Scheme of Teaching

&

Detailed Syllabus

For

Masters in Technology

Biomedical Engineering

M. Tech. (BM)

(Two Year Program)

(w.e.f. Academic Session 2018–19)

School of Engineering & Technology

Shobhit Institute of Engineering & Technology

(Deemed to-be University)

NH-58, Modipuram, Meerut (U.P.) – 250110

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Overview: Biomedical Engineering integrates biological, chemical, physical, mathematical, computational sciences with engineering principles and techniques to apply to the problems in the medical field. The main purpose of the field is to improve patient health care and the quality of life for healthy individuals. Therefore, it advances fundamental concepts and creates knowledge from the molecular to the organ systems levels. The broad research and development array of the biomedical engineering area consists of medical imaging, image processing, physiological signal processing, synthesis and design of biocompatible prostheses, medical devices, material-cell interactions, nano-patterned surfaces, biosensors, biocompatibility, tissue engineering, mechanical analysis of locomotion and movement, cell and tissue mechanics, mechanical characterization and identification of biological materials, biomechanical modeling and simulation, biostatics and biodynamics of solids and fluids, biomolecular systems, genome assembly, protein structure and alignment, prediction of gene expression, etc.

Programme Objectives:

1 **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2 **Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3 **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4 **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5 **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6 **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7 **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8 **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9 **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10 **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11 **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12 **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs):

1. Acquire knowledge of Instrumentation and Control Engineering with ability to evaluate, analyze and synthesize knowledge related to Biomedical Instrumentation.
2. Analyze complex problems related to Instrumentation and Control Engineering and synthesize the information for conducting research.
3. Think laterally to solve problems related to Instrumentation and Control Engineering with emphasis on Biomedical Instruments/devices/equipment and provide / suggest a range of solutions considering health, safety, societal, and environmental factors.
4. Extract knowledge through literature survey, experimentation and appropriate research methodology, techniques and tools.
5. Learn and use contemporary tools for solving problems related to Biomedical Instrumentation, measurement analysis and Control etc.
6. Understand group dynamics and rational analysis in order to achieve common goals. PO7: Ability to write clearly and to document own work for effective utilization.
7. Engage in life-long learning and learning through mistakes with / without external feedback.
8. Understand the impact of research and responsibility in order to contribute to the society. PSO10: Understand the role of a leader, leadership principles and attitude conducive to effective professional practice of Instrumentation and Control Engineering.

Eligibility Criteria:

This program is open to the students with an undergraduate degree from departments of science, medicine, and, engineering. Graduates might be required by the Admission Committee to take preparatory courses for a period of up to 2 semesters depending on the individual's background. Major research areas are Bioelectrical Engineering, Biomaterials, Biomechanics, Biomolecular Engineering

Credit Distribution:

Category	Courses	L	T	P	Credits
Core (BME)	9	27	9	-	**36**
Departmental Elective	3	9	3	0	**12**
Laboratory	2	-	-	8	**4**
Internship / Project/ Seminar	3	0	0	16	**22**
Total	**17**	**36**	**12**	**24**	**74**

Course Code	Course name	Course outcomes	
Semester I			
BMMT-501	**Applied Bioelectricity**	CO1	Identify the major bones and their processes as they relate to each region of the body.
		CO2	Identify the findings from a simulated healthcare record such as electrocardiogram data and pulmonary ventilation outcomes.
		CO3	Tell briefly the basic components and functions of the gastrointestinal, renal/urinary, endocrine/metabolic, hepatic/biliary, genital/reproductive and immunologic, systems.
		CO4	Identify the major structures of the human anatomy for the following;(i). Head and neck, thoracic, abdominopelvic, and upper and lower extremities,(ii). Major skeletal muscles, their actions, origins, insertions, and peripheral nerves,(iii). Central nervous system and plexuses,(iv). Respiratory system, and(v). Cardiovascular/hematologic system.
BMMT-503	**Biomaterials and Nanomedicine**	CO1	Characterize the material and define their biological application.
		CO2	Aware with the several applications of nanomaterials in biomedical.
		CO3	Differentiate between the biocompatible and non-biocompatible materials.
		CO4	Understand the basic knowledge of Nanotechnology and DNA structures.
		CO5	Provide the knowledge in basics of nanotechnology in biotechnology.
			Understand the application of Nanomaterials in biotechnology and acquire the knowledge about the DNA, proteins, amino acids, drug delivery, biomedicine etc.
BMMT-505	**Bio-instrumentation**	CO1	To understand the fundamentals of biomedical signals.
		CO2	To impart knowledge about the neurological signal processing.
		CO3	To provide a deep knowledge about the cardiological signal processing and analysis.
		CO4	To apply adaptive filtering techniques for canceling noise and interference in the various Bio-signals.
		CO5	To learn about pattern classification techniques and their use in diagnosis.
BMMT-521	**Human Anatomy and Physiology / Biomedical**	CO1	To describes the form and organization of various anatomical structures and determines how they can functions.

	Computing	CO2	To give terms with precise meaning helps investigators to communicate effective.
		CO3	To provide knowledge about systems and how they are dependent on each other to survive and operate the human body.
		CO4	Provide the knowledge for sequence alignment and visualization along with phylogenetic and microarray analysis.
Semester II			
BMMT-502	**Biomedical Imaging**	CO1	To gain knowledge about the various image enhancement techniques.
		CO2	To study the basic image fundamentals and transforms applicable in medical image analysis.
		CO3	To apply various segmentation techniques and algorithms in Medical Images.
		CO4	To study the applications of medical image analysis in various imaging modalities.
		CO5	To acquire knowledge about the medical image registration and fusion techniques.
BMMT-504	**Advance Biomechanics**	CO1	To study about the bone structure and functions of skeletal muscle.
		CO2	To study the structure, movements, and loads applied on Upper Extremity and Lower Extremity.
		CO3	To study about the Linear and Angular kinetics and kinematics of human movement.
		CO4	To understand the fundamentals of finite element analysis.
		CO5	To implement the fundamental processing of Ansys.
BMMT-506	**Biosensors and Transducers**	CO1	To understand the fundamentals of biomedical signals.
		CO2	To impart knowledge about the neurological signal processing.
		CO3	To provide a deep knowledge about the cardiological signal processing and analysis.
		CO4	To apply adaptive filtering techniques for canceling noise and interference in the various Bio-signals.
		CO5	To learn about pattern classification techniques and their use in diagnosis.
BMMT-508	**IPR and Biomedical Ethics**	CO1	To gain knowledge on basic human values.
		CO2	To understand how to take responsibility for morals and mistakes.
		CO3	To understand the role of engineers in decision-making.
		CO4	To get familiar of ethical issues in medicine, health care and life science
		CO5	To develop aptitude to understand law and problems relevant to it.

Semester-III			
BMMT-601	**Rehabilitation Engineering**	CO1	To study about the basic concepts of robots and types of robots.
		CO2	To study about manipulators, actuators and grippers.
		CO3	To study about various types of sensors and power sources.
		CO4	To study the various applications of robot in the medical field.
BMMT-603	**BioMems and Embedded System**	CO1	To understand the working of MOEMS Technology.
		CO2	To understand the working principle of MEMS & Microsystems.
		CO3	To understand the concepts of BioMEMS& its application in healthcare.
		CO4	To study about the biomedical Nanotechnology & its application in research domain.
		CO5	To give an insight to the DNA based BioMEMS.
BMMT-621	**Biomedical application to Physiotherapy and Orthotics**	CO1	To understand the basics of Biomechanical, physiological and anthropometric background.
		CO2	To impart the knowledge about the user information, controls, relationship between information and operation.
		CO3	To gain a deep knowledge about the different guidelines related to environmental factors.
		CO4	To understand basics of Tissue Engineering
		CO5	To understand fundamentals of cell mechanisms
		CO6	To teach the Physical & biological principles that serve as the scientific basis for understanding the interactions of biological molecules and cells with biomaterials employed for the fabrication of permanent implantable prostheses and as matrices for tissue engineering.
		CO7	To Study ergonomics in healthcare.
BMMT-623	**Biomedical Signal Processing / Biomedical Information Technology**	CO1	To understand the fundamentals of biomedical signals.
		CO2	To impart knowledge about the neurological signal processing.
		CO3	To provide a deep knowledge about the cardiological signal processing and analysis
		CO4	To apply adaptive filtering techniques for canceling noise and interference in the various Bio-signals
		CO5	To learn about pattern classification techniques and their use in diagnosis.
		CO6	To make them understand organs and advances in medical informatics and telemedicine.
		CO7	To impart knowledge on management of medical data.
		CO8	To introduce the basic concepts of tele-radiology.

