar circuits, skin impedance, galvanic skin response measurement, total body impedance, cardiac output, neural activity, respiratory activity, impedance plethysmography ,Special features of bioelectric amplifiers, safety requirements, realization of bioelectric amplifiers, carrier amplifiers, chopper amplifiers, phase sensitive detector, isolation amplifiers, and instrumentation amplifiers.Recording of bioelectric events-Analog recording system, digital recording and data logging including the use of micro-processor and flash memory chips. Recording of ECG, EMG & EEG signals. Holter monitor and cardiac stress test. Components of patient monitoring system, sources of artifacts & their implication, organization and equipments used in ICCU & ITU. Computer assisted patient monitoring system.Patient safety and electromedical equipments

Essential Reading :

1. Cromwell, Weibell & Pfeiffer, *Biomedical Instrumentation & Measurement*, Prentice Hall, India ;2nd. Edn. 2003
2. J. Webster, *Bioinstrumentation*, Wiley & Sons.2004,

Supplementary Reading :

1. Joseph Bronzino, *Biomedical Engineering & Instrumentation*, PWS Engg. Boston.3rd Edn.
2. John Enderle, *Bioinstrumentation*, Morgan & Claypool Publisher 2006.
3. R. S. Khandpur *Handbook of Bio-Medical Instrumentation*, Tata McGraw Hill, 2003
4. Carr & Brown, *Introduction to Biomedical Equipment Technology,* Pearson Education, Asia.4th Edn.

BM 613 BIOMEDICAL ENGINEERING 4 Credits [3-1-0]

General Introduction, Cellular organization, tissues, major organ systems, homeostasis. Evolution of biomedical instrumentation, components of biomedical instrumentation system, transducers, biosignals, biosensors, biopotential and physical measurements, blood gases & pH sensors, bioanalytical sensors, optical sensors,Bioelectric phenomena-Neurons, basic biophysics tools and relationship, equivalent circuit model for the cell membrane, Hodgkin-Huxley model for the action potential, model of the whole neuron. Natural and biomimetic materials, biopolymer synthesis, phase separation in polymers, self assembly, biocompatibility, polymer degradation, biomedical applications including drug delivery, tissue regeneration. Cell structure and components, protein structure, cell membranes, dynamics & morphogenesis of tissue, Growth factor, cell-material interaction, role of mechanical and biochemical environment, bioreactor for tissue growth, tissue grafts ,Fundamental Laws of mechanics, muscle and joint reaction forces, stress and strain, material behavior, soft tissue mechanics, Orthopadic mechanics, cardiac mechanics, blood flow and pressure measurement,Computational biology, the modeling process, bionetworksBiomedical imaging, radiation imaging, diagnostic ultrasound imaging, X-ray, medical resonance imaging, comparison of imaging modes.

Essential Reading :

1. John D. Enderle, Susan M. Blanchard, Joseph D; Bronzino, *Introduction to Biomedical Engineering*- Academic Press, 2005
2. Joseph D. Bronzino ,*Biomedical engineering fundamentals* ; CRC Press, 2006

Supplementary Reading :

1. Arthur B. Ritter, Stanley Reisman, Bozena B. Michniak, *Biomedical Engineering Principles*, CRCPress, 2005
2. Silver Frederick H ,Biomaterials, *Medical Devices and Tissue Engineering*, Chapman & Hall, London- 1994
3. Leslie, Cromwell, Fred J. Weibell, Erich A. Pfeiffer; *Biomedical Instrumentation and Measurements*; 2nd ed. Pearson Education-2004
4. Sujata V. Bhat , *Biomaterials*, 2nd Edition-,Narosa Publishing House- 2005

BM 614 BIOMEDICAL IMAGE PROCESSING 4 Credits [3-1-0]

Digital image fundamentals: representation - elements of visual perception - simple image formation model - Image sampling and quantization - basic relationships between pixels - imaging geometry. Review of matrix theory results: Row and column ordering - Toeplitz, Circulant and Block matrices. Review of Image transforms: 2D-DFT, FFT, W alsh , Hadamard ,

Haar, DCT and W avelet transforms. Image enhancement: Spatial domain methods: point processing - intensity transformations, histogram processing, image subtraction, image averaging; Spatial filtering- smoothing filters, sharpening filters. Frequency domain methods: low pass filtering, high pass filtering, homomorphic filtering. Generation of spatial masks from frequency domain specifications. Image restoration: Degradation model - Diagonalization of circulant and Block circulant matrices - Algebraic approaches- Inverse filtering - W iener filter - Constrained Least squares restoration - Interactive restoration -Geometric transformations. Fundamentals of Colour image processing: colour models - RGB, CMY, YIQ, HIS - Pseudo color image processing - intensity slicing, gray level to color transformation. Image compression: fundamentals- redundancy: coding, inter pixel, psychovisual, fidelity criteria, Models, Elements of information theory, Error free compression- variable length, bit plane, lossless predictive, Lossy compression- lossy predictive, transform coding. Fundamentals of JPEG, MPEG, Fractals. Image segmentation: Detection of discontinuities - point, line and edge and combined detection ; Edge linking and boundary description - local and global processing using Hough transform Thresholding - Region oriented segmentation - basic formulation, region growing by pixel aggregation, region splitting and merging - Use of motion in segmentation. Fundamentals of Representation and Description.

Essential Reading

1. Gonzalez and Woods, *Digital Image Processing*, 2 Ed, Pearson Education, 2002.
2. Anil K. Jain, *Fundamentals of Digital Image Processing*, Pearson Education, 2003.

Supplementary Reading

1. Mark Nelson, Jean- Loup Gailly, *The Data compression Book,* 2 Ed, bpb Publications.
2. Pratt William K., *Digital Image Processing*, John Wiley & sons
3. Chanda & Majumdar, *Digital Image Processing and Analysis*, PHI.
4. M.Sonka,V. Hlavac, R. Boyle, *Image Processing, Analysis and Machine Vision*, Vikas Publishing House

BM 615 MATHEMATICAL METHODS AND COMPUTER APPLICATIONS IN BIOMEDICAL ENGINEERING **4 Credits [3-1-0]**

Mathematical modeling and solution of biomedical problems namely respiratory rate, blood flow, cardiac output and impedance diffusion, ultra filtration etc. Operational research applied to the description of physiological systems and signals processing by interfacing instrumentation, biomedical variability and probabilistic solution to medical decision making, population dynamics perturbation technique in dealing with the problems of thermodynamics. Stochastic process . Finite- Difference method. Use of computers in physiological data acquisition and analysis. Programming, storage and display of data with reference to bioelectric potentials. Applications of Microprocessor and Microcontroller in medicine. Digital filters; FIR and IIR type and their application to biomedical signal filtering. Data reduction techniques. Spectrum analysis. Intelligent computing systems in medicine; Introduction to Intelligence and Artificial Intelligence. Heuristic search method, knowledge Based system, ANN architecture and learning algorithms. Evolutionary computing and Genetic Algorithm. Use of computers in physiological data acquisition and analysis. Programming, storage and display of data with reference to bioelectric potentials. Applications of Microprocessor and Microcontroller in medicine. Digital filters; FIR and IIR type and their application to biomedical signal filtering. Data reduction techniques. Spectrum analysis. Intelligent computing systems in medicine; Introduction to Intelligence and Artificial Intelligence. Heuristic search method, knowledge Based system, ANN architecture and learning algorithms. Evolutionary computing and Genetic Algorithm (EC-GA) Fuzzy Logic and

its application in decision making. Application of ANN, EC, GA, FL in Medical data analysis and diagnosis.

