SCHOOL OF BIOMEDICAL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY, KURUKSHETRA

MASTER OF TECHNOLOGY (BIOMEDICAL ENGINEERING)
(W.E.F. 2013-14)

FIRST SEMESTER

Course No.	Title	Schedule of Teaching		Credit Point
		L-T-P	Total	
BME 501T	Biomedical instrumentation	3-0-0	3	3
BME 503T	Biomaterials and artificial organs	3-0-0	3	3
BME 505T	Biomedical signal processing	3-0-0	3	3
BME 507T	Anatomy and physiology	3-0-0	3	3
BME 509T	Bio-embedded systems	3-0-0	3	3
BME 511P	Lab.-I	0-0-4	4	2
BME 513P	Seminar-I	0-0-2	2	2
	Total	15-0-6	21	18

Weightage for Theory Courses:
During Semester Evaluation Weightage – 50%
End Semester Examination Weightage – 50%

Weightage for Lab. Courses:
During Semester Evaluation Weightage – 60%
End Semester Examination Weightage – 40%

MASTER OF TECHNOLOGY
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(W.E.F. 2013-14)

BIOMEDICAL INSTRUMENTATION

Course No. BME 501T **Credits: 3**
L T P Total **Sessional-50 Theory-50**
3 0 0 3 **Duration of Exam- Three hours**

INTRODUCTION TO BIOMEDICAL INSTRUMENTATION: Development of biomedical instrumentation, Biometrics, Introduction to the main-instrument system, Components of the main instrument system, Physiological Systems of the body, Problems encountered in measuring a living system, Design for bio-medical problems.

BIOPOTENTIALS AND ELECTRODES: Origin of Bioelectric potentials. The electrode-electrolyte system. polarizable and non-polarizable electrodes. Skin contact impedance. Electrodes for ECG, EEG & EMG, Microelectrodes.

BIOMEDICAL RECORDERS; Electrocardiograph, electroencephalograph & Electromyograph, Blood pressure measurement: direct and indirect methods.

BLOOD FLOWMETERS: Electromagnetic, Ultrasonic, NMR and Laser Doppler Blood flowmeters.

X-RAY IMAGING: X-ray machine. Image intensifiers & image noise. X-ray computed tomography. Emission computed tomography.

MAGNETIC RESONANCE IMAGING: MRI, Benefits and limitations of MRI

ULTRASOUND IMAGING AND THERAPY: Physics of ultrasonic waves. Generation, detection, absorption, reflection and diffraction of ultrasonic waves. Pulse echo system. Ultrasonic scanning: A-scanners & B-scanners.

RADIOTHERPY: Radiobiology and radiation physics treatment planning, Particle beam therapy, biological effects, Dosimetry in modern radiation therapy, Dose measurement.

Suggested reading:

1. A handbook of Biomedical Instrumentation by RS Khandpur
2. Biomedical Instrumentation & Measurement by Leslie Cromwell, Fred J Weibell & Erich A Pfeiffer.
3. Medical Instrumentation: Application and Design by Webster.
4. Medicine & Clinical Engineering by Bertil Jacobson & John G Webster.

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BIO-MATERIALS AND ARTIFICIAL ORGANS

Course No. BME 503T **Credits: 3**
L T P Total **Sessional-50 Theory-50**
3 0 0 3 **Duration of Exam- Three hours**

Structure of biomaterials :
Definition and classification of biomaterial – mechanical properties –visco – elasticity, elasticity of Non – Hoopkean material

Biocompatibility :
Wound healing process – body response to implants – blood compatibility

Metallic implants :
Stainless steel – cobalt based alloys – titanium based alloys –applications – deterioration of metallic implants

Ceramic and polymeric implants :
Aluminum oxides, Hydrokyapatite, Glass ceramics carbons, polymerization, acrylic polymers, rubbers, high strength thermoplastics, medical applications, deterioration of polymers.

Soft – tissue replacement implants :
Sutures, Surgical tapes, adhesives, percutaneous and skin implants

Hard – tissue replacement implants :
Internal fracture fixation devices, joint replacements dental implants

Artificial kidney devices :
Methods of artificial waste removal – hemodialysis, artificial kidney system.

Artificial heart – lung devices :
Use of patients Lungs for gas exchange – the ideal heart – lung devices – comparison of natural and artificial lungs.

