SCHEME OF INSTRUCTION AND EVALUATION
B.E. (BIOMEDICAL ENGINEERING)

BE (Other branches) with MINORS In DEGREE with extra 18 credits in BME

Sl.No	Course Code	Course Name	Contact hours per week		Scheme of Examination		Credits	SEM
			L	P	CIE	SEE		
		THEORY						
1.	MR 501 BM	Human Anatomy and Physiology	3	-	40	60	3	V
2.	MR 601 BM	Instrumentation for Medical Applications	3	-	40	60	3	V
3.	MR 602 BM	Basic Diagnostic and Therapeutic Equipment	3	-	40	60	3	VI
4.	MR 701BM	Medical Imaging Modalities	3	-	40	60	3	VII
5.	MR 702 BM	Materials for Medical Implants	3	-	40	60	3	VII
		PRACTICALS						
6.	MR 861 BM	Project Work	-	6	50	50	3	VIII
		TOTAL	**15**	**6**	**250**	**350**	**18**	

L-Lectures
T-Tutorials
P-Practicals
CIE-Continuous Internal Evaluation
SIE-Semester End Evaluation

MR 501 BM

Human Anatomy and Physiology

Instruction	3 Periods per week
Duration of University Examination	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

COURSE OBJECTIVES:

1. To study systemic anatomy i.e., the structure and position of the systems in the human body like the respiratory, circulatory, digestive, urinary, reproductive, endocrine and nervous systems.
2. This course is designed such that the student is exposed to various mechanisms involved in the normal functioning of human body underlining the basic working principles of different biological processes with Engineering tools.

COURSE OUTCOMES:

1. Able to classify the various systems of human body and identifying their functionality
2. Able to understand musculoskeletal skeletal system and different joints
3. Able to understand nervous system and assess functionality of brain
4. Able to evaluate CVS by BP and heart rate
5. Able to perceive the importance of Respiratory System and identifying the need for ventilators

UNIT-I

Musculo-Skeletal System: Bones: Types with examples. Joints: Types with examples. Structure and Classification of synovial joint with examples. Muscular system. Types and locations. Structure of a skeletal muscle. Important muscle of limbs-location. Actions.
Smooth muscle, Cardiac Muscle, Skeletal muscle, Excitation-Contraction coupling, Sarcomere-Contractile Unit, Motor Unit.

UNIT-II

Nervous System: Classification into Central Nervous System (CNS), Peripheral Nervous System (PNS), Autonomic Nervous System (ANS).
Spinal cord. Subdivisions of brain. Base of brain with cranial nerve attachments. Brain stem, Cerebellum, Cerebrum, Diencephalon, Ventricular System, Special Senses.
Higher functions of Brain (Perception, Rule of special senses, Learning and memory), Cybernetics of living systems, Neuro-Endocrine Control System, Servo mechanism, Motor skills.

UNIT-III

Cardiovascular System: Heartchambers and heart valves. General plan of Circulatory System-major blood vessels, Systemic and pulmonary circulation. Conducting system of the Heart, Generation of ECG.

UNIT-IV

Respiratory system: Various parts of Respiratory System-Trachea, Bronchial tree, Lungs.Perfusion and Diffusion limited process, Ventilation, Alveolar, Physiological and anatomical shunts and dead spaces. Mechanism of Inspiration and Expiration.

UNIT-V

Urinary system: Parts of Urinary System. Kidneys, Ureter, Urinary Bladder and Urethra. Mechanism of filtration and urine formation.

Regulation of volume and composition of Body fluids, Clearance equations, Acid-Base Balance, regulation of Body Temperature. Hormonal regulation of Body functions.

Suggested Readings:

1. Gibson J, *Modern Physiology & Anatomy for Nurses*, Blackwell Scientific Publishers, 1981
2. 2.CharlesE.Tobin, *Basic Human Anatomy*, McGraw Hill, 1980.
3. Mount Castle, Textbook of Medical Physiology.
4. Best and Taylor, Physiological basis of Medical Practice.
5. John. Herbert Green, An Introduction to physiology, Oxford University Press, 1976 5
6. Gillain pocock, Christopher D. Richards, Human Physiology, The Basis of Medicine, Oxford University Press, 2004

MR 601 BM

INSTRUMENTATION FOR MEDICAL APPLICATIONS

Instruction	3 Periods per week
Duration of University Examination	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

UNIT- I

Block diagram of a medical instrumentation system, Challenges faced with physiological measurements. Medical instrument specifications. Electrodes for biophysical sensing, medical surface electrode. Micro electrodes. Applications of biopotential electrodes.

