BIOSCIENCES AND BIOENGINEERING□

(Biomedical Engineering): BM

Introduction

The Biomedical Engineering Group (BME) at IIT Bombay was set up in 1988. It is now a part of Department of Biosciences and Bioengineering (BSBE). Biomedical Engineering is one of the youngest disciplines in engineering and has made tremendous progress in the last 4 decades. This has been aided by rapid advancements in Semiconductor Technology, Information Technology, and Biotechnology. In the field of Biomedical Engineering, researchers with expertise in diverse areas work towards the unified goal of creating products and techniques for better health care. The backgrounds of faculty in BME at IIT Bombay reflect the wide spectrum of expertise required to make better and more affordable health care a reality. Further, the students admitted to the program have backgrounds in Engineering, Physical Sciences, Life Sciences and Medicine, making it the only program in the country to offer M.Tech. admission to such a unique mix of candidates. The creation of a heterogeneous class composition promotes interaction between students and faculty of different backgrounds and provides opportunities for research in exciting interdisciplinary areas.

Course work & Project

Over the first two semesters, M.Tech. students are required to do substantial amount of course work to complement their undergraduate or masters level education. The third semester is devoted mostly to the M.Tech. project although some courses may be taken during that period. The fourth semester is fully devoted to completion of the project. The curriculum has been designed to provide all students with a general background in Biomedical Engineering followed by more specific knowledge in the area of their choice. The former is achieved through core (for everyone) and compulsory (for students with a particular background) courses in the first semester. Electives taken during the second and third semester provide specialized knowledge in the area of the individual interest.

In the first semester, students with backgrounds in life sciences and medicine are required to take compulsory courses in mathematics, electronic circuits and instrumentation. Students with backgrounds in physical sciences and engineering take courses in physiology. There are other elective courses to be taken as well.

In the second semester, all students have to go through a core course on Biostatistics. Further, everyone is required to present a seminar on a topic related to Biomedical Engineering under the guidance of a faculty. The rest of the courses are electives, which the students choose after consultation with the faculty adviser.

Electives are offered in biopotentials, bioelectricity, ergonomics, medical sensors, biosensors, bioMEMS, medical imaging physics, biomaterials, drug delivery, cellular & tissue engineering, microfluidics, computational modeling, biomechanics, etc. All students are required to take a course designated as an Institute Elective offered by departments other

than BSBE. In special cases electives other than the institute elective may be taken from other departments in IIT after obtaining necessary permissions from the Department Post Graduate Committee.

ELIGIBILITY FOR ADMISSION

First class or 60% marks (55% marks for SC/ST) in *:

* as specified in the clause '8' in the "Important Guidelines for M.Tech. Application" of this brochure.

i. B.Tech/B.E./AMIE or equivalent in Biomedical, Chemical, Computer Science, Electrical, Electronics, Instrumentation, Mechanical Engineering, Metallurgy and Materials Science, Telecommunications Engineering and Engineering Physics. OR

ii. M.Sc. or equivalent in Biochemistry, Biophysics, Biotechnology, Ceramics, Chemistry, Electronics, Ergonomics, Materials Science, Mathematics, Molecular Biology, Physics and Physiology; OR*

iii. MBBS OR *

iv. M. Pharm OR *

v. B.V.Sc., B.D.S., B.P.Th., B.O.Th. andB.Pharm. degree (Duration 4 years or more) OR

vi. B.Tech. (Biotechnology) and Valid GATE score in any discipline for engineering and science graduates, or AIIMS / All India MCI/JIPMER/PGI Chandigarh/AFMC-Pune/DNB Part I national level medical

vii. postgraduate entrance examinations or GATE Life Sciences examination for medical and biological sciences.

* Candidate with qualifications mentioned against (iii), (iv) & (v) must submit a certificate for their having First class or 60% marks (55% for SC/ST)* in qualifying degrees, failing which, they will not be eligible for admission to M.Tech in Biomedical Engineering

All India level Pre-M.D.S/ M.V.Sc., M.Pharm. Selection examination for B.V.Sc., B.D.S and B.Pharm. Eligibility/rank certificates of all such entrance examinations are required.

Written test and Interview

Prospective candidates called for the interview will be required to appear in a written test in the morning of the first day of the interview. The written examination, of two hours duration, will be conducted in Mathematics (for candidates with a Medical/Pharmacy/Life Sciences background), in Biology/Physiology (for candidates with Engineering/Physical sciences background) and in Mathematics & Biology/Physiology (for candidates with Biotechnology and Biomedical Engineering background). The syllabi for the tests will be in

accordance with the 12th standard syllabi of CBSE.

