B.Tech. (Biomedical Engineering)

Academic Year 2023-2024
(New)

Department of Biomedical Engineering
School of Engineering &Technology

Central University of Rajasthan
NH-8, Bandarsindri, Kishangarh, Ajmer
Rajasthan 305817

Preamble:

The Central University of Rajasthan was established in the year 2009 by an act of Parliament by India's government with a motto to provide quality education to all sections of society, in particular to the deprived, and with a vision of education for sustainable development. Continuing with the motto and of its establishment and concept, we are in the continuous process of imparting quality education for all the sections of society and equipping them with apprised knowledge in their area and making them inclined towards their goals both professionally, personally, and socially. We are committed to producing graduates capable of leading the society in the path of prosperity and fraternity. The university has been offering a Master of Technology (M. Tech) program in Computer Science & Engineering with a specialization in Information Security and B.Tech. In CSE and ECE under the School of Engineering and Technology. The university intends to introduce an undergraduate program in engineering (Bachelor of Technology) in **Biomedical Engineering** to widen our horizon and serve society by producing engineering graduates with advanced medical skills to lead the nation towards sustainable development.

ABOUT THE DEPARTMENT

Biomedical Engineering is the junction of engineering, the life sciences, and healthcare. This implicates collaborating with clinicians and life science researchers to develop medicine, medical technologies, devices, equipment, software solutions, and computer systems related to the field. Biomedical Engineering is one of the three departments in the School of Engineering, Central University of Rajasthan (CURAJ), a central university located in Ajmer, Rajasthan, India. CURAJ has ten schools, twenty academic departments, and one community college covering Technology, Science, Humanities, Commerce, Management, Public Policy, and Social Science programs with a strong emphasis on scientific, technological, social education, and research. Total student enrolment at the university exceeds 1700 and includes students from over 23 states.

The vision of the Department:

To implement advanced engineering and science principles in the broad area of biology, and medicine, and improve healthcare delivery to humans in association with the clinical world.

The mission of the Department:

Apply knowledge of engineering, biology, and clinical principles to the design, development, and evaluation of drugs and various medical devices for cost-effective diagnosis and therapeutics to treat multiple ailments.

Biomedical Engineering is a multidisciplinary science, technology, and engineering degree identified as one of its niche engineering branches. It is a degree that combines biology and engineering materials and principles of medicine, aiming to streamline healthcare services in the country.

The overall cost of healthcare is likely to increase due to increased awareness and population. Moreover, the increased knowledge of recent medical advancements among the general population has led to an increased number of patients seeking biomedical solutions for their health issues. This will, in turn, increase the need for engineers in the biomedical field and likely result in faster-than-average growth in associated occupations long-lasting unmet need for scholars in the field of **Biomedical Engineering.**

Approved Intake (30)

Admission through JEE Main: 30 (Seats)

B. Tech. course in Biomedical Engineering (4 years)

Biomedical Engineering is an applied interdisciplinary field of technology. The program aims to cutting-edge knowledge to address the problems in the field of healthcare. The overall objective of the course is to prepare skilled biomedical engineers who can work on artificial organs, prosthetics, medical instruments, and health care delivery systems. The course will focus on the following core areas:

1- Biosensors and device development

Biosensors are analytical tool that senses analyte and generate an equivalent electrical signal with the help of a transducer. The biosensors are used in many applications including healthcare diagnostics, environmental monitoring, and food monitoring, etc. The biosensors can be incorporated with the electronic device to capture the generated signal.

2- Biomedical Imaging and biomedical devices

Biomedicals has developed from early simple uses of X-rays for diagnosis of fractures to technological developments in MRI, PET, SPECT, CT, ultrasound, acoustic elastography, optical coherence tomography, cardiac electrical potential mapping, human visual perception, image-guided intervention, and contrast agents. Microscopy has made advancements with fluorescence and confocal imaging enabling the visualization of structure and function at the microscopic scale and in three dimensions.

3-Biomechanic Systems: Musculoskeletal modeling, bone biomechanics, soft tissue mechanics, control of neuroprocessing for motor function, neuromuscular control systems, human locomotion, Cells, and tissues, studying their mechanics and mechanobiology.

4- Biomaterials, Tissue Engineering and nanomedicine

Biomaterial have made an enormous impact on the treatment of injury and disease and are used throughout the body. Because of the complexity of cell and tissue reactions to biomaterial, there is always a need for design, selection, synthesis and fabrication of new biomaterials. Tissue engineering aims to construct, restore, maintain, or improve damaged tissues or whole organs. Nanomedicine has revolutionized the drug delivery approaches and lessen the side-effects and improve drug absorption.

Program-specific Objectives:

1. Graduates of the program will adapt to the continuous changes in the field of Biomedical Engineering.
2. To grasp concepts of engineering mathematics and apply them in correlated engineering domains to evaluate real-world problems in health care.
3. The ability to grasp the research advancements and evolve with innovative ideas to contribute towards cost effective product development for providing access of health care services to masses.

Program Outcomes – Competencies – Performance Indicators

PO 1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization for the solution of complex engineering problems.	
Competency	**Indicators**
1.1 Demonstrate competence in mathematical modeling	1.1.1 Apply mathematical techniques such as calculus, linear algebra, and statistics to solve problems 1.1.2 Apply advanced mathematical techniques to model and solve Biomedical engineering problems
1.2 Demonstrate competence in basic sciences	1.2.1 Apply laws of natural science to an engineering problem
1.3 Demonstrate competence in engineering fundamentals	1.3.1 Apply fundamental engineering concepts to solve engineering problems
1.4 Demonstrate competence in specialized engineering knowledge to the program	1.4.1 Apply integrated engineering concepts to solve engineering problems.
PO 2: Problem analysis: Identify, formulate, research literature, and analyses complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	
Competency	**Indicators**
2.1 Demonstrate an ability to identify and formulate complex engineering problem	2.1.1 Articulate problem statements and identify objectives 2.1.2 Identify engineering systems, variables, and parameters to solve the problems 2.1.3 Identify the mathematical, engineering and other relevant knowledge that applies to a given problem
2.2 Demonstrate an ability to formulate a solution plan and methodology for an engineering problem	2.2.1 Reframe complex problems into interconnected sub-problems 2.2.2 Identify, assemble and evaluate information and resources. 2.2.3 Identify existing processes/solution methods for solving the problem, including forming justified approximations and assumptions 2.2.4 Compare and contrast alternative solution processes to select the best process.
2.3 Demonstrate an ability to formulate and interpret a model	2.3.1 Combine scientific principles and engineering concepts to formulate model/s

	(mathematical or otherwise) of a system or process that is appropriate in terms of applicability and required accuracy. 2.3.2 Identify assumptions (mathematical and physical) necessary to allow modeling of a system at the level of accuracy required.
2.4 Demonstrate an ability to execute a solution process and analyze results	2.4.1 Apply engineering mathematics and computations to solve mathematical models 2.4.2 Produce and validate results through skillful use of contemporary engineering tools and models 2.4.3 Identify sources of error in the solution process, and limitations of the solution. 2.4.4 Extract desired understanding and conclusions consistent with objectives and limitations of the analysis
PO 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 public health and safety, and cultural, societal, and environmental considerations.	
Competency	**Indicators**
3.1 Demonstrate an ability to define a complex/ open-ended problem in engineering terms	3.1.1 Recognize that need analysis is key to good problem definition 3.1.2 Elicit and document, engineering requirements from stakeholders 3.1.3 Synthesize engineering requirements from a review of the state-of-the-art 3.1.4 Extract engineering requirements from relevant engineering Codes and Standards such as, DCA, FDA, BIS, ISO and ASTM. 3.1.5 Explore and synthesize engineering requirements considering health, safety risks, environmental, cultural and societal issues 3.1.6 Determine design objectives, functional requirements and arrive at specifications
3.2 Demonstrate an ability to generate a diverse set of alternative design solutions	3.2.1 Apply formal idea generation tools to develop multiple engineering design solutions 3.2.2 Build models/prototypes to develop a diverse set of design solutions 3.2.3 Identify suitable criteria for the evaluation of alternate design solutions
3.3 Demonstrate an ability to select an optimal design scheme for further development	3.3.1 Apply formal decision-making tools to select optimal engineering design solutions for further development 3.3.2 Consult with domain experts and stakeholders to select candidate engineering design solution for further development
3.4 Demonstrate an ability to advance an engineering design to defined end state	3.4.1 Refine a conceptual design into a detailed design within the existing constraints (of the resources) 3.4.2 Generate information through appropriate

	tests to improve or revise the design
PO 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.	
Competency	**Indicators**
4.1 Demonstrate an ability to conduct investigations of technical issues consistent with their level of knowledge and understanding	4.1.1 Define a problem, its scope and importance for purposes of investigation 4.1.2 Examine the relevant methods, tools and techniques of experiment design, system calibration, data acquisition, analysis and presentation 4.1.3 Apply appropriate instrumentation and/or software tools to make measurements of physical quantities 4.1.4 Establish a relationship between measured data and underlying physical principles.
PO 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.	
Competency	**Indicators**
5.1 Demonstrate an ability to identify/ create modern engineering tools, techniques and resources	5.1.1 Identify modern engineering tools such as computer-aided drafting, modeling and analysis; techniques and resources for engineering activities 5.1.2 Create/adapt/modify/extend tools and techniques to solve engineering problems
5.2 Demonstrate an ability to select and apply discipline-specific tools, techniques and resources	5.2.1 Identify the strengths and limitations of tools for (i) acquiring information, (ii) modeling and simulating, (iii) monitoring system performance, and (iv) creating engineering designs. 5.2.2 Demonstrate proficiency in using discipline-specific tools
5.3 Demonstrate an ability to evaluate the suitability and limitations of tools used to solve an engineering problem	5.3.1 Discuss limitations and validate tools, techniques and resources 5.3.2 Verify the credibility of results from tool use with reference to the accuracy and limitations, and the assumptions inherent in their use.
PO 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.	
Competency	**Indicators**
6.1 Demonstrate an ability to describe engineering roles in a broader context, e.g. pertaining to the environment, health, safety, legal and public welfare	6.1.1 Identify and describe various engineering roles; particularly as pertains to protection of the public and public interest at the global, regional and local level

6.2 Demonstrate an understanding of professional engineering regulations, legislation and standards	6.2.1 Interpret legislation, regulations, codes, and standards relevant to your discipline and explain its contribution to the protection of the public
PO 7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and the need for sustainable development.	
Competency	**Indicators**
7.1 Demonstrate an understanding of the impact of engineering and industrial practices on social, environmental and in economic contexts	7.1.1 Identify risks/impacts in the life-cycle of an engineering product or activity 7.1.2 Understand the relationship between the technical, socio-economic and environmental dimensions of sustainability
7.2 Demonstrate an ability to apply principles of sustainable design and development	7.2.1 Describe management techniques for sustainable development 7.2.2 Apply principles of preventive engineering and sustainable development to an engineering activity or product relevant to the discipline
PO 8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	
Competency	**Indicators**
8.1 Demonstrate an ability to recognize ethical dilemmas	8.1.1 Identify situations of unethical professional conduct and propose ethical alternatives
8.2 Demonstrate an ability to apply the Code of Ethics	8.2.1 Identify tenets of the BMES professional code of ethics. 8.2.2 Examine and apply moral & ethical principles to known case studies
PO 9: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	
Competency	**Indicators**
9.1 Demonstrate an ability to form a team and define a role for each member	9.1.1 Recognize a variety of working and learning preferences; appreciate the value of diversity on a team 9.1.2 Implement the norms of practice (e.g. rules, roles, charters, agendas, etc.) of effective team work, to accomplish a goal.
9.2 Demonstrate effective individual and team operations-- communication, problem-solving, conflict resolution and leadership skills	9.2.1 Demonstrate effective communication, problem-solving, conflict resolution and leadership skills 9.2.2 Treat other team members respectfully 9.2.3 Listen to other members 9.2.4 Maintain composure in difficult situations
9.3 Demonstrate success in a team-based project	9.3.1 Present results as a team, with smooth integration of contributions from all individual efforts
PO 10: Communication: Communicate effectively on complex engineering activities with the engineering community and with the 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	
Competency	**Indicators**
10.1 Demonstrate an ability to comprehend technical literature and document project work	10.1.1 Read, understand and interpret technical and non-technical information 10.1.2 Produce clear, well-constructed, and well-supported written engineering documents 10.1.3 Create flow in a document or presentation - a logical progression of ideas so that the main point is clear
10.2 Demonstrate competence in listening, speaking, and presentation	10.2.1 Listen to and comprehend information, instructions, and viewpoints of others 10.2.2 Deliver effective oral presentations to technical and non-technical audiences
10.3 Demonstrate the ability to integrate different modes of communication	10.3.1 Create engineering-standard figures, reports and drawings to complement writing and presentations 10.3.2 Use a variety of media effectively to convey a message in a document or a presentation
PO 11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	
Competency	**Indicators**
11.1 Demonstrate an ability to evaluate the economic and financial performance of an engineering activity	11.1.1 Describe various economic and financial costs/benefits of an engineering activity 11.1.2 Analyze different forms of financial statements to evaluate the financial status of an engineering project
11.2 Demonstrate an ability to compare and contrast the costs/benefits of alternate proposals for an engineering activity	11.2.1 Analyze and select the most appropriate proposal based on economic and financial considerations.
11.3 Demonstrate an ability to plan/manage an engineering activity within time and budget constraints	11.3.1 Identify the tasks required to complete an engineering activity, and the resources required to complete the tasks. 11.3.2 Use project management tools to schedule an engineering project, so it is completed on time and on budget.
PO 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.	
Competency	**Indicators**
12.1 Demonstrate an ability to identify gaps in knowledge and a strategy to close these gaps	12.1.1 Describe the rationale for the requirement for continuing professional development 12.1.2 Identify deficiencies or gaps in knowledge and demonstrate an ability to source information to close this gap

12.2 Demonstrate an ability to identify changing trends in engineering knowledge and practice	12.2.1 Identify historic points of technological advance in engineering that required practitioners to seek education in order to stay current 12.2.2 Recognize the need and be able to clearly explain why it is vitally important to keep current regarding new developments in your field
12.3 Demonstrate an ability to identify and access sources for new information	12.3.1 Source and comprehend technical literature and other credible sources of information 12.3.2 Analyze sourced technical and popular information for feasibility, viability, sustainability, etc.