Essential Reading :

1. Stanley Dunn, Alkis Constantinides, Prabhas V. Moghe, *Numerical Methods in Biomedical Engineering*, Academic Press, 2005
2. Shiyi Shen, Jack A. Tuszynski, *Theory and Mathematical Methods in Bioinformatics,* Springer; 1 edition 2008

Supplementary Reading :

1. George Dassios ,Dimitrios I Fotiadis, Christos V Massalas , Kiriakie Kiriaki, *Mathematical Methods in Scattering Theory and Biomedical Technology*, Chapman & Hall/CRC; 1 edition 1998
2. Arthur B. Ritter ,Stanley Reisman, Bozena B. Michniak ;*Biomedical Engineering Principles*, CRC; 1 edition 2005
3. J. Middleton, Gyan Pande, M. L. Jones, *Computer Methods in Biomechanics and Biomedical Engineering*, 2 CRC; 2 edition 1999
4. John Enderle ,Susan M. Blanchard ,Joseph Bronzino, *Introduction to Biomedical Engineering*, Second Edition Academic Press; 2 edition 2005

BM 616 PHARMACEUTICAL TECHNOLOGY 4 Credits [3-1-0]

Tablet: Types, definition, preparation ; Tablet coating: Coating processes, film testings and film defects ; Capsules: Method of capsule production ; Parenteral products: Route of administration; selection of vehicles; added substances; containers; suspension and emulsion for injections; production-facilities, environmental control, personel, cleaning of containers and closures, sterilization of equipment, compounding the product, filtration of solutions, filling and sealing procedures, sterilization of products; various quality control test for parenteral products. Opthalmic products: eye drops, eye lotions, eye ointments, formulation, additives, preparation, sterilizing, packaging, contact lens solutions ; Aerosols: mode of operations, propellants, containers, valves, actuators and buttons, diptubes, packing, application and testing ; Liposomes: fundamentals of manufacturing, evaluation, advantages & limitations, application. Niosomes & their fundamentals ; Iontophoresis & sonophoresis: fundamentals, evaluation & applications ; Protein, peptide & gene deliveries: Their basics, success, limitation and application ; Other Important delivery systems: Microcapsules, nanoparticles, mucoadhesives, buccal and sublingual preparations, transdermal patches & other topical products, multiple emulsion and solid dispersion.

Essential Reading :

1. H. A. Lieberman, L. Lachman and J. B. Schwartz, *Pharmaceutical Dosage forms (Vol 1, 2 and 3)*, Second edition, Informa Health Care.
2. Mathiowitz Edith, *Encyclopedia of Controlled Drug Delivery* , John Wiley & Sons

Supplementary Reading :

1. Binghe Wang, Teruna J. Siahaan, Richard A. Soltero , *Drug Delivery: Principles and Applications* , John Wiley & Sons.
2. T. Scheper , *Gene Therapy and Gene Delivery Systems (Advances in Biochemical Engineering / Biotechnology)*, Springer.

BM 617 ELECTRODIAGNOSIS, THERAPY AND ELECTRICAL SAFETY 4 Credits [3-1-0]

Review of biopotentials. Electrodes as bioelectric transducers : The electrode-electrolyte interface; Specification and selection criteria for electrodes; Surface, needle, implanted electrodes; Polarizable and non-polarizable electrodes; Practical considerations ; Instrumentation for biopotential recording : Practical considerations for optimum performance; Reduction of interference, grounding, safety. Electrical Stimulation : Use in generating evoked potentials, and for therapeutic correction (ECT, pacemakers, defibrillation); Stimulation parameters; Safety limits and precautions ; Safety : Hazards associated with the use of electrical / electronic instruments; Provisions for safety; Clinical safety norms. Commonly measured biopotentials and their clinical interpretation ENG, ECG, EMG, etc.; Sensory evoked potentials (visual, auditory, somatosensory).

Essential Reading :

1. M.J. Aminoff , *Electrodiagnosis in Clinical Neurology*, 3rd edition, Churchill Livingstone, USA, 1992.
2. J.A. Delisa, H.J. Lee, E.M. Baran, K.S. Lai & N. Spielholz , *Manual of Nerve Conduction and Clinical Electrophysiology*, 3rd Edition, Academic Press, New York, 1993.

Supplementary Reading :

1. J. Kimura (Ed.) : *Peripheral Neuropathy vol. 1*, W.B. Saunders & Co., Philadelphia, 1984
2. Cadick, Mary Capelli-Schellpfeffer, and Dennis K. Neitzel ; *Electrical Safety Handbook* by John 2005 , McGraw-Hill Professional; 3 edition

BM 618 BIOMEMS AND BIOSENSORS 4 Credits [3-1-0]

Sensor architecture and Classification; Medically significant measurands, functional specifications of medical sensors; Sensor characteristics : linearity, repeatability, hysteresis, drift; Sensor models in the time & frequency domains. Sensors for physical measurands**:** strain, force, pressure, acceleration, flow, volume, temperature and biopotentials. Sensors for measurement of chemicals: potentiometric sensors, ion selective electrodes, ISFETS; Amperometric sensors, Clark Electrode; Biosensors, Catalytic biosensors, immunosensors ; Different Transduction principles: Classification of transducers, selecting of transducers, circuit based on transduction.Temperature transducers: thermo-resistive transducers, thermoelectric, p-n junction, chemical thermometry. Displacement transducers: potentiometer, resistive strain gauges, inductive displacement, capacitive displacement transducer, force transducer. Pressure transducer: variable capacitance pressure transducers, LVDT transducers, strain gauge transducers,semiconductor transducers, catheter tip transducers. Photoelectric transducers: photo-emissive tubes, photovoltaic cell,photoconductive cell. Flow transducers: different types of flow sensors and detectors. Piezoelectric transducers and their applications.Study of biological sensors: Sensors / receptors in the human body, basic organization of nervous system-neural mechanism and circuit processing. Chemoreceptor: hot and cold receptors, barro receptors, sensors for smell, sound, vision, osmolality and taste. Sensor models in the time and frequency domains.Biochemical Transducers: Electrode theory: electrode-tissue interface, metal-electrolyte interface, electrode-skin interface,electrode impedance, electrical conductivity of electrode jellies and creams.Biopotential electrodes: microelectrodes, body surface electrodes, needle electrodes. Reference electrodes: hydrogen electrodes, silver-silver chloride electrodes, Calomel electrodes. Recording electrodes for ECG, EEG, and EMG. Transducers for the measurement of ions and dissolved gases, pH electrode,

specific ion electrodes.Bio sensors: Ion exchange membrane electrodes, enzyme electrode, glucose sensors, immunosensors. Basic principles of MOSFET biosensors & BIOMEMS.

Essential Reading :

1. *Handbook of Biosensors and Electronic Noses: Medicine, Food and the Environment*: CRC-Press; 1 edition;1996
2. Steven S. Saliterman, *Fundamentals of BioMEMS and Medical Microdevices* ,SPIE Press Monograph Vol. PM153, 2006

Supplementary Reading :

1. *Biosensors*: Oxford University Press, USA; 2 edition, 2004
2. D. L. Wise, *Biosensors: Theory and Applications*, CRC Press,1993
3. Rao & Guha, *Principles of Medical Electronics & Biomedical Instrumentation*, Orient Longman.2001
4. Gerald Urban, *BioMems*, Springer; 1 edition, 2006

BM 621 ADVANCED BIOMATERIALS 4 Credits [3-1-0]

Introduction, biomaterials in medicine,Metallic implant materials: different types, Host tissue reaction with biometal, corrosion behavior and the importance of passive films for tissue adhesion. Hard tissue & Soft tissue replacement.Polymeric implant materials: Types and classification, Mechanical, Surface, Electrochemical, & Physiochemical properties of biopolymers. Biodegradable polymers for medical application. Synthetic polymeric membranes and their biological applications.Ceramic implant materials: Types of bioceramics, Importance of wear resistance and low fracture toughness. Host tissue reactions: importance of interfacial tissue reaction. Composite implant materials: Mechanics of improvement of properties by incorporating different elements. Composite theory of fiber reinforcement. Polymers filled with osteogenic fillers. Host tissue reactions.Testing of Biomaterials: biocompatibility, blood compatibility and tissue compatibility, Toxicity tests, sensitization, carcinogenicity, mutagenicity and special tests, In vitro and In vivo testing .Sterilisation of implants and device :ETO, gamma radiation, autoclaving. Effects of sterilization.