		CO9	Brief about various applications in telemedicine.
Semester-VIII			

Subject		L	T	P	Credit
Semester I					
BMMT- 501	Applied Bioelectricity	3	1	0	4.0
BMMT- 503	Biomaterials and Nanomedicine	3	1	0	4.0
BMMT- 505	Bio-instrumentation	3	1	0	4.0
BMMT- 521	Human Anatomy and Physiology / Biomedical Computing	3	1	0	4.0
BMMT- 551	Bio-instrumentation Lab	0	0	3	2.0
BMMT- 581	Seminar	0	3	0	2.0
Total					20.0
Semester II					
BMMT- 502	Biomedical Imaging	3	1	0	4.0
BMMT- 504	Advance Biomechanics	3	1	0	4.0
BMMT- 506	Biosensors and Transducer	3	1	0	4.0
BMMT- 508	IPR and Biomedical Ethics	3	1	0	4.0
BMMT- 552	Biomedical testing and calibration Lab	0	0	4	2.0
BMMT- 582	Seminar	0	3	0	2.0
Total					20.0
Semester III					
BMMT- 601	Rehabilitation Engineering	3	1	0	4.0
BMMT- 603	BioMems and Embedded System	3	1	0	4.0
BMMT- 621	Biomedical application to Physiotherapy / Biomedical application to Prosthetics and Orthotics	3	1	0	4.0
BMMT- 623	Biomedical Signal Processing Biomedical Information Technology	3	1	0	4.0
BMMT- 671	Minor Project	0	0	8	4.0
Total					20.0
Semester IV					
BMMT- 692	Dissertation	0	0	28	14.0
		Total			14.0
		Grand Total			74.0

Course code	**BMMT-501**				
Category	Core Biomedical				
Course title	**Applied Bioelectricity**				
Scheme and Credits	**Credit**	**L**	**T**	**P**	
	4	4	0	0	
Pre-requisites (if any)	Basic Knowledge of Biology				
Objectives	The prime concern of this syllabus is to integrate the individual functions of all the cells and tissues and organs into functional whole, the human body. Since function is dependent on a structure, the curriculum lays stress on functional anatomy of the organs. It attempts to highlight the necessary bodily balances and internal bodily control so called homeostasis as well as present their abnormal function in disease. It provides a link between basic sciences and Medicine.				
Outcomes	Upon successful completion of the course, the student will be able to: Label the functions of the human anatomy and physiology from a regional perspective for the following regions and systems: a. Head and neck, thoracic, abdominopelvic, and upper and lower extremities. 1. Major skeletal muscles, their actions, origins, insertions, and peripheral nerves. c. Central nervous system and plexuses d. Respiratory system e. Cardiovascular/hematologic system 2. Identify the major structures of the human anatomy for the following: a. Head and neck, thoracic, abdominopelvic, and upper and lower extremities. b. Major skeletal muscles, their actions, origins, insertions, and peripheral nerves. c. Central nervous system and plexuses d. Respiratory system e. Cardiovascular/hematologic system 3. Identify the major bones and their processes as they relate to each region of the body. 4. Tell briefly the basic components and functions of the gastrointestinal, renal/urinary, endocrine/metabolic, hepatic/biliary, genital/reproductive and immunologic, systems. 5. Identify the findings from a simulated healthcare record such as electrocardiogram data and pulmonary ventilation outcomes.				
Unit I	Introduction, Genesis of mechanism, production and transmission of bioelectric signals, measurement of signals and their analysis in basic and clinical electrophysiology. Electrical properties of biological tissues, DNA, dielectrical theories, biological bond water, electrical model of membrane and cell, biological electrolytes, frequency dependent bioelectrical phenomena.				**08**
Unit II	Biomedical applications of electric and magnetic fields. Electro-stimulation and fracture healing. Electroporation, Electrical Shock Trauma. Electrical Stimulation of the Central Nervous System. Transcranial Magnetic Stimulation of Deep Brain Regions. An Implantable Bionic Network of Injectable Neural Prosthetic Devices: The Future Platform for Functional Electrical Stimulation and Sensing to Restore Movement and Sensation. Computational Methods and Software for Bioelectric Field Problems, Biomagnetism and measurements.				**08**
Unit III	Principles of design and operation of therapeutic medical devices used in the cardiovascular, nervous systems and orthopedic appliances. Includes membrane potential, action potentials, channels, Axon Transmission and synaptic transmission. Hodgkin-Huxley formulation, Membrane conductance, Nerve conduction, membrane properties from current voltage relations, Models of squid axon. Propagation of impulses in unmyelinated and myelinated nerve fiber. Electrical properties of receptors. Intensity-frequency relationship. Electrical properties of synaptic junctions - EPSP and IPSP.				**08**

Unit IV	Electrocardiography, Characteristics of Action potentials at SA Node, Atria, AV Node, Purkinje fibers and Ventricles. ECG Complexes. 12 lead ECG. Standard leads of Einthoven. Pericardial leads and Augmented limb leads. Relationship between unipolar extremity leads and standard Bipolar leads, Impedance Plethysmography, Impedance Cardiography, Tissue Characterization, EEG, ENG, ERG, EOG, Electrogastrography, EMG and Neurography.	**08**
Unit V	Electrical Impedance Spectroscopy and tomography, Electrotherapy, Body Composition Analysis, Implanted Active Thoracic, Defibrillation and Electroshock, Electrosurgery, Cell Suspensions, Skin Instrumentation, Non-medical Applications, Electrical Safety. Physiotherapy and Instrumentation.	**08**
References	1. L.a. Geddes, L.e. Baker, *Principles of Applied Biomedical Instrumentation*, 3rd edn., Wiley India Pvt. Ltd, New Delhi, 2008. 2. A. A. Marino, *Modern Bioelectricity*, CRC Press, New York 1988. 3. J. Behari, *Biophysical Bone Behaviour: Principles and Applications*, John Wiley & Sons (Asia) Pvt. Ltd, Singapore, 2009. 4. J. G. Webster, *Medical Instrumentation: Application and Design*, 3rd edn., Wiley India Pvt. Ltd, New Delhi, 2007. 5. R. Plonsey and R. C. Barr, *Bioelectricity: A Quantitative Approach*, 3rd edn., Springer 2007.	

Course code	**BMMT-503**				
Category	Core Biomedical				
Course title	**Biomaterials and Nanomedicine**				
Scheme and Credits	**Credit**	**L**	**T**	**P**	
	4	4	0	0	
Pre-requisites (if any)	Basic Knowledge of Biology				
Objectives	Basic objective of this subject is to introduce the students with the characterization techniques of the biomaterials and their application.				
Outcomes	Upon successful completion of the course, the student will be able to: 1. Characterize the material and define their biological application 2. Aware with the several applications of nanomaterials in biomedicals. 3. Differentiate between the biocompatible and non-biocompatible materials. 4. Understand the application of Nanomaterials in biotechnology and acquire the knowledge about the DNA, proteins, amino acids, drug delivery, biomedicine etc. 5. Understand the basic knowledge of Nanotechnology and DNA structures. 6. provide the knowledge in basics of nanotechnology in biotechnology.				
Unit I	Biomaterials: Definition, Classification, properties and biocompatibility. Biological responses (extra and intra-vascular system). Controlling and Assessing Cell–Biomaterial Interactions at the Micro and Nanoscale. Surface properties of materials, physical properties of materials, mechanical and thermal properties.				**08**
Unit II	Metallic Biomaterials, Ceramic Biomaterials, Polymeric Biomaterials, Composite Biomaterials, Biodegradable Polymeric Biomaterials, Tissue-Derived Biomaterials (Collagen and Chitin-based biomaterials), Polymeric hydrogels, Soft Tissue Replacements, Hard Tissue Replacements, Standards of implant materials, Types of implants in surgical uses and probability of implant failures.				**08**
Unit III	Characterization of biomaterials, drug delivery applications, tissue engineering from both orthopaedic and vascular perspective. Definition of biocompatibility, blood compatibility and tissue compatibility. Toxicity tests: acute and chronic toxicity studies, sensitization, carcinogenicity, mutagenicity and special tests. ETO, gamma radiation, autoclaving. Effects of sterilization on material properties. *In vitro* testing (Mechanical testing), *In-vivo* testing (animals) and *Ex-vivo* testing: *in vitro* testing simulating the *in vivo* conditions.				**08**
Unit IV	Different types of Nanoparticles, Biocompatible Nanomaterials and Nanodevices Promising for Biomedical Applications, Methods and Applications of Metallic Nanoshells in Biology and Medicine, Micro- and Nano-electromechanical Systems, Microfluidics and Nanofluidics, Nanotechnology on a Chip, Microscopy for Nanoparticle Characterization, Biomedical Applications of Self-Assembly of Nanoparticles.				**08**
Unit V	Nanoparticles in Medical Diagnostics and Therapeutics, Magnetic Nanoparticles as Contrast Agents for Medical Diagnosis. Nanopharmaceuticals, Role of Nanotechnology in Biological Therapies, Nanodevices for Medicine and Surgery, Nanotechnologies related to Oncology, neurology, cardiology, Orthopedics (Novel Bionanomaterials for Orthopedics), microbiology, Regenerative Medicine				**08**

	& Tissue Engineering, and Nano-Ophthalmology, Research and Education in Nanomedicine, Future of Nanomedicine.	
References	1. J. B. Park, *Biomaterial: An Introduction*, Springer., New York, USA, 2007. 2. B. D. Ratner, A. S. Hoffman, FJ. Schoen, JE. Lemons. *An Introduction to Materials in Medicine*, 2nd edn., Elsevier Academic Press, London, 2004. 3. T. S. Hin, *Engineering Materials for Biomedical Applications*, World Scientific Publishing Co. Pte. Ltd. 2004. 4. D. V. Rai, R. C Sobti and R. Bahadur, *Emerging Trends in Biomedical Science and Health*. I.K. International, Chandigarh, India, 2009. 5. B. Basu, D.S. Katti, and A. Kumar, *Advanced Biomaterials: Fundamentals, Processing, and Applications*, Wiley-American Ceramic Society, 2009.	