Detailed Scheme

SEMESTER- I

SEMESTER I						
Sr. No	**Course Code**	**Course Name**	**L**	**T**	**P**	**Credits**
			Hours/week			
1	BME 101	Engineering Mathematics-I	3	1	0	4
2	BME 102	Introduction to Biomedical Engineering	3	0	0	3
3	BME 103	Basic Electrical Engineering	3	0	1	4
4	BME 104	English (Language and Communication Writing Skills-I)	3	1	0	4
5	BME 105	Introduction to Programming (Shifted from 2nd Semester to 1st Semester)	3	1	0	3
6	BME 106	Programming Lab (shifted from 2nd Semester to 1st Semester)	0	0	2	2
Total Credit						**20**

SEMESTER II

SEMESTER II						
Sr. No	**Course Code**	**Course Name**	**L**	**T**	**P**	**Credits**
			Hours/week			
1	BME 107	Engineering Mathematics-II	3	1	0	4
2	BME 108	Basic Electronics Engineering	3	0	2	4
3	BME 109	Universal Human Value (UHV)	3	0	1	4
4	BME 110	Biomedical Engineering Workshop	3	1	0	4
5	BME 111	Engineering Physics (Syllabus Update)	1	0	4	4
6	BME 112	Engineering Chemistry (syllabus update)	3	0	2	4
Total Credit						**20**

* *The Course on University Human Value (UHV) is a compulsory course as an audit course that should be cleared by all the students; however, this will not affect the credits of the program.

SEMESTER III

Sl. No	COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	C
THEORY							
1.	BME 201	Biomechanics	BS	3	0	0	3
2.	BME202	Electronic devices and circuits	ES	3	0	0	3
3.	BME203	Molecular and Cellular Biology	BS	3	0	0	3
4.	BME204	Circuit Theory and Network Analysis	PC	3	0	0	3
5.	BME205	Human Anatomy and Physiology	PC	3	0	0	3
PRACTICALS							
6.	BME206	Electronic devices and circuits Lab	PC	0	0	4	2
7.	BME207	Molecular and Cellular Biology Lab	PC	0	0	4	2
8.	BME208	Human anatomy and physiology laboratory	PC	0	0	4	2
						TOTAL	**21**

SEMESTER IV

Sl. No	COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	C
THEORY							
1.	BME 209	Signals and system design (Name change)	ES	3	0	0	3
2.	BME210	Biomedical Instrumentations	PS	3	0	0	3
3.	BME211	Pathology and human diseases	PC	3	0	0	3
4.	BME212	Biomaterials	PC	3	0	0	3
5.	BME213	Digital System Design	PC	3	0	0	3
PRACTICALS							
6.	BME214	Biomedical Instrumentations and Devices lab	PC	0	0	4	2
7.	BME215	Biomaterials Lab	PC	0	0	4	2
8.	BME216	Digital System Design Lab	PC	0	0	4	2
						TOTAL	**21**

SEMESTER V

Sl. No	COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	C
THEORY							
1.	BME301	Environmental Studies	PC	3	0	0	3
2.	BME302	Biomedical Imaging	PC	3	0	0	3
3.	BME303	Invasive and non-invasive medical Diagnostic Technique	PC	3	0	0	3
4.	BME304	Analog Electronics	PC	3	0	0	3
5.	----	Program electives I	PC	3	0	0	3
PRACTICALS							
6.	BME305	Immunotechnology lab	PC	0	0	4	2
7.	BME306	Analog Electronics lab	PC	0	0	4	2
8.	BME307	Biomedical Imaging Laboratory	PC	0	0	4	2
						Total	**21**

SEMESTER VI

SI. NO	COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	C
THEORY							
1.	BME308	Measurements and Instrumentations	PC	3	0	0	3
2.	BME309	Sensors & Transducers in Healthcare	PC	3	0	2	4
3.	BME310	Microcontrollers and embedded system	PC	3	0	2	4
4.	BME311	Medical Image Processing	PC	3	0	2	4
5.	----	Program electives II	PC	3	0	0	3
6.	BME 312	Project I	PC	0	0	6	3
						TOTAL	**21**
Internship: 6-8 weeks of industrial training can be conducted at the end of the VI Semester but evaluation will be done next (VII) semester.							

SEMESTER VII

SI. NO	COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	C
1.	BME401	Digital Signal Processing	PC	3	0	0	3
2.	BME402	Biological Control Systems	PC	3	0	0	3
3.	BME403	Biomics implants and Artificial Organs	PC	3	0	0	3
4.	BME404	Neuro science and Nero technology	PC	3	0	0	3
5	BME405	Project II	PC	0	1	5	2
6.	BME406	Short Internship		0	0	2	1
7	----	Program electives III	PE	3	0	0	3
						TOTAL	**18**

SEMESTER VIII

SI. NO	COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	C
1.	--	Program electives IV	PE	3	0	0	3
2.	--	Program electives V	PE	3	0	0	3
3.	--	Program electives VI	OE	3	0	0	3
4.	BME407	Project III	PC	0	1	16	9
						TOTAL	**18**
L: Lecture, T: Tutorial, P: Practical, C: Credit							

TOTAL NO. OF CREDITS: 160

List of Program electives/open electives

BME 315: Immunotechnology
BME 316: Tissue Engineering and Regenerative Medicine
BME 317: Electronic Circuit for Biomedical Instruments
BME 318: Hospital system management
BME 319: 3D printing technology
BME 320: Medical Nanotechnology
BME 321: Pharmaceutical Microbiology and Biotechnology

BME 408: Introduction to MEMS
BME 409: Biostatistics
BME 410: Artificial intelligence and neural networks in medicine
BME 411: Nanoelectronics
BME 412: Machine learning and AI
BME 413: Microprocessors Theory and Application
BME 414: Information theory and coding
BME 415: Speech and Audio Processing
BME 416: Electronic Measurement and Instruments
BME 417: Biomedical Hazards & Safety
BME 418: Regulatory processes and bioethics
BME 419: Bioinformatics and Drug Discovery
BME 420: Molecular Imaging (imaging of chemistry and biology)

"In addition to above-mentioned subjects, some other subjects may be considered as open electivesoffered by other departments of the university and through MOOC

DETAILED SYLLABUS

SEMESTER-I

BME 101: Engineering Mathematics-I		
Teaching Scheme	Examination Scheme	Credits allocated
Theory 3 h/week+ Tutorial 1h/week	End of semester Examination-60 marks	Theory-3, Tutorial-1
Course Prerequisite: Knowledge of 10+2 Mathematics.		
Course Objective: To provide the students with sufficient knowledge in matrix, calculus, and differentiation, so that it can be used in their respective fields of Engineering.		
Course Outcomes: On completion of this course, students will be able to		
CO1: Apply elementary transformations to reduce the matrix into the echelon form and normal form to determine its rank and interpret the various solutions of a system of linear equations. **CO2:** To understand mean values theorems, differentiation, curvature, concavity, etc. **CO3:** To apply integration, integrals in higher order applications. **CO4:** To understand different functions of vector calculus and to apply them in further synthesis.		
Level	Bachelor	
	Course Content	
Unit -I	Rank and inverse of a matrix by elementary transformation, consistency of the linear system of equations and their solution. Eigen values and Eigen vectors. Cayley-Hamilton theorem (statement only) & its applications.	10 hrs
Unit-II	Mean value theorems and their geometrical interpretations, Taylor's and Maclaurin's series expansions, Successive differentiation and Leibnitz theorem; Indeterminate forms, L'Hospital Rule, Asymptotes, Curvature, Concavity and convexity, point of inflexion.	10 hrs
Unit-III	Integration as inverse process of differentiation; Integration by substitution, The fundamental theorem of calculus, Definite integrals and its application to find area under simple curve and area between two curves, Area of a curve using multiple integral.	10 hrs
Unit-IV	Differentiation and integration of vector functions of scalar variables, scalar and vector fields, gradient, Directional derivative. Gauss's and Stokes's theorems (statement only) and their simple applications.	10 hrs
Internal assessment		
Part A	CIA-I: Unit I, and II	20 Marks
	CIA-II: Unit III, and IV	20 Marks

Part B	ESE: Term Exam	60 Marks

Text/Reference Books:

1. R.K.Jain & S R K Iyengar, Advanced Engineering Mathematics, Narosa Pub.House
2. Thomas & Finney, Advanced calculus and geometry Addison-Wesley Pub. Co.
3. D. W. Jordan & P Smith, Mathematical Techniques, OXFORD
4. Peter V. O'Neil, Advanced Engineering Mathematics, Cengage Learning,NewDehli
5. B.V.Ramana, Higher Engineering Mathematics, McGraw – Hill.
6. Methods of Real Analysis by R. R. Goldberg.
7. Foundation of Differential Calculus by Euler, Translated by J.D. Blanton, Springer-Verlag, New York, 2000.
8. Calculus, Vol. 1, 2 by T. Apostol, John Wiley.
9. Differential and Integral Calculus by Shanti Narayan.

BME 102: Introduction to Biomedical Engineering		
Teaching Scheme	**Examination Scheme**	**Credits allocated**
Theory 3 hrs/week	End of semester Examination-60 marks	Theory-3
	Internal assessment:40 marks	
Course Prerequisite: NA		
Course Objective: 1. To explain the basic function of sensors. 2. To explain the basic physics of biomedical instrumentation. 3. To explain the basic physics of Bio imaging systems. 4. To explain the science of life.		
Course Outcomes: On completion of this course, students will be able to		
CO1: Understand the basic concepts of sensors and transducers. **CO2:** Understand the basic physics of medical instrumentation. **CO3:** Understand the basic physics of medical imaging systems. **CO4:** Understand the biological function of human body.		
	Course Content	
Unit -I	Introduction to Sensors Introduction to Biomedical Sensors General concept and terminology, Sensor classification and calibration, static and dynamic characteristics, errors and uncertainty. Resistive sensors, Capacitive sensors, Inductive sensors, Electromagnetic sensors. Biosensors Operating principle, biological elements in biosensors, Immobilization of the biological component.	10 hrs
Unit-II	Basics of Biomedical Engineering, Biosignals, Bio instrumentations, Biomedical Imaging, Biosensors, Embedded Systems in Biomedical, Point-of-care Devices, Biosciences.	10 hrs

Unit-III	Introduction to Biomedical Imaging Systems Introduction to X-Rays, CT, MRI, Ultrasound. Difference in CT and MRI. Use of Ultrasound. Application of MRI and CT. Imaging vital organs using CT, MRI and Ultrasound. Exclusion criteria of MRI.	10 hrs
Unit-IV	Structures of prokaryotic and Eukaryotic cells, levels of organization, cellular organelles and functions, Bio-macromolecules-proteins, carbohydrates, nucleic acids, lipids , central Dogma of Molecular Biology.	10 hrs
Assessment		
Part A	CIA-I: Unit I	**20 Marks**
	CIA-II: Unit II, III	**20 Marks**
Part B	End Semester Exam	**60 Marks**

Essential Readings

1. John C. Webster, Medical Instrumentation Leighton, Mifflin Co Boston, USA
2. R. S. Khandpur Handbook of Biomedical Instrumentation, Tata McGraw hill, Pub. Co.Ltd., New Delhi.