UNIT-II

Signal acquisition, transduction, active vs passive sensors, sources of errors in sensors, Working principles andmedical applications of sensors and transducers- resistive, inductive, capacitive.

UNIT-III

Basic requirements for the display and recording of Biopotential signals. PMMC writing systems-Direct writing recorders and ink-jet recorders. Thermal writing. Array recorders-thermal and electrostatic recorders. Medical Oscilloscopes, Multibeam and Non-fade display systems, LCD, OLED systems.

UNIT-IV

Working principles, components and medical applications of Colorimeter, spectrophotometer, Flame photometer-Absorption & Emission photometry, Flurometry, Mass spectrophotometer, Electrophoresis Apparatus, Chromatograph.

UNIT-V

Working principles, components and medical applications of Nebulizer, Humidifiers, Suction apparatus. Fluid warmer, Fumigator, Oxygen concentrator. Oximeters, Automatic differential blood cell counters, Blood gas Analyzer.

Suggested Readings:

1. Webster J.G., *Medical Instrumentation Application and Design*. Houghton Mifflin, 2009.
2. Carr and Brown, *Introduction to Biomedical equipment technology*, 2011.
3. Khandpur R.S. *Hand Book of Biomedical Instrumentation*, Tata McGrawHill,2003.

MR 602 BM

BASIC DIAGNOSTIC AND THERAPEUTIC EQUIPMENT

Instruction	3 Periods per week
Duration of University Examination	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Course Objectives:

- To make the students understand the operating principles of a wide range of Biomedical Equipment.
- To familiarize the students with the operating principles of the equipment.
- To enable the students to gain knowledge on the applications of various medical equipment.

Course Outcomes: Upon completion of the course, the students will be able to

1. Assess use of electrical stimulation principles to overcome cardiac rhythm disturbances.
2. Comprehend the principles of Anesthesia machine, functions of respiratory equipment and ventilators and sterilization equipment.
3. Assess the need and operating principle of equipment used in audiometry, Neonatology and drug delivery.
4. Comprehend the principles of Hemodialysis machine,
5. Perceive the governing principles of surgical diathermy and radiotherapy

UNIT – I

Electrocardiography: Block diagram of ECG. Blood Pressure measurement: Components and working principle of sphygmomanometer. Direct and indirect methods of Blood Pressure measurements. Electromagnetic and Ultrasonic techniques of Blood flow measurement.

UNIT-II

Electroencephalography: EEG-Block diagram, 10-20 electrode placement. Resting rhythms. Evoked potentials and their measurement. Filters for EEG rhythm analysis.

Electromyography: Introduction to EMG signals. EMG-Block diagram and circuits. Electrodes and their placement. Nerve conduction velocity, determination-using EMG, Stimulators for EMG recording.

UNIT – III

Cardiac Pacemakers: Types of arrhythmias, Pacemaker types-Asynchronous, Synchronous, External and implantable, Working principle, block diagram.

Synchronous/Demand Pacemaker: Modes of triggering-ventricular triggered and atrio-ventricular synchronized pacemaker, Programmable pacemaker, Microprocessor based implantable pacemaker, Rate responsive pacemaker.

Defibrillators: Need for Defibrillators, D.C. Defibrillator, Need for Synchronous Defibrillators, Automatic/Advisory External Defibrillators (AED), Implantable defibrillators.

UNIT – IV

Ventilators: Block diagram, Modes of ventilators, Types of ventilators-CPAP, BiPAP.

Heart lung Machine: Working principle. Components of heart lung machine. Functional details of Bubble, Thin Film and membrane-type of blood oxygenators.

UNIT – V

Haemodialyzers - Dialyzers, principle of dialyzers, Membranes of the haemodialyzers, Types of Dialysis and merits and demerits.

Lithotriptors: Principles and Applications, Need for Lithotriptor, First Lithotriptor Machine, Modern Lithotriptor Systems, Extra-corporeal shock-wave Therapy

Suggested Reading:

1. John G. Webster, "Medical Instrumentation-Application and Design", John Wiley and sons Inc., 3rd Ed., 2003.
2. Khandpur R.S., Hand Book of Biomedical Instrumentation, Tata Mc.Graw Hill Pub Co.Ltd., 2nd ed., New Delhi, 2016.
3. Joseph J. Carr ad John M. Brown, Introduction to Biomedical Equipment Technology, Pearson Education, 2001.
4. Harry Bronzino E, Handbook of Biomedical Engineering and Measurements, Reston, Virginia.
5. Joseph J.Carr and John M.Brown, Introduction to Biomedical equipment technology, John Wiley and sons, New York, 1997.