Course code	**BMMT-505**				
Category	Core Biomedical				
Course title	**Bio-instrumentation**				
Scheme and Credits	**Credit**	**L**	**T**	**P**	
	4	4	0	0	
Pre-requisites (if any)	Basic understanding of signal processing				
Objectives	Basic objective of this subject is to create the Understanding of basic concepts of biomedical signals and to analyze the various				
Outcomes	Upon successful completion of the course, the student will be able to: 1. To understand the fundamentals of biomedical signals 2. To impart knowledge about the neurological signal processing 3. To provide a deep knowledge about the cardiological signal processing and analysis 4. To apply adaptive filtering techniques for canceling noise and interference in the various Bio-signals 5 To learn about pattern classification techniques and their use in diagnosis				
Unit I	Introduction: Development of biomedical instrumentation, 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. The transducer and transduction principles, Active and Passive transducers, Types of Transducers.				**08**
Unit II	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				**08**
Unit III	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.				**08**

Unit IV	Muscle-Load Oscillations: Detection, Analysis, and Models. Parallel Information Processing in Biological Systems: From Phototransduction to Neural Networks, Noninvasive Measurement of Intracranial Pressure, Chemistry and Potential Methods for in Vivo Glucose Sensing, Invasive and Noninvasive Blood Gas Monitoring, Characterization of the Conduction Properties of Nerves with the Distribution of Fiber Conduction Velocities, Biocatalytic Membrane Electrodes	**08**
Unit V	Modeling and Identification of Lung Parameters, Noncontact Temperature Measurements in Medicine, Electrochemically Simulated Hearing Loss and the Perception of Degraded Speech, Immobilized Bioelectrochemical Sensors, Systems for Monitoring Brain Function, Automated Monitoring and Interpretation of Sensory Evoked Potentials.	**08**
Course Title	Bioinstrumentation Lab.	**CR**
Course code	**BMMT-551**	**1.0**

PRACTICALS : (Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Transducers for physiological parameters. Blood Flow and Pressure Measurement (Direct blood pressure measurement Indirect blood pressure measurement), Electromagnetic flow meter and Ultrasonic flow meter.
2. Polygraph studies – ECG, EMG & EEG experiments. Bio – Medical instrumentation amplifiers. Human Body Composition & Fluid Measurement. Nerve – muscle stimulation.
3. Spiro meter and respiratory measurements. Photometric and optical instrumentation, photoplethysmography. Amplifiers, Low pass and High pass Filters.
4. Data acquisition application using NI-DAQmx & Data acquisition application using Lab VIEW. Computerized signal acquisitions A/D, D/A interfacing.

References

1. R. S. Khandpur, Handbook of Bio-Medical Instrumentation, Tata McGraw Hill, India, 2005.
2. C. R. Rao and S. K. Guha, Principles of Medical Electronics and Biomedical Instrumentation (Biomedical engineering), Universities Press,India, 2004.
3. C. W. Pfeiffer, Biomedical Instrumentation & Measurement, Cromwell-Prentice Hall of India, New Delhi, 2003.
4. J. G. Webster, Bioinstrumentation, 3rd edn, Wiley & Sons.2004.
5. J. Bronzino, Biomedical Engineering & Instrumentation, CRC Publication, 2006.

Course code	**BMMT-521**				
Category	Departmental Elective				
Course title	**Human Anatomy and Physiology**				
Scheme and Credits	**Credit**	**L**	**T**	**P**	
	4	4	0	0	
Pre-requisites (if any)	Basic understanding of signal processing				
Objectives	A good understanding of human anatomy and physiology which is basis of medicine.				
Outcomes	1.To describes the form and organization of various anatomical structures and determines how they can functions 2. To provide knowledge about systems and how they are dependent on each other to survive and operate the human body 3. To give terms with precise meaning helps investigators to communicate effective				
Unit I	Geometrical orientations of body planes. Anatomy and structure of muscle. Types of muscles: Skeletal muscle, Smooth muscle, Cardiac muscle, functions of muscle tissue, muscle tone and fatigue. . Classification of bones and types of joints, bone cells and their functions. Axial skeleton- skull, sinuses, Fontanelles, vertebral column- characteristics of typical vertebra, different parts of vertebral column (parts only), features of vertebral column, movements and functions of vertebral column, sternum, ribs, shoulder girdle and upper limb, pelvic girdle and lower limb.				**08**
Unit II	Introduction, Blood vessels- Arteries and Arterioles, Veins and Venules, capillaries and sinusoids, control of blood vessel diameter, blood supply- internal respiration, cell nutrition. Heart- position, structure- pericardium, myocardium, endocardium, interior of the heart, flow of blood through the heart, blood supply to heart, Conducting system of the heart, factors affecting heart rate, the Cardiac cycle, cardiac output, blood pressure, control of blood pressure, pulse and factors affecting the pulse rate. Circulation of the blood- pulmonary circulation, systemic circulation, aorta, circulation of blood to head and neck, circulation of blood to upper limb, portal circulation. Composition of Blood – Blood cells and their functions. Cell counting, Hemoglobin, Blood groups, Coagulation, Blood transfusion				**08**
Unit III	Structure of neurons, Cell bodies, Axon and Dendrites, Types of nerves, Synapse and neurotransmitters, neuromuscular junction. Central nervous system: neuroglia, meninges, ventricles of the brain and CSF. Brain: Cerebrum, functions of cerebrum, functional areas of the cerebrum. Brainstem: Cerebellum, Spinal cord- grey matter, white matter, motor nerve tracts, spinal nerves: nerve roots, plexuses, cranial nerves. Autonomic nervous system (in brief) functions and effects. Sensory organs, special sensors, auditory pathway, visual pathway, olfactory pathway, gustatory pathway.				**08**
Unit IV	Structure and functions of digestive system organs, chemical digestion in small intestine and large intestine. Pancreas and Liver. Nose and Nasal cavity- position, structure and functions, pharynx, position, structure, functions. Larynx: position, structure and functions. Trachea, bronchi, bronchioles and alveoli, lungs- position, associated structure, pleura and pleural cavity. Respiration- muscles of				**08**

	respiration, cycle of respiration, variables affecting respiration, lung volumes and capacity.	
Unit V	Pituitary gland, thyroid gland, parathyroid gland, adrenal gland. Parts of urinary system, gross and microscopic structure of the kidney, functions of the kidneys, ureter, urinary bladder, urethra, micturition. Reproductive system: Female- Uterus, Ovaries, Male- Scrotum, Testis. The internal environment and homeostasis.	**08**
References	1. A. C. Guyton and E. Hall, *Textbook of Medical Physiology*, 11th edn., Elsevier. 2005. 2. W. F. Ganong, *Review of Medical Physiology*, 22nd edn., McGraw Hill, New Delhi, 2005. 3. S. J. McPhee, D. Gary, *Pathophysiology of Disease an Introduction to Clinical Medicine*, 6th edn., McGraw-Hill, 2009. 4. S. Standring, *Gray's Anatomy: The Anatomical Basis of Clinical Practice*, 40th edn., Churchill Livingstone, 2008. 5. E. P. Widmaier, *Vander's Human Physiology: The Mechanisms of Body Function*, McGraw-Hill Science, 2007.	

Course code	**BMMT-521**				
Category	Departmental Elective				
Course title	**Biomedical Computing**				
Scheme and Credits	**Credit**	**L**	**T**	**P**	
	4	4	0	0	
Pre-requisites (if any)	Basic understanding of signal processing				
Objectives	This course will introduce the discipline of computational biology and drug design. It has been designed to explain the different aspects of nucleotide and protein sequence analyses, sequence alignments and their applications in understanding biology. The course will also emphasize on the strategic issues in drug discovery and development, principles of computational methods involved in lead generation virtual screening, quantitative structureactivity relationship and molecular docking.				
Outcomes	Students would be able in Sequence alignment and visualization and Phylogenetic and microarray analysis				
Unit I	Introduction to Bio-Computing: Computer applications with emphasis on digital image acquisition, analysis processing and enhancement, tomographic reconstruction, display, and recordings of findings. Mathematical models of physiologic systems.				**08**
Unit II	Algorithms Analysis: Introduction to design and analysis of algorithms, Control structures: recursion, backtracking, Data structures: sequences, linked lists and binary search trees, Elementary searching and sorting, Introduction to assertions and loop invariants.				**08**
Unit III	Architecture of Object Modeling: Introduction to object and classes, links and associations, generalizations, Object modeling and Dynamic modeling Encapsulation and representational abstraction. Inheritance. Polymorphic programming.				**08**
Unit IV	Discrete Coding: Survey of discrete mathematics and its applications, An introduction to graph theory, Fundamental principles of communication theory, information measures, entropy, mutual information, divergence; source encoding, Huffman codes, lossless source coding theorem.				**08**
Unit V	Database Architecture: Data models: relational, entity-relationship. Relational query languages: relational algebra and SQL. Relational database design, Application interfaces and embedded SQL, Storage and indexing.				**08**
References	1. A. M. Tenenbaum, Y. Langsam and M.J. Augenstein*, Data Structures Using C*. PHI, 2006. 2. J. Rumbaugh, M. Blaha, W. Premerlani, F. Eddy and W. Lorensen. *Object-Oriented Modeling and Design*, PHI, 1991. 3. R. Elmasri and S. Navathe. *Fundamentals of Database Systems*, Addison Wesley, 2006.				