RESEARCH AREAS

Currently fundamental and applied research is being conducted in the following broad areas, which the students can choose to do projects in:

 Biomedical transducers and sensors including biosensors and bioMEMS devices

- Biomaterials and tissue engineering

- Bionanotechnology

 Biophysics, cellular mechanics and computational biology

- Controlled drug delivery systems

 Computational neurophysiology

- Microfabrication and microfluidics

- Telemedicine and knowledge based systems

M.Tech. (Biomedical Engineering)

First Semester

Core or Compulsory Courses

Code	Subject Name	L	T	P	C	
For all students						
HS 791	Communication skills	0	0	0	P/NP	
BB 792	Communication skills	0	0	0	P/NP	
BB 651 **OR** BB 653	Virtual instrumentation in BME **OR** Experimental Techniques in BME	1	0	2	4	
For Bio-background students						
BB 503 **OR** BB 505 **OR** BB 553	Genetic engineering **OR** Molecular immunology **OR** Bioinformatics	2	1	0	6	From the M.Sc. (Biotechnology) curriculum
BB 604	Biomathematics	2	1	0	6	
For Engg-background students						
BB 603	Physiology for engineers	3	0	0	6	
BB 411	Molecular Cell Biology	2	1	0	6	From the M.Sc. (Biotechnology) curriculum

Electives: 18 credits

Total credits: 34

Electives for Semester I (Half-semester courses)

Code	Subject Name	L	T	P	C
BB 601	Introduction to bio-nanotechnology	3	0	0	3
BB 661	Biopotentials I: Cellular Signals	3	0	0	3
BB 663	Medical imaging physics	3	0	0	3
BB 665	Biomaterials	3	0	0	3
BB 669	Signals & systems in Biomedical Engineering	3	0	0	3
BB 671	Biopotentials II: Clinical Signals	3	0	0	3
BB 673	Medical sensors	3	0	0	3
BB 675	Elements of circuits and instrumentation	2	0	2	3
BB 677	Introduction to biomechanics	3	0	0	3
BB 679	Drug delivery	3	0	0	3

Second Semester

Core or Compulsory Courses

Code	Subject Name	L	T	P	C
For all students					
BB 694	Credit seminar	0	0	0	4
BB 621	Biostatistics	3	0	0	6

Electives: 24 credits

Total credits: 34

Electives for Semester II (Full-semester courses)

Code	Subject Name	L	T	P	C
BB 606	Cellular electricity: physics & modeling	3	0	0	6
BB 608	Advanced Biomaterials & Regeneration	3	0	0	6
BB 610	Biomedical microsystems	3	0	0	6
BB 612	Cell mechanics and mechanobiology	3	0	0	6
BB 614	Biosensors	3	0	0	6
BB 616	Cellular and tissue engineering	3	0	0	6
BB 618	Medical instrumentation	3	0	0	6
BB 620	Ergonomics	3	0	0	6
BB 622	Introduction to medical informatique	3	0	0	6
BB 624	Microfluidics: physics and applications	3	0	0	6
BB 626	Modeling Biological Systems and Processes	3	0	0	6

Code	Subject Name	L	T	P	C
	Institute elective (to be taken either in the 2nd or the 3rd semester)	3	0	0	6

Third Semester (proposed)

Code	Subject Name	L	T	P	C
BB 697	Project Stage I	0	0	0	44

Code	Subject Name	L	T	P	C
	Institute elective (to be taken either in the 2nd or the 3rd semester)	3	0	0	6

Contact hours: 0; Credits: 44

Fourth Semester

Code	Subject Name	L	T	P	C
BB 698	Project Stage II	0	0	0	48

Contact hours: 0; Credits: 48

Credit structure:

Credits Course work	**Sem. 1**	**Sem. 2**	**Sem. 3**	**Sem. 4**	**Total**
Core course	12	-	-	-	12
Compulsory depending on background	0	6	-	-	6
Elective	12-18	12-24	-	-	24-42
Institute elective	-	0-6	0-6	-	6
Courses outside dept.	0-6	0-6	0-12	-	0-24
Seminar	0	4	-	-	4
Lab course Core (to choose 1 of 2 courses)	4	0	-	-	4
R & D project	-	-	-	-	-
Communication (P/NP)	+4	-	-	-	+4
Training (P/NP)	-	-	-	-	-
Course total	**34-40**	**34-40**	**0-18**	**-**	**68-80**
Project	-	-	44	48	92
Total	**34**	**34**	**44-62**	**48**	**160-172**

BB601 Introduction to BioNanotechnology 3 0 0 3

Introduction to Bio-Nanotechnology, Cellular nanostructures, self-assembly of colloidal nanostructures of biological relevance, biofunctional nanoparticles, Nanoparticles for drug delivery (including solid lipid nanoparticles, synthetic and biopolymeric nanoparticles), carbon nanotubes, polymeric nanofibers, quantum dots, magnetic nanoparticles and gold nanostructures for theranostics, Multilayer Thin Film: Polyelectrolyte multilayers, coated colloids, smart capsules, Nanoengineered biosensors, Nanotechnology for Biodefense, Implants and Prosthesis, Implications in neuroscience, tissue engineering and cancer therapy, and Environmental and safety aspects of bio-nanotechnology.

Texts & References

- Multilayer Thin Films; GeroDecher, Joseph B. Schlenoff, Wiley-VCH Verlag GmbH & Co. KGaA, 2003
- Bionanotechnology: Lessons from Nature; David S. Goodsell, Wiley-Liss, 2004
- Biomedical Nanotechnology; Neelina H. Malsch;CRC Press, 2005

- Nanotechnologies for the Life Sciences, Vol 2, Biological and pharmaceutical nanomaterials; Challa Kumar, Wiley-VCH, 2006.