BME103: Basic Electrical Engineering		
Teaching Scheme	Examination Scheme	Credits allocated
Theory 3 hrs/week	End of semester Examination-60 marks	Theory-3
Practical 2hrs/week	Internal assessment:40 marks	Lab-1
		Total-4
Course Prerequisite: Students should have basic knowledge on Physics and Mathematics		
Course Objective: The main objective of this course is to understand the laws of electrical technology, operation of power converter and working of important electrical installation used in domestics or household purposes		
Course Outcomes: On completion this course, students will be able to		
1. To understand and analyze basic electric and magnetic circuits 2. To study the working principles of electrical machines and power converters. 3. To introduce the components of low voltage electrical installations		
Course Content:		
Unit -I	**DC Circuits:** Electrical circuit elements (R, L and C), voltage and current sources, Kirchoff current and voltage laws, analysis of simple circuits with dc excitation. Superposition, Thevenin and Norton Theorems. Time-domain analysis of first-order RL and RC circuits.	10 hrs

Unit-II	**AC Circuits:** Representation of sinusoidal waveforms, peak and rms values, phasor representation, real power, reactive power, apparent power, power factor. Analysis of single-phase ac circuits consisting of R, L, C, RL, RC, RLC combinations (series and parallel), resonance. Three phase balanced circuits, voltage and current relations in star and delta connections.	10 hrs
Unit-III	**Transformers:** Magnetic materials, BH characteristics, ideal and practical transformer, equivalent circuit, losses in transformers, regulation and efficiency. Auto-transformer and three-phase transformer connections.	10 hrs
Unit-IV	**Electrical Machines and power converter:** Generation of rotating magnetic fields, Construction and working of a three-phase induction motor, Significance of torque-slip characteristic. Loss components and efficiency, starting and speed control of induction motor. Single-phase induction motor. Construction, working, torque-speed characteristic and speed control of separately excited dc motor. Construction and working of synchronous generators; DC-DC buck and boost converters, duty ratio control. Single-phase and three-phase voltage source inverters; sinusoidal modulation	10 hrs
Unit-V	**Electrical Installations:** Components of LT Switchgear: Switch Fuse Unit (SFU), MCB, ELCB, MCCB, Types of Wires and Cables, Earthing. Types of Batteries, Important Characteristics for Batteries. Elementary calculations for energy consumption, power factor improvement and battery backup	10 hrs
Internal assessment		
Part A	CIA-I: Unit I, II and III	
	CIA-II: Unit IV, V, and VI	
Basic Electrical Engineering Laboratory		
	List of Experiments	

1. Introduction and use of measuring instruments – voltmeter, ammeter, multi-meter, oscilloscope. Real-life resistors, capacitors and inductors.
2. Identification various passive components without multimeters.
3. Measuring the steady-state and transient time-response of R-L, R-C, and R-L-C circuits to a step change in voltage (transient may be observed on a storage oscilloscope). Sinusoidal steady state response of R-L, and R-C circuits – impedance calculation and verification. Observation of phase differences between current and voltage. Resonance in R-L-C circuits.
4. Observation of the no-load current waveform on an oscilloscope (nonsinusoidal wave-shape due to B-H curve nonlinearity should be shown along with a discussion about harmonics). Loading of a transformer: measurement of primary and secondary

voltages and currents, and power.

5. Observation of Star and Delta connections. Voltage and Current relationships (line-line voltage, phase-to-neutral voltage, line and phase currents). Phase-shifts between the primary and secondary side. Cumulative three-phase power in balanced three-phase circuits.
6. Demonstration of cut-out sections of machines: dc machine (commutator-brush arrangement), induction machine (squirrel cage rotor), synchronous machine (field winging - slip ring arrangement) and single-phase induction machine.
7. Torque Speed Characteristic of separately excited dc motor.
8. Synchronous speed of two and four-pole, three-phase induction motors. Direction reversal by change of phase-sequence of connections. Torque-Slip Characteristic of an induction motor. Generator operation of an induction machine driven at supersynchronous speed.
9. Synchronous Machine operating as a generator: stand-alone operation with a load. Control of voltage through field excitation.
10. Demonstration of (a) dc-dc converters (b) dc-ac converters – PWM waveform (c) the use of dc-ac converter for speed control of an induction motor and (d) Components of LT switchgear.

Text Books:

1. Charles K. Alexander, Matthew N.O. Sadiku, "Fundamentals of Electric Circuits", McGraw Hill Education; 5th edition (1 July 2013)
2. Abhijit Chakrabarti, and Sudipta Nath, "BASIC ELECTRICAL ENGINEERING", McGraw Hill Education; 1st edition (1 July 2017).
3. D. P. Kothari and I. J. Nagrath, "Basic Electrical Engineering", Tata McGraw Hill, 2010

Reference Books:

1. D. C. Kulshreshtha, "Basic Electrical Engineering", McGraw Hill, 2009.
2. L. S. Bobrow, "Fundamentals of Electrical Engineering", Oxford University Press, 2011.
3. E. Hughes, "Electrical and Electronics Technology", Pearson, 2010.
4. V. D. Toro, "Electrical Engineering Fundamentals", Prentice Hall India, 1989.

BME 104: English Language And Communication Skills	
Examination Scheme	Credits allocated
End of semester Examination-60 marks	Theory-3
Internal assessment:40 marks	Lab-1
	Total-4

Unit I Grammar and its Usage

i. Phrases, clauses and elements of a sentence ii. Articles, Tenses and Modals

Unit II Oral and Written Communication

i. Letter Writing-Formal and Informal

ii. Short Presentation, so as to get across one's perspective, 200-250 words

Unit III Forms of Writing

i. Extract from Abdul Kalam's Wings of Fire, Section One : Orientation

ii. Resume Writing and Job Application.

Recommended Reading:

1. Thomson, A.J. & Martinet: A Practical English Grammar; Oxford University Press.

2. Hyland, Ken: Second Language Writing; University of Michigan Press.

3. Gabor Don: How to start conversations and make friends; New York: Fireside

4. Krishnaswamy, N: Modern English – A Book of Grammar, Usage and Composition, Macmillan India Ltd.

5. Quirk and Greenbaum: A University Level Grammar of English, Pearson

BME105: Introduction to Programming		
Teaching Scheme	Examination Scheme	Credits allocated
Theory 3 hrs/week	End of semester Examination-60 marks	Theory-3
Practical 2hrs/week	Internal assessment:40 marks	Lab-1
		Total-4
Course Prerequisite: Students should have basic knowledge of Computer fundamentals		
Course Objective: The main objective of this course is to understand the concept of problem-solving using algorithm and programming.		
Course Outcomes: On completion this course, students will be able to		
• To develop algorithms for arithmetic and logical problems • To translate the algorithms to programs & execution • To decompose a problem into functions and synthesize a complete program		
Course Content:		
Unit -I	**Introduction to Programming:** Concept of programming, program development steps, programming languages, concept of high-level, assembly and low-level programming languages, Concept of algorithms, representing algorithms through flow chart, pseudo code, introduction to the editing tools such as vi or ms-vc editors, concepts of the finite storage	10 hrs
Unit-II	**Programming using C:** Structure of c program, a simple c program, identifiers, basic data types and sizes, constants, variables, arithmetic, relational and logical operators, increment and decrement	10 hrs

	operators, conditional operator, bit-wise operators, assignment operators, expressions, type conversions, conditional expressions, precedence and order of evaluation, c primitive input output using getchar and putchar, exposure to the scanf and printf function, statements and blocks, if and switch statements	
Unit-III	**Iterations and Subprograms:** Concept of loops, while, do-while and for statements, break, continue, goto and labels, introduction to arrays- concepts, declaration, definition, accessing elements, storing elements, two-dimensional and multi-dimensional arrays, applications of arrays. Concept of sub-programming, functions, parameter passing, storage classes- extern, auto, register, static, scope rules, user defined functions, standard library functions, recursive functions.	10 hrs
Unit-IV	**Pointers and Strings:** Pointers- concepts, character pointers and functions, pointers to pointers, pointers and arrays, argument passing using pointers, array of pointers, passing arrays as arguments, String and string functions.	10 hrs
Unit-V	**Structures and File handling:** Derived types- structures- declaration, definition, passing strings as arguments, programming examples, union. File handling-reading from file, writing in file, updating in file.	10 hrs
Internal assessment		
CIA-I:	Unit I, II	**20 Marks**
CIA-II:	Unit III and IV	20 Marks

Reference Books:

1. Problem Solving and Program Design in C, by Jeri R. Hanly, Elliot B. Koffman, Pearson Addison-Wesley, 2006.
2. Computer Concepts and Programming by Anami, Angadi and Manvi, PHI Publication.
3. Problem Solving and Programming in C, R.S. Salaria, Khanna Publishing House..
4. Computer Fundamentals and Programming in C. Reema Thareja, Oxford Publication.

BME106-Programming Lab
1. Write a program to calculate the area of triangle using formula at=√s(sa)(s-b)(s-c). 2. Basic salary of an employee is input through the keyboard. The DA is 25% of the basic salary while the HRA is 15% of the basic salary. Provident Fund is deducted at the rate of 10% of the gross salary (BS+DA+HRA). Program to calculate the Net Salary. 3. Write a C program for computation of slope of a straight line with following rules: A. Consider the equation of line: y = mx+c B. Here user will provide the value of (x,y and c) the compute slope of line.

C. If you find the slope of line the also write code to compute the value of "y" at any value of "x" given by user.

4. Write a C program to compute your age in number of days by given date of birth.
5. Write a C program to print table of any given number.
6. Write a C program to compute the factorial of any given number.
7. Write a C program to check whether number is prime or not prime.
8. Write a C program to print the list of all EVEN numbers upto the given range i.e user will input two numbers start and end; you have to print even numbers in this range.
9. Write a C program to print the following pattern:

```
*
**
***
****
*****

    *
   **
  ***
 ****
******
```

10. Write a C program to check whether a number is palindrome or not.
11. Write a C program to find sum of first and last digit of a numbe.
12. WAP in c to merge two different 1-D arrays.
13. WAP in c to sort the array elements in ascending order.
14. WAP in c to find the median of array elements.
15. WAP in c to perform Matrix Multiplication of two matrices, the size of both matrices must be given by the user.
16. WAP in c to find that two matrices are equal.
17. WAP in c to input your name and print in uppercase letters.
18. WAP in c to store your enrolment numbers and print them in reverse order.
19. WAP in c to store any enrollment number from your batch, find the branch in enrollment number, and print the branch name.
20. Define a structure that can describe a hotel. It should have the member that includes the name, address, grade, room charge and number of rooms. Write a function to print out hotel of given grade in order of room charges.
21. Write a program to find the largest no among 20 integers array using dynamic memory allocation.
22. Write a program to print all the prime number, between 1 to 100 in file prime.txt.
23. Write a program to read number from file and then write all 'odd' number to file ODD.txt & all even to file EVEN.txt.
24. Write a c program to copy & count the character content of one file says a.txt to another file b.txt.
25. Write a program to take 10 integers from file and write square of these integer in other file.

Internal assessment		
CIA-I:	Unit I, II	**20 Marks**
CIA-II:	Unit III and IV	20 Marks

Text Books:

1. Schum‟s Outline of Programming with C by Byron Gottfried, McGraw-Hill
2. The C programming by Kernighan Brain W. and Ritchie Dennis M., Pearson Education.
3. Computer Basics and C Programming by V.Rajaraman , PHI Learning Pvt. Limited, 2015.

Computer Concepts and Programming in C, E Balaguruswami, McGraw Hill

Reference Books:

4. Problem Solving and Program Design in C, by Jeri R. Hanly, Elliot B. Koffman, Pearson
   Addison-Wesley, 2006.
5. Computer Concepts and Programming by Anami, Angadi and Manvi, PHI Publication.
6. Problem Solving and Programming in C, R.S. Salaria, Khanna Publishing House.

Computer Fundamentals and Programming in C. Reema Thareja, Oxford Publication.