Reference Books :
1. “Biomaterials science and engineering” 1984, Plenum press, New York, John Bu Park
2. “Biomaterial – an Interfacial approach” 1982, Academic press, New York, L.L. Hence & E.C. Ethridge.
3. “Biomedical engineering principles – an introduction to fluid, heat and mass transport processors” 1976, Marcel Decker, New York, David D. Cooney
4. Introduction to Bio – Materials by J. Park.

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BIOMEDICAL SIGNAL PROCESSING

Course No. BME 505T **Credits: 3**
L T P Total **Sessional-50 Theory-50**
3 0 0 3 **Duration of Exam- Three hours**

Fundamentals of Discrete-Time signals and systems
Concepts of system, signal. Sampling Process. Impulse Response. Z-Transform, Discrete Transfer function, Discrete Fourier Transform(DFT), Fast Fourier Transform(FFT). Medical Applications

The Electroencephalogram(EEG)
Applications, Signal Processing, Modeling and Artifacts. Nonparametric and Model-based spectral analysis, EEG segmentation, Joint Time-Frequency Analysis. Evoked Potential Modalities, Noise Characteristics, Noise reduction by Ensemble Averaging and Linear Filtering, Single-Trail Analysis and adaptive Analysis Using Basis Functions

Wavelets
Continuous Wavelet Transform. Discrete wavelet transform. Reconstruction. Recursive multi resolution decomposition. Types of wavelets-Haar wavelet, Daubechies wavelet, Biorthogonal wavelet. Coislet wavelet, Morlet wavelet, Mexican Hat wavelet, Symlet wavelet. Medical applications

The Electromyogram (EMG)
The electrical Activity of Muscles, Amplitude Estimation in the surface EMG, Spectral Analysis of the surface EMG, Conduction velocity Estimation, Modeling the EMG, EMG Signal Decomposition

The Electrocardiogram(ECG)
Heart Rhythms, Heart beat Morphologies, Noise and Artifacts, Baseline Wander, Power line interference, Muscle Noise Filtering, QRS Detection, Wave Delineation, Data Compression, Heart Rate Variability, Acquisition and RR Interval conditioning , Spectral Analysis of Heart Rate Variability.

Suggested Reading:
1. Leif Sornmo and Pablo Laguna, Bioelectrical Signal Processing in Cardiac and Neurological Applications, Academic Press, 2005
2. Willis J. Tompkins, Biomedical Digital Signal Processing, Prentice-Hall, 1993.
3. Rangaraj M. Rangayyan, Akay Metin(Editor),Biomedical Signal Analysis: A Case Study Approach, Wiley Interscience, 2001.
4. Roberto Cristi, Modern Digital Signal Processing

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ANATOMY AND PHYSIOLOGY

Course No. BME 507T **Credits: 3**
L T P Total **Sessional-50 Theory-50**
3 0 0 3 **Duration of Exam- Three hours**

Organization of Human Body: Anatomical position, terminology, regions and planes. Basic anatomy and physiology of cells, Tissues (epithelial, connective, muscle, nervous, blood, glands), Permeability of cell membrane, genesis of membrane potential excitation of cell.

Skeletal System: Functions of skeletal system, Anatomy of long bone, Bone histology, Naming all bones of axial and appendicular skeleton, Formation, growth and repair, Structural and functional classification of joints, Types of movement, Calcium homeostasis.

Muscular System: Functions of muscular system, Names of all major muscles, Origin, insertion and action, Sliding Filament Model, Neuromuscular junction, Structure (gross and microscopic), Physiology of muscle contraction, Muscle metabolism (ATP), Fiber types, Exercise physiology.

Cardiovascular System: Functions of circulatory system, Heart structures (chambers, valves, and vessels), Circulatory routes (systemic, pulmonary, coronary and hepatic portal), Blood vessels and pressure, Blood components, function and typing, Blood clotting, Regulation and conduction (EKG). Blood- composition, blood groups, role of R.B.C and W.B.C.

Lymphatic/Immune System: Functions of lymphatic system, Structures (vessels, nodes, cells), Lines of defense, Humoral immune response, Cell mediated immune response, Immune cell types.

Digestive System: Functions of digestive organs, Modes of mechanical digestion, Chemical digestion (hormones, enzymes, pH), Absorption and elimination, Name parts of GI Tract and accessory organs, Nutrition and metabolism (production of ATP).