BB 603 PHYSIOLOGY FOR ENGINEERS 3 0 0 6

Basic cell physiology; Biochemical cycles.
Systemic physiology: Neuromuscular system; Blood and lymph; Circulatory system; Respiratory and Cardiovascular system, Gastro-intestinal system; Kidney and excretory system; Sensory systems- visual, auditory, vestibular; Endocrine- pituitary, adrenal, pancreas, Clinical and technological implications

Texts & References:

- Arthur C. Guyton: Textbook of Medical Physiology, 8th ed, Prism Books (Pvt) Ltd & W.B. Saunders Company, 1991.
- W.F.Ganong, Review of Medical Physiology, 13th ed., Prentice-Hall, 17th edition, 1995.

BB 604 BIO - MATHEMATICS 2 1 0 6

Mathematical and computational problems in the context of biology and medicine with emphasis on deterministic models. Models from epidemiology, cell design, enzyme kinetics, genomics, drug kinetics and design, and sports medicine.

Review of sets, number system and operators, sequences and series, exponential, logarithm and trigonometric functions, limits, derivatives, and graphing of functions. Polynomials, roots, approximation to functions. Function maxima and minima. Integration. Linear ordinary differential equations. Second order partial differential equations. Transform techniques. Difference approximations, discrete models, and numerical solutions, error analysis. Introduction to algorithmics for biology and medicine. Examples for modeling and analysis from population

growth, spread and arrest of diseases, tumour growth, biomechanics, and theoretical neuroscience. Solutions using Matlab and SciLab.

Texts & References:

- J. D. Murray, Mathematical biology: an introduction, 3rd ed., New York, Springer 2002.
- R. W. Shonkwiler, Mathematical Biology: An Introduction with Maple and Matlab, Springer 2009.
- E. Kreyszig. Advanced Engineering Mathematics, 9th Ed., Wiley, 2006

BB 606 Cellular electricity: physics & modeling 3-0-0-6

Action potential of excitable cells: Quantitative description, Hodgkin-Huxley model, significance of parameters in Hodgkin-Huxley equations; Voltage-clamp experiments: design, and analysis of results; Factors determining the initiation, amplitudes, and kinetic properties of action potentials. Passive membrane electrical properties: Cellular resistance, capacitance, time constant and space constant, methods of measurement; Importance in cellular excitation and signaling: Impulse propagation.
Electrophysiology of synaptic transmission: Prejunctional and postjunctional electrical events; time courses of transmitter-activated membrane currents and potentials in skeletal and smooth muscle; Electrical models of the skeletal and smooth muscle membranes

Texts/References

- J.G. Nicholls, A.R. Martin & B. Wallace: From Neuron to Brain, 3rd ed., Sinauer, Sunderland, 1992.
- R.D. Barr & R.L. Plonsey: Bioelectricity: A Quantitative Approach, Academic Press, N.Y., 1988.
- E.R. Kandel & J. Shwartz (ed.): Principles of Neural Science, 3rd ed., 1991.

BB 608 Advanced Biomaterials & Regeneration 3-0-0-6

Design of biomaterials for drug delivery, biomedical devices and tissue regeneration;
Trigger responsive materials, smart in situ gels: applications for drug delivery & tissue engineering
Scaffolds for tissue engineering: osteogenesis, role of nanocomposites and self assembly, biomimetic scaffolds for compact and cancellous bone regeneration
Role of growth factors and stem cells, Chondrogenesis and tissue engineering scaffolds for articular cartilage replacement, osteochondral defects, Vascular grafts, endothelial cell seeding, tissue engineered vessels, Barrier functions of skin, epidermal and dermal skin replacements, full thickness tissue engineering of skin for burns and diabetic ulcers
Mechanical and bioprosthetic heart valves, modulation of thrombogenicity, surface modification strategies, Ocular materials, contact lenses, intra-ocular lenses, corneal regeneration, Implant associated biofilms,
Nerve regeneration tubes, strategies for neuronal regeneration and treatment of spinal cord injuries

Texts/References

- Ratner B D, Hoffmann A S, Schoen F J, Lemons J E. Biomaterials science: An introduction to materials in medicine, Academic Press, 2004.
- Lanza R, Langer R, Vacanti J. Principles of tissue engineering, Academic Press, New York,

2007.