	4. A. Silberschatz, H.F. Korth and S. Sudarshan., *Database System Concepts*. McGraw-Hill, 2002. 5. N. Deo., *Graph Theory with Applications to Engineering and Computer Science*, PHI, 2002.

Course code	**BMMT-502**				
Category	Core Biomedical				
Course title	**Biomedical Imaging**				
Scheme and Credits	**Credit**	**L**	**T**	**P**	
	4	4	0	0	
Pre-requisites (if any)	Awareness with the imaging techniques				
Objectives	To acquire knowledge about fundamental concepts of medical image analysis and apply the image processing techniques in different medical imaging modalities for computer aid diagnosis.				
Outcomes	1.To study the basic image fundamentals and transforms applicable in medical image analysis 2. To gain knowledge about the various image enhancement techniques 3. To apply various segmentation techniques and algorithms in Medical Images 4. To acquire knowledge about the medical image registration and fusion techniques 5. To study the applications of medical image analysis in various imaging modalities				
Unit I	Biomedical Images: Introduction, Body Temperature as an Image, Transillumination, Light Microscopy, Electron Microscopy, Xray Imaging, Breast cancer and mammography, Tomography, Nuclear Medicine Imaging, Ultrasonography, Magnetic Resonance Imaging, Objectives of Biomedical Image Analysis, Computeraided Diagnosis.				**08**
Unit II	Image Quality and Information Content: Difficulties in Image Acquisition and Analysis, Characterization of Image Quality, Digitization of Images, Contrast and Resolution. Removal of Artifacts: Characterization of Artifacts, Filters and Comparative Analysis of Filters for Noise Removal, Application of Multiframe Averaging in Confocal Microscopy. Image Enhancement.				**08**
Unit III	Detection of Regions of Interest: Detection of Isolated Points and Lines, Edge Detection, Segmentation and Region Growing, Detection of Objects of Known Geometry, Methods for the Improvement of Contour or Region Estimates, Analysis of Shape(Representation of Shapes and Contours), Texture analysis in Biomedical Images, Analysis of Oriented Patterns (Directional Distribution, Directional Filtering Gabor Filters and Directional Analysis via Multiscale Edge Detection)				**08**
Unit IV	Image Reconstruction from Projections: Projection Geometry, Algebraic Reconstruction Techniques, Imaging with Diracting Sources, Display of CT Images, Microtomography. Deconvolution Deblurring and Restoration:Linear Spaceinvariant Restoration Filters, Blind Deblurring, Homomorphic Deconvolution, Spacevariant Restoration, Restoration of				**08**

	Nuclear Medicine Images.	
Unit V	Image Coding and Data Compression : Fundamental Concepts of Coding, Transform Coding, Interpolative Coding, Predictive Coding, Application in Source Coding of Digitized Mammograms, Pattern Classification and Diagnostic Decision: Supervised Pattern Classification, Unsupervised Pattern Classification, Measures of Diagnostic Accuracy and Reliability.	**08**
References	1. R. M. Rangayyan, *Biomedical image analysis*. CRC Press, 2005. 2. W. R. Hendee, E. Russell Ritenour, *Medical Imaging Physics*. Wiley-Liss, 2002. 3. J. L. Prince, M. Jonathan, *Medical Imaging, Signals and systems*. Pearson Prentice Hall 2006. 4. K. M. Mudry, R. Plonsey, J. D. Bronzino, *Biomedical imaging*. CRC press, Boca Raton, FL, 2003. 5. D. V. Rai and R. Bahadur, *Medical physics and Biomedical Instrumentation*, New Era international imprint, Chandigarh, India, 2009.	

Course code	**BMMT-504**				
Category	Core Biomedical				
Course title	**Advance Biomechanics**				
Scheme and Credits	**Credit**	**L**	**T**	**P**	
	4	4	0	0	
Pre-requisites (if any)	None				
Objectives	To provide the knowledge of mechanics of human movement and finite element analysis				
Outcomes	1.To study about the bone structure and functions of skeletal muscle 2. To study the structure, movements, and loads applied on Upper Extremity and Lower Extremity 3. To study about the Linear and Angular kinetics and kinematics of human movement 4. To understand the fundamentals of finite element analysis 5. To implement the fundamental processing of Ansys				
Unit I	Structure and functions of cartilages, tendons, ligaments, stress-strain relationship, soft tissue mechanics, mechanical testing of soft tissues standard sample preparation, cross-section measurement, clamping of the specimen, strain measurement, environmental control), time dependent properties of tissues and testing.				**08**
Unit II	Bone structure & composition mechanical properties of bone, cortical and cancellous bones, viscoelastic properties, Maxwell & Voight models – anisotropy, Electrical properties of bone, fracture mechanism and crack propagation in bones, mechanism involved in fracture, repairing of bones, mechanical properties of collagen rich tissues, teeth and its properties.				**08**
Unit III	Review of the principles of mechanics, Vector mechanics- Resultant forces of Coplaner & Non-coplaner and Concurrent & non-concurrent forces, parallel force in space, Equilibrium of coplanar forces, Newton's laws of motion, Work and energy, Moment of inertia.				**08**
Unit IV	Skeletal joints, skeletal muscles, basic considerations, basic assumption and limitations, forces and stresses in human joints, mechanics of the elbow, mechanics of shoulder, mechanics of spinal column, mechanics of hip, mechanics of knee, mechanics of ankle. Human locomotion, gait analysis and goniometry, Ergonomics, Foot Pressure measurements Pedobarograph, Force platform, mechanics of foot. Stress analysis & instrumentation. Spine structure and it's biomechanics				**08**

Unit V	Heart valves, artificial heart valves, biological and mechanical valves development, Heterogrils, Homograil, testing of valves. Viscosity and capillary viscometer, Rheological properties of blood, laminar flow, Couette flow and Hagen-poiseuille equation, turbulent flow.	**08**
References	1. K. B. Sahay, R. K. Saxena, *Biomechanics*. John Wiley & Sons, India, 1989. 2. D. Schneck and J.D. Bronzino, *Biomechanics : principles and applications*. CRC Press, India, 2003. 3. D. Knudson, *Fundamentals of Biomechanics*. Springer Science, USA, 2007. 4. J. M. Hausdorff, *Gait Disorders Evaluation and Management*. Taylor & Francis, USA, 2005. 5. D. V. Rai, R Bahadur, *Trends in Medical physics and Biomedical instrumentation*. New Era international, India, 2009.	

Course code	**BMMT-506**				
Category	Core Biomedical				
Course title	**Biosensors and Transducer**				
Scheme and Credits	**Credit**	**L**	**T**	**P**	
	4	4	0	0	
Pre-requisites (if any)	None				
Objectives	Understanding of basic concepts of biomedical signals and to analyze the various Signal processing techniques used for biomedical signals.				
Outcomes	1. To understand the fundamentals of biomedical signals 2. To impart knowledge about the neurological signal processing 3. To provide a deep knowledge about the cardiological signal processing and analysis 4. To apply adaptive filtering techniques for canceling noise and interference in the various Bio-signals 5 To learn about pattern classification techniques and their use in diagnosis				
Unit I	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.				**08**
Unit II	Sensor architecture and Classification. Sensor characteristics. Sensor models in the time & frequency domains. Sensors for physical measurements (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.				**08**
Unit III	Basic requirements of transducers. Passive and Active transducers. Classification based on application and operating principle. Principle of operation, associated circuits and applications of temperature and displacement transducers. Electrochemical transducers-Electrode potential and reference electrodes. Potentiometric sensors. Amperiometric sensors. Electro-chemical gas sensors. Optically – based Chemical Transducers –Spectrophotometric chemical analysers, Fiber optic chemical transducer. Chemical Transducers of Acoustic and Thermal Properties. Biosensors – Enzymes-based bio-sensors, Immuno Sensors, microbial sensors.				**08**

Unit IV	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.	**08**
Unit V	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.	**08**
Course code	BMMT-552	**CR**
Course title	**Biomedical testing and calibration Lab**	**2.0**

1. Working principle and operation of testing and calibrating instruments and their components.
2. To test various electronic components and parts of biomedical devices.
3. To assemble various electronic components to design a biomedical devices i.e. biostimulators, electrodes, bioamplifiers.
4. To test and calibrate the signal generators, biomedical devices and components.

References	1. D. G. Buerk. *Technomic Biosensors. Theory and Applications*. Wiley and Sons, USA, 1995. 2. L.a. Geddes, L.e. Baker, *Principles of Applied Biomedical Instrumentation*, 3rd edn., Wiley India Pvt. Ltd, New Delhi, 2008. 3. D. L. Wise, *Bioinstrumentation and Biosensors*, CRC Press, 1991. 4. G. Ramsey. *Commercial Biosensors: Applications to Clinical, Bioprocess, and Environmental Samples*, Wiley-Interscience, 1998. 5. T. Togowa, P.A. Oberg, T. Togawa, *Biomedical Transducers And Instruments*, Crc Press, 2009.