2nd SEMESTER

BME 107: Engineering Mathematics-II		
Teaching Scheme	Examination Scheme	Credits allocated
Theory 3 h/week+ Tutorial 1h/week	End of semester Examination-60 marks	Theory-3, Tutorial-1
Course Prerequisite: Knowledge of 10+2 Mathematics.		
Course Objective: To provide the students with sufficient knowledge of differential equations, higher orders, power series and Fourier series, so that it can be used in their respective fields of Engineering.		
Course Outcomes: On completion this course, students will be able to		
CO1: Analyze the behavior of functions by using differential equations concepts. CO2: To understand second order and higher order differential equations. CO3:- To understand series solutions and to apply in higher order applications. CO4:- Analyze Fourier series, partial differential equations and to apply in further synthesis.		
Level	Bachelor	
Course Content:		
Unit -I	Differential equations of first order & of first degree: Linear form, reducible to linear form, exact form, Reducible to exact form, Picard's Theorem (Statement only).	10 hrs
Unit-II	Unit-2: Differential equations of second & higher order with constant coefficients.	10 hrs
Unit-III	Sequence, Power series, radius of conversions, solution in series of second order LDE with variable co-efficient (C.F. only). Regular Single points and extended power series (Frobenius Method).	10 hrs
Unit-IV	Fourier series, half range series, change of intervals, harmonic analysis. Formulation and classification of linear and quasi linear partial differential equation of the first order, Lagrange's method for linear Partial Differential Equation of the first order.	10 hrs
Internal assessment		
Part A	CIA-I: Unit I, and II	20 Marks
	CIA-II: Unit III, and IV	20 Marks
Part B	ESE: Term Exam	60 Marks

Text/Reference Books:

1. Erwin Kreyszig, Advanced Engineering Mathmatics, John Wiley.
2. B.V.Ramana, Higher Engineering Mathematics, McGraw – Hill.
3.Peter V. O'Neil, Advanced Engineering Mathematics, Cengage Learning, NewDehli
4. M Ray, A Text Book On Differential equations Students Friends & Co., Agra-2
5. Robert C. Mcowen, Partial Differential Equation Pearson Education.
6. George F. Simmons & S.G. krantz, Differential Equation Tata McGraw – Hill.
7. R.K.Jain & S R K Iyengar, Advanced Engineering Mathematics, Narosa
8. T Amarnath , An Elementary course in partial differential equations, Narosa, New Delhi.

9. S. G. Deo and V. Raghavendra: Ordinar Differential Equations, Tata McGraw Hill Pub. Co. ,New Delhi

BME 108: Basic Electronic Engineering		
Teaching Scheme	Examination Scheme	Credits allocated
Theory 3 hrs/week	End of semester Examination-60 marks	Theory-3
Practical 2hrs/week	Internal assessment:40 marks	Lab-1
		Total-4
Course Prerequisite: Students should have basic knowledge on Physics and Mathematics		
Course Objective: 1. The students will learn about the concepts and theories of diodes and transistors used in almost every electronic device. 2. To make the students familiar with simple logic principles used in advance digital electronics and communication. 3. Give introduction to electronic instrumentation used to measure electronic/electrical parameters.		
Course Outcomes: On completion this course, students will be able to		
CO1: Learn the operation of diodes and transistors and their basic applications in electronic devices. **CO2:** Understand the number system and their interconversions. **CO3:** Understand about digital electronics. They will get insights on digital logics theorems and basic combinational logic devices. **CO4:** Develop understanding about the basic electronic instrumentation.		
Course Content:		
Unit -I	Diodes and Applications covering, Semiconductor Diode - Ideal versus Practical, Resistance Levels, Diode Equivalent Circuits, Load Line Analysis; Diode as a Switch, Diode as a Rectifier, Half Wave and Full Wave Rectifiers with and without Filters; Breakdown Mechanisms, Zener Diode – Operation and Applications; Diode as clipper and clampers; Opto-Electronic Devices – LEDs, Photo Diode and Applications	10 hrs
Unit-II	Transistor Characteristics covering, Bipolar Junction	10 hrs

	Transistor (BJT) –Construction, Operation, Amplifying Action, Common Base, Common Emitter and Common Collector Configurations, Operating Point, Voltage Divider Bias Configuration; DC and AC load line analysis, Q point; Darlington pair, Field Effect Transistor (FET)	
Unit-III	Binary Numbers, Decimal to Binary and Binary to Decimal Conversion, BCD, Octal and Hexadecimal numbers, Negative numbers representation, 1's, 2's, Complements, Logic gates including Universal Gates, BCD codes, Excess-3 code, Gray code, Hamming code. Boolean Algebra, Basic Theorems and properties of Boolean Algebra,Truth Tables and Functionality of Logic Gates – NOT, OR, AND, NOR, NAND, XOR and XNOR Integrated Circuits (ICs)	12 hrs
Unit-IV	Measurement, Sensors, Laboratory measuring instruments: digital multi-meters and Cathode Ray Oscilloscopes (CRO's), Measurement of resistance (Carey Foster bridge), Capacitance (De Sauty's bridge), and Self-inductance (Anderson's bridge) using different bridges.	8 hrs
Internal assessment		
Part A	CIA-I: Unit I, II and III	20
	CIA-II: Unit IV, V, and VI	20
	EoS	60
Basic Electronics Engineering Laboratory		
List of Experiments		

1. V-I Characteristics of Silicon & Germanium PN Junction diodes
2. Signal characterization using CRO-Applications
3. Diode as clipper and clamper
4. V-I Characteristics of Zener Diode
5. Characteristics of BJT in Common Emitter Configuration
6. Regulated power supply using Transistor and Zenner Diodes
7. Half Wave and Full Wave Rectifier Without Filter
8. Half Wave and Full Wave Rectifier with Filter
9. Common Emitter BJT Amplifier
10. Applications of Operational Amplifier
11. Introduction to Logic Gates

Text/Reference Books:

1. Basic Electronics- Devices, Circuits and IT Fundamentals, Prentice Hall, India.
2. Electronics A Systems Approach", 4/e - Pearson Education Publishing Company Pvt Ltd, 2011 by Neil Storey.
3. Electronic Devices and Circuits" Salivahanan, N Suresh Kumar, 3/e, McGraw Hill Publications, 2013.
4. Basic Electronics & Linear Circuits, Bhargava N. N., D C Kulshreshtha and S C Gupta, Tata McGraw Hill, 2/e, 2013

BME 109: Universal Human Values		
Teaching Scheme	**Examination Scheme**	**Credits allocated**
Theory 3 hrs/week	End of semester Examination-60 marks	Theory-3
	Internal assessment:40 marks	
Course Prerequisite: NA		

Course Objective:

1. To help the students having the clarity about human aspirations, goal, activities and purpose of life.
2. To facilitate the competence to understand the harmony in nature/existence and participationof human being in the nature/existence.
3. To help the students to develop the understanding of human tradition and its variouscomponents.

Course Outcomes: On completion of this course, students will be able to

1. The methodology of this course is exploration and thus universally adaptable. It involves a systematic and rational study of the human being vis-à-vis the rest of existence.
2. It is free from any dogma or set of do's and don'ts related to values.
3. It is a process of self-investigation and self-exploration, and not of giving sermons. Whatever is found as truth or reality is stated as a proposal and the students are facilitated and encouraged to verify it in their own right, based on their Natural Acceptance and subsequent Experiential Validation.
4. This process of self-exploration takes the form of a dialogue between the teacher and the students to begin with, and then to continue within the student leading to continuous self-evolution.
5. This self-exploration also enables them to critically evaluate their preconditioning and present beliefs.

	Course Content	
Unit -I	**Introduction:** The basic human aspirations and their fulfillment through Right understanding andResolution; All-	8 hrs

	encompassing Resolution for a Human Being, its details and solution of problems in the light of Resolution.	
Unit-II	**Understanding Human being and its expansion:** The domain of right understanding starts from understanding the human being (the knower, the experience and the doer); and extends up to understanding nature/existence – its interconnectedness and co-existence; and finally understanding the role of human being in existence (human conduct).	8 hrs
Unit-III	**Activities of the Self:** Understanding the human being comprehensively is the first step and the core theme of this course; human being as co-existence of the self and the body; the activities and potentialities of the self; Reasons for harmony/contradiction in the self.	8 hrs
Unit-IV	**Understanding Co-existence with other orders:** The need and the process of inner evolution (through self-exploration, selfawareness and self-evaluation)- particularly awakening to activities of the Self: Realization, Understanding and Contemplation in the Self (Realization of Co-Existence, Understanding of Harmony in Nature and Contemplation of Participation of Human in this harmony/ order leading to comprehensive knowledge about the existence).	8 hrs
Unit-V	**Expansion of harmony from self to entire existence:** Understanding different aspects of All-encompassing Resolution (understanding, wisdom, science etc.), Holistic way of living for Human Being with All-encompassing Resolution covering all four dimensions of human endeavour viz., realization, thought, behavior and work (participation in the larger order) leading to harmony at all levels from self to Nature and entire Existence.	8 hrs
Assessment		
Part A	CIA-I: Unit I	**20 Marks**
	CIA-II: Unit II, III	**20 Marks**
Part B	End Semester Exam	**60 Marks**

BME 110: Biomedical Engineering Workshop		
Teaching Scheme	**Examination Scheme**	**Credits allocated**
Theory 3 hrs/week	End of semester Examination-60 marks	Theory-3
	Internal assessment:40 marks	
Course Prerequisite: NA		
Course Objective: To gain familiarity with the tools which is widely used in Biomedical Engineering.		
Course Outcomes: On completion of this course, students will be able to		
CO1: Understand the basic concepts of sensors and transducers. **CO2:** Understand the basic physics of medical instrumentation. **CO3:** Understand the basic physics of medical imaging systems. **CO4:** Understand the biological function of human body.		
	Course Content	
Unit -I	Sensors and Transducers: Optical, Thermal, Mechanical Electrochemical. Patient Monitoring: BP, HR/PR, SPO2, Breathing Rate, Blood group, and components.	10 hrs
Unit-II	Study of laboratory instruments, basic principle of function and handling: analytical lab balance, pipettes,pH meter, biosafety cabinet, autoclave, spectrophotometer, centrifuge and microscope. Preparation of solution (molar, percent and X solutions).	10 hrs
Unit-III	Visualize various Medical images such as CT, MRI. Process images using common tools of medical images such as 3D Slicer, Mango and ITK-Snap.	10 hrs
Unit-IV	Biomedical signals and Instrumentations: ECG, EMG, EEG, PCG, EOG.	10 hrs
Assessment		
Part A	CIA-I: Unit I	**20 Marks**
	CIA-II: Unit II, III	**20 Marks**
Part B	End Semester Exam	**60 Marks**
Essential Readings		
3. John C. Webster, Medical Instrumentation Leighton, Mifflin Co Boston, USA 4. R. S. Khandpur Handbook of Biomedical Instrumentation, Tata McGraw hill, Pub. Co.Ltd., New Delhi.		

BME111: Engineering Physics		
Teaching Scheme	Examination Scheme	Credits allocated
Theory 3 hrs/week	End of semester Examination-60 marks	Theory-3
Practical 2hrs/week	Internal assessment:40 marks	Lab-1
		Total-4
Course Prerequisite: Students should have basic knowledge on Physics		
Course Objective: 1. To explain the basic, make up of LASER. 2. To explain the basics of radiation. 3. To explain the origin of Ultrasonic waves. 4. To explain the basics of optical fiber.		
Course Outcomes: On completion this course, students will be able to		
CO1: Understand the function of LASER. **CO2:** Understand the origin of X-rays and magnetic resonance. **CO3:** Understand the basic physics of medical imaging systems. **CO4:** Understand the basic function of optical fiber.		
Unit -I	Introduction to LASER. Characteristics of LASER beam. Spontaneous and stimulated emission of radiation. Population Inversion. Difference between Gas and Solid LASER. Ruby LASER, He-Neon LASER, Semi-conductor LASER. Application of LASER. Properties and Uses of LASER.	10 hrs
Unit-II	Introduction to X-Rays. Origin of X-Ray. Application of X-Rays. Application of X-rays in industry and medical applications. Introduction to Magnetic radiation. Application of magnetic radiation. Introduction to MRI.	10 hrs
Unit-III	Introduction to Ultrasound. Production-properties and propagation of ultrasonic waves. Applications of Ultrasound. Different types of Ultrasound mode.	10 hrs
Unit-IV	Introduction to optical fibers, principle of propagation of light in optical fibers, acceptance angle and acceptance cone, numerical aperture, types of optical fibers, modes of propagation and refractive index profiles. Introduction to fiber Splices- Fusion splice – Mechanical splice – Snug tube splice – Loose tube splice – Multiple splice – Protection of splice - Connectors: - SMA – STC – Bionic etc, - Coupling – Passive – Stan – TEE types.	10 hrs
Internal assessment		
Part A	CIA-I: Unit I	
	CIA-II: Unit II and Unit III	

Engineering Physics Laboratory		
	List of Experiments	
1. Study the function of Solid LASER. 2. Study the function of Gas LASER. 3. Study Ultrasound images. 4. Study X-ray images. 5. Study MRI images.		
Text Books: 1. A textbook on Engineering Physics by SO Pillai Sivakami		