Excretory System: Functions of urinary system, Kidney, ureter, bladder, urethra, Microanatomy and function of nephron, Formation of urine-steps involved.

Nervous System: Functions of nervous system, Nerve cell anatomy, Neural physiology (action potential, synaptic transmission, Na/K pump), Brain anatomy and hemispheres, Spinal cord anatomy, reflex arc, PNS (autonomic and somatic), Sensory motor nerve functions.

Suggested reading:

1. Charles E. Tobin, Basic Human Anatomy, Mc Graw Hill Publication.
2. J. H. Green An Introduction to Human Physiology.
3. H.B. Charles and B.N. Taylor; The Physiological Basis of Medical Practice. William and Wilkins, Baltimore, 1985.
4. C.A. Keele and Eric Neil; Samson Wright's Applied Physiology. ELBS, London, 1984.

5. S. West, E.R. Todd, W.S. Mason and H.J.T. Van Bruggen; Text Book of Biochemistry. Macmillan Co., 1976.
6. A.G. Guyton; Textbook of Medical Physiology; Saunders, Philadelphia, 1986.
7. Anatomy and Physiology in Health and Illness: Ross and Wilson (ELBS pub).
8. Human Physiology by A. Vander, J. Sherman and D. Luciano Mc Graw Hill.
9. Principles of Anatomy and Physiology: Tortora and Grabowski. (Haper Collin pub.).

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BIO-EMBEDDED SYSTEMS

Course No. BME 509T **Credits: 3**
L T P Total **Sessional-50 Theory-50**
3 0 0 3 **Duration of Exam- Three hours**

Introduction to microcontrollers, Architecture of 8051 microcontroller, basic instruction set, programming, timer operation, serial data communication, interfacing with D/A and A/D converters.

Introduction to Digital Signal Processors, Architectures of TMS-320 series, instruction set, Programming and Interfacing.

Applications of Microcontrollers and Digital Signal Processors in medical systems.

References:

1. K.J. Ayala, “Micro Controller”, Penram International.
2. Reference Manual of TMS-320 Digital Signal Processor.

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SECOND SEMESTER

Course No.	Title	Schedule of Teaching		Credit Point
		L-T-P	Total	
BME 502T	Medical imaging & processing	3-0-0	3	3
BME 504T	Diagnostic & therapeutic equipment	3-0-0	3	3
BME 506T	Tissue engineering	3-0-0	3	3
BME 508T	Electromagnetic bio-interaction	3-0-0	3	3
BME 510T	Bio nanotechnology	3-0-0	3	3
BME 512P	Lab.-II	0-0-4	4	2
BME 514P	Seminar-II	0-0-2	2	2
	Total	15-0-6	21	18

Weightage for Theory Courses:
During Semester Evaluation Weightage – 50%
End Semester Examination Weightage – 50%

Weightage for Lab. Courses:
During Semester Evaluation Weightage – 60%
End Semester Examination Weightage – 40%

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MEDICAL IMAGING & PROCESSING

Course No. BME 502T **Credits: 3**
L T P Total **Sessional-50 Theory-50**
3 0 0 3 **Duration of Exam- Three hours**

Basic Medical Imaging Modalities- X-ray, CT , Ultrasound, MRI, PET-CT, SPECT-CT, Gamma Camera, Catheterization Lab. Aspects of light imaging, convolutions and transforms, photometry lenses and depth of field, Image perception and 3D Imaging, Image acquisition, Display, Image processing operations, scanning & segmentation.

CT: Basic concepts of CT , Non Spiral CT technology, Concepts of Spiral CT Scanner , Multi Slice spiral technology , Various Peripheral devices. Applications: Multiplanar Reconstruction, Maximum Intensity Projection, 3D, CT Angio, Osteo , Dental, Perfusion (Body & Neuro), Virtual Endoscopy, Cardiac CT (Calcium scoring, Coronary Angiography, Lesion Quantification).

Magnetic Resonance Imaging : Permanent & Super conducting magnets, Signal generation and detection, signal characteristics, signal localization, Fourier transforms in MRI, Imaging Reconstruction. Image artifacts. Coil technology, Parallel acquisition techniques, Various peripheral devices. Applications: Functional Imaging, Perfusion & Diffusion imaging (Echo planar imaging), Multi direction diffusion tensor imaging, Single & Multi Voxel Spectroscopy, MR Angiography, MRCP, Cardiac MRI (Myocardium viability, Valve function etc.,).