Essential Reading

1. Sujata V. Bhat, *Biomaterials*, **,** Springer, 2002.
2. Buddy D. Ratner, Fredrick J. Schoen, Allan S. Hoffman, Jack E. Lemons "*Biomaterials Science: An introduction to Materials in medicine*, Academic Press, 2004.

Supplementary Reading

1. Jonathan Black, *Biological Performance of materials*, Taylor & Francis,2006
2. C.P.Sharma & M.Szycher, *Blood compatible materials and devices*, Technomic Publishing Co. Ltd., 1991.
3. Piskin & A.S Hoffmann, *Polymeric Biomaterials* (Eds), Martinus Nijhoff Publishers, 1986
4. J B Park, *Biomaterials - Science and Engineering*, Plenum Press, 1984.

BM 622 NANOTECHNOLOGY IN MEDICAL APPLICATION 4 Credits [3-1-0]

What is nanotechnology, examples of nanostructures, nanodefinitions, nanoscale, unique properties of nanoscale matrices, Nanoparticles - quantum dots, metal nanoparticles, magnetic nanoparticles, conjugation, fabrication, advantages and issues, Nanofibers – electrospin fibers,

self assemble fibers, conjugation, fabrication, advantages and issues. Carbon nanotubes, Nanoporous materials – phase separation, hydro gels, Biomedical Applications – drug delivery, tissue regeneration, cancer detection, imaging and diagnostics, outlook for future.

Essential Reading :

1. C.N.R. Rao, A.Muller, A.K. Chutham. *Vol 1 & Vol 2:The Chemistry of Nanoparticles (Synthesis, Properties and Applications)* –WILEY-VCH
2. Challa Kumar :*Tissue, cell and organ engineering*, Vol 9 WILEY-VCH, 2006
3. *Nanomaterials for Medical Diagnosis and Therapy* – Vol 10 by Challa Kumar, WILEY-VCH, 2007

Supplementary Reading :

1. William A. Goddard III, Donald W Brenner, Sergey E. Lyshevski, Gerald J. Iafrate: *Handbook of Nanoscience, Engineering, and Technology,* CRC Press Taylor and Francis Group, 2007
2. Bhushan:Springer *Handbook of Nanotechnology* –Springer,2007
3. Challa Kumar: *Nanomaterials for Cancer Diagnosis & Therapy – Vol 6 & 7*, -WILEY-VCH,2007 edition.
4. Challa Kumar :*Nanodevices for Life Sciences – Vol 4*, -WILEY-VCH, 2006 edition

BM 623 CELL PHYSIOLOGY AND BIOPOTENTIAL 4 Credits [3-1-0]

Introduction to molecular and cellular Biology; Molecules, membranes and cells; Cell structure and function: organelles, cytoskeleton and plasma membrane; Metabolism and energy cycles; Synthesis of proteins and nucleic acids; Transport across cell membranes and cytoplasm; Cell to cell biochemical signaling: hormones, receptors and synaptic transmission; Cytoskeleton and movement, Actin and Myosin; Energetics of ion pumps. Origin of biopotentials; Resting membrane potential; The resting membrane as a potassium electrode; Nernst potential; Selective permeability and the Donnan equilibrium; Action potentials: ionic basis, properties of generation and conduction, examples in different cell types, relation to surface-recorded signals; Synaptic potentials: passive properties and integration.

Essential Reading

1. Nicholas Sperelakis: *Cell Physiology Source Book: A Molecular Approach* **,** Academic Press; 3rd edition 2001;
2. David Landowne: *Cell Physiology* ; McGraw-Hill Medical; 1 edition 2006

Supplementary Reading

1. David J. Aidley, *The Physiology of Excitable Cells* ;Cambridge University Press; 4 edition 1998;
2. J. Darnell, H. Lodish, D. Baltimore: *Molecular Cell Biology*, Scientific American Books, New York, USA. 1996.
3. A. Loewy, et al. : *Cell Structure and Function: An Integrated Approach*, 3rd Edition, Saunders, Chicago, 1991.

BM 624 SURFACE ENGINEERING OF SURGICAL TOOLS AND MEDICAL DEVICES 4 Credits [3-1-0]

Introduction to surface engineering, Need for surface engineering of Medical implants and equipment.Surface Modification of Biomaterials, Wettability in Biomaterials Science and Modification Techniques, Atomic Scale Machining of Surfaces.Anodization, Titanium Dioxide Coatings in Medical Device Applications, The Effect of Shape and Surface Modification on the Corrosion of Biomedical Nitinol Alloy Wires exposed to Saline Solution.Cardiovascular Interventional and Implantable Devices ; Surface Engineering Artificial Heart Valves to Improve Quality of Life and Lifetime using Modified Diamond-like Coatings, Diamond Surgical Tools, Dental Tool Technology. Nanocrystalline Diamond: Deposition Routes and Clinical Applications Advanced techniques of modifying implant material surfaces (like Laser Surface Treatmen, PVD, CVD, ion implantation etc.) Environmental Engineering Controls and Monitoring in Medical Device Manufacturing, Biomaterial-Cell-Tissue Interactions In Surface Engineered Carbon-Based Biomedical Implants and Devices, Machining Cancellous Bone Prior to Prosthetic Implantation, Bonelike Graft for Regenerative Bone Applications. Titanium and Titanium Alloy Applications in Medicine.

Essential Reading

1. Jürgen Breme, C. James Kirkpatrick ,Roger Thull: *Metallic Biomaterial Interfaces* , Wiley-VCH; 1 edition , 2008
2. D.M. Brunette, P. Tengvall, M. Textor, P. Thomsen: *Titanium in Medicine: Material Science, Surface Science, Engineering, Biological Responses and Medical Applications* ; Springer; 1st edition ;2001;

Supplementary Reading

1. Jan Eirik Ellingsen, S. Petter Lyngstadaas: *Bio-Implant Interface: Improving Biomaterials and Tissue Reactions*: CRC Press, 2003:
2. Gerhard Rakhorst, Rutger Ploeg; *Biomaterials In Modern Medicine: The Groningen Perspective* **;**World Scientific Publishing Company; 1 edition 2008;

BM 625 ADVANCED TISSUE ENGINEERING 4 Credits [3-1-0]

Introduction, structural and organization of tissues: Epithelial, connective; vascularity and angiogenesis, basic wound healing, cell migration, current scope of development and use in therapeutic and in-vitro testing. Cell culture- Different cell types, progenitor cells and cell differentiations, different kind of matrix, cell-cell interaction. Aspect of cell culture: cell expansion, cell transfer, cell storage and cell characterization, Bioreactors ; Molecular biology aspect- Cell signaling molecules, growth factors, hormone and growth factor signaling, growth factor delivery in tissue engineering, cell attachment: differential cell adhesion, receptor-ligand binding, and Cell surface markers.Scaffold and transplant- Engineering biomaterials, Degradable materials, porosity, mechanical strength, 3-D architecture and cell incorporation. Engineering tissues for replacing bone, cartilage, tendons, ligaments, skin and liver. Basic transplant immunology, stems cells ; Case study and regulatory issues-cell transplantation for liver, musculoskeletal, cardiovascular, neural, visceral tissue engineering. Ethical, FDA and regulatory issues.