BME 112: Engineering Chemistry		
Teaching Scheme	Examination Scheme	Credits allocated
Theory 3, Practical 2 hrs/week	End of semester Examination-60 marks Theory-3, Practical-1	Total 4 Course Prerequisite: Knowledge of 10+2 Chemistry. Course
Total		4
Course Objective: 1. To understand different types of bonds and interactions. 2. To understand the properties of water, thermodynamic principles, concept of buffer and redox reactions. 3. To study the structure of bio molecules 4. To understand the application of spectroscopy.		
Course Outcomes: On completion this course, students will be able to		
1. Derive thermodynamic parameters and apply fundamental laws to solve thermodynamic problems **2.** Apply the chemistry of pH for biological systems**.** **3.** Differentiate between different bio molecules in terms of their structure and properties. 4. To employ various spectroscopic techniques in identifying the structure and correlate it with their properties.		
Level	Bachelor	
	Course Content	
Unit -I	Types of bonds and interactions, Properties of Water, Acid-base and pH concept, Henderson-Hasselbalch equation, Buffers, Thermodynamic principle,	12 hrs

	Concept of free energy and standard free energy change, relationship between standard free energy change and equilibrium constant, Redox reaction and free energy change in redox reaction	
Unit-II	Bio molecules and their properties, amino acids and proteins, properties of amino acids (amphoteric molecules, ionisation, zwitterions, pk values) peptide bond and its geometry, protein structure, carbohydrates, epimers, anomer, glycosidic bond, structural and storage polysaccharides, reducing and non-reducing sugar, nucleotides and nucleic acids, nitrogeneous bases, structure of double stranded DNA, lipids, enzyme and vitamins.	12 hrs
Unit-III	Chromatography, Partition Chromatography, Size exclusion Chromatography, Ion Exchange Chromatography, Affinity Chromatography, Spectroscopy, Absorbtion spectroscopy, Beer-Lambert's law, Fluorescence spectroscopy, Nuclear Magnetic resonance, Mass spectroscopy, Infrared spectroscopy.	12 hrs
Internal assessment		
Part A	CIA-I: Unit I	20 Marks
	CIA-II: Unit II and III	20 Marks
Part B	ESE: Term Exam	60 Marks

Text/Reference Books:

1. Introduction of fundamentals of spectroscropy, by C.N Banwell.
2. Molecular Spectroscopy-C. N. Banwell& McCash
3. University chemistry, by B. H. Mahan.
4. Lehninger: Principles of Biochemistry, Nelson, D.L. and Cox
5. Fundamental of Biochemistry, Voet and Voet- provide necessary details on latest edition Edited by Prof. Hiren K Das (JNU)

List of experiments:

1. Safety measure in laboratories, use and calibration of pipettes
2. Chromatography of amino acids.
3. Study of colorimetery.
4. Spectrophotometery principles.
5. Study of pH meter and titration curve
6. Quantitative estimation of glucose.
7. To examine reducing and non-reducing sugars.
8. To estimate protein concentration- Lowry method
9. To estimate nucleic acids
10. Investigation of redox reaction.
11. Determination of specific rotation of a given optically active compound and %composition of its aqueous solution using Polarimeter.

SEMESTER III

BME 201: Biomechanics		
Teaching Scheme	**Examination Scheme**	**Credits allocated**
Theory 3 hrs/week	End of semester Examination-60 marks	Theory-3
	Internal assessment:40 marks	
Course Prerequisite: NA		
Course Objective: 1. To study various principles of Biomechanics and vector mechanics 2. To employ various mechanics rules with the equilibrium of coplanar forces and forces used in fluid flow.		
Course Outcomes: On completion of this course, students will be able to		
1. Learn various theorems which help to understand the biomechanics forces. 2. Understand the mechanism of body fluid flow.		
	Course Content	
Unit -I	Review of principles of mechanics, vector mechanics - resultant forces of coplanar and non- coplanar and concurrent and non-concurrent forces, parallel forces, equilibrium of coplanar forces, Newton's laws of motion, work and energy, moment of inertia; Analysis of rigid bodies in equilibrium, free body diagrams, system analysis in equilibrium, types of support or joint, Analysis of joints in various postures, Basic assumptions and limitations, biomechanical analysis of elbow, shoulder, spinal column, hip knee and ankle	10 hrs
Unit-II	Forces involved in blood flow, general Bernoulli's equation, wind Kessel model, the stress in the ventricular wall, pressure-volume loop. Hagen-poiseuille law – derivation and applications, steady laminar flow in elastic tube, wave propagation in blood, reflection and transmission of waves at arterial junctions, blood flow in veins, microcirculation	10 hrs
Unit-III	Mechanism of airflow, respiratory cycle, lung ventilation model, methods of determining pressure, flow rate and volume spirometry, respiratory plethysmography, diagnostic significance of the lung-ventilation model, static and dynamic respiratory mechanics tests; Design of orthopedic implant, specifications for a prosthetic joint, biocompatibility, requirement of a biomaterial, characteristics of different types of biomaterials, manufacturing process of implants, fixation of implants.	10 hrs
Assessment		
Part A	CIA-I: Unit I	**20 Marks**
	CIA-II: Unit II, III	**20 Marks**

Part B	End Semester Exam	60 Marks

Essential Readings

1. YCFung, *Biomechanics: MechanicalPropertiesofLivingTissues*, Springer, 2ndEdition, 1993.
2. N. OzkayaandM. Nordin, *Fundamentals of Biomechanics-Equilibrium, Motion and Deformation*, Springer-verlag, 2nd Edition1999
3. J. GWebster, *Medical Instrumentation –Application and design*, JohnWileyand sons Inc. 3rded. 2003.
4. D. Dowson and V. Wright, *An introduction to Biomechanics of joints and joint replacements*, Mechanical Engineering
5. Publications, 1980
6. Y. C. Fung, *Biodynamics-circulation*, Springer-Verlag, 1994.

BME202-- Electronics Devices And Circuits		
Teaching Scheme	**Examination Scheme**	**Credits allocated**
Theory 3 hrs/week	End of semester Examination: 60 marks	Theory-3
	Internal assessment: 40 marks	

Course Prerequisite: NA

Course Objective:

- Understand the semiconductor devices principles and their performances to apply for different purposes.
- Comply and verify the device parameters.
- Simulate electronics circuits using required simulation software to obtain desired results.
- Understand and verify simulated circuit with hardware implementation.
- Implement hardwired circuit to test performance and application for what it is being designed.
- Analyze and model for small signal BJT and MOSFET devices
- Understand and apply the concept of feedback to tune the devices performances.
- Understand the behavior of transistors at low and high frequency

Course Outcomes: On completion of this course, students will be able to

- To introduce the students to details concept on semiconductor devices (such as BJT, MOSFET).
- To introduce the concept of positive and negative feedback in electronic circuits.
- To analyse and interpret FET and MOSFET circuits for small signal at low and high frequencies.

	Course Content	
Unit -I	**Bipolar Junction Transistors DC Circuits** Transistor Configurations: CE,CB and CC, The Operating	10 hrs

	Point, Bias Stability, Transistor, Fixed bias, Emitter Bias, Self Bias etc., Stabilization against Variations in ICO, VBE and β, , Bias Compensation Techniques, Thermal Runaway, Thermal Stability.	
Unit-II	**BJT at Low Frequencies** Two Port Devices and the Hybrid Model, Transistor Hybrid Model, Small Signal Amplifier Performance in terms of h-parameters, exact analysis of BJT CE, Comparison of CE, CC & CB Amplifier's performance parameters, High Input Impedance Transistor Circuits.	10 hrs
Unit-III	**BJT at High Frequency** Frequency Response of an Amplifier, Step Response of an Amplifier, Bandpass of Cascaded Stages, RC-Coupled Amplifier, Low-Frequency Response of an RC-Coupled Stage, The Hybrid- π Common-Emitter Transistor Model, Hybrid-π Conductance, The Hybrid-π Capacitances, The CE short-Circuit Current Gain, Current Gain with Resistive Load.	10 hrs
Unit-IV	**Feedback amplifiers and Oscillators** The Feedback Concept, The Transfer gain with Feedback, General Characteristics of Negative- Feedback Amplifiers, Topologies of Negative-Feedback, Summery of Effect of Negative- Feedback on Gain, Input Resistance, Output Resistance & Bandwidth of Amplifier, Sinusoidal Oscillators, The Transistor Phase-Shift Oscillator, A General form of LC Oscillator Circuit, Transistor Hartley & Colpitts Oscillator.	10 hrs
Unit-V	**Large Signal Low Frequency Amplifiers** Classification of Amplifies, Class A Large-Signal Amplifiers, Second –Harmonic Distortion, The Transformer-Coupled Audio Power Amplifier & it's Efficiency, Class B Amplifiers, Class B Push-Pull & Complementary-Symmetry Amplifier, Class AB Operation.	10 hrs
Assessment		
Part A	CIA-I: Unit I	**20 Marks**
	CIA-II: Unit II, III	**20 Marks**
Part B	End Semester Exam	**60 Marks**

Essential Readings

1. Millman Halkias, "Integrated Electronics-Analog and Digital Circuits and Systems",Tata McGraw Hill, 2000.
2. Donald Neaman, "Electronic Circuit Analysis and Design",3rd Edition, Tata McGrawHill.
3. David A.Bell,"ElectronicDevicesandCircuits",5thEdition, Oxford press
4. R. L. Boylstad, and L. Nashlesky, "Electronic Devices and circuits Theory", 9th Edition,Prentice Hall of India, 2006.
5. Anil K. Maini and Varsha Agarwal "Electronic Devices and Circuits", Wiley India.

6. Phillip E. Allen, Douglas R. Holberg, "CMOS Analog Circuit Design", Second Edition,Oxford.
7. K. R. Botkar, "Integrated Circuits", 5th Edition, Khanna Publication.

BME203-Molecular And Cellular Biology		
Teaching Scheme	**Examination Scheme**	**Credits allocated**
Theory 3 hrs/week	End of semester Examination: 60 marks	Theory-3
	Internal assessment: 40 marks	
Course Prerequisite: NA		
Course Objective: To enable B.Tech. students learn basics of cell and molecular biology		
Course Outcomes: On completion of this course, students will be able to		
	Course Content	
Unit -I	Introduction of Eukaryotic vs. Prokaryotic cell. Components of Eukaryotic Cell (Cell Organelles- Nucleus, Endoplasmic Reticulum, Golgi Apparatus, Mitochondria, Lysosome, Peroxisome Protein Sorting & Transport – Cytoskeleton& Cell Movement – The Plasma Membrane). Structure and function of macromolecules- Carbohydrate, lipids, protein and DNA, RNA. Cell Cycle: stages, regulation of cell cycle specific genes, cellular aspects of diseases. Central Dogma of Molecular Biology.	10 hrs
Unit-II	Cell signaling, Receptors for Cell Signaling and Signaling Pathways. Cell Junctions: Types and structure of junctions (Desmosomes, Hemi-desmosomes, Adherens junctions, Tight junctions, Gap junction) Cell Adhesion Molecules: classification (NCAM, Cadherin, Integrins etc.), function Cell surface.	10 hrs
Unit-III	Receptors: Ion linked Receptors, Enzyme Linked Receptors, Cytokine Receptor superfamily, GPCR Signal Transduction via Surface Receptors: Emphasis on GPCR pathways, cAMP Signaling from Receptor to Function Dual Signaling Pathway: Inositol phosphates and protein kinase C, calcium & calmodulin Cross-Talk, signal amplification & cascade mechanisms.	10 hrs
Assessment		
Part A	CIA-I: Unit I	**20 Marks**
	CIA-II: Unit II, III	**20 Marks**
Part B	End Semester Exam	**60 Marks**

ESSENTIAL READING
• G. Karp, Cell and Molecular Biology: Concepts and Experiments, Wiley • G. Nindl Waite, Applied Cell and Molecular Biology for Engineers, McGraw-Hill • B. Alberts, Molecular Biology of the Cell, Garland Science

BME204-Circuit Theory and Network Analysis		
Teaching Scheme	**Examination Scheme**	**Credits allocated**
Theory 3 hrs/week	End of semester Examination: 60 marks	Theory-3
	Internal assessment: 40 marks	
Course Prerequisite: 10+2 physics and linear algebra		
Course Objective: To introduce the fundamentals of electrical network analysis using graph theory, matrices, differential equations, network theorems, symmetrical component analysis. To introduce transient network analysis and their application. To introduce multiport network, network function and network synthesis techniques.		
Course Outcomes: On completion of this course, students will be able to		
CO1: Understand the use of network topology and network solving techniques for solving complex electrical networks. CO2: Understand the importance of transients in electrical circuits and can apply to real life problem. CO3: Students would be able to know various two port parameters, network functions, pole zero plot and the time domain behavior of electrical networks. CO4: Students would be able to design and analyze passive electrical circuits using network synthesis techniques and the basic idea about electrical filters.		
	Course Content	
Unit -I	Network Topology: Concept of network graphs, tree, link, cut set, network matrices, node incidence matrix, loop incidence matrix, cut set incidence matrix, Formulation and solution of network equilibrium equations on loop and node basis	9 hrs
Unit-II	Network Analysis Techniques and Theorems: Elements of electrical circuits and their properties, Mesh current and Node voltage analysis using matrices, Thevenin's, Norton's, Superposition, Maximum power transfer theorem, Substitution theorem, Compensation theorem, Reciprocity theorem, Millman's theorem, Tellegen's theorem for AC and DC networks, Duality and concept of dual network, Resonance in series and parallel circuits. Transient Network Analysis: Laplace transform fundamentals, properties, initial and final value theorems, convolution integral, waveform synthesis, Response of RL, RC and RLC networks using Laplace Transforms for unit step, impulse, ramp, sinusoidal, exponential and combination of these inputs, application of transient network analysis.	12 hrs