Course code	**BMMT-508**				
Category	Core Biomedical				
Course title	**IPR and Biomedical Ethics**				
Scheme and Credits	**Credit**	**L**	**T**	**P**	
	4	4	0	0	
Pre-requisites (if any)	None				
Objectives	The course will explore the major ethical issues confronting the practices of medicine and biomedical sciences				
Outcomes	1. To gain knowledge on basic human values 2. To understand how to take responsibility for morals and mistakes 4. To understand the role of engineers in decision making. 5. To develop aptitude to understand law and problems relevant to it 6. To get familiar of ethical issues in medicine, health care and life science				
Unit I	Introduction to intellectual property. Patents and patent rights. Types of patent. Methodology of patenting. Protecting intellectual property by filing a patent. Patent infringement and freedom to operate. Trademarks. Copyrights, Copyright Act 1957. .				**08**
Unit II	Intellectual property commercialization and technology transfer. Licensing. Biomedical business models and IP management strategies. International convention related to Intellectual Property, Establishment of WIPO, Mission and Activities. Indian Position Vs WTO and Strategies, Indian IPR legislations, commitments to WTO-Patent Ordinance and the Bill, Draft of a national Intellectual Property Policy.				**08**
Unit III	Engineering Bioethics and Morality. Technology, Engineering, and Economics. Engineering Competence. Engineering: Integrated and Specialized. Systematics: Incorporating Ethics into the Design Process. Major Bioethical Areas. Human Enhancement. Organ Transplantation. Responsible Conduct of Human Research. Animal Testing. Genetically Modified Organisms. Environmental Health: The Ethics of Scale and the Scale of Ethics Temporal Aspects of Bioethical Decisions.				**08**
Unit IV	Professional Zeitgeist: opinion and thought of Engineers, Improvement *versus* Enhancement. Moral Coherence, Creativity and Bioethics. The Ethical Quandary of Enhancement, Scientific Dissent. Codes of Ethics.				**08**
Unit V	Making Ethical Decisionsin Engineering. Bioethical Research and Technological Development. Bioethical Success and Failure. Justice and Fairness as Biomedical and Biosystem Engineering Concepts. Sustainable				**08**

	Bioethics. Engineering Wisdom. Practical Bioethics.	
References	1. N. R. Subbaram, *Handbook of Indian Patent Law and Practice*, S. Viswanathan (Printers and Publishers) Pvt. Ltd., India, 1998. 2. S. S. Mehta, *Commercializing Successful Biomedical Technologies: Basic Principles for the Development of Drugs, Diagnostics and Devices*, Cambridge University Press, UK, 2008. 3. D. A.Vallero, *Biomedical Ethics for Engineers: Ethics and Decision Making in Biomedical and Biosystem Engineering*. Academic Press, USA, 2007. 4. T. L. Beauchamp, *Principles of Biomedical Ethics*, Oxford University Press, USA, 2001 5. T. Mappes, D. D Grazia, *Biomedical Ethics*, McGraw-Hill, 2005.	

Course code	**BMMT-601**				
Category	Core Biomedical				
Course title	**Rehabilitation Engineering**				
Scheme and Credits	**Credit**	**L**	**T**	**P**	
	4	4	0	0	
Pre-requisites (if any)	Knowledge of motion sensors, actuators and power sources.				
Objectives	To provide the basic knowledge on design, analysis, control and working principle of robotics in surgery, rehabilitation and drug delivery (Nano robot).				
Outcomes	1. To study about the basic concepts of robots and types of robots. 2. To study about manipulators, actuators and grippers. 3. To study about various types of sensors and power sources 4. To study the various applications of robot in the medical field.				
Unit I	Introduction of rehabilitation Engineering. Anthropometry: Methods for Static and dynamic Measurements: Area Measurements,Measurement of characteristics and movement, Measurement of Muscular Strength and Capabilities. Measurement tools and processes in Rehabilitation engineering: fundamental principles, structure, function; performance and behaviour. Subjective and objective measurement methods.				**08**
Unit II	Ergonomic aspects in designating devices: Introduction to Models in Process Control, Design of Information Devices, Traditional Devices, V.D.U' s, Using colour, Design of Controls.				**08**
Unit III	Engineering concepts in sensory rehabilitation Engineering. Sensory augmentation and substitution: Visual system: Visual augmentation, Tactual vision substitution, and Auditory vision substitution. Auditory system: Auditory augmentation, Audiometer, Hearing aids, cochlear implantation, visual auditory substitution, tactual auditory substitution, Tactual system: Tactual augmentation, Tactual substitution.				**08**
Unit IV	Artificial Larynx (pneumatic & electronic): Analyzing artificial electronic larynx, Augmentative communication, control and computer access (AAC): user interface; outputs; acceleration techniques; Intervention and other issues.				**08**
Unit V	Orthopedic Prosthetics and Orthotics in rehabilitation: Engineering concepts in motor rehabilitation, applications. Computer Aided Engineering in Customized Component Design. Intelligent prosthetic knee. A hierarchically controlled prosthetic hand. A self-aligning orthotic knee joint. Externally powered and controlled Orthotics and Prosthetics. FES systems-Restoration of hand function, restoration of standing and walking, Hybrid Assistive Systems (HAS). Active Prostheses: Active above				**08**

	knee prostheses. Myoelectric hand and arm prostheses- different types, block diagram, signal flow diagram and functions. The MARCUS intelligent Hand prostheses.	
References	1. B. Joseph, *Handbook of biomedical engineering*. 2nd edn.,CRC Press, USA, 2004. 2. R. A Cooper, H. Ohnabe, and D. A. Hobson *An Introduction to Rehabilitation Engineering (Series in Medical Physics and Biomedical Engineering),* Taylor & Francis, 2006 3. R.V. Smith and J. H. Leslie. *Rehabilitation Engineering*, CRC Press, USA, 1990. 4. S. L. Michlovitz, *Modalities for Therapeutic Intervention*, F A Davis Co, 2005. 5. S. Kumar, *Perspectives in Rehabilitation Ergonomics*, CRC Press, 1997.	

Course code	**BMMT-601**				
Category	Core Biomedical				
Course title	**Rehabilitation Engineering**				
Scheme and Credits	**Credit**	**L**	**T**	**P**	
	4	4	0	0	
Pre-requisites (if any)	Knowledge of motion sensors, actuators and power sources, electronics and nanotechnology				
Objectives	To enable the students to acquire knowledge about the principles & application of BioMEMS & NEMS				
Outcomes	1. To understand the working principle of MEMS & Microsystems 2. To understand the working of MOEMS Technology 3. To understand the concepts of BioMEMS & its application in healthcare 4. To give an insight to the DNA based BioMEMS 5. To study about the biomedical Nanotechnology & its application in research domain				
Unit I	Introduction to BioMEMS. Silicon Microfabrication. "Soft" Fabrication Techniques. Polymer Materials. Microfluidic Principles. Sensor Principles and Microsensors. Microactuators and Drug Delivery. Clinical Laboratory Medicine.				**08**
Unit II	Micro-Total-Analysis Systems (μTAS). Detection and Measurement Methods. Genomics and DNA Microarrays. Proteomics and Protein Microarrays. Emerging BioMEMs Technology. Packaging, Power, Data, and RF Safety. Biocompatibility, FDA, and ISO 10993.				**08**
Unit III	Soft-lithography, Micromolding, Microstereolithography, Thick-film deposition, Self-assembled monolayers (SAMs). Microfluidic Principles, Science of fluid behavior in microchannels. Microfluidic devices, Microchannels, Microfilters, Microvalves, Micropumps, Microneedles, Microreserviors Emerging Bio MEMS.				**08**
Unit IV	Characteristics of Embedding Computing Applications, Concept of Real time Systems, Challenges in Embedded System Design Process, Requirements, Specifications, Architecture Design, Designing of Components, System Integration. Embedded System Architecture, Instruction Set Architecture, CISC and RISC instruction set architecture.				**08**
Unit V	Basic Embedded Processor/Microcontroller Architecture, CISC Examples, 8051 RISC Example, ARM, DSP Processors, Harvard Architecture, PIC Memory System Architecture, Caches, Virtual Memory, Memory Management Unit and Address Translation, I/0 Sub-system, Busy-wait I/0, DMA, Interrupt driven I/0				**08**
References	1. F. Mauro, *BioMEMS and Biomedical Nanotechnology*. Springer, USA, 2007. 2. S. Saliterman, *Fundamentals of BioMEMS and Medical Microdevices*. Spie-				

	international Society for Optical Engine, USA, 2006. 3. K. J. Ayala, *The 8051 Micro controller-Architechture, Programming and Applications*. 2nd edn., Penram International Publishing, 2005. 4. R. Kamal, *Embedded Systems: Architecture, Programming and Design*, 2nd Edn., McGraw-Hill (India), 2009. 5. G. Urban, *BioMEMS (Microsystems),* Springer, 2006.