- Atala A. Foundations of regenerative medicine: clinical and therapeutic applications Academic Press, 2009

BB 610 Biomedical Microsystems 3-0-0-6

Introduction; Photolithography; Crystallography, Mask Design Wet and Dry Etching; Thin Film Deposition and Growth Electroplating, Molding, LIGA, Bonding and Sacrificial Processes, Polymer Processing and Rapid Prototyping, u-TAS: Fluid Control Components, Sample Handling, Separation Components and Detection, Cell Handling and Characterization Systems, Systems for Biotechnology and PCR, Miniature Biosensors, Biosensor Arrays and Implantable Devices Neural Interfaces, Microsurgical Tools, Microneedles, and Drug Delivery, Miniature Bioreactors and Microsystems for Tissue Engineering, Optical Biosensors, Packaging of Microfluidic and Optical Systems, Nanotechnology, Metrology

Texts/References

- Manz and H. Becker, Eds., Microsystem Technology in Chemistry and Life Sciences, Springer-Verlag, New York, 1999.
- Marc J. Madou, Fundamentals of Microfabrication: The Science of Miniaturization, Second Edition, CRC Press; 2nd edition, 2002

BB 612 Cell mechanics and Mechanobiology **3 0 0 6**

Mechanical forces are known to play an increasingly important role during development, normal function as well as in disease. This course will focus on the physical interactions between cells and their surroundings. Students will learn how cells sense and respond to external forces and cues, and how these mechanical inputs influence subcellular biochemistry and cell behavior. They will also study various experimental techniques that have been developed for probing cell structure, manipulating cells and measuring their mechanical properties.

Text & References:

- B. Alberts, D. Bray, J. Levis, M. Raff, K. Roberts & J. D. Watson: Molecular Biology of the Cell; 5th Ed, Garland Science
- Fung, Y. C.: Biomechanics: Mechanical Properties of Living Tissues. 2nd Ed., Springer.
- R. Kamm and M. K. Mofrad. Cytoskeletal Mechanics: Models and Measurements. Cambridge University Press.

BB614 Biosensors 3 0 0 6

Introduction to biosensors and classification. Different tranduction mechanisms in sensors. Types of recognition layers. Examples and functioning of different types of biosensors including, but not restricted to, optical, mechanical (e.g. microcantilever, piezo, SAW, etc), electrochemical, FET, thermal, etc. Analytical modelling of biosensors.

Text & References

- Handbook of biosensors and biochips: Marks, Robert S....et al.: John Wiley, 2007
- Engineering biosensors , kinetics and design applications by Ajit Sadana..San Diego, Academic Press, 2002
- Biosensors by Tran Minh Canh. London. Chapman and Hall, 1993.
- Biosensors: theory and applications by Donald G. Buerk. Lancaster: Technomic Pub., 1993.

- Applied biosensors / edited by Donald L. Wise. Boston: Butterworths, 1989
- Biosensors: fundamentals and applications / edited by Anthony P.F. Turner, Isao Karube and George S. Wilson
- Biosensors and their applications by Victor C. Yang and That T. Ngo
- Biosensors by Jon Cooper and Tony Cass
- Journal papers from Biosensors and Bioelectronics, IEEE sensors journal and other journals in this domain.

BB 616 Cellular and Tissue Engineering 3 0 0 6

Basic cell biology, cell-matrix interactions, receptor biology, cell culture, gene therapy and gene transfer techniques, protein and peptide engineering, stem cell programming, controlled release and drug delivery, tissue ablation, engineering angiogenesis, vascularization, material based immuntherapy and case studies involving skin, bone, liver, muscle tissue engineering.

Text & References:

- Blitterswijk CV, Tissue Engineering, Academic Press (2008).
- Saltzman WM, Tissue Engineering, Oxford University Press (2004).
- Lanza RP, Langer R, Vacanti JP, Principles of Tissue Engineering, Academic Press, 3rd Edition (2007).
- Palsson B and Bhatia SN, Tissue Engineering, Pearson Prentice Hall (2003).

BB 618 Medical Instrumentation 3 – 0 – 0 – 6

Medical measurands; Sensor characteristics and design for measurement of medical parameters like ECG, arterial flow, blood pressure, heart sounds; Biopotential amplifiers, charge amplifiers and other interfaces; Signal conditioning and display. Medical imaging considerations; X-rays, X-ray tube design, film and detector design; CT - scanners: generations and basic algorithms. Elements of electrical safety; Built-in safety features for medical instruments.

Texts & References

- J.G. Webster (Ed.): Medical Instrumentation - *Application and Design*; Houghton Mifflin Co., Boston, 1992.
- R. Aston: *Principles of Biomedical Instrumentation and Measurement*, Merril Publishing Co., Columbus, 1990.
- R.S.C. Cobbold: *Transducers for Biomedical Measurements*: *Principles and Applications*, John Wiley & Sons, 1974.
- E.O. Doeblin: *Measurement Systems, Application and Design*, McGraw-Hill, 1985.
- W. Welkowitz, S. Deutsch & M. Akay: *Biomedical Instruments - Theory and Design*, 2nd Ed., Academic Press, San Diego CA, 1992.
- A. Macovski: *Medical imaging systems*, Prentice-Hall, Englewood Cliffs, 1983.

BB 620 Ergonomics 3 – 0 – 0 – 6

Introduction to Ergonomics and its application; Man-Machine-Environment System; Anthropometry and joint motions; Work Posture, Environmental factors and human performance. Designing of Controls and Displays, Control panel Organization; Principals of product design; Problem solving; Seminar on ergonomics related issues in Medicine.

Texts/ References

- E.J. McCormick: *Human Factors in Engineering and Design*, Tata Mcgraw-Hill, 1976.