Essential Reading

1. Bernhard Palsson, Sangeeta Bhatia ,*Tissue Engineering*, Pearson Prentice Hall, 2003
2. Robert. P.Lanza, Robert Langer & William L. Chick, *Principles of tissue engineering*, Academic press,1997

3. Gordana Vunjak-Novakovic, R. Ian Freshney, *Culture of Cells for Tissue Engineering*, WIS, 2006

Supplementary Reading

1. B. Palsson, J.A. Hubbell, R.Plonsey & J.D. Bronzino, *Tissue Engineering*, CRC- Taylor & Francis
2. Joseph D., Bronzino *The Biomedical Engineering –Handbook*, CRC; 3rd edition , 2006

BM 626 ADVANCED BIOMECHANICS 4 Credits [3-1-0]

Scalar and vector quantities. Different operations on vector. Forces and moments, system of forces, resultant of system of forces in 3D and 2D. Equilibrium equations. Applications with example on human body. Work-energy equations: Applications to Biomedical system. Stress-strain diagram. Stress concentration. Mechanical properties of human bone. Mechanical properties of cortical bone, properties of cancellous bone, viscoelasticity, elastic model of bone. Mechanical testing of soft tissues ; Principle of continuum mechanics. Tensor treatment to explain elastic, viscoelaslicity, electric and electromechanical properties of bones, teeth and connective tissues. Wave propagation in extended and partly bound media and its application in analyzing the structural micro textural symmetry in calcified tissues. Theoretical models for bone as a hierarchical composite. Dental forces, implant-tissue biomechanics, Crack propagation in bones, dynamic models. Wolf's law and introduction to orthopedic biomechanics. Human body dynamics and locomotion analysis. Pressure sore biomechanics. Interaction between tissues and support surface. Mechanics of spinal distraction rods. Biomechanics of human motion and control interfaces with application to limb orthotics and prosthetics. Design of hip prosthesis. Automated driver's training programme. Sports biomechanics.

Essential Reading

1. Y C Fung, *Biomechanics: Mechanical Properties of Living Tissues*, springer, 2nd edition, 1993.
2. Nihat Ozkaya and margarita nordin, *fundamentals of biomechanics-equilibrium, motion and deformation*, springer-verlag, 2nd edition 1999.

Supplementary Reading

1. John G Webster, *Medical instrumentation –Application and design*, John wiley and sons Inc. 3rd ed. 2003.
2. D. Dowson & V. Wright, *An introduction to Biomechanics of joints and joint replacements*, Mechanical Engineering Publications , 1980
3. Y. C. Fung, *Biodynamics- circulation*, springer-verlag, 1994.

BM 627 QUANTITATIVE PHYSIOLOGY 4 Credits [3-1-0]

Skeletal system: Classification of bones, joints and muscles, major muscles of limbs and their actions. Functional concept of the human body, bone and muscle physiology ; Nervous system & special senses: Brain and spinal cord, peripheral autonomic nervous system, nerve physiology, EEG, MEG & ECG. Eye & ear Cardio Vascular System: Structure & function of Heart & blood vessels. Special functional tissue of heart. E.C.G. Cardiac cycle. Blood – composition, Function, blood group, Blood clotting. Blood Pressure-regulation & controlling factors Respiratory system: Upper and lower respiratory tract, Structure and Function of respiratory membrane. Pulmonary circulation. Mechanics of breathing. Transport and control of

gases. Lungs volume and capacities. Regulation of respiration . Pulmonary function tests. Endocrine Glands: types, location, description and functions, Digestive system: Parts of digestive system. Gastro intestinal tract and associated glands Urinary system: Parts and function of urinary system. Male and female reproductive system. Lymphatic system: Spleen, glands and lymph nodes.

Essential Reading

1. Richard S Snell, *Clinical Anatomy by Regions*: Lippincott Williams & Wilkins, 8th edition, 2007.
2. Richard Drake, A. Wayne Vogl, Adam W. M. Mitchell, and Richard Tibbitts, *Gray's Atlas of Anatomy*: Churchill Livingston, 1st edition, 2007.

Supplementary Reading

1. Kenneth Saladin, *Anatomy & Physiology: The Unity of Form and Function*, McGraw-Hill College, 2006
2. *Gray's Anatomy for Students*: Churchill Livingstone; 1 edition (October 19, 2004)
3. Elaine N. Marieb, JonMallatt, Patricia Brady Wilhelm Addison, *Human Anatomy*, Wesley, 2007.
4. David Shier, Jackie Butler, Ricki Lewis *Hole's Human Anatomy & Physiology* McGraw-Hill College, 2006

BM 628 BIOMATERIALS CHARACTERIZATION 4 Credits [3-1-0]

Materials characterization - definition ; importance and application, Principles and general methods of compositional and structural characterization, techniques of X-ray, electron and neutron diffraction, EDAX, Thermal methods - DTA, TGA, DSC, DMA, temperature dependent rheology. Microscopy - optical, electron (TEM, SEM), Atomic force microscopy, optical profilometer and confocal laser scanning microscopy, Spectroscopy – UV-visible, fluorescence & phosphorescence IR, Raman and NMR spectroscopy, ESCA and Auger spectroscopy.

Essential Reading

1. Joon Park and R.S. Lakes: *Biomaterials: An Introduction*, Third edition, Springer.
2. A. H. Beckett and J. B. Stenlake :*Practical Pharmaceutical Chemistry (Part II)*, Fourth edition, Cbs Publishers & Distributors.

Supplementary Reading

1. Edith Mathiowitz :*Encyclopedia of Controlled Drug Delivery* John Wiley & Sons
2. Robert M. Silverstein, Francis X. Webster: *Spectrometric Identification of Organic Compounds* Seventh edition, John Wiley & Sons

BM 629 BIOCERAMICS AND BIOCOMPOSITES 4 Credits [3-1-0]

Classification of bio-ceramic materials for medical applications. Alumina and zirconia in surgical implants, bioactive glasses and their clinical applications, A.W. machinable and phosphate glass ceramics. Dense and porous hydroxyl apatite calcium phosphate ceramics, coatings and resorbable ceramics. Carbon as an implant. CMC and PMC composites. Characterization of bio-ceramics. Regulation of medical devices ; Types of composites and their advantages. Reinforcement: Glass, boron, carbon, organic and ceramic fibers, their structure, properties and processing. Matrix materials: Polymers, metal and ceramic matrices, their structure, properties

and processing. Wettability and interface bonding ; Polymer matrix composites: Lamina, laminate composites. Primary and Secondary manufacturing; Lay-up, Filament winding, pultrusion, compression moulding. Machining, drilling and routing, applications. Metal matrix composites: processing techniques and applications. Ceramic Matrix composites; processing techniques and applications. Introduction to Nanocomposites and applications Micromechanic: Mechanical properties, thermal properties and load transfer. Macromechanics: Elastic behavior, fracture behavior, fatigue behavior, creep behavior of composites. Tribological and electrical behavior of composites. Degradation of composites due to various environmental conditions, corrosion resistance of composite. Designing with composites Biological application of composites.

Essential Reading

1. Larry L. Hench and June Wilson :*An Introduction to Bioceramics* ;World Scientific Publishing Company; 1 edition 1993
2. Sharon Brown **,** Ian Clarke**,** Paul Williams ;*Bioceramics*; Trans Tech Publications, Ltd. 2002

Supplementary Reading

1. T. Kokubo: *Bioceramics and their clinical applications*;CRC; 1 edition, 2008
2. Joon Park; *Bioceramics: Properties, Characterizations, and Applications* : Springer; 1 edition 2008
3. Amar K. Mohanty Manjusri Misra Lawrence T. Drzal *Natural Fibers, Biopolymers, and Biocomposites* CRC; 1 edition 2005

BM 630 ADVANCED BIOELECTRICITY 4 Credits [3-1-0]

Bioelectricity generation at the cellular and sub cellular level. Types & characteristics of biopotentials. Measurement of bioelectric potentials from cells, tissue and people ; Basic electro magnetic theory-scalar and vector quantities. Gradient, divergence, Laplacian operators. Vector identity Gauss theorem, green's theorem, electrical source and fields, fundamental relationships, poisons equation, concept of monopole and dipole field.Action potential and propagation- membrane structure and nernst potential and resisting potential. Action potential and origin and characteristics. Application of nerst equation in bio fluids. Voltage clamp. Hodgkin-Huxley equations and analysis. Core conductor model, propagation in myelinated and unmyleinated nerve fibre.Electrical activity of skeletal muscle and neuromuscular junction, neuromuscular transitions, origin of EPSP and IPSP. Neuro-muscular block, determination of degree of neuro muscular block. Muscle structure and contraction. Excitation contraction merchanism.Electro physiology of heart – properties of cardiac muscle, heart, electrical activity of the heart. Standard leads, lead vectors, Recording of the ECG from the surface. Dipole theory of the heart. Relationship between the different ECG leads.Applications of bioelectric phenomena