Course code	**BMMT-621**				
Category	Departmental Elective				
Course title	**Biomedical application to Prosthetics and Orthotics**				
Scheme and Credits	**Credit**	**L**	**T**	**P**	
	4	4	0	0	
Pre-requisites (if any)	Knowledge of motion sensors, actuators and power sources, electronics and nanotechnology				
Objectives	To provide the ability to solve day to day work problem by safe and efficient means.				
Outcomes	1. To understand the basics of Biomechanical, physiological and anthropometric background. 2. To impart the knowledge about the user information, controls, relationship between information and operation. 3. To gain a deep knowledge about the different guidelines related to environmental factors. 4. To understand the design factors for health, safety and comfort 5. To Study ergonomics in healthcare.				
Unit I	Introduction to prosthetics and Orthotics, Requirements, models and design. Engineering Concepts in Sensory Rehabilitation, Motor Rehabilitation, Communication Disorders, Computer-Aided Engineering in customized component design. Intelligent prosthetic knee, Hierarchically controlled prosthetic hand, Self-aligning orthotic knee joint.				**08**
Unit II	Externally powered and controlled orthotics and prosthetics: FES systems: Restoration of hand function, standing and walking. Hybrid Assistive Systems (HAS). Active Above Knee Prostheses. Myoelectric hand and arm prostheses.				**08**
Unit III	Technology of metal and metal paste electrodes, the equivalent circuit between electrodes, stability, source of unwanted voltage electrode systems. Other types of myoelectrodes micro electrodes, implanted electrodes, comparison with surface electrodes. Sensors, microprocessors etc.				**08**
Unit IV	Sensory augmentation and substitution: Visual system: Visual augmentation. Tactual vision substitution, Auditory vision substitution; Auditory system: Auditory augmentation. Cochlear implantation, Visual auditory substitution, Tactual auditory substitution, Tactual system: Tactual augmentation. Tactual substitution, Augmentative communication, Control and Computer Access: User Interface, Intervention and other Issues.				**08**
Unit V	Introduction to orthotics terminologies, various materials used in orthotics. Different types of orthoses: user's client assessment & prescription criteria, measuring & casting, cast modification, three point				**08**

	force system, fabrication, fitting , alignment , check out & finishing of following of following devices . Shoe modification, Ankle foot orthoses, Club foot orthosis, fracture orthoses.	
References	1. C.J. Robinson, *Rehabilitation Engineering*, CRC Press, 1995. 2. E. Ballabio, *Rehabilitation Technology*, IOS Press, 1993. 3. C. Partridge, *Neurological Physiotherapy: Bases of Evidence for Practice, Treatment and Management of Patients Described by Specialist Clinicians*. Weily & Sons, 2002. 4. W. E. Finn and P. G. Presti, *Handbook of Neuroprosthetic Methods (Biomedical Engineering)*, CRC Press, 2002. 5. R. A. Cooper, *Rehabilitation Engineering Applied to Mobility and Manipulation (Series in Medical Physics and Biomedical Engineering),* Taylor & Francis, 1995.	

Course code	**BMMT-621**				
Category	Departmental Elective				
Course title	**Biomedical application to Physiotherapy**				
Scheme and Credits	**Credit**	**L**	**T**	**P**	
	4	4	0	0	
Pre-requisites (if any)	----				
Objectives	Understanding of advanced technology of tissue engineering and regenerative medicine				
Outcomes	• To understand basics of Tissue Engineering • To understand fundamentals of cell mechanisms • To teach the Physical & biological principles that serve as the scientific basis for understanding the interactions of biological molecules and cells with biomaterials employed for the fabrication of permanent implantable prostheses and as matrices for tissue engineering. • To understand application of Tissue Engineering				
Unit I	Introduction and types of physiotherapy, Massage and manipulation, Electrical treatments such as ultrasound and infra-red radiation, Exercise therapy, including mobilising and strengthening techniques, Hydrotherapy (exercise in water).				**08**
Unit II	Respiratory care, Cardiothoracics, Spinal conditions, Neurology, Different modalities for experimental treatments. Spinal cord injury recovery by pulsed electromagnetic field and stem cells. Emerging clinical applications of electrical stimulation: opportunities for restoration of function. Stimulators of the central nervous system, Time-reversal acoustics in biomedical engineering. Mechanical bio-effects of ultrasound. Progress in researches on application of functional electrical stimulation technique in paraplegic walking.				**08**
Unit III	Rheumatology, Women's health, Paediatrics, Mental health, Oncology, Burns and plastic surgery, Advanced Physiotherapy Studies (Current health management issues, Pain measurement, Advanced respiratory care, Advanced neurology)				**08**
Unit IV	The treatment of patients with back problems, neck problems and problems at other joints, the management of fractures, dislocations and soft tissue injuries, Includes the management of patients following trauma or elective surgery, Management of problems in children and the elderly.				**08**
Unit V	Rehabilitation of people who have suffered a stroke or brain injury, Rehabilitation following severe back injuries resulting in paraplegia,				**08**

	Working with people with multiple sclerosis and Parkinson's disease, Working with children with complex problems for example, cerebral palsy.	
References	1. Low and Reed. *Electrotherapy Explained: Principles and Practice*. Butterworth-Heinemann, 2006. 2. P. A Jennifer, A. B. Webber. *Physiotherapy for Respiratory and Cardiac Problems.* Churchill Livingstone.1998 3. J. H. Carr. *Neurological Rehabilitation: Optimizing Motor Performance*. Butterworth-Heinemann,1998 4. R. Mathur. *Pain Updated: Mechanisms and Effects.* Anamaya Publisher, New Delhi. 2006 5. J. Dyro. *Clinical Engineering Handbook (Biomedical Engineering)*, Academic Press, 2007.	

Course code	**BMMT-623**				
Category	Departmental Elective				
Course title	**Biomedical Signal Processing**				
Scheme and Credits	**Credit**	**L**	**T**	**P**	
	4	4	0	0	
Pre-requisites (if any)	Basic understanding of signal processing				
Objectives	Understanding of basic concepts of biomedical signals and to analyze the various signal processing techniques used for biomedical signals.				
Outcomes	1. To understand the fundamentals of biomedical signals 2. To impart knowledge about the neurological signal processing 3. To provide a deep knowledge about the cardiological signal processing and analysis 4. To apply adaptive filtering techniques for canceling noise and interference in the various Bio-signals 5 To learn about pattern classification techniques and their use in diagnosis				
Unit I	Physiological origins of biosignals, Types of Biosignals: Bioelectric signals, Bioimpedance signals, Bioacoustic signals, Biomagnetic signals, Biomechanical signals, Biochemical signals, Biooptical signals, Basics of Bioelectrical Signals at Cellular Level and Body Surface level. Bioelectrical Signals: Electroencephalogram (EEG), Electrocardiogram (ECG), Electromyogram (EMG), Electroneurogram (ENG), Electroretinogram (ERG), Electrooculogram (EOG), Electrogastrogram (EGG).				**08**
Unit II	Characteristics of Biomedical Signals; Typical measurement systems, Transducers, Analog Signal Processing, Source variability: Noise, Analogue Filters, Analogue to Digital conversion, Frequency-Domain Analysis Digital Biomedical Signal Acquisition and Processing, Compression of Digital Biomedical Signals.				**08**
Unit III	Time–Frequency Signal Representations for Biomedical Signals, Wavelet (Time-Scale) Analysis in Biomedical Signal Processing, Higher-Order Spectral Analysis,				**08**
Unit IV	Neural Networks in Biomedical Signal Processing, Complexity, Scaling, and Fractals in Biomedical Signals, Medical Devices and Systems,				**08**
Unit V	Advanced Signal Processing Techniques: Optimal and Adaptive Filters. Multivariate Analysis: Principal Component and Independent Component Analysis, Fundamentals of Image processing: MATLAB Image Processing Toolbox. Future Directions: Biomedical Signal Processing and Networked, Multimedia Communications.				**08**

References	1. D. C. Reddy, *Biomedical Signal Processing – Principles and Technique*, Tata McGraw-Hill.,2005 2. A. Antoniou , *Digital Signal Processing*, McGraw Hill, 2005 3. J. G. Prokis and D.G. Manolakis, *Digital Signal Processing: Principles, Algorithm and Applications*, PHI/Pearson Education, 1996. 4. J. L. Semmlow, *Biosignal and Biomedical Image Processing: MATLAB-Based Applications*, CRC Press, 2004. 5. K. Najarian and R. Splinter, *Biomedical Signal and Image Processing*, CRC Press, 2005.