- O.P. Astrand & R. Kaare: *Textbook of Work Physiology*, McGraw Hill, 1970.
- W.T. Singleton: *The Body at Work: Biological Ergonomics*, Cambridge University Press, 1982.
- E.R. Tichauer: *The Biomechanical Basis of Ergonomics*, Wiley, 1978.
- R.D. Huchingson: *New Horizons for Human Factor Design*, McGraw-Hill, 1981.

BB 621 Biostatistics 3-0-0-6

Analytics in biology and medicine. Probability, statistics and stochastics. Applications in biology and medicine will be given at each topic below.
A. Descriptive statistics, quantitative parameters and inferential statistics.
B. Events and samples spaces, algebra of events, Venn diagram, random events, axiomatic definition of probability, probability as relative frequency. Independence, mutually exclusive events, conditional events, Bayes' rule and theorem, counting-permutation-combination and probability, application to diagnostics, types of errors, evaluation of odds and risks.
C. Random variables as functions, discrete and continuous random variables, probability mass function, common discrete distributions – Bernouli, Binomial, Geometric, Poisson, z-transform, marginal and joint distributions, applications
D. Continuous random variables and distributions, Normal, exponential and gamma, Chi Square, t, and F distributions, characteristic/moment-generating functions
E. Estimation of mean and variance and their distributions, Central Limit Theorem and sample size, confidence intervals, applications
F. Testing for single or two populations for the mean with and without knowledge of variance, Normal and Student `t' test, Chi Square/F test for the variance of one/two populations, G.
G. Independence of attributes and Chi Square test for goodness of fit.
H. Experimental design: randomization, factorial, Latin square, and sequential cross-over design, F Test and Applications.
I. Non-parametric and distribution-free statistics, some important nonparametric tests; sign test, Wilcoxon's rank test and Spearman's rank, correlation.
J. Classification (differential diagnosis), sequential clinical trials, and other applications.
K. Introduction to regression and time-series, data mining for patterns, analytics.
L. Laboratory sessions for descriptive statistics, testing and experimental design, using open source software R
Texts/References

- Martin Bland: An Introduction to Medical Statistics, Oxford University Press, 1995.
- Wayne Daniel: Biostatistics: Foundation for Analysis in the Health Sciences, 5th ed., John Wiley & Sons, New York, 2009. 9th Edition
- Marcello Pagano, Principles of Biostatistics, Cengage Learning India, 2000, 2nd Edition
- P. G. Hoel, S. C. Port, and C. J. Stone, Introduction to Statistical Theory, Universal Book Stall, New Delhi, 1994

BB 622 Introduction to Medical Informatique 3 – 0 – 0 – 6

Data and information capture in health care management and clinical delivery systems; Multimodal data; Epidimeology and etiology data; Data quality; Importance of data organization. Organization and retrieval of health care and clinical data; Data base systems and implementation for medical applications; Multi-sensor data with particular relevance to the organization of images. Intelligent systems approaches in medicine; Paradigms of inferencing; Building of knowledge-based systems; Treatment of uncertainty; Learnability and adaptive systems. Networked systems and intelligent retrieval; Web-based inferencing. Building and use of decision support systems for clinical applications.

Texts/ References

- T. Deutsch, E. Carson & E. Ludwig: *Dealing with Medical Knowledge - Computers in Clinical Decision Making*, Plenum Press, 1994.
- J.A. Reggia & S. Tuhrim (Eds.): *Computer-Assisted Medical Decision Making*, Vol. 1 & 2, Springer Verlag, 1985.
- T. Linden & M. L. Kienholz: *Dr. Tom Linden's Guide to Online Medicine*, McGraw Hill, 1995.
- J.A. Anderson: *An Introduction to Neural Networks*, MIT Press, 1995.

BB 624 Microfluidics: physics and applications 3-0-0-6

Fluid mechanics at the microscale; issues with flow characterization and control (mixing and separation, pumps and valves); introduction to droplet manipulation and digital microfluidics; specific examples from different with emphasis on biomedical applications.

- Micro- and Nanoscale Fluid Mechanics: Transport in Microfluidic Devices, Brian J. Kirby (Cambridge University Press), 1st edition, 2010.
- Microfluidics for Biotechnology, Jean Berthier and Pascal Silberzan (Artech House), 2nd edition, 2009.
- Microfluidics for Biological Applications, Edited by Wei-Cheng Tian and Erin Finehout, (Springer), 1st edition, 2008

BB 626 Modeling Biological Systems and Processes

Examples of simple models to understand different types of biological processes such as Lotka-Voltera model, simple epidemic model, reaction-diffusion models, drift-diffusion models. Introductions to stochastic processes in biology, Introduction to Fokker-Planck and Langevin equations. Introduction to computer simulations. Introductions to different types of simulations- Molecular Dynamics, Monte Carlo and Langevin dynamics simulations. Simple examples of application of direct Monte Carlo simulation and Gillespie algorithm to a number of simple stochastic biological systems.

Physical Biology of the Cell, R Phillips, J Kondev, J. Theriot, Garland Science, 2009.
A Course in Mathematical Biology: Quantitative Modeling with Mathematical and Computational Methods, Gerda de Vries, Thomas Hillen, Mark Lewis, Birgitt Schõnfisch, Johannes Muller, SIAM, 2006.