Unit-III	Two-port networks and Network functions: z-parameters, yparameters, h-parameters, and ABCD parameters; reciprocity and symmetry in two-port networks, image and iterative impedances; poles and zeros, driving point and transfer functions, restrictions on poles and zeros for network functions, time domain behavior from pole zero plot.	12 hrs
Unit-IV	Network Synthesis: Poles and zeros of network functions, positive real functions and their properties, tests for positive real functions, Hurwitz polynomials; Driving-point synthesis of LC, RC and RL networks, Foster forms and Causer forms. Introduction to filters.	9 hrs
Assessment		
Part A	CIA-I: Unit I	**20 Marks**
	CIA-II: Unit II, III	**20 Marks**
Part B	End Semester Exam	**60 Marks**

ESSENTIAL READING

- Text/Reference Books: 1. M.E. Valkenburg, "Network Analysis," 3rd Ed., Pearson Prentice Hall, 2006.
- F. F. Kuo, "Network Analysis and Synthesis," 2nd Ed., Wiley India, 2007.
- W.H. Hayt, J. E. Kemmerly and S. M. Durbin, "Engineering Circuit Analysis," 6th Edition, Tata McGraw Hill, 2007.
- C.K. Alexander and M.N.O. Sadiku, "Fundamentals of Electric Circuits," 3rd Edition, Tata McGraw Hill, 2008. 5. Sudhakar, S S Palli, "Circuits and Networks", 2nd Edition, Tata McGraw Hill.

BME 205-Human Anatomy & Physiology		
Teaching Scheme	**Examination Scheme**	**Credits allocated**
Theory 3 hrs/week	End of semester Examination: 60 marks	Theory-3
	Internal assessment: 40 marks	

Course Prerequisite: NA

Course Objective:

1. To enable B.Tech students to learn the basics of Human Anatomy and Physiology.
2. To explain the different biological systems with their working, importance, types, and associated diseases.

Course Outcomes: On completion of this course, students will be able to

CO1: Explain the knowledge of basic human physiological and anatomical aspects.
CO2: Describe students with updated knowledge of blood group testing and an overview of the immune system and the nervous system.
CO3: Explain the musculoskeletal system and respiratory systems with their working, significance, types, importance, and associated diseases.
CO4: Describe the physiology and anatomy of gastro urinal systems and cardiovascular

systems.		
	Course Content	
Unit -I	Important Blood Vessels of different parts of body. Blood Cell – Composition – Fluid and electrolytic balance - Blood Groups – Estimation of RBC, WBC, and platelet. Overview of Immune system – Immune response – models of immune response – Autoimmune diseases. Nervous System – Structure and functions of Neurons, Synapse, Reflex action, and Receptors – Velocity of Conduction of Nerve Impulses – Nervous control of Heart.	10 hrs
Unit-II	Musculo Skeletal System – Muscle Tissue, Structure of Skeletal Muscle, Types of Muscle, Types of Joints, Major Muscles of Limbs, and their actions. Respiratory system - Various parts of Respiratory System-Trachea, Bronchial tree, Lungs, Physiological aspects of respiration - Exchange of gases – Regulation of Respiration. Disturbance of respiration function. Pulmonary function test – Artificial respiration – Cardio-pulmonary Resuscitation.	10 hrs
Unit-III	Gastro Urinal system, Digestion, and absorption – Movement of GI tract, Structure and function of kidneys and Nephron – Mechanism of Urine formation – Urine Reflex – Skin and Sweat Gland – Temperature regulation. Cardiovascular system – Heart and vascular system, Lymphatic System ECG – Blood Pressure – Homeostasis –Cardiac output – Coronary and Peripheral Circulation – Heart Sounds. Bohr effect, Applied aspects, Ventilators, Oxygen Therapy.	10 hrs
Assessment		
Part A	CIA-I: Unit I	**20 Marks**
	CIA-II: Unit II, III	**20 Marks**
Part B	End Semester Exam	**60 Marks**
ESSENTIAL READING		
• Sujit K.Chaudhuri – Concise Medical Physilogy – New Central Book agency, 1997 • Arthur.C.Guyton – Textbook of Medical Physiology – Prism Book (p) Ltd. 1996. • CL.Ghai – A textbook of Practical physiology – 5th Ed Jaypee Medical Publishers, 2003 • Sarada Subramanyam, K.Madhavan Kutty and H.D.Singh – Text book of 'Human Physiology S.Chand & Company, 1996		

BME 206 electronic devices and circuits Lab		
Teaching Scheme	**Examination Scheme**	**Credits allocated**
Practical 2 hrs/week	End of semester Examination: 60 marks	Practicals-2
	Internal assessment: 40 marks	

Course Prerequisite: NA

Course Objective:

1. To introduce the students to details concept on semiconductor devices (such as BJT, MOSFET).
2. To introduce the concept of positive and negative feedback in electronic circuits.
3. To analyse and interpret FET and MOSFET circuits for small signal at low and high frequencies

Course Outcomes: On completion of this course, students will be able to

CO1: Have complete knowledge on the operation of semiconductor devices.
CO2: Improve experimental skill on various circuit and devices.
CO3: Have details knowledge on the concept of positive/negative feedback and various oscillators.

Course Content:

1) Construct the HW, FW and Bridge rectifier using IN4007 diode on Breadboard
2) Study of clipper, clamper and doubler of diode using DSO
3) Construct the regulated power supply using Zenner diode and Transistor
4) Construct the CE/CB/CC Transistor Configuration for the verification of input and output Characteristics. Find out the h-parameter values from CE IV characteristics.
5) Verify DC operating point for a single stage BJT in CE configuration.
   - Calculate values biasing resistors (R1,R2,RE) to operate BJT at a certain VCEQ & ICQ
   - Build the circuit with these components Measure VCEQ, ICQ, IBQ and VBEQ and Compare measured quantities with theoretical values
6) Build and test single stage CE amplifier.
   - Connect coupling and emitter bypass capacitors
   - To measure the voltage gain, input resistance (Ri), output Resistance (Ro) of the amplifier.
   - Verify phase difference between input and output voltage. To measure the bandwidth using square wave testing.
7) Simulate a Single stage BJT amplifier (CE, CB and CC) for given specifications.(DC & AC Analysis)
   - To measure the voltage gain (AV), input resistance (Ri), output
   - Resistance (RO) of the CE, CB and CC amplifier.
   - To observe and print input and output waveforms to understand the phase difference in each configuration.

8) Construct frequency response of single stage CE RC coupled amplifier
   - To study the effect of coupling capacitor and bypass capacitor on low frequency response.
   - To study effect of external shunting capacitor on high frequency response (To restrict bandwidth).
   - To understand dominant RC circuit for fL and fH.
9) Voltage-Series feedback amplifier
   - To identify topology of feedback with proper justification.
   - To measure voltage gain, input resistance, output resistance and bandwidth (using square wave testing) for without feedback.
   - To measure voltage gain, input resistance, output resistance and bandwidth (using square wave testing) for with feedback.
   - To verify the improvement in various parameters as per the derived equations.
10) Simulation of current shunt feedback amplifier
   - To identify topology of feedback with proper justification.
   - To measure current gain, input resistance, output resistance and bandwidth for without feedback.
   - To measure current gain, input resistance, output resistance and bandwidth for with feedback.
   - To verify the improvement in various parameters as per the derived equations.
11) Simulation of transistorized oscillator
   - Implement the Phase shift oscillator.
   - Verify Barkhausen criteria.
   - Implement the crystal oscillator (series / parallel resonance circuit).
   - To observe the output voltage waveform.
   - To calculate frequency of oscillation theoretically and practically.
12) Build & Test transistorized oscillator
   - Implement the LC (Colpitts / Hartley) oscillator.
   - Verify Barkhausen criteria.
   - To observe the output voltage waveform.
   - To calculate frequency of oscillation theoretically and practically.
13) Complementary Symmetry push pull amplifier
   - To verify DC condition
   - To understand class of operation.
   - To calculate the percentage conversion efficiency.
   - To calculate power dissipation of both transistors.
   - To observe and elimination of crossover distortion.

Assessment		
Part A	CIA-I	**20 Marks**
	CIA-II	**20 Marks**
Part B	End Semester Exam	**60 Marks**

BME 207 Cell and Molecular and Cellular Biology Laboratory		
Teaching Scheme	**Examination Scheme**	**Credits allocated**
Practical 2 hrs/week	End of semester Examination: 60 marks	Practicals-2
	Internal assessment: 40 marks	
Course Prerequisite: NA		
Course Objective: To includes the study of the Cell and Molecular Biology		
Course Outcomes: On completion of this course, students will be able to Understand the importance of Cell and Molecular Biology		
Course Content:		
1. Preparation of different stock solutions used in molecular biology (Solutions used in PCR,electrophoresis, DNA isolation, RNA isolation and Protein isolation) 2. Isolation of DNA from human blood Quantification of DNA and RNA through spectrophotometer4- DNA amplification through polymerase chain reaction 3. Separation of different sized DNA fragments on agarose gel 4. Downloading various sequences from GenBank in FAST format, 10. 5. Demonstration ofBLASTn, BLASTp and phylogentic tree preparation using MEGA software. 6. Isolation of different cell organelles from cell 7. Study of Spectrophotometry.9-Study of pH meter. 8. Study of Flame photometry-Analysis of Na and K in an unknown sample. 9. Quantitative estimation of glucose. 10. Quantitative estimation of Urea. 11. Quantitative estimation of Creatinine.		
Assessment		
Part A	CIA-I	**20 Marks**
	CIA-II	**20 Marks**
Part B	End Semester Exam	**60 Marks**

BME 208 Human anatomy and physiology laboratory		
Teaching Scheme	**Examination Scheme**	**Credits allocated**
Practical 2 hrs/week	End of semester Examination: 60 marks	Practicals-2

	Internal assessment: 40 marks	

Course Prerequisite: NA

Course Objective:

Anatomy Laboratory

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.

Physiology Laboratory

This course deals with the overall functioning of a living organism which has undergone a variably rapid change all through its process of evolution. Casting a systematic array of different systems such as respiratory, circulatory, neuro-muscular mechanisms, stimuli propagation etc, emphasizing on the clinical importance of the same.

Course Outcomes: On completion of this course, students will be able to

Anatomy Laboratory

1- Understand the various human tissue structures.
2- Identify different organs of the body and their locations.
3- Able to identify the different lobes of the brain.
4- Able to perceive the importance of a dissertation.
5- Able to identify different joints and their importance.

Physiology Laboratory

1. Able to record BP.
2. To evaluate visual, auditory systems in human being.
3. Able to record various biopotentials.
4. Able to record and evaluate respiratory system.
5. To understand the muscular activity.

Course Content

Anatomy Laboratory

No. of Experiments

1-Histology-Slides of primary tissues of body Study of Gross anatomy of the human body
2-Study of dissected Upper Limb
3-Study of dissected Lower Limb
4-Study of dissected Brain
5- Study of dissected Thorax-Heart
6- Study of dissected Thorax-Major Blood Vessels
7- Study of dissected Thorax-Various parts of respiratory system-Trachea, Lungs.
8- Study of dissected abdomen-Digestive organs.
9- Study of dissected abdomen-Other abdominal organs.