Gamma Camera : Physics of Gamma camera, basic Instrumentation, Imaging techniques, SPECT & Whole Body studies. Applications of Gamma camera in Cardiology, Nephrology, Neurology etc., Ultrasound Scanner : Principles of Ultrasound, Basic Ultrasound instrumentation, Imaging techniques (A mode, B Mode, 2B, B/M, 4B , Gated Mode, 3D, 4D, M-Mode, Echocardiography) , Image recording devices, Image artifact, Biological effects.

Digitized image functions, Dirac distributions, convolution, Fourier transform, Images as linear system. Image digitization, sampling, Quantization, color images. Digital image properties, Metric and topological properties, Histogram visual perception, Image quality, Noise. Data structures for image analysis, data representation, traditional and hierarchical data structures.

Image Enhancement. Contrast manipulation, histogram equalization, Laplacian derivatives, Sobel and Klisch operators, rank operators –textural analysis. Image pre processing – pixel brightness transformations, Geometric transformations, local pre processing, Image restoration. Imaging filters.

Thresholding and Segmentation. Detection methods, optimal thresholding, multi-spectral thresholding. Edge based segmentation, Region based segmentation, Matching, Advanced optimal border and surface detection approaches.

Restoration. Deterministic, geometric linear filtration, inverse filtering, power spectrum equalization, stochastic. Wiener filtering. Registration, anatomy based, object based, scene based.

Suggested Reading:

1. John C Russ, *The image processing handbook*, CRC and IEEE press –1999.
2. Milan Sonka, Vaclav Hlavac,Roger Boyle, *Image processing, analysis and machine vision*, 2nd edition, Brooks/Cole publishing Co., 1999.
3. Jayaram, Kudupa and Gabor,T Herman, *3D imaging in medicine*, 2nd edition, CRC press, 2000.
4. Craig A. Hindley, *Practical image processing in C*, John Wiley and Sons 1991.
5. Hykes, Heorick, Starchman, *Ultrasound physics and Instrumentation MOSBY year book*, 2nd Ed., 1992.
6. Stewart C. Bushong, *Magnetic Resonance Imaging- physical and biological principles*, MOSBY, 2nd Ed.,1995.
7. Zhi-Pei Laing and Paul C. Lauterbur, *Principles of Magnetic Resonance imaging –A signal*

processing perspective, Metin Akay (Editor), IEEE press, New York, 2000.

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DIAGNOSTIC AND THERAPEUTIC EQUIPMENT

Course No. BME 504T **Credits: 3**
L T P Total **Sessional-50 Theory-50**
3 0 0 3 **Duration of Exam- Three hours**

Analytical Instrumentation: UV/Visible Spectrophotometer, Atomic Absorption Spectrophotometer, Mass Spectrophotometer, Radio Chemical Instruments, Automated biochemical Analysis system, Gas Chromatography – Liquid Chromatography, Blood Gas Analyzer, Blood Cell Counter, Auto Analyzer. CO_2 incubators, Cryo Centrifuges.

Cardiac Valves, different types – Mechanical and Tissue types. Angioplasty. Balloon and Stent Angioplasty. Stents, different types – coil, slotted tubular, drug eluting stents, Sterilization techniques: Autoclave, Gas, Dry Heat, Radiation, Dry Steam sterilization. Lithotripsy Systems. Techniques and Equipment

Intensive Coronary Care UNITs: Central Monitoring system, Drug Delivery Systems, Intelligent Drug Delivery, Neurological Instrumentation, Respiratory Care UNIT Equipment, Nebulizers, Mechanical Ventilators, CPAP. Advanced Life Support Systems: Cardiac Life Support Equipment, Pediatric Advanced Life support & Neonatal Resuscitation.

Operation Theatre Equipment : Surgery Equipment, Electrosurgical UNITs, Laser Surgery, CO_2, Nd YAG, Ruby, Argon, Krypton, Lasers. Endoscopy Types, Rigid, Flexible. Illuminations and Image transmission systems Laparoscopy, Keyhole surgery. Perfusion Equipment, Anaesthesia, Ventilators, Heart Lung machine, Fumigators

Radio Therapy. Cobalt UNIT, Ionization Chambers, Geiger Muller Counters, Gas proportional counters, Scintillation Counters, Solid State Radiation Detectors, Linear Accelerators, Radiation Therapy Stimulator, Treatment planning system.