Dynamic Models in Biology, Stephen P. Ellner, John Guckenheimer, Princeton University Press, 2006.

BB 651 Virtual instrumentation in BME 1 0 2 4

Introduction to bioelectric signals. Analog to Digital Conversion and Data Acquisition Cards. Hardware interfacing. Programming in C for Virtual Instrumentation. Building Graphical User interfaces for use in data acquisition. Signal sampling fundamentals for Data Acquisition. Basic signal processing techniques. Acquisition of general waveforms and biosignals. Issues in online monitoring. Web-based online monitoring.

Texts & References:

Biomedical Signal Analysis by RM Rangayan Microcomputer Interfacing by J.J. Carr LabWindows CVI manuals (National Instruments)

BB 653 Experimental techniques in Biomedical Engineering 1 0 2 4

Laboratory techniques in biomedical engineering: principles, experimental use and applications for different techniques including advanced microscopy techniques (electron microscopy, atomic force microscopy, confocal microscopy), microfluidics, spirometry. Introduction to different techniques of computer simulation and development of computational models using experimental data

Texts & References Will be suggested by respective faculty from books and journals depending on the specific experimental techniques being covered.

BB 661 BIOPOTENTIALS I: CELLULAR SIGNALS 3 0 0 3

Origin of biopotentials: resting membrane potential; Nernst potentials. Selective permeability and the Donnan equilibrium; Goldman-Hodgkin-Katz equation. Action potentials: ionic basis, properties of generation and conduction, examples in different cell types. Intracellular and extracellular recording: biophysical outcomes. Paper discussion.

Texts & References

- Brown AG Nerve Cells and Nervous Systems, Narosa, 1991.
- Kuffler SJ, Nicholls J, Martin AR From Neuron to Brain, 4th Ed, Sinauer, 2002.
- Guyton, A.C. Medical physiology, 8th/ 9thIntnl Edn.,Philadelphia, W.B. Saunders, 2001/2006.

BB 663 MEDICAL IMAGING PHYSICS 3 0 0 3

Planar X-rays: electromagnetic radiation, generation and characteristics of x-rays, x-ray tubes, interaction of x-rays with tissues.
Magnetic resonance imaging (MRI): concept of spin and nuclear magnetic resonance, spin decay through interaction with tissues, use of different magnets in MRI systems, one or two simple imaging sequences.
Ultrasound: characteristics of sound waves, piezoelectricity and generation of ultrasound, interaction of ultrasound with tissues, Doppler effect and its uses

Texts & References

- Introduction to Medical Imaging: Physics, Engineering and Clinical Applications, Nadine Barrie Smith and Andrew Webb (Cambridge University Press, 1st edition, 2011).
- Medical Imaging Physics, William R. Hendee and E. Russell Ritenour (Wiley-Liss, 4th edition, 2002).

BB 665 BIOMATERIALS 3 0 0 3

Structure and property relationships of different classes of biomaterials; Interactions of materials with the human body; Criteria for selection of biomaterials for specific medical applications,

Concepts of Biocompatibility, mechanical properties of biomaterials, corrosion and biodegradation, Composite materials and applications; Nanostructured biomaterials, Orthopedic implants, dental materials, vascular grafts, ocular materials, drug delivery carriers, introduction to tissue regeneration scaffolds.

Texts & References

- Ratner B, Hoffman A. et al. Biomaterials science: An introduction to materials in medicine, Academic Press, 2004
- Fredrick H. Silver: Biomaterials, Medical Devices & Tissue Engineering: An integrated approach. Chapman & Hall, 1994

BB 669 SIGNALS AND SYSTEMS IN BIOMEDICAL ENGINEERING 3 0 0 3

Introduction to Signals and systems, Unit Step, Impulse, Sinusoidal and Exponential Signals, Properties of systems, Discrete time convolution and properties, Continuous time convolution and properties, Fourier series and properties, Fourier Transform and properties, Laplace Transform and properties, Z-Transform and biomedical examples of the above

Texts & References

- Devasahayam, Suresh R., Signals and Systems in Biomedical Engineering: Signal Processing and Physiological Systems Modeling, New York: Kluwer Academic/Plenum Pub., 2000.
- Signals and Systems Analysis In Biomedical Engineering, Second Edition [Hardcover], Robert B. Northrop, ISBN-10: 1439812519 | ISBN-13: 978-1439812518 | Edition: 2
- Signals and Systems for Bioengineers, Second Edition: A MATLAB-Based Introduction (Biomedical Engineering) [Hardcover] John Semmlow (Author) ISBN-10: 0123849829 | ISBN-13: 978-0123849823 | Edition: 2

BB 671 Biopotentials II: Clinical Signals 3 0 0 3

Axons and muscle cells as transmission-line cables; introduction to cable theory. Neurotransmission, synaptic potentials and synaptic integration: application of GHK equation and cable theory. Translation of cell-level signals to surface-recorded signals: compound nerve and muscle action potentials. Biophysics of ENG & EMG recording, elements of motor and sensory testing. Paper discussion.