Course code	**BMMT-623**				
Category	Departmental Elective				
Course title	**Biomedical Information Technology**				
Scheme and Credits	**Credit**	**L**	**T**	**P**	
	4	4	0	0	
Pre-requisites (if any)	Basic understanding of signal processing				
Objectives	To enable the students to gain knowledge in various aspects of informatics and telemedicine related to health and the techniques to apply these in proper health care delivery				
Outcomes	1. To make them understand organs and advances in medical informatics and telemedicine. 2. To impart knowledge on management of medical data 3. To provide an in-depth knowledge about data security and standards. 4. To introduce the basic concepts of tele-radiology. 5. To brief about various applications in telemedicine.				
Unit I	Medical Imaging, Electronic Medical Records, Image Data Compression and Storage, Content-Based Medical Image Retrieval.				**08**
Unit II	Data Modeling and Simulation, Techniques for Parametric Imaging, Data Processing and Analysis, Data Registration and Fusion.				**08**
Unit III	Data Visualization and Display, Data Communication and Network Infrastructure, Data Security and Protection for Medical Images, Biologic Computing, PACS and Medical Imaging Informatics for Filmless Hospitals.				**08**
Unit IV	KMeX: A Knowledge-Based Digital Library for Retrieving Scenario-Specific Medical Text Documents, Integrated Multimedia Patient Record Systems, Computer-Aided, Diagnosis, Clinical Decision Support Systems, Medical Robotics and Computer-Integrated Interventional Medicine.				**08**
Unit V	Functional Techniques for Brain Magnetic Resonance Imaging, Molecular Imaging in Cancer, Molecular Imaging in Biology and Pharmacology, Telemedicine to Ubiquitous M-Health: The Evolution of E-Health Systems, Introduction to Multimedia and its application in medicine.				**08**
References	1. D. D. Feng, *Biomedical information technology*. Amsterdam ; Boston : Elsevier/Academic Press, 2008. 2. M. Akay, A. Marsh, *Information Technologies in Medicine*, Volume 1, Medical Simulation and Education. Wiley-IEEE Press, 2001 3. C. S. Pattichis, D. I. Fotiadis. *Information Technology in Biomedicine.* Wiley-IEEE Press, 2010. 4. A. Shukla and R. Tiwari, *Biomedical Engineering and Information Systems:*				

	Technologies, Tools and Applications, Medical Information Science Reference, India, 2010. 6. C. S. Pattichis and D. I. Fotiadis, *Information Technology in Biomedicine*, IEEE Press Series on Biomedical Engineering, 2009.K. Najarian and R. Splinter, *Biomedical Signal and Image Processing*, CRC Press, 2005.

M.Tech Biomedical

(2018-19)

COs Mapping with POs & PSOs

(Three Level : 3-Strongly Related , 2-Moderate, 1-Slightly)

Applied Bioelectricity BMMT-501

CourseOutcomes

CO1: Major skeletal muscles, their actions, origins, insertions, and peripheral nerves. c. Central nervous system and plexuses d. Respiratory system e. Cardiovascular/hematologic system

CO2: Identify the major structures of the human anatomy for the following: a. Head and neck, thoracic, abdominopelvic, and upper and lower extremities. b. Major skeletal muscles, their actions, origins, insertions, and peripheral nerves. c. Central nervous system and plexuses d. Respiratory system e. Cardiovascular/hematologic system

CO3: Identify the major bones and their processes as they relate to each region of the body.

CO4: Tell briefly the basic components and functions of the gastrointestinal, renal/urinary, endocrine/metabolic, hepatic/biliary, genital/reproductive and immunologic, systems.

CO5: Identify the findings from a simulated healthcare record such as electrocardiogram data and pulmonary ventilation outcomes.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8	PSO 9	PSO 10
CO 1	1	2	2	1	2	2	1	1	2	1	1	2	1	1	1	2
CO 2	1	1	2	3	2	1	2	3	2	3	2	1	2	2	2	2
CO 3	3	2	2	2	2	2	2	3	3	2	2	3	2	2	2	2
CO 4	2	2	3	1	2	2	1	1	1	1	1	2	1	2	2	1
CO 5	3	2	1	3	1	1	3	2	1	1	1	2	2	2	2	2
Average	**2.0**	**1.8**	**2.0**	**2.0**	**1.8**	**1.6**	**1.8**	**2.0**	**1.8**	**1.6**	**1.4**	**2.0**	**1.6**	**1.8**	**1.8**	**1.8**

Biomaterials and Nanomedicine BMMT-503

CourseOutcomes

CO1: Characterize the material and define their biological application

CO2: Aware with the several applications of nanomaterials in biomedicals.

CO3: Differentiate between the biocompatible and non-biocompatible materials.

CO4: Understand the application of Nanomaterials in biotechnology and acquire the knowledge about the DNA, proteins, amino acids, drug delivery, biomedicine etc.

CO5: Understand the basic knowledge of Nanotechnology and DNA structures.

CO6: Provide the knowledge in basics of nanotechnology in biotechnology.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8	PSO 9	PSO 10
CO 1	2	1	2	2	3	2	2	2	2	2	1	1	2	1	2	1
CO 2	1	2	3	2	2	1	1	2	1	2	1	1	2	1	2	2
CO 3	2	3	3	3	2	2	2	2	3	3	2	2	2	2	2	2
CO 4	3	2	1	2	1	1	2	1	2	2	1	2	1	2	3	1
CO 5	2	3	1	2	1	1	2	2	2	2	2	1	2	2	1	2
CO 6	1	1	1	1	2	2	2	1	1	1	2	3	1	2	1	1
Average	**1.8**	**1.5**	**1.8**	**2.0**	**1.8**	**1.5**	**1.8**	**1.6**	**1.8**	**2.0**	**1.5**	**1.6**	**1.6**	**1.6**	**1.8**	**1.5**

Bio-instrumentation BMMT-505

CourseOutcomes

CO1: To understand the fundamentals of biomedical signals

CO2: To impart knowledge about the neurological signal processing

CO3: To provide a deep knowledge about the cardiological signal processing and analysis

CO4: To apply adaptive filtering techniques for canceling noise and interference in the various Bio-signals

CO5: To learn about pattern classification techniques and their use in diagnosis.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8	PSO 9	PSO 10
CO 1	1	2	2	1	2	2	1	1	2	1	1	2	1	1	1	2
CO 2	1	1	2	3	2	1	2	3	2	3	2	1	2	2	2	2
CO 3	3	2	2	2	2	2	2	3	3	2	2	3	2	2	2	2

CO 4	2	2	3	1	2	2	1	1	1	1	1	2	1	2	2	1
CO 5	3	2	1	3	1	1	3	2	1	1	1	2	2	2	2	2
Average	**2.0**	**1.8**	**2.0**	**2.0**	**1.8**	**1.6**	**1.8**	**2.0**	**1.8**	**1.6**	**1.4**	**2.0**	**1.6**	**1.8**	**1.8**	**1.8**

Human Anatomy and Physiology BMMT-521

CourseOutcomes

CO1: To describes the form and organization of various anatomical structures and determines how they can functions

CO2: To provide knowledge about systems and how they are dependent on each other to survive and operate the human body

CO3: To give terms with precise meaning helps investigators to communicate effective.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**	**PSO 6**	**PSO 7**	**PSO 8**	**PSO 9**	**PSO 10**
CO 1	2	1	1	2	2	2	2	1	1	2	2	2	1	1	1	2
CO 2	1	1	3	2	3	2	2	2	2	1	2	2	2	2	2	2
CO 3	2	2	2	2	1	2	1	1	3	3	1	1	3	2	2	1
Average	**1.6**	**1.3**	**1.6**	**2.0**	**2.0**	**2.0**	**1.6**	**1.3**	**2.0**	**2.0**	**1.6**	**1.6**	**2.0**	**1.6**	**1.6**	**1.6**

Biomedical Computing BMMT-521

CourseOutcomes

CO1: Students would be able in Sequence alignment and visualization and Phylogenetic and microarray analysis.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**	**PSO 6**	**PSO 7**	**PSO 8**	**PSO 9**	**PSO 10**
CO 1	3	2	1	1	2	1	2	2	1	1	1	2	1	2	1	1
Average	3	2	1	1	2	1	2	2	1	1	1	2	1	2	1	1

Biomedical Imaging BMMT-502

CourseOutcomes

CO1: To study the basic image fundamentals and transforms applicable in medical image analysis

CO2: To gain knowledge about the various image enhancement techniques

CO3: To apply various segmentation techniques and algorithms in Medical Images

CO4: To acquire knowledge about the medical image registration and fusion techniques

CO5: To study the applications of medical image analysis in various imaging modalities.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8	PSO 9	PSO 10
CO 1	1	1	1	2	2	1	2	2	1	2	2	1	1	2	1	1
CO 2	2	2	2	2	2	1	1	2	3	2	1	2	3	2	3	2
CO 3	2	2	2	2	2	3	2	2	2	2	2	2	3	3	2	2
CO 4	1	2	2	1	3	2	2	3	1	2	2	1	1	1	1	1
CO 5	2	2	2	2	1	3	2	1	3	1	1	3	2	1	1	1
Average	**1.6**	**1.8**	**1.8**	**1.8**	**2.0**	**2.0**	**1.8**	**2.0**	**2.0**	**1.8**	**1.6**	**1.8**	**2.0**	**1.8**	**1.6**	**1.4**

Advance Biomechanics BMMT-504

CourseOutcomes

CO1: To study about the bone structure and functions of skeletal muscle

CO2: To study the structure, movements, and loads applied on Upper Extremity and Lower Extremity

CO3: To study about the Linear and Angular kinetics and kinematics of human movement

CO4: To understand the fundamentals of finite element analysis

CO5: To implement the fundamental processing of Ansys.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8	PSO 9	PSO 10
CO 1	1	2	1	1	2	1	1	1	1	1	2	2	1	2	1	1