MR 701 BM

MEDICAL IMAGING MODALITIES

Instruction	3 Periods per week
Duration of University Examination	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

COURSE OBJECTIVES:

- To familiarize the students with various medical imaging modalities.
- To make learners understand the principles, detectors and operating procedures of X-ray, CT, MRI, ultrasound, PET and SPECT.
- To make the students learn the advantages, disadvantages and hazards of various medical imaging equipment.

COURSE OUTCOMES: Upon completion of the course, the students will be able to:

1. Interpret the working principle and operating procedure and applications of X-ray equipment.
2. Understand the image reconstruction techniques and applications of CT.
3. Summarize the image acquisition and reconstruction techniques in MRI.
4. Comprehend the working principle, modes and medical applications of ultrasound imaging.
5. Examine the operation and applications of PET, SPECT and radio nuclide instrumentation.

UNIT-I

X ray Imaging: Electromagnetic spectrum, Production of X-rays, X-ray tubes- Stationary and Rotating Anode types, Block diagram of an X-Ray Machine, Collimators and Grids, Timing and Exposure controls. X-Ray Image visualization-Films, Fluorescent screens, Image Intensifiers.

UNIT-II

Computed Tomography: Basic principles, CT number scale, CT Generations. Major sub systems- Scanning system, processing unit, viewing unit, storage unit. Need and Principle of sectional imaging. Applications of CT - Angio, Osteo, Dental, Perfusion (Body &Neuro), Virtual Endoscopy, Coronary Angiography.

UNIT-III

Ultrasound Imaging: - Principles of image formation -Imaging principles and instrumentation of A-mode, B-Mode, Gating Mode, Transmission mode and M-mode. Basics of multi-element linear array scanners, Digital scan conversion.

Doppler Ultrasound and Colour Dopplerimaging, Image artifacts, Biological effects, Ultrasound applications in diagnosis, therapy and surgery.

UNIT- IV

Magnetic Resonance Imaging: Principles of NMR imaging systems, Image reconstruction techniques-Relaxation processes, imaging/ pulse sequences, types of coils, biological effects and advantages of NMR imaging.

UNIT-V

Nuclear Medicine–Radioisotopes in medical diagnosis, Basic instrumentation- Radiation detectors, Pulse height analyzer, Rectilinear scanner, Gamma camera.Emission Computed Tomography (ECT), Principle and instrumentation of Single Photon Emission Computed Tomography(SPECT) and Positron Emission Tomography (PET).
Comparison of SPECT, PET and combined PET/ X-ray CT.

Suggested reading:

1. Khandpur R.S., *Handbook of Biomedical Instrumentation*, Tata McGraw Hill, 2016.
2. S Webb, "*The Physics of Medical Imaging*", Adam Highler, Bristol Published by CRC Press, 1988.
3. A C Kak, "*Principle of Computed Tomography*", IEEE Press New York, 1988.
4. Hykes, Heorick, Starchman, *Ultrasound physics and Instrumentation* MOSBY year book, 2nd Ed. 1992.
5. Stewart C.Bushong, *Magnetic Resonance Imaging- physical and biological principles*, MOSBY, 2nd Ed., 1995.

MR 702 BM

MATERIALS FOR MEDICAL IMPLANTS

Instruction	3 Periods per week
Duration of University Examination	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

COURSE OBJECTIVES:

- To understand the medical device classes and regulatory efforts
- To understand the of national and international medical device regulations and standards
- To know about the patents and intellectual property rights.

COURSE OUTCOMES: Upon completion of the course, the student will be able to

1. Differentiate the medical devices under their respective classes.
2. Design medical products using different methodologies
3. Deliver the rules of Indian Medical Device Regulations-2017
4. Understand the product safety and legal issues
5. Apply the concepts in design of medical equipment.

UNIT 1

Biomaterial and its properties: Definition and need, Types of Biomaterials, Requirements of an ideal biomaterial, Biocompatibility. Characterization of materials – Mechanical, chemical, thermal, electrical, optical and other properties.

UNIT II

Materials used as biomaterials and their properties: Properties of metallic biomaterials – stainless steels, Cobased alloys, Ti and Ti–based alloys, Ni-Ti alloys. Properties of Ceramic biomaterials - Aluminum Oxides, Calcium Phosphate, Glass ceramics and Carbons. Properties of Polymeric biomaterials – Polyamides, Polyethylene, Polyacrylates, Polyvinyl Chloride.

UNIT-III

Tissue response to biomaterials and testing of biomaterials: Inflammation, wound–healing and foreign body response, systemic toxicity and hypersensitivity, Blood compatibility, Carcinogenicity, implant–associated infection. In-Vitro and In-Vivo assessment of tissue compatibility and testing of blood–material interaction.

UNIT-IV

Soft tissue replacements: Sutures, Surgical tapes and Staples, Tissue Adhesives, Percutaneous Devices, Artificial Skin, Maxillofacial implant, Ear and Eye Implants, Fluid Transfer Implants, Vascular Implants, Valve Implants,

UNIT-V

Hard tissue replacements: Wires, Pins, Screws, Fracture Plates-Cortical and Cancellous Bone Plates. Intramedullary devices, spinal fixation devices. Lower extremity Implants, Upper Extremity Implants, Endosseous Tooth Implants–Subperiosteal and staple /Transosteal implants, Interface of orthopedic implants.

Suggested Reading:

1. Joon B. Park and Roderic S. Lakes, *Biomaterials – An introduction* Plenum Press, 2nd Edition,1992.

2. Buddy D. Ratner, Allan S. Hoffman, Frederick, J. Schoen and Jack E. Lemons, *Biomaterials Science – An Introduction to materials in Medicine,* Academic Press, 1996.

3. John Enderle, Susan Blanchard and Joseph Bronzino, I*ntroduction to Biomedical Engineering*, 2nd Edition, Elsevier Academic Press, 2009.

4. Roger Narayan, *Biomedical Materials*, Springer, 2009. 5. NPTEL Video lecture: *Introduction to Biomaterials.*

Course Code	Course Title					Course Type	
MR 861 BM	**Project Work**					Core	
Prerequisite	Contact hours per week					Scheme of Evaluation		Credits
	L	T	D	P		CIE	SEE	
	-	-	-	6		50	50	3

Course Objectives:

- To enhance practical and professional skills of the students
- To expose the students to hospital/ medical industry practices and team work

Course Outcomes: At the end of the course, the student will be able to:

1. Synthesize knowledge and skills previously gained and apply these to new technical problem.
2. Select from different methodologies, methods and analyses to produce a suitable research design, and justify their design.
3. Present the findings of their technical solution in a written report.
4. Develop oral and written communication skills to present and defend their work in front of technically qualified audience

Guidelines:

The project topic should be selected / chosen to ensure the satisfaction of the urgent need to establish a direct link between education, national development and productivity and thus reduce the gap between the world of work and the world of study.

After multiple interactions with guide and based on comprehensive literature survey, the student shall identify the domain and define dissertation objectives. The referred literature should preferably include IEEE/IET/IETE/Springer/Science Direct/ACM journals in the areas of Biomedical Instrumentation, Computing and Processing (Hardware and Software), Circuits-Devices and Systems, Robotics and Control Systems, Signal and Image Processing and Analysis and any other related domain. In case of industry-sponsored projects, the relevant application notes, product catalogues should be referred and reported. The student is expected to detail out specifications, methodology, resources required, critical issues involved in design and implementation and phase wise work distribution, and submit the proposal within a month from the date of registration.

A document report comprising of summary of literature survey, detailed objectives, project specifications, paper and/or computer aided design, proof of concept/functionality, part results, record of continuous progress. In case of unsatisfactory performance, committee may recommend repeating the Project work.

The evaluation and award of credits based on the performance of the students is done by a committee constituted by the Head of the department.

- Project topics may be chosen by the student with advice and approval from the faculty members
- Oral presentation is an important aspect of engineering education.
- Project topics may be chosen by the student with advice and approval from the faculty members.
- Students are to be assessed and evaluated as per the following criteria.

Each student is required to:

1. Submit a one-page synopsis at the beginning of the semester for display on the notice board (by 2nd week after commencement of the semester)
2. Give a 20-minutes demo and demonstrate the work through an LCD PowerPoint presentation followed by a 10 minutes discussion.
3. Submit a report on the project work with list of references and slides used.
4. Project reviews are to be scheduled from the 3rd week of the semester to the last week of the semester and any change in schedule should be discouraged.
5. Batch size should be ONE.
6. Finalization of the projects will be done by the supervisor at the concerned department.
7. Two reviews to be conducted – One during 5th week and another during 10th week and final evaluation shall be conducted during 15th to 16th week.
8. Students are required to give Presentations during the reviews.
9. Students are required to submit project report.

Distribution of marks for Continuous Internal Evaluation (CIE) – 50 Marks

Evaluation Criteria	**Maximum Marks**
Literature Review	05
Problem Formulation	05
Design/ Methodology	15
Implementation & Results	15
Presentation& Documentation	10

Distribution of marks for Semester End Examination (SEE) – 50 Marks

Evaluation Criteria	**Maximum Marks**
Design/ Methodology	10
Implementation & Results	15
Presentation & Documentation	15
Publication in a conference/ Journal (Published / accepted)(Compulsory)	10