Suggested Reading :

1. John G. Webster (Editor-in-Chief), *Encyclopedia of Medical Devices and Instrumentation* Vol.1 to Vol.4, John Wiley and Sons, 1988.
2. Khandpur R. S., *Handbook of Bio-Medical Instrumentation*, Tata McGraw Hill, 2nd Ed., 2003.
3. Joseph Bronzino (Editor-in-Chief), *Handbook of Biomedical Engineering*, CRC Press, 1995.
4. Harry Bronzino E, *Handbook of Biomedical Engineering and Measurements*, Reston, Virginia.

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TISSUE ENGINEERING

Course No. BME 506T **Credits: 3**
L T P Total **Sessional-50 Theory-50**
3 0 0 3 **Duration of Exam- Three hours**

Growth and Differentiation, Organisation of cells into Higher ordered structures, Dynamics of cells- ECM interactions, Matrix molecules and Their ligands, Inductive Phenomena, Cell Determination and Differentiation, Mechanical and Chemical determination of Tissue Development , Animal Cell Culture, Regulations of cell Behaviours cellular proteins, Growth factors , Tissue Assembly in Micro Gravity, In vivo Synthesis of Tissues and Organs.

Organotypic and Histiotypic Models of Engineered Tissues, Quantitative aspects of Tissue Engineering: Basic Issues in Kinetics, Transport and Mechanics, Patterning of cells and their environment, Cell Interactions with Polymers, Matrix Effects , Polymer Scaffold Processing, Biodegradable Polymers .

Approaches to transplanting Engineered cells and Tissues, Cryopreservation, Immunomodulation, Immuno isolation, Engineering challenges in immune isolation, Fetal tissue Engineering, Pluri potent stem cells, Gene Therapy.

Applications: Breast Reconstruction, Cardiovascular Systems-Blood Vessels, Small diameter Vascular Grafts, Cardiac Prosthesis. Cornea. Endocrinology and Metabolism-Bioartificial Pancreas, Parathyroid.

Musculoskeletal System-Structural Tissue Engineering, Bone Regeneration through Cellular Engineering. Gastrointestinal System –Alimentary tract, Liver, Hepato Assist liver support system, Linage Biology and liver. Hematopoitic Systems-Red Blood Cell Substitutes, Lymphoid Cells, Hemapoietic Stem Cells. Kidney and Genitourinary system-Renal Replacement Devices, Genitourinary System.

Suggested Reading :

1. Robert P. Lanza, Robert P. Langer, Joseph P. Vacanti, *Principles of Tissue Engineering*, Academic Press, 2nd ed. 2000.
2. Farshid Guilak, David L. Butler, Steven A. Goidstein, *Functional Tissue Engineering*, Springer Verlag, 2004.
3. Frederick H. Silver, *Biomaterials, and Medical Devices & Tissue Engineering: An integrated approach*, Chapman & Hall, London, 1994.

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BIOLOGICAL EFFECTS OF RADIATION

Course No. BME 508T **Credits: 3**
L T P Total **Sessional-50 Theory-50**
3 0 0 3 **Duration of Exam- Three hours**

Electromagnetic Spectrum, Exposure and absorption parameters, International guidelines, Currents induced in standing human being for vertically polarized plane wave exposure conditions, contacts hazards in VLF to HF band, thermal implications of high SARs. Coupling of human body to RF magnetic fields, Radio Frequency protection guide(RFPG).

EM bio engineering: Extremely LF,EM fields, dielectric heating, broadcast radiation, MW ovens, EM fields in medicine, electrical properties of biological substances, Interaction mechanisms. Application of the finite-differences time domain and the SINC-function Fast Fourier Transform method of moments.

Role of Experimental Techniques and Instrumentation in bioelectromagnetics: Irradiation systems for bioeffects experiments, Far-field exposure techniques, Instrumentation, Measurements of internal fields and radiofrequency absorption in biological systems, Instruments for measuring Specific Absorption Rates.

EM energy absorption in human and animals: Measurement techniques, Free space irradiation conditions, Ground effects, SAR exposure assessment and safety guidelines. Biological effects and Health implications: Effects due to extremely LF and 60 Hz fields.