Essential Reading

1. Robert Plonsey, Roger C. Barr, *Bioelectricity: A Quantitative Approach*, Springer; 3rd ed. edition (June 21, 2007).
2. John Webster. *Medical Instrumentation – Application and Design*. John Wiley and Sons. Inc., New York. Third edition 2003

Supplementary Reading

1. D P Zipes and Jalife, *Cardiac Electro-physiology: from cell to bedside*, Saunders, Philadelphia, 1990.
2. L.A. Geddes, *Principles of Applied Biomedical Instrumentation*, John Willy and sons, 1989

BM 631 DIAGNOSTIC IMAGING AND RADIATION BIOLOGY 4 Credits [3-1-0]

Basic concepts, types, sources and characteristics of electromagnetic radiations and its influence on living beings with particular emphasis on human beings. Review of atomic structure and atomic particles : electrons, protons, neutrons, positrons, neutrinos, etc.; Classification of elements as per the periodic table; Atomic transitions - electron transitions and the generation of x-rays; Nuclear transitions and radioactive decay of nuclei. Characteristics of x-ray beams; Interaction with matter; Attenuation and interaction of x-rays in the human body; Films and fluoroscopic screens; CT Scan and its algorithm. Detrimental effects of radiation; Radiation safety and dosimetry; Overview of generation of radioisotopes. Radiopharmaceuticals,Radiotherapy,Physics of ultrasound imaging; Uses in diagnosis. Interaction of Ultrasound with tissue;Physics of Nuclear Magnetic Resonance and its application in the field of diagnostic medicine. Lasers, its classification, basic concept, types and their Biomedical Applications. Laser use in surgery, diagnosis and in promotion of healing. Safety with biomedical lasers.

Essential Reading

1. W.R.Hendee & E.R.Ritenour, *Medical Imaging Physics*,3rd editions, Mosbey Year-Book, Inc., 1992.
2. Jerrold T. Bushberg, J. Anthony Seibert, Edwin M. Leidholdt Jr., John M. Boone *The Essential Physics of Medical Imaging* ,2nd Edition, Lippincott Williams & Wilkins, 2001

Supplementary Reading

1. Dowsett, Kenny & Johnston, "*The Physics of Diagnostic Imaging*", Chapman & Hall Medical, Madras/London, 1998
2. Reiner Salzer; *Biomedical Imaging: Principles and Applications*; Wiley-Interscience ;2008

BM 632 ARTIFICIAL ORGAN AND REHABILITATIVE ENGINEERING 4 Credits [3-1-0]

Introduction to artificial organs: Biomaterials used in artificial organs and prostheses, Rheological properties of blood, blood viscosity variation, Casson equation, flow properties of blood, problems associated with extracorporeal blood flow ; Artificial kidney: kidney filtration, artificial waste removal methods, hemodialysis, equation for artificial kidney and middle molecule hypothesis. Hemodialysers, mass transfer Analysis, regeneration of dialysate, membrane configuration, wearable artificial kidney machine, separation of antigens from blood in ESRD patients ; Artificial heart-lung machine: lungs gaseous exchange/ transport, artificial heart-lung devices. Oxygenators, Liver support system, artificial pancreas, blood and skin ; Audiometry: air conduction, bone conduction, masking, functional diagram of an audiometer. Hearing aids, Opthalmoscope, retinoscope, I.A.B.P principle and application ; Rehabilitation Engineering: Impairments, disabilities & handicaps, measurement & assessment, engineering concepts in sensory & motor rehabilitation. Engg. concept in communication disorders, Rehabs for locomotion, visual, speech & hearing, Artificial limb & hands, prosthetic heart valves,

Externally powered & controlled orthotics & prosthetics, Myoelectric hand & arm prostheses, marcus intelligent hand prostheses, gait study, spinal rehabilitation.

Essential Reading

1. Gerald E Miller, *Artificial Organs*, Morgan & Claypool, 2006
2. Kondraske, G. V, *Rehabilitation Engineering*. CRC press 1995

Supplementary Reading

1. Bronzino Joseph, *Hand book of biomedical Engineering*, Springer, 2000
2. R. S.Khandpur, *Biomedical Instrumentation: Technology and Application*, McGraw-Hill Professional
3. Ballabio E.etal, *Rehabilitation Engineering*. IOS press 199.
4. Warren E. Finn ,Peter G. LoPresti; *Handbook of Neuroprosthetic Methods* CRC; 1 edition 2002

BM 633 INTRODUCTION TO NANOBIOTECHNOLOGY 4 Credits [3-1-0]

Introduction to Bio-Nanotechnology, Cellular nanostructures, self-assembly of colloidal nanostructures of biological relevance, bioactive nanoparticles (respiratory surfactants, magnetic nanoparticles), Nanoparticles for drug delivery (including solid lipid nanoparticles, synthetic and biopolymeric nanoparticles), carbon nanotubes, polymeric nanofibers, Implications in neuroscience, tissue engineering and cancer therapy, and Environmental and safety aspects of bio-nanotechnology. Introduction to Nanotechnology, Multilayer Thin Film: Polyelectrolyte multilayers, coated colloids, smart capsules, LbL self-assembly, Colloids and Colloid Assemblies for Bio-nanotechnology, Nanoengineered biosensors, Fiber Optic Nano-sensors in medical care, Semiconductor and Metal Nanoparticles: Synthesis and Applications, Nanotechnology in Tissue Engineering, Microemulsions and Drug Delivery in Nanotechnology.

Essential Reading

1. Gero Decher, Joseph B. Schlenoff, *Multilayer Thin Films*, Wiley-VCH Verlag GmbH & Co. KGaA, 2003
2. David S. Goodsell, *Bionanotechnology : Lessons from Nature*, Wiley-Liss , 2004.

Supplementary Reading:

1. Kenneth J. Klabunde , *Nanoscale Materials in Chemistry* , John Wiley & Sons, Inc., 2001
2. *Nanobiotechnology: Concepts, Applications and Perspectives* by Christof M. Niemeyer and Chad A. Mirkin Wiley-VCH; 1 edition, 2004

BM 641 IMMUNOTECHNOLOGY 4 Credits [3-1-0]

Characteristics of animal cells and their implication on process design Nutritional requirements and serum free culture of mammalian cells Kinetics of growth and product formation ; Reactor systems for large-scale production using animal cells ; Production of Polyclonal antibodies with different types of antigens: antigen preparation and modification, adjuvants does and rute of antigen administration, collection of sera, purification of antibodies ; Hybridoma technology. production and applications of monoclonal antibodies for diagnosis and therapy ; Production of virus vaccines, specific vaccines ; Production of cellular chemicals like Interferons, Interleukin etc. Immunoassay procedures.

Essential Reading :

1. A Moran and J P. Gosling, *Immunotechnology: Principles, Concepts and Applications*, John Wiley & Sons, 2008.

Supplementary Reading :

1. D. P. Stites, J.D.Stobo, H.H.Fudenberg and J.V. Wells, *Basic and Clinical Immunology*. Large medical publications, 5th Edition, 1987.

BM 642 ADVANCED CELL & MOLECULAR BIOLOGY 4 Credits [3-1-0]

Organization of viral, prokaryotic and eukaryotic genomes: Cot curves, repetitive and unique sequences, kinetics and sequence complexities, satellite DNA, DNA melting and buoyant density ; Organelle genomes, Rearrangement and amplification of DNA in the genome, DNA replication models, DNA polymerases - mode of action, DNA damage, DNA repair and recombination., RNA polymerases and reverse transcriptase: structure and mechanism of action ; Enzymes involved in DNA modifications, methylases, demethylases, DNases, DNA gyrase, Topoisomerase, Organization structures and function of ribonucleoproteins, Protein synthesis: Genetic code, mechanism and regulation of protein synthesis, Development, Molecular basis of development in animals and plants , Homeobox gene expression and Pattern formation in development, DNA methylation, gene expression, chromosomal inactivation and sex determination , Oncogenes, proto-oncogenes and etiology of cancer.