Texts & References

- Kuffler SJ, Nicholls J, Martin AR From Neuron to Brain, 4th Ed, Sinauer, 2002
- Daube, J. R. (Ed.) Clinical neurophysiology. Oxford University Press 2002

BB 673 Medical Sensors 3 0 0 3

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

Texts & References

- John G. Webster (ed.): Medical Instrumentation - Application and Design; Houghton Mifflin Co., Boston, 1992.
- Richard Aston: Principles of Biomedical Instrumentation and Measurement, Merril Publishing Co., Columbus, 1990.
- Richard S.C. Cobbold: Transducers for Biomedical Measurements: Principles and Applications, John Wiley & Sons, 1974
- Ernest O. Doeblin: Measurement Systems, Application and Design, McGraw-Hill, 1985
- A.P.F. Turner, I. Karube & G.S. Wilson: Biosensors: Fundamentals & Applications, Oxford University Press, Oxford, 1987

BB 675 ELEMENTS OF CIRCUITS AND INSTRUMENTATION 2 0 2 3

Review of Basic Electric Circuits: Kirchhoff's laws, Thevenin's and Norton's Theorems; Complex impedance and phasors; Electronic Devices: PN junction diodes, diode circuits; Transistors: bipolar and field-effect transistors; Integrated circuit fabrication; Operational Amplifiers, amplifier circuits, non-linear circuits; Transfer functions, Bode plots, Filters.

Boolean algebra; Logic circuits: Simple logic circuits, combinational logic, sequential logic, multivibrators, counters.

Text & References:

- J. Millman: Microelectronics- Digital and Analog Circuits and Systems, McGraw-Hill, 1979.
- H. Taub & D. Schilling: Digital Integrated Electronics, McGraw-Hill, 1977.
- A.P. Malvino: Electronic Principles, 5th edition, Tata-Mcgraw Hill, 1997.
- P. Horowitz & W. Hill: The Art of Electronics, 2nd ed. (Cambridge Low Price Editions), Cambridge University Press, 1996.

BB 677 Introduction to Biomechanics 3 0 0 3

Vector Algebra, Forces and Moments, Equilibrium, Stress and Strain, Constitutive Equation, Flow Properties of Blood, Mechanics of Red Blood Cells, Mechanics of endothelium, Viscoelastic Fluids and Solids, Skeletal & Heart Muscle.

Texts & References

- I. H. Shames and K. M. Rao. Engineering mechanics: statics and dynamics, 4th Edn, Pearson.

2006

- I. H. Shames and J. M. Pittaresi. Introduction to Solid Mechanics. 3rd Edn., Prentice Hall of India. 2009.
- C. Ross Ethier and Craig A. Simmons: Introductory Biomechanics: From Cells to Organisms. 2nd Edn., Cambridge University Press. 2009
- Fung, Y. C.: Biomechanics: Mechanical Properties of Living Tissues. 2nd Ed., Springer. 1993.

BB 679 Drug Delivery 3 0 0 3

Fundamentals of drug delivery, including physiology, pharmacokinetics, drug diffusion and permeation through biological barriers; Various types of drug and gene delivery routes including oral, transdermal, implantable, targeted and pulmonary; Controlled drug delivery, biomaterials used in drug delivery, particle targeting via receptor-ligand interactions, intracellular transport of collodial particles, protein and peptide delivery, synthetic gene delivery vectors; Case studies of current pharmaceutical products.

Texts & References

- Saltzman WM, Engineering Principles for Drug Therapy, Oxford University Press (2001).
- Wang B, Siahaan T, Soltero R, Drug delivery principles and applications, Wiley-Interscience (2005).

BB 803 Advanced Cellular Electrophysiology 3 0 0 6

Current-voltage curves for voltage-gated ion channels: generation and analysis. Ca channel I-V curves: Goldman equation. Input resistance: theory, measurement, inferencing.?? Applications to skeletal and smooth muscle. Extensions of cable theory: predictions of cable equation; finite cables. Electrical models of neurotransmission in neurons, skeletal muscle and smooth muscle. Modelling of synaptic potentials based on impulse response. Special properties of syncytial tissues: input resistance, current-voltage relations, behaviour of synaptic potentials and spikes. Ca dynamics: components of Ca flux.?? Computational modelling: the compartmental?? modelling approach. Modelling passive structures, active properties, neurotransmission. Paper discussion

Texts & References

- Methods in neuronal modeling: from ions to networks; Eds C. Koch, I. Segev. Cambridge: MIT Press 1998.
- Computational neuroscience: realistic modeling for experimentalists; Ed: De Schutter, E. Boca Raton: CRC Press 2001
- Foundations of cellular neurophysiology; Johnston, D., Wu, S. Cambridge: MIT Press, 1995
- Cellular biophysics.302240 Weiss, T.F.302240 Cambridge: MIT Press, 1996
- The NEURON book.302240 Carnevale, T, Hines MJ.302240 Cambridge: Cambridge University Press 2005.