Biological effects of millimeter wave radiation: Experimental approaches, frequency specific effects, genetic systems, cellular and sub cellular effects. Electromagnetic methods for medical applications.

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.

Suggested Reading:

1. Gandhi Om.P, Biological effects and medical applications of Electromagnetic Energy Biophysics and Bioengineering series, Prentice Hall Advanced reference series, Englewood cliffs, New Jersey,1990
2. Franceschetti G, Om P Gandhi and Matini Grandlfo,Electromagnetic biointeraction,Plenum Press, New York,1989.

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BIO-NANOTECHNOLOGY

Course No. BME 510T **Credits: 3**
L T P Total **Sessional-50 Theory-50**
3 0 0 3 **Duration of Exam- Three hours**

INTRODUCTION TO NANOTECHNOLOGY: Nanomaterials, Fullerenes and carbon forms. Nanoparticles and Colloids, structure and bonding in nanoparticles, Nanomaterials fabrication by Bottom-up and Top down approaches, Classification of nanodevices based on the characteristics, Quantum dots and their properties.

MEMS & NEMS: Definition of MEMS, materials for MEMS (Silicon, Polymers and metals) and their properties, Deposition processes, Photolithography, and etching processes, Limitations of MEMS, NEMS, difference between MEMS and NEMS, properties of NMES, fabrication processes,
applications.

NANO-AND MICRO SYSTEMS: Biomimetics, Biological analogies, and design– Biomimetics Fundamentals, Biomimetics for NEMS and MEMS, Nano-ICs and Nanocomputer architectures, Biomimetics and nervous systems.

NANOMEDICINE: Medical use of Nanomaterials, Drug delivery systems. Cancer treatment, Surgery. Drug tracking systems. Targeted drug delivery systems. Applications of Nanomaterials in Medical imaging.

BIO MOLECULAR NANOTECHNOLOGY: Nanorobots and their application, nanosensors based on biomolecules, nanoparticles for gene delivery systems, Biosensors, Optical biosensors and their application.

Suggested Books:

1.Micro-Electro Mechanical and Nano-Electro Mechanical Systems, Fundamental of Nano- and Micro-Engineering. Sergey Edward Lyshevski, Lyshevski Edward Lyshevski,CRC Press

2.Nanomaterials:Synthesis,Properties and Applications, A.S.Edelstein and R.C.Cammarata(edits),Institute of Physics

3.Micro-Electro Mechanical and Nano-Electro Mechanical Systems, Sergy Edward Lyshevski,CRC Press

4. Lynn E. Foster, Foreword by George Allen, Foreword by Joe Lieberman, Nanotechnology: Science, Innovation, and Opportunity, Nanomedicine: Basic Capabilities, Vol. 1 by Robert A. Freitas Jr. 1999 Rev

5. Neelina Malsch , Biomedical nanotechnology by CRC press release, *Malsch TechnoValuation, Utrecht, The Netherlands*

THIRD SEMESTER

Course No.	Title	Schedule of Teaching		Credit Point
		L-T-P	Total	
BME 515P	Preparatory Work for Dissertation	0-0-20	20	10
			20	10

NOTE: The Preparatory work for dissertation shall be evaluated by a committee comprising the following {on the basis of one mid semester seminar and one end semester seminar presented and one end semester report submitted by the candidate}.

1. HOD or faculty nominee proposed by HOD.
2. Dissertation Supervisor (and co-supervisor).
3. Two senior most faculty members of the department.

FOURTH SEMESTER

Course No.	Title	Schedule of Teaching				Credit Point
		Lecturer	Tutorial	Practical	Total	
BME 516D	Dissertation	0	0	32	32	16
					32	16

NOTE:

I. The Dissertation shall be evaluated by a committee comprising the following through presentation cum viva-voce examination.
1...HOD or faculty nominee proposed by HOD.
2. Dissertation Supervisor (and co-supervisor).
3. One external expert appointed by the department.

II. For award of grade, following criteria to be used.

Grade	Conditions to be fulfilled
A+	One paper accepted/published in SCI Journal
A	One good quality paper accepted/published in non-paid journal or two good quality papers presented in International/National Conference.*
B	One good quality paper presented in International Conference
C/D	In other cases

* Conference organized by IIT/NIT/a premier R & D organization.

Non-Credit Based Dissertation Evaluation