Essential Reading :

1. B.Alberts, A.Johnson, J.Lewis and M.Raff, *Molecular Biology of the Cell,* Garland Science; 5th edition.

Supplementary Reading :

1. H. Lodish, A Berk, C.A. Kaiser and M.Krieger, *Molecular Cell Biology*, W. H. Freeman**,** 6th edition, 2007.

BM 644 MOLECULAR BIOLOGY OF CANCER 4 Credits [3-1-0]

Carcinogenesis, cancer initiation, promotion, & progression, Cellular proto-oncogenes, oncogene activation, Growth factors, growth factor receptors, signal transduction, Transcription factors, Retroviral oncogenes, Tumor suppressor genes, Cancer cell cycles, DNA viruses/cell immortalization, Tumor suppressor gene pathways, DNA methylation, epigenetic silencing of suppressor genes, Genomic instability, Apoptosis, Free radicals, antioxidants, and cancer, Metabolic oxidative stress and cancer, Epidemiology of selected cancers, Gene rearrangements, detecting oncogene abnormalities in clinical specimens, Cell:cell interactions, cell adhesion, angiogenesis, invasion and metastasis.
Strategies of anticancer chemotherapy, Strategies of anticancer gene therapy, Translating therapies from laboratory to clinic, Gene discovery in caner research, cancer genome anatomy project, Cancer immunity and strategies of anticancer, immunotherapy.

Essential Reading :

1. M.Khan and S.Pelengaris, *The Molecular Biology of Cancer***,** First edition, Wiley-Blackwell, 2006.

Supplementary Reading :

1. L.Pecorino, *Molecular Biology of Cancer: Mechanisms, Targets, and Therapeutics,* 2nd edition, Oxford University Press, USA; 2008.

BM 645 PROTEIN CONFORMATIONAL DISEASES AND THERAPY **4 Credits [3-1-0]**

Introduction to Protein Architecture, Cooperative Transitions in Protein Molecules, Kinetics of Protein Folding and the Energy Landscape Model, Introduction to Misfolding, Aggregation, and Disease, Thermodynamics of protein folding, misfolding and aggregation ; Neurodegenerative disorders, Alzeimer's disease, Parkinson's disease, Prion disease, polyglutamine diseases, Amyloidosis. Other protein misfolding disorders: Cystic fibrosis, alpha-antitrypsisn deficiency, Fabry disease, cancer ; Various Experimental Models in diseases. Disease mechanism, Genetic mutation in diseases,Dysfunction of proteasome in diseases.Role of chaperones in various pathogenesis ; Study of Disordered Proteins and Aggregation, Intrinsically Disordered Proteins ; Current therapy; chemicals drugs, chaperone-based therapy in neurodegeneration, Proteasome inhibitors, Gene therapy etc.

Essential Reading :

1. V.N. Uversky and V. N. Uversky, A.Fink, *Protein Misfolding, Aggregation and Conformational Diseases (Protein Reviews)*, First edition, Springer, 2007.
2. H. J.Smith, C.Simons, and R.D. E. Sewell, *Protein Misfolding in Neurodegenerative Diseases: Mechanisms and Therapeutic Strategies (Enzyme Inhibitors)*, First edition, CRC, 2007.

Supplementary Reading :

1. J.Ovádi and F.Orosz, *Protein folding and misfolding: neurodegenerative diseases (Focus on Structural Biology)***,** First edition, Springer, 2009.

BM 646 RECOMBINANT DNA TECHNOLOGY **4 Credits [3-1-0]**

Tools of recombinant DNA: restriction endonucleases and other enzymes; vecors; plasmid ; Bacteriophage and other viral vectors, cosmids, Ti plasmid, yeast artificial chromosome. c-DNA and genomic DNA library, gene isolation, gene cloning, expression of cloned gene, DNA labeling by radioactive and non radioactive methods ; DNA sequencing, Chemical cleavage and dideoxy methods; oligonucleotide synthesis; polymerase chain reaction ; Southern and Northern blotting, in situ hybridization. DNA markers: restriction fragment length polymorphism, random amplified ploymorphic DNA, DNA finger printing, and their applications ; Site-specific and oligonucleotide directed mutagenesis, antisense and ribozyme technology; genetic diagonosis, gene transfer technologies; transgenics; gene therapy.

Essential Reading :

1. O.S. Reddi, *Recombinant DNA Technology,* Allied Publishers Pvt. Ltd. 2000.

Supplementary Reading :

1. A.Prokop, R.K. Bajpai, and C.S. Ho, *Recombinant DNA Technology and Applications*, Mcgraw-Hill, 1991.

BM 647 INDUSTRIAL PHARMACOLOGY 4 Credits [3-1-0]

Unit processes taking place in industrial pharmacy and Pharmaceutics (II). Different formulation techniques. Granulation and compression processes that are carried out in pharmaceutical companies. New technologies: Granulation for controlled release, extrusion, spheronisation, fluidisation techniques, spray drying, melt extrusion and roller compaction. The module will examine current granulation theory and practice. Emphasis will be made on how this theory and practice relates to current pharmaceutical development and production, with special reference to the machinery used. Initial validation issues will also be addressed.

BM 649 NUTRITIONAL SCIENCES AND PLANT BASED PRODUCTS 4 Credits [3-1-0]

Chemical nature, physiology, metabolism and biochemical/molecular mode of action of nutrients; assessment of nutrition status (anthropometric, biochemical and dietary) and requirements of nutrients for different physiological groups; functional significance of nutrition - physical work, psychosocial development, immunity, reproductive performance, drug utilisation; nutritional deficiency disorders-clinical manifestations and diagnosis; diet and degenerative diseases-role of functional foods (nutraceuticals-plants based products); food toxicities; reaching nutrients to the community-food fortification, food processing, nutrition intervention programmes, dietary diversification.

Essential Reading :

1. M. J Chrispeels, *Plants, Genes, and Crop Biotechnology,* Jones and Bartlett Publishers, Inc., 2 Sub edition, 2002.

Supplementary Reading :

1. P.B. Kaufman, L.J. Cseke, S. Warber, and J. A. Duke, *Natural Products from Plants*.

BM 651 ADVANCED BIOINFORMATICS 4 Credits [3-1-0]

Protein - general introduction, forces that determine protein structure and physicochemical properties. Mechanisms of protein folding, molten globule structure, characterization of folding pathways. Determination of protein structure by various spectroscopic techniques. Background and basic principles, Absorption and Fluorescence, Circular Dichroism, FT-Raman, FT-IR, NMR, X-ray crystallography, MALLS. Thermal properties of proteins and application of DSC. Protein denaturation, aggregation and gelation. Flow properties of proteins and sensory properties of proteinaceous foods. Protein functionality. Protein raw materials- cereals, legume, oil seeds and pseudo cereals. Muscle protein, Milk protein, Egg protein. Protein modification as result of technological processes: thermal, enzymatic, physical, pressure, solvents, interactions. Nutritive role of food proteins.

Essential Reading :

1. J.L. Cleland and C.S. Craik, *Protein Engineering: Principles and Practice,* Wiley-Liss, ISBN-13: 978-0471103547, 1 edition, February 7, 1996.

Supplementary Reading :

1. S. Lutz and U. T. Bornscheuer, *Protein Engineering Handbook,* Wiley-VCH, New edition ISBN-13: 978-3527318506, January 20, 2009.
2. C. Gibas and P. Jambeck, *Developing Bioinformatics Computer Skills,* O'Reilly & Associates, 2001.