For Bio Background students

BB 503: Genetic Engineering (2 1 0 6)

Concept of recombinant DNA technology and purpose, basic methology, use of plasmids, Type I, II and III restriction modification systems, type II restriction endonucleases, nomenclature and sequence recognition, mcr and rnrr genotypes, linkers, adaptors, blunt end ligation, homopolymeric tailing, Transformation, methods in screening recombinant DNA. Radioactive and non-radioactive methods for labeling DNA: Nick translation, random priming, use of Klenow enzyme, T4 DNA polymerase, bacterial alkaline phosphatase, polynucleotide kinase, hybridization techniques, northern, Southern and colony hybridization. Restriction maps and mapping techniques. PCR technology, enzymes in PCR, hot-start, touchdown PCR, primer design, introduction of restiction sites etc. Construction of cDNA libraries in plasmids, hybrid select translation, RT-PCR and quantitative RT-PCR. Strategies for maximizing gene expression, prokaryote expression vectors; pMal, GST fusion vectors, pET vectors and their applications in expression, quantitation, purification. Inclusion bodies, approaches to solubilization, Intein based expression and peification vectors. Cloning in M13 mp vectors, application to DNA sequencing, site-directed mutagenesis; PCR-based mutations. Transcription vectors. Lambda vectors; insertion and replacement vectors, selection and screening recombinant phage, in vitro packaging, genomic libraries and cDNA cloning, application of lgt10, lgt11, lZAP vectors. Cosmid vectors. Yeast transformation, yeast cloning vectors, specialized vectors such as gap and retrievers, principles and application of dihybrid systems. Cloning and expression in mammalian cells, methods of selection and screening, application of reporter genes. Basic principles of transcriptomics and proteomics.

Text/References:

- W. Old & Primrose; Principles of Gene Manipulation. S.B.University Press, 6th edition, 2001.
- T. Maniatis, E.F. Fritsch & J. Sambrook; Molecular Cloning: A Laboratory Manual. CSHL, 3rd edition, 2002.
- M.A. Innis, D.H. Gelfand, J.J. Sninsky & T.J. White. PCR Protocols. Academic Press, 1990.

BB 505 Molecular Immunology (2 1 0 6)

Natural immunity, defensins, pathogen associated recognition motifs, Toll receptors, complement system, applications of complement proteins in rapid clearance of pathogens, acquired immunity: immune cells, antigens haptens, B and T cell epitopes, antibodies: structure and function, monoclonal antibodies, single chain antibodies, domain antibodies, antigen antibody reactions, genetics of immunoglobulins and antibody diversity, Major Histocompatibility Complex, structure and functions of class I and class II MHC molecules, antigen presentation by MHC and non MHC molecules, cytokines, in vivo regulation of immune responses, B and T cell activations, hypersensitivity, mucosal immunity, introduction to transplantation immunology tolerance, tumor immunology and vaccines.

Text/References:

- Janes Kuby; Immunology 2nd edition. W.H. Freeman and Company New york (1994).
- I. M. Roit; Essential Immunology. Blackwell Scientific publication,1988.
- W.E. Paul; Fundamental Immunology. Raven Press, 1998.

- Immunobiology: the immune system in health and disease. 5th ed. C A Janeway et al., Garland Publishing company, 2001.
- Cellular and Molecular Immunology. 4th ed. A K Abbas, A H Lichtman, J S Pober, W B Saunders Company, 2000.

BB 553 Bioinformatics (1 0 4 6)

Introduction; Databases - sequence, structure, non-redundant; Sequence alignment - pairwise and multiple; phylogenetics; ORFinder; Structure prediction methods – high-accuracy, template based, free modeling (new folds); Secondary structure prediction; Pattern recognition – PSSMs, weight matrices; hidden Markov models

Text/References:

- Bioinformatics. Keith, J. Humana Press, 2008.
- Computer methods for macromolecular sequence analysis. R.F.Doolittle, Academic Press, 1996.
- Bioinformatics. Sequence and genome analysis. D.W.Mount. Cold Spring Harbor Lab. press. 2004.
- Bioinformatics and functional genomics. J. Pevsner. Wiley-Liss, 2003.
- Encyclopedia of Genetics, Genomics, Proteomics & Bioinformatics, Jorde et al., (eds.) John Wiley and Sons, 2005.

For Engg-background students

BB 411 Introduction to Molecular Cell Biology

Biochemical unity and biological diversity. Relationship between structure and function. Separation techniques: basis and importance. Microbial kingdom. Prokaryotes, eukaryotes, archaea. Microbial growth. Hemoglobin: portrait of an allosteric protein. Enzymes. Catalytic and regulatory strategies. Carbohydrates, lipids, membranes. Signal transduction. Metabolism: basic concepts and design. Oxidative and photo-phosphorylation. Integration of metabolism. Flow of genetic information. Recombinant DNA technology. Genomes. Concept of homology.

Text/References:

- Biochemistry by Berg, Tymoczko, Stryer, 6th ed. 2007, WH Freeman and Co.
- Principles of Biochemistry by Voet and Voet, 3rd ed. 2008, Wiley.
- Molecular Cell biology by Lodish et al., 6th ed., 2008, Freeman.