Physiology Laboratory

1. Recording of B.P. by different methods.

2. Effect of exercise on BP 3. Effect of posture on BP 4. Vital capacity by Spiro meter 5. Effect of posture on Vital capacity 6. Calculation of Vital Index 7. Recording of EMG and ECG 8. Examination of Sensory system 9. Examination of Motor System 10. Study of Rate of Conduction of Nerve impulse.		
Assessment		
Part A	CIA-I	**20 Marks**
	CIA-II	**20 Marks**
Part B	End Semester Exam	**60 Marks**

SEMESTER-IV

<table>
<tr><th colspan="3">BME 209: Signals, and System Design</th></tr>
<tr><th>Teaching Scheme</th><th>Examination Scheme</th><th>Credits allocated</th></tr>
<tr><td>Theory 3 hrs/week</td><td>End of semester Examination: 60 marks</td><td>Theory-3</td></tr>
<tr><td></td><td>Internal assessment: 40 marks</td><td></td></tr>
<tr><td colspan="3">Course Prerequisite: NA</td></tr>
<tr><td colspan="3">Course Objective:
To understand basic of signals and systems.
To understand design and realization of filter.
To understand biomedical signal processing.</td></tr>
<tr><td colspan="3">Course Outcomes: On completion of this course, students will be able to</td></tr>
<tr><td colspan="3">To learn basic of signals, systems and their classification.
To learn designing and realization of filter and digital filter.
To learn biomedical signal processing.</td></tr>
<tr><td></td><td>Course Content</td><td></td></tr>
<tr><td>Unit -I</td><td>Basics of signals and systems:
Signals and system: Representation of continuous and discrete time signals, Elementary signals, Basic Operation on Signals, Classification of Signals, systems and its classification.
Transform Theory: Fourier Transform, Discrete Fourier transform, Fast Fourier Transform, Z Transform, ROC and pole -zero placement, Impulse and step response.</td><td>10 hrs</td></tr>
<tr><td>Unit-II</td><td>Filters: Realization of Various Filters (LP, HP, BP, BS, Notch), Transfer Function & Frequency Response; Magnitude and Delay Response.
Digital Filter: Design of Finite Impulse response and Infinite Impulse Response digital filter, realization of Digital Filter.</td><td>10 hrs</td></tr>
<tr><td>Unit-III</td><td>Biomedical Signal Processing: Noises and Artifacts Present in ECG and EEG signal, Removal of Noise and Artifacts from ECG and EEG, ECG signals characteristics; The P, QRS, and T waves in the ECG, QRS detection, ST segment analyser, Arrhythmia analyser. EEG rhythms & waveform categorization, Correlation Analysis of EEG Rhythms, Detection of EEG rhythms.</td><td>10 hrs</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">Assessment</td></tr>
<tr><td>Part A</td><td>CIA-I: Unit I</td><td>20 Marks</td></tr>
<tr><td></td><td>CIA-II: Unit II, III</td><td>20 Marks</td></tr>
<tr><td>Part B</td><td>End Semester Exam</td><td>60 Marks</td></tr>
<tr><td colspan="3">ESSENTIAL READINGS</td></tr>
<tr><td colspan="3">Oppenheim, A.V., Willsky, A.S. and Nawab, S.H., 2012. Signals and systems, PHI learning Pvt. Ltd.
Salivahanan S., Vallavraj A., Gnanapriya C, 2005. Digital Signal Processing, Tata</td></tr>
</table>

McGraw Hill Publishing.
- Lathi, B.P., 1965. Signals, systems and communication. John Wiley & Sons Canada.
- Kani, A.N., 2010. Signals & Systems. Tata McGraw-Hill Education.
- Rangayyan, R.M., 2015. Biomedical signal analysis (Vol. 33). John Wiley & Sons.
- Reddy, D.C., 2005. Biomedical signal processing: principles and techniques. McGraw- Hill.

BME210-Biomedical Instrumentation		
Teaching Scheme	**Examination Scheme**	**Credits allocated**
Theory 3 hrs/week	End of semester Examination: 60 marks	Theory-3
	Internal assessment: 40 marks	
Course Prerequisite: NA		
Course Objective: • To study different types of biomedical electrode and sensors. • To study different types of biomedical devices. • To study patient monitoring system and safety in hospital.		
Course Outcomes: On completion of this course, students will be able to		
• To learn different types of biomedical electrode and sensors. • To learn different types of biomedical devices. • To learn patient monitoring system and safety in hospital.		
	Course Content	
Unit -I	Basics of Biomedical Instrumentation: Bioelectric potential and Electrodes- Basis concepts of medical instrumentation Resting and action potential, electrode theory, Bio potential electrodes, Electrodes and sensors for ECG, EEG, EMG, ERG, and EOG, micro electrodes, skin surface electrodes.	10 hrs
Unit-II	Biomedical Devices: working principle, measuring procedure and applications of Pacemaker, Audiometer, Defibrillator, ECG, EEG, EMG, PCG, ERG, and EOG. Electrosurgical Unit: Principles of cutting, coagulation, fulguration; Electrosurgical generators: spark gap & solid-state generators, Safety features.	10 hrs
Unit-III	Patient Monitoring systems: Cardiac monitors, bedside monitors, central monitors, Biomedical measurement and devices for heart rate, pulse rate, temperature, Blood pressure, respiration rate, Pulmonary function measurements.	10 hrs

	Electrical hazards in hospitals: Patient electrical safety, types of hazards, patient isolation, physical effects of current, let go current, Micro shocks, different ways for electrical accident to occur, safety instruction circuits, electrical grounding & effects.	
Assessment		
Part A	CIA-I: Unit I	**20 Marks**
	CIA-II: Unit II, III	**20 Marks**
Part B	End Semester Exam	**60 Marks**
ESSENTIAL READINGS		
5. John C. Webster, Medical Instrumentation Leighton, Mifflin Co Boston, USA 6. R. S. Khandpur Handbook of Biomedical Instrumentation, Tata McGraw hill, Pub. Co.Ltd., New Delhi. 7. Applied Biomedical Instrumentation, La Geddes and L.E. Baker. Dewhurst, D.J., 2014. An Introduction to Biomedical Instrumentation: Pergamon International Library of Science, Technology.		

BME 211 Pathology and Human disease		
Teaching Scheme	**Examination Scheme**	**Credits allocated**
Theory 3 hrs/week	End of semester Examination: 60 marks	Theory-3
	Internal assessment: 40 marks	
Course Prerequisite: NA		
Course Objective: • To enable B.Tech students learn Provide a framework for understanding the pathophysiologic mechanisms responsible for diseases of major public health importance. • Explain the pathologic processes underlying structural and functional disorders and their clinical significance. • Describe variables or risk factors influencing the adaptive potential of individuals within their environment and throughout their life span.		
Course Outcomes: On completion of this course, students will be able to		
•		
	Course Content	
Unit -I	General pathophysiology: Cells, tissues, organ structure and function. Pathophysiologic mechanisms of acute and chronic injury, necrosis/apoptosis & tissue repair (the healing process). Cardiovascular diseases: Hyperlipidemia, atherosclerosis, coronary artery disease, hypertension, heart failure,	10 hrs

	thromboses, and stroke.	
Unit-II	Biomedical Devices: working principle, measuring procedure and applications of Pacemaker, Audiometer, Defibrillator, ECG, EEG, EMG, PCG, ERG, and EOG. Electrosurgical Unit: Principles of cutting, coagulation, fulguration; Electrosurgical generators: spark gap & solid-state generators, Safety features. Cancers: Molecular basis for cancer development and progression, etiologic factors related to development of cancer, kinetics of tumor growth and the genetic contribution to cancer. Specific cancers covered in the course include lung, breast, colorectal, cervix, and prostate. Infectious diseases: Immune function and immune pathology, categories of infectious agents, mechanisms and pathogenesis of infectious diseases, tuberculosis, malaria, influenza, and HIV/AIDS.	10 hrs
Unit-III	Chronic health conditions: An overview of the genetic contribution to chronic disease, obesity, diabetes mellitus, chronic obstructive pulmonary disease (COPD), renal disease, and Alzheimer's disease.	10 hrs
Assessment		
Part A	CIA-I: Unit I	**20 Marks**
	CIA-II: Unit II, III	**20 Marks**
Part B	End Semester Exam	**60 Marks**
ESSENTIAL READINGS		
• The Nature of Disease-Pathology for the Health Professions, Author: McConnell, Publisher: Lippincott Williams & Wilkins, second edition, 2014.		

BME 212-Biomaterials		
Teaching Scheme	**Examination Scheme**	**Credits allocated**
Theory 3 hrs/week	End of semester Examination: 60 marks	Theory-3
	Internal assessment: 40 marks	
Course Prerequisite: NA		
Course Objective: •		
Course Outcomes: On completion of this course, students will be able to •		
	Course Content	
Unit -I	Fundamentals of biomaterials science. Concept of biocompatibility. Classes of biomaterials used in medicine,	10 hrs

	basic properties, medical requirements and clinical significance. Disinfection and sterilization of biomaterials. Physico-chemical properties of biomaterials: mechanical (elasticity, yield stress, ductility, toughness, strength, fatigue, hardness, wear resistance), tribological (friction, wear, lubricity), morphology and texture, physical (electrical, optical, magnetic, thermical), chemical and biological properties.	
Unit-II	Elements in contact with the surface of a biomaterial: blood composition, plasma proteins, cells, tissues. Phenomena at the bio interfaces. Molecular and cellular processes with living environment, blood-materials interaction, short- and long-term reactions to the body.	10 hrs
Unit-III	Testing of biomaterials: in vitro, in vivo preclinical and in vivo clinical tests. Technologies of biomaterials processing, as implants and medical devices; improvement of materials biocompatibility by plasma processing.	10 hrs
Assessment		
Part A	CIA-I: Unit I	**20 Marks**
	CIA-II: Unit II, III	**20 Marks**
Part B	End Semester Exam	**60 Marks**

ESSENTIAL READINGS

- H.Boenig, Fundamentals of Plasma Chemistry and Tehnology, Technomic PublishingCo.Inc. Lancaster Basel, 1990. 2. Practical Surface Analysis,
- 2ndedition, Edited by D.Briggs, M.P.Seah, J.Wiley & Sons Ltd, 1990.
- Biomaterials Science, An Introduction to Materials in medicine, Eds. B. D. Ratner and A. S.Hoffman, Academic Press, New York, 1996.
- Plasma-surface modification of biomaterials, P.K.Chua, J.Y.Chena, L.P.Wanga, N.Huang,Elsevier Science B.V, 2002.
- XXX – Articles about Biomaterials and Biocompatibility.

BME 213- Digital System Design		
Teaching Scheme	**Examination Scheme**	**Credits allocated**
Theory 3 hrs/week	End of semester Examination-60 marks Internal assessment:40 marks	Theory-3

Course Prerequisite: NA

1. To acquaint the students with the fundamental principles of two-valued logic and various devices used to implement logical operations on variables.
2. To lay the foundation for further studies in areas such as VLSI, computer, microprocessor etc.

CO1: Use the basic logic gates and various reduction techniques of digital logic circuit in detail. CO2: Design combinational and sequential circuits. CO3: Design and implement hardware circuit to test performance and application. CO4: Understand the basic operation of memory devices.		
	Course Content	
Unit -I	Combinational Logic Design: Review of Boolean algebra and DeMorgan's theorem, Standard representations of logic functions, k map representation (upto 6 variables) of logic functions (SOP and POS forms), minimization of logical functions for min -terms and max - terms, don't care conditions, Design Examples: Arithmetic Circuits, BCD - to – 7 segment decoder, Code converters. Adders and subtractor, ALU, Digital Comparator, Parity generators/checkers, Multiplexers and their use in combinational logic designs, multiplexer trees, De - multiplexers and their use in combinational logic designs, Decoders, demultiplexer trees.	10 hrs
Unit-II	Sequential Logic Design and VHDL basic: Flip flop basics, Building blocks of SR, JK, MS J -K flip flop, D and T flip - flops. Use of preset and clear terminals, Excitation Table for flip flops, Conversion of flip flops. Application of Flip flops: Registers, Shift registers, Synchronous and ripple Counters (ring counters, twisted ring counters), Sequence Generators, up/down counters, Clock Skew, Clock jitter, Effect on synchronous designs; Design entry: Schematic, FSM & HDL, different modeling styles in VHDL, Data types and objects, Dataflow, Behavioral and Structural Modeling, Synthesis and Simulation VHDL constructs and codes for combinational and sequential circuits .	12 hrs
Unit-III	Logic Families Classification of logic families, Characteristics of digital ICs -Speed of operation, power dissipation, figure of merit, fan in, fan out, current and voltage parameters, noise immunity, operating temperatures and power supply requirements; TTL logic: Operation of TTL NAND gate, active pull up, wired AND, open collector output, unconnected inputs; Tri-State logic. CMOS logic – CMOS inverter, NAND, NOR gates, unconnected inputs, wired logic, open drain output. Interfacing CMOS and TTL; Comparison table of Characteristics of TTL, CMOS, ECL, RTL, I2L, DCTL.	8 hrs
Unit-IV	Programmable Logic Devices and Semiconductor Memories Programmable logic devices: Detail architecture, Study of PROM, PAL, PLA, Designing combinational circuits using PLDs. General Architecture of FPGA and CPLD Semiconductor memories: memory organization and operation, expanding memory size, Classification and characteristics of memories, RAM, ROM, EPROM, EEPROM, NVRAM,	10 hrs

	SRAM, DRAM.	
Assessment		
Part A	CIA-I: Unit I	**20 Marks**
	CIA-II: Unit II, III	**20 Marks**
Part B	End Semester Exam	**60 Marks**

ESSENTIAL READINGS

1. Text Books: 1. R.P. Jain, "Modern digital electronics", 3rd edition, 12threprint Tata McGraw Hill Publication, 2007.
2. M. Morris Mano, "Digital Logic and Computer Design" 4th edition, Prentice Hall of India, 2013.
3. P. Albert Malvino and A. Jerrald Brown, "Digital Computer Electronics" Glencore Publishers.
4. R. J. Tocci, N. S. Widmer and G. L. Moss, "Digital Systems, Principles and Applications", Pearson Publishers.