BM 652 BIOPHYSICS AND STRUCTURAL BIOLOGY 4 Credits [3-1-0]

Principles of protein structures: Three dimensional conformations of proteins, Ramachandran plot, motifs, folds, mechanism of protein folding, fibrous proteins, membrane proteins and their structures. Hydrogen bonding, hydrophobic interactions, ionic interactions, disulphide bonds and their role in protein structure. Secondary structural elements and organisation of tertiary structure. Helix-coil transition and zipper model ; **Principles of Nucleic acid structures :** Nucleic acid structure and composition, supercoiling of DNA, denaturation and renaturation kinetics, nucleotide sequence composition: unique, middle and highly repetitive DNA ; **Methods of determination of biomolecular structures:** Macromolecular structure determination: X-ray crystallography, optical, UV and IR spectroscopy, luminescence, fluorescence, magnetic resonance and electron microscopy ; **Biomolecular interactions :** Protein-Protein interactions, protein-carbohydrate interactions, Protein-DNA interactions. General features and thermodynamic aspects of protein folding, Detection of folding intermediates, Complex and folding kinetics.

Essential Reading :
1. D. L. Nelson and M.M. Cox, *Lehninger Principles of Biochemistry*, W. H. Freeman; Fourth Edition, 2004.
2. K.E van Holde, C.Johnson, and P.Shing Ho**,** *Principles of Physical Biochemistry,* Prentice Hall, Second edition, 2005.

Supplementary Reading :
1. P.R. Bergethon**,** *The Physical Basis of Biochemistry: The Foundations of Molecular Biophysics*, Springer, Corrected edition, 2000.

BM 653 PROTEIN ENGINEERING 4 Credits [3-1-0]

Introduction: Design and construction of novel proteins and enzymes, Conformation of proteins in general and enzymes in particular, Effect of amino acids on structure of proteins, Energy status of a protein molecule, Structure function relations of enzymes, Physical methods such as x-ray crystallography for determination of protein structure, Site directed mutagenesis for specific protein function, Basic concepts for design of a new protein/enzyme molecule, Specific examples of enzyme engineering, -Tryesyl t RNAsynthetase, Dihydrofolate reductase, Subtilisin.

Essential Reading :
1. C.Köhrer and U.L. RajBhandary, *Protein Engineering (Nucleic Acids and Molecular Biology)*, Springer, 1 edition.
2. J. L. Cleland and C.S. Craik, *Protein Engineering: Principles and Practice,* Wiley-Liss, 1 edition.

Supplementary Reading :
1. S.Lutz and U.T.Bornscheuer, *Protein Engineering Handbook* , Wiley-VCH; New edition.

BM 654 CELL AND PROTEIN PROCESSING 4 Credits [3-1-0]

Basics of cells and proteins, related processing steps, structural and dynamic properties of bulk and confined water, mechanism of protein stabilization during freeze drying, spray drying and storage, Freeze drying and spray drying fundamental issues, freezing and drying induced perturbations of protein structure and mechanism of stabilization, molecular mobility of freeze dried formulation and effect on storage stability, formulation characterization, freeze drying of biological standards, technical procedures for operation of sterilization-in-place process for production of freeze drying equipment, irradiation of freeze dried vaccine and other select biological products.

BM 663 ADVANCED BIOCHEMICAL ENGINEERING 4 Credits [3-1-0]

Concept of ideal reactors based on flow characteristics, design of ideal reactors using material and energy balance equations. Single reactors, with ideal flow condition, comparison of volumes of plug flow reactor and chemostat. Multiple reactors-methods to show how total volume is affected in multiple reactors. Searching for mechanism – Arrhenius equation – Batch reactor analysis for kinetics (synchronous growth and its application in product production). Growth Kinetics: Batch growth quantifying cell concentration, growth profiles and kinetics in batch culture, fed batch growth, continuous growth and their growth kinetic quantification, chemostat growth, semi-continuous / exponential feeding strategy. Maximizing the yield of intermediate product in series reactions Design principles – Non isothermal reactions and pressure effects; Non-ideal flow in bioreactors-reasons for non-ideality, concept of RTD studies, characterization of non-ideality using RTD studies, various distribution functions, conversions using tracer studies. Diagnosing the ills of non ideal bioreactors, various models of non ideal flow. Design and analysis of bioreactors-stability and analysis of bioreactors, biomass production and effect of dilution rate. Design and operation of various bioreactors, viz CSTF, fed batch systems, air-liftbioreactors, fluidized bed bioreactors. Scale up of bioreactors. Criteria for selection of bioreactors.

Essential Reading :

1. M.L. Shuler and F.Kargi, *Bioprocess Engineering: Basic Concepts* (2nd Edition),. Prentice Hall PTR; 2 edition, 2001.

Supplementary Reading :

1. J.E. Bailey and D.F. Ollis, *Biochemical Engineering Fundamentals,* McGraw Hill Higher Education, 2nd edition, 1986.

BM 664 INDUSTRIAL MICROBIOLOGY 4 Credits [3-1-0]

Chemical composition of food; Structure, properties, chemical and biochemical function of food constituent water, protein, fats, carbohydrates; enzymes, vitamins and minerals; pigments, colour and flavourings; Food additives and contaminants. Chemical changes during food processing, Chemical spoilage of food. Introduction to food microorganisms, Morphology and charactristics of bacteria, yeasts and molds, Factors affecting microbial growth and decay. Microbial growth and death kinetics. Food poisoning, intoxicating and infective organism. Microbial spoilage of foods.

Essential Reading :

1. M.J. Waites, N. L. Morgan, J.S. Rockey, and G.Higton, *Industrial Microbiology: An Introduction,* Wiley-Blackwell, ISBN-13: 978-0632053070, 2001.

Supplementary Reading :

1. Samuel and Dunn, C.Prescott, *Industrial Microbiology,* McGraw Hill; 3Rev Ed edition (1959); ISBN-13: 978-0070507487.

BM 665 BIOPROCESS AND PLANT DESIGN 4 Credits [3-1-0]

Introduction; General design information; Mass and energy balance; Flowsheeting; Piping and instrumentation ; Materials of construction for bioprocess plant; Mechanical design of process equipment; Vessels for biotechnology application; Design of bioreactors ; Design considerations for maintaining sterility of process streams and process equipment; Selection and specification of major equipment used in bioprocess industries ; Utilities for biotechnology production plants; Process economics ; Bioprocess validation; Safety considerations; Case studies.

Essential Reading :

1. B. K. Lydersen, N.A. D'Elia, and K. L. Nelson, *Bioprocess Engineering***,** Wiley-Interscience; 1st edition, 1994.

Supplementary Reading :

1. P.M. Doran, *Bioprocess Engineering Principles***,** Academic Press; 1st edition, 1995.

BM 667 BIOLOGICAL WASTE TREATMENT 4 Credits [3-1-0]

This course provides students with a working knowledge of solid/liquid hazardous biological waste management and cleanup processes used around the world. The topics covered include a historical perspective; regulations pertaining to solid and hazardous wastes; waste characterization and risk assessment; waste handling, collection and transport; waste treatment and disposal methods, including biological and chemical treatment, incineration, pyrolysis, landfill, and site remediation. Waste minimization and cost analysis are also discussed.

BM 669 ADVANCED BIOSEPARATION 4 Credits [3-1-0]

Introduction; An overview of bioseparation. Separation of cells and other insolubles from fermented broth. Filtration and microfiltration, centrifugation (batch, continuous, basket). Cell disruption: Physical methods (osmotic shock, grinding with abrasives, solid shear, liquid shear), Chemical methods (alkali, detergents), Enzymatic methods ; Products isolation: Solvent Extraction and adsorption method, precipitation (ammonium sulphate. Organic solvents, high molecular weight polymers), chromatographic separation; affinity, size exclusion, Thin layer, ion exchange chromatography. ultrafiltration, Reverse Osmosis, Electrophoretic separation ; Products polishing: Crystallization and drying.

Essential Reading :

1. PA Belter, EL Cussler and WS Hu, *Bioseparations: Downstream Processing for Biotechnology*, John Wiley and Sons, 1988.