CO 2	3	2	3	2	1	2	2	2	2	2	2	2	1	1	2	2
CO 3	3	3	2	2	3	2	2	2	2	2	2	2	3	2	2	2
CO 4	1	1	1	1	2	1	2	1	2	2	1	3	2	2	1	2
CO 5	2	1	1	1	2	2	2	2	2	2	2	1	3	2	2	2
Average	**2.0**	**1.8**	**1.6**	**1.4**	**2.0**	**1.6**	**1.8**	**1.6**	**1.8**	**1.8**	**1.8**	**2.0**	**2.0**	**1.8**	**1.6**	**1.8**

Biosensors and Transducer BMMT-506

CourseOutcomes

CO1: To understand the fundamentals of biomedical signals

CO2: To impart knowledge about the neurological signal processing

CO3: To provide a deep knowledge about the cardiological signal processing and analysis

CO4: To apply adaptive filtering techniques for canceling noise and interference in the various Bio-signals

CO5: To learn about pattern classification techniques and their use in diagnosis.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**	**PSO 6**	**PSO 7**	**PSO 8**	**PSO 9**	**PSO 10**
CO 1	1	1	2	1	1	2	1	2	1	1	1	2	1	1	2	1
CO 2	1	1	3	2	2	1	2	2	2	2	2	2	1	1	2	2
CO 3	2	2	2	3	2	2	3	2	3	2	3	2	3	1	2	1
CO 4	2	2	2	1	1	2	1	1	1	1	1	1	1	2	2	2
CO 5	2	2	1	3	1	1	2	2	2	2	3	2	2	3	2	2
Average	**1.8**	***1.6***	***2.0***	***2.0***	***1.6***	***1.6***	***1.8***	***1.8***	***1.8***	***1.6***	***2.0***	***1.8***	***1.6***	***1.6***	***2.0***	***1.6***

IPR and Biomedical Ethics BMMT-508

CourseOutcomes

CO1: To gain knowledge on basic human values

CO2: To understand how to take responsibility for morals and mistakes

CO3: To understand the role of engineers in decision making.

CO4: To develop aptitude to understand law and problems relevant to it

CO5: To get familiar of ethical issues in medicine, health care and life Science.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8	PSO 9	PSO 10
CO 1	2	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1
CO 2	1	1	2	2	1	2	1	2	1	1	1	2	1	1	1	1
CO 3	1	1	3	2	2	1	2	2	2	2	2	2	1	1	2	2
CO 4	2	2	2	3	2	2	3	2	3	2	3	2	3	1	2	1
CO 5	2	2	2	1	1	2	1	1	1	1	2	3	1	2	2	2
CO 6	2	2	2	3	2	1	2	2	2	2	3	1	2	3	2	2
Average	**1.6**	***1.5***	***2.0***	***2.0***	***1.5***	***1.5***	***1.6***	***1.6***	***1.6***	***1.5***	***2.0***	***2.0***	***1.5***	***1.5***	***1.6***	***1.5***

Rehabilitation Engineering BMMT-601

CourseOutcomes

CO1: To study about the basic concepts of robots and types of robots.

CO2: To study about manipulators, actuators and grippers.

CO3: To study about various types of sensors and power sources

CO4: To study the various applications of robot in the medical field.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8	PSO 9	PSO 10
CO 1	2	2	1	1	1	2	1	1	1	1	2	3	1	2	2	2
CO 2	2	1	2	3	3	1	2	2	2	2	3	1	2	3	2	2
CO 3	1	2	2		2	1	2	2	2	2	2	1	1	2	1	1

				2												
CO 4	2	2	2	2	2	1	1	2	3	2	1	2	3	1	3	2
Average	**1.7**	**1.7**	**1.7**	**2.0**	**2.0**	**1.2**	**1.5**	**1.7**	**2.0**	**1.7**	**2.0**	**1.7**	**1.7**	**2.0**	**2.0**	**1.7**

BioMEMS & NEMS BMMT-602

CourseOutcomes

CO1: To understand the working principle of MEMS & Microsystems

CO2: To understand the working of MOEMS Technology

CO3: To understand the concepts of BioMEMS & its application in healthcare

CO4: To give an insight to the DNA based BioMEMS

CO5: To study about the biomedical Nanotechnology & its application in research Domain.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**	**PSO 6**	**PSO 7**	**PSO 8**	**PSO 9**	**PSO 10**
CO 1	2	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1
CO 2	1	1	2	2	1	2	1	2	1	1	1	2	2	3	1	2
CO 3	1	1	3	2	2	1	2	2	2	2	2	2	2	1	2	2
CO 4	2	2	2	3	2	2	3	2	2	2	3	2	3	2	2	1
CO 5	2	2	2	1	2	2	1	1	2	2	2	2	1	2	2	2
Average	**1.6**	***1.4***	***2.0***	***1.8***	***1.6***	***1.2***	***2.0***	***2.0***	***1.6***	***1.6***	***1.8***	***2.0***	***1.8***	***1.8***	***1.6***	***1.6***

Biomedical application to Prosthetics and Orthotics BMMT-621

CourseOutcomes

CO1: To understand the basics of Biomechanical, physiological and anthropometric background.

CO2: To impart the knowledge about the user information, controls, relationship between information and operation.

CO3: To gain a deep knowledge about the different guidelines related to environmental factors.

CO4: To understand the design factors for health, safety and comfort

CO5: To Study ergonomics in healthcare.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8	PSO 9	PSO 10
CO 1	1	2	2	1	2	2	1	1	2	1	1	2	1	1	1	2
CO 2	1	1	2	3	2	1	2	3	2	3	2	1	2	2	2	2
CO 3	3	2	2	2	2	2	2	3	3	2	2	3	2	2	2	2
CO 4	2	2	3	1	2	2	1	1	1	1	1	2	1	2	2	1
CO 5	3	2	1	3	1	1	3	2	1	1	1	2	2	2	2	2
Average	**2.0**	**1.8**	**2.0**	**2.0**	**1.8**	**1.6**	**1.8**	**2.0**	**1.8**	**1.6**	**1.4**	**2.0**	**1.6**	**1.8**	**1.8**	**1.8**

Biomedical application to Physiotherapy

CourseOutcomes

CO1: To understand basics of Tissue Engineering

CO2: To understand fundamentals of cell mechanisms

CO3: To teach the Physical & biological principles that serve as the scientific basis for understanding the interactions of biological molecules and cells with biomaterials employed for the fabrication of permanent implantable prostheses and as matrices for tissue engineering.

CO4: To understand application of Tissue Engineering.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8	PSO 9	PSO 10
CO 1	1	2	2	2	3	1	2	2	2	1	2	1	1	2	1	1
CO 2	2	2	1	2	1	2	1	2	3	3	1	2	3	1	3	2
CO 3	1	2	3	2	2	2	2	2	1	2	2	1	1	2	1	1

CO 4	2	2	2	2	2	1	1	2	1	2	1	2	3	1	3	2
Average	**1.5**	**2.0**	**2.0**	**2.0**	**2.0**	**1.5**	**1.5**	**2.0**	**1.7**	**2.0**	**1.5**	**1.5**	**2.0**	**1.5**	**2.0**	**1.5**

Biomedical Signal Processing BMMT-623

CourseOutcomes

CO1: To understand the fundamentals of biomedical signals

CO2: To impart knowledge about the neurological signal processing

CO3: To provide a deep knowledge about the cardiological signal processing and analysis

CO4: To apply adaptive filtering techniques for canceling noise and interference in the various Bio-signals.

CO5: To learn about pattern classification techniques and their use in diagnosis.

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**	**PSO 6**	**PSO 7**	**PSO 8**	**PSO 9**	**PSO 10**
CO 1	2	1	1	2	1	1	1	2	1	2	2	1	2	2	1	1
CO 2	2	3	2	1	2	2	2	2	1	1	2	3	2	1	2	3
CO 3	3	2	2	3	2	2	2	2	3	2	2	2	2	2	2	3
CO 4	1	1	1	2	1	2	2	1	2	2	3	1	2	2	1	1
CO 5	1	1	1	2	2	2	2	2	3	2	1	3	1	1	3	2
Average	**1.8**	**1.6**	**1.4**	**2.0**	**1.6**	**1.8**	**1.8**	**1.8**	**2.0**	**1.8**	**2.0**	**2.0**	**1.8**	**1.6**	**1.8**	**2.0**

Biomedical Information Technology

CourseOutcomes

CO1: To make them understand organs and advances in medical informatics and telemedicine.

CO2: To impart knowledge on management of medical data

CO3: To provide an in-depth knowledge about data security and standards.

CO4: To introduce the basic concepts of tele-radiology.

CO5: To brief about various applications in telemedicine.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8	PSO 9	PSO 10
CO 1	2	2	3	1	1	1	2	1	1	1	1	2	1	1	1	1
CO 2	1	1	2	2	2	1	2	2	3	2	2	2	2	1	2	2
CO 3	2	3	3	3	2	2	3	3	2	3	3	3	3	2	2	3
CO 4	2	2	1	1	2	1	1	1	1	1	1	1	1	2	2	1
CO 5	2	2	1	1	3	3	2	2	3	2	3	2	2	2	2	2
Average	**1.8**	**2.0**	**2.0**	**1.6**	**2.0**	**1.6**	**2.0**	**1.8**	**2.0**	**1.8**	**2.0**	**2.0**	**1.8**	**1.6**	**1.8**	**1.8**