BME-214 Biomedical Instrumentations and devices laboratory

Teaching Scheme	Examination Scheme	Credits allocated
Practical 2 hrs/week	End of semester Examination: 60 marks Internal assessment: 40 marks	Practicals-2

Course Prerequisite: NA

Course Objective:

To provide knowledge related to Biomedical instrumentations and device-associated techniques.

Course Outcomes: On completion of this course, students will be able to

To operate Biomedical instruments like ECG, spirometers, EMG, etc.

Course Content:

1- Blood Pressure Measurement
2- Real time monitoring of Echocardiography
3- Working on different types of Diathermy equipment study

a-Shortwave Diathermy, b-Ultrasound Diathermy, c-Surgical Diathermy

4- ECG wave analysis using the simulator
5- Real time patient monitoring system
6- Ultrasound blood flow measurement to identify arteries and veins
7- Respiratory system analysis using Spirometer
8- Analysis of ECG abnormal wave pattern using Arrhythmia Simulator.
9- EEG wave analysis using the simulator.
10- Auditory system check-up using Audiometer.
11- Heart sound measurement using PCG.
12- Biotelemetry.
13- Pacemaker Module.
14- ECG heart rate alarm system with HRV.

15- EMG Biofeedback with NCV		
Assessment		
Part A	CIA-I	**20 Marks**
	CIA-II	**20 Marks**
Part B	End Semester Exam	**60 Marks**

BME 215- Biomaterials Lab		
Teaching Scheme	**Examination Scheme**	**Credits allocated**
Practical 2 hrs/week	End of semester Examination: 60 marks Internal assessment: 40 marks	Practicals-2

Course Prerequisite: NA

Course Objective:

1. Develop skills to design and conduct experiments, as well as analyze and interpret data.
2. Surface analysis of surface dependent engineering properties of the biomaterials.
3. Understanding the methods for biocompatibility improvement and practical aspects of biomedical devices: sterilization, manufacturing, clinical trials and ethical issues, the price of implants and allocation of resources.

Course Outcomes: On completion of this course, students will be able to

1. Students will be able to explain the concepts of stress and strain, and the parameters used to characterize the physical bulk and surface properties of materials.
2. Students will be able to describe the composition, structure and mechanical properties of the main classes of biomaterials- metals, ceramics, polymers, composites and the body tissues explain and give an example of how composition, structure and treatment modify the mechanical properties.
3. Students will be able to describe the interactions of biomaterials with the biological environment - stability, corrosion, and hemo-compatability.
4. Students will be able to describe and give an example of how biomaterials are used to fabricate devices for clinical use.

Course Content:

- Determination of tensile and compressive strengths of implant material.
- Determination of modulus of rigidity of different biomaterials.
- To study the influence of surface roughness on the wetability of the implant material.
- Determination of surface energy of implant materials through contact angle measurement.
- Determination of glass transition temperature of polymer and polymer composite. Measurement of rheological properties of solvent/solution.
- Determination of roughness of different implant materials.

- Determination of coefficient of friction and wear resistance of different implant surfaces.
- Study the pitting corrosion behavior of stainless steel in simulated body fluid.
- Determination of corrosion rate of metallic implant in simulated body fluid. Synthesis of nano particles by chemical route.
- To conduct surface coating on metallic implants by electrochemical methods.
- To conduct surface modification on medical implants by physical and chemical methods. Estimation of haemocompatibility of biomaterials by hemolysis studies.

Assessment		
Part A	CIA-I	**20 Marks**
	CIA-II	**20 Marks**
Part B	End Semester Exam	**60 Marks**

BME 216: Digital System Design Lab		
Teaching Scheme	Examination Scheme	Credits allocated
Lab 3 hrs/week	End of semester Examination-60 marks	02
	Internal assessment:40 marks	
		Total-02

Course Prerequisite: Students should have basic knowledge on Basic Electronics and Electronics Devices and Circuits.

Course Objective:

1. To know the concepts of Combinational circuits.
2. To understand the concepts of flipflops, registers and counters etc.

Course Outcomes: On completion this course, students will be able to

CO1: Learn basics of logics gates.
CO2: Construct basic combinational circuits and verify their functionalities.
CO3: Learn the designing of various sequential circuits.
CO4: Construct various digital circuits and their operations.

Course Content:

1) Study of switches using discrete components a)Diode as a Switch b)Transistor as a switch
2) Verify four voltage and current parameters for TTL and CMOS (IC 74LSXX, 74HCXX), (Refer Data-Sheet).
3) Study of Universal Gates (NAND Gate and NOR Gate) and Implementation of a function using universal gate
4) Verification of Demorgan's Law using TTL IC
5) Study of IC-74LS153 as a Multiplexer. (Refer Data-Sheet).
   - Design and Implement 8:1 MUX using IC-74LS153 & Verify its Truth Table.
   - Design & Implement the given 4 variable function using IC74LS153. Verify its Truth-Table.

6) Study of IC-74LS138 as a Demultiplexer/ Decoder (Test benches and FSM excluded)
   - Design and Implement full adder and subtractor function using IC-74LS138.
   - Design & Implement 3-bit code converter using IC-74LS138.(Gray to Binary/Binary to Gray)
7) Study of IC-74LS83 as a BCD adder,(Refer Data-Sheet).
   - Design and Implement 1 digit BCD adder using IC-74LS83
   - Design and Implement 4-bit Binary subtractor using IC-74LS83.
8) Study of IC-74LS85 as a magnitude comparator,(Refer Data-Sheet)
   - Design and Implement 4-bit Comparator.
   - Design and Implement 8-bit Comparator
9) Study of encoders and 7 segment converter
10) Study of Counter ICs (74LS90/74LS93). (Refer Data-Sheet
   - Design and Implement MOD-N and divide by N counter using IC-74LS90 and draw Timing Diagram.
   - Design and Implement MOD-N and divide by N counter using IC-74LS93 and draw Timing Diagram.
11) Study of synchronous counter
   - Design & Implement 4-bit Up/down Counter and MOD-N Up/down Counter using IC-74HC191/IC74HC193. Draw Timing Diagram
12) Study of Shift Register (74HC194/74LS95)
   - Design and Implement Pulse train generator using IC-74HC194/IC74LS95 (Use right shift/left shift).
   - Design and Implement 4-bit Ring Counter/ Twisted ring counter using shift registers IC 74HC194/IC74LS95.
13) Study of Flipflop: RS Flip-Flop, D Flip-Flop, JK Flip-Flop, T Flip-Flop and Master-Slave Flip-Flop.

Internal assessment		
Part A	CIA-I: First 4 Experiments	
	CIA-II: First 6 Experiments	

SEMESTER-V

BME 301: Environmental Studies

Syllabus will be provided by respective department

BME 302 Biomedical Imaging		
Teaching Scheme	**Examination Scheme**	**Credits allocated**
Theory 3 hrs/week	End of semester Examination-60 marks	Theory-3
	Internal assessment:40 marks	
Course Prerequisite: NA		
Course Objective: 1. To understand the Physics of medical imaging modalities 2. To understand advanced medical image techniques. 3. To understand medical image acquisition and processing.		
Course Outcomes: On completion of this course, students will be able to		
1. Learn about Basic medical image modalities. 2. Learn about advance medical imaging techniques. 3. Learn about medical image processing.		
	Course Content	
Unit -I	X-ray Machines and Digital Radiography: Basis of Diagnostic Radiology, Nature of X-rays, X- ray Machine, Visualization of X-rays, Dental X-ray Machines, Portable and Mobile X-ray Units, Physical Parameters for X-ray Detectors, Digital Radiography. Ultrasonic Imaging Systems: Diagnostic Ultrasound, Physics of Ultrasonic Waves, Medical Ultrasound, Basic Pulse-echo Apparatus, A-Scan, Echocardiograph (M-mode), B-Scanner, Real- time Ultrasonic Imaging Systems, Digital Scan Converter, Biological Effects of Ultrasound.	10 hrs
Unit-II	Nuclear Medical Imaging Systems: Radioisotopes in Medical Diagnosis, Physics of Radioactivity, Radiation Detectors, Radio-isotope Rectilinear Scanner, The Gamma Camera, Emission Computed Tomography (ECT), Single-photon Emission Computed Tomography (SPECT), Positron Emission Tomography (PET Scanner). Magnetic Resonance Imaging System, Principles of NMR Imaging Systems, Image Reconstruction Techniques, Basic NMR Components, Biological Effects of NMR Imaging. Computerized Tomography: Construction, function and operation of a CT scanner, Clinical applications	10 hrs

Unit-III	Medical Image Processing: Filtering of images, Image enhancement, Histogram Equalization & Contrast Adjustment, Spatial Transformation, Edge Detection Techniques, Region Based Processing, Color Based Image Processing, Image Segmentation.	10 hrs
Assessment		
Part A	CIA-I: Unit I	**20 Marks**
	CIA-II: Unit II, III	**20 Marks**
Part B	End Semester Exam	**60 Marks**

ESSENTIAL READINGS

1. R. S. Khandpur, Biomedical Instrumentation 3rd Edition (India Professional Science &Technology Electrical Engineering), McGraw Hill Education; Third edition (4 August 2014).
2. Digital Image Processing by Rafael .C .Gonzalez and Richard. E
3. Gonzalez R C, Woods R E, "Digital Image Processing", Third Edition, Prentice Hall, 2007.
4. Atam Dhawan, "Medical Image Analysis", John Wiley, 2003
5. Mark A Brown, Richard C Semelka, "MRI: Basic Principles and Applications", John Wiley, Third Edition, 2003
6. Joie P Jones, Manbir Singh and Cho Z.H., "Foundations of Medical Imaging", John Wiley, 1993.
7. William R Hendee, E. Russell Ritenour, "Medical Imaging Physics", 4th ed., John Wiley & Sons, Inc., New York, 2002.
8. Paul Suetens, "Fundamentals of Medical Imaging", 2nd ed., Cambridge University press, 2009.
9. J. Michael Fitzpatrick and Milan Sonka, "Handbook of Medical Imaging, Vol. 2, SPIE Press, 2000

BME 303: Analog Electronics		
Teaching Scheme	Examination Scheme	Credits allocated
Theory 3 hrs/week	End of semester Examination-60 marks	Theory-3
Course Prerequisite: Knowledge of 10+2 Math, Linear Algebra, signal and systems, and Fourier Transforms.		
Course Objective:		
Course Outcomes: On completion this course, students will be able to		
CO1: Analyse and design different BJT Circuits i.e amplifiers and oscillator circuits. CO2: Explain concepts and applications of power amplifiers and Tuned amplifiers. CO3: Compare and apply different concepts of feedback methods in practical circuits. CO4: Classify different OP-Amp configurations based on their design and working. CO5: Design of different Op- Amp circuits for practical electronic project design.		
Level	Bachelor	

Course Content:		
Unit -I	**OP-AMP Basics** Introduction to op-amps, ideal Characteristics, Pin configuration of 741 op-amp, Block diagram of OP-AMP, Bias, offsets and drift, bandwidth and slew rate; Offset and Frequency compensation, Exercise problems; Need and types of level shifter, current mirror circuits; Voltage series and voltage shunt feedback amplifier and its effect on Ri, Ro, bandwidth and voltage gain	08 hrs
Unit-II	**Linear and Non-linear applications of OPAMP** Inverting and non-inverting amplifiers and their analysis, Applications: inverting and non- inverting summers, Differential Amplifier configurations, Ideal integrator, practical integrator with frequency response, Ideal differentiator, practical differentiator with frequency response; Comparator, characteristics of comparator, applications of comparator, Schmitt trigger (symmetrical/asymmetrical), clippers and clampers, voltage limiters, Square wave generator, triangular wave generator, Need of precision rectifier, Half wave, Full wave precision rectifiers, peak detectors, sample and hold circuits.	12 hrs
Unit-III	**Unit III: Converter and Filters** V-F, I-V and V-I converter, DAC: types of DAC, characteristics, specifications, advantages and disadvantages of each type of DAC, ADC: types of ADC, characteristics, specifications, advantages and disadvantages of each type of ADC; Design and frequency scaling of First order and second order Active Filters, Low pass, High pass, Band pass and Band Reject filters, Butterworth, Chebychev filters.	