Supplementary Reading :

1. R Ghosh, *Principles of Bioseparation Engineering*, World Scientific Pte. Ltd, 2006.
2. RG Harrison, PW Todd, SR Rudge. D Petrides, DP Petrides, *Bioseparations Science and Engineering*, Oxford University Press, 2002.

BM 671 ADVANCED BIOSEPARATION LABORATORY 2 Credits [0-0-3]

1. Separation of proteins (>60 kDa) from cell debris using centrifugation and dialysis.
2. Study of desalting out of proteins.
3. Separation of proteins using HPLC and quantify the fractions.
4. Separation of binary protein complex using FPLC.
5. Separation of protein complex using sucrose gradient method.
6. Separation of proteins using Electrophoresis methods.
7. Isolation of DNA using from cell extract.
8. Separation of various molecular weight proteins using reverse osmosis and ultrafiltration techniques.

Essential Reading :

1. D. Forciniti, *Industrial Bioseparations: Principles and Practice***,** Wiley-Blackwell; First edition, 2008.

Supplementary Reading :

1. *Downstream Processing of Proteins: Methods and Protocols (Methods in Biotechnology)*, Humana Press; First edition, 2000.

BM 672 CELL AND PROTEIN PROCESSING LABORATORY 2 Credits [0-0-3]

Introduction to cells and proteins, their sensitivity to different processing exercises. Differential scanning calorimetric properties of proteins and cells in the presence and absence of excipients. Study of processing caused changes/damages in proteins and cell membrane using Infrared Spectrometry. Cell counting, cell separation using Flow Cytometer. Studies on cell death using Flow Cytometer. Use of fluorescent tag and tagged antibody for identification of proteins and cells using fluorescent spectrometry. Biostabilization of cells and proteins using freeze drying technique. Biostabilization of cells using Spray drying technique. Biostabilization of cells and proteins using spray drying technique.

BM 673 ADVANCED BIOCHEMICAL ENGINEERING LABORATORY 2 Credits [0-0-3]

BM 674 BIOINFORMATICS LABORATORY 2 Credits [0-0-3]

Introduction and getting used to biological databases, data type and data retrieval. Sequence alignment and phylogenetic trees. Pair wise sequence alignment, multiple sequence alignment, ClustalW, dendograms. Protein structure prediction. Structure visualization, Secondary structure prediction, Structural prediction through homology modeling, Stereo chemical quality. Drug design. Structure Drawing, Docking.

BM 675 BIOMEDICAL EQUIPMENT DESIGN LABORATORY 2 Credits [0-0-3]

1. Design of ECG heart rate alarm system
2. Design of ECG heart rate monitor system
3. Design of ECG simulator
4. Design of EMG biofeedback system
5. Design of Nerve Simulator
6. Design of electronic Stethoscope
7. Design of Pacemaker
8. Design of Digital Flow monitor
9. Design of Digital Pressure Monitor
10. Design of Biotelemetry
11. Design of Respiration Rate monitor
12. Design of Peripheral Pulse Heart rate system
13. Design of Peripheral Pulse Heart rate monitor
14. Design of Temperature control system

BM 676 ADVANCED BIOMEDICAL INSTRUMENTATION LABORATORY 2 Credits [0-0-3]

1. Study of safety analyzer, Power Isolation, Isolation Transformer and DC-Dc Converters.
2. Study of Ultrasound diathermy, Short wave Diathermy, Timer Circuit
3. Study of ECG Amplifier-Lead Selector, QRS component
4. Study of Fetous Doppler and Fetous Monitor for Transmitter and Detector
5. Study of Pacemaker with simulator circuit
6. Measurement of Blood Flow Velocity using Ultrasonic blood flow Monitor
7. Study and Characterization of Biotransducer-Pressure, Temperature, Humidity using LVDT, Temperature Amplifier.
8. Study & Characterization of Bioelectrodes- ECG, EMG, EEG using Amplifiers
9. Study of EMG processor with simulator and EMG Amplifier
10. Study of X-RAY Radiography System with Dark room process
11. Study of EEG system and Characterization of Amplifier with simulator
12. Study of EMG /ECG amplifier Isolation of Bio-signal using analog circuit
13. Study of Galvanic Skin Resistance using GSR System
14. Study of PCG (Phonocardiograph) for Measurement of Heart Sound
15. Determination of Pulmonary Function Using Spirometer
16. Measurement of Respiration rate using thermister for Apnea study and Baby Incubator study
17. Measurement of Pulse Rate using photoelectric transducer Heart rate monitor and study of plythesmograph, F-V converter
18. Study of artificial respiratory system

BM 677 BIOMEDICAL SIGNAL PROCESSING LABORATORY 2 Credits [0-0-3]

1. Use of DSP processor 6X and 2X series for
   a. Sine wave generation using C.
   b. Linear and circular convolution
   c. Finding DFT and IDFT of a given density
   d. Realization of FIR and IIR filters
   e. Plotting the power spectral density
2. Designing an FIR filter using MATLAB and DSP Kit.
3. Designing an IIR filter using MATLAB and DSP Kit.
4. Fourier analysis of periodic signal.
5. Time frequency domain properties of different windows using MATLAB.
6. Implementation of the Double-Precision Complex FFT for ECG signal.
7. Design of Notch filter for elimination of 50Hz from ECG signal.
8. EMG processing using MATLAB –Rectification and Signal Averaging.
9. Signal Averaging Improvement in the SNR using coherent and incoherent Averaging
10. Data Polishing: Mean and Trend Removal
11. PSD Estimation
12. LMS based Algorithm for Adative Noise Canceling
13. Data Compression Techniques: AZTEC, TP, CORTES, KL TRANSFORM
14. Classification of EEG waves

BM 678 BIOMEDICAL IMAGE PROCESSING LABORATORY 2 Credits [0-0-3]

Implementation of the below Algorithms

1. Algorithms for low Pass filter, High Pass Filter, Median filter
2. Prewitt Edge, quich Edge detector
3. Miller's Algorith
4. Cooley- Turkey Algorithm
5. Numerical Implementation of the TWO Dimensional F.F.T.
6. Reconstruction Algorithm for Parallel Projections
7. Reconstruction Algorithm for Fan Beam Projections
8. Re-sorting Algorithm
9. Back Projection Algorithm
10. Algebric Reconstruction Techniques (A.R.T.)
11. Simultaneous Algebric Reconstruction Technique (S.A.R.T.)
12. Simultaneous Iterative Reconstruction Technique (S.I.R.T.)

Using MATLAB or C Language

BM 681 SPECIAL TOPIC IN BIOTECHNOLOGY & MEDICAL ENGINEERING – I 03/04 Credits

BM 682 SPECIAL TOPIC IN BIOTECHNOLOGY & MEDICAL 03/04 Credits

ENGINEERING – II

BM 683	**SPECIAL LABORATORY IN BIOTECHNOLOGY & MEDICAL ENGINEERING – I**	**02 Credits [0-0-3]**
BM 684	**SPECIAL LABORATORY IN BIOTECHNOLOGY & MEDICAL ENGINEERING – II**	**02 Credits [0-0-3]**
BM 685	**SEMINAR & TECHNICAL WRITING – I**	**02 Credits [0-0-3]**
BM 686	**SEMINAR & TECHNICAL WRITING – II**	**02 Credits [0-0-3]**
BM 687	**SEMINAR & TECHNICAL WRITING – III**	**02 Credits [0-0-3]**
BM 688	**SEMINAR & TECHNICAL WRITING – IV**	**02 Credits [0-0-3]**
BM 691	**SUMMER RESEARCH / INDUSTRIAL PROJECT**	**04 Credits**
BM 692	**COMPREHENSIVE VIVA VOCE**	**04 Credits**
BM 693	**RESEARCH PROJECT - I**	**08 Credits**
BM 694	**RESEARCH PROJECT - II**	**08 Credits**
BM 695	**RESEARCH PROJECT REVIEW – I**	**08 Credits**
BM 696	**RESEARCH PROJECT REVIEW – II**	**04 Credits**
BM 699	**DISSERTATION**	**08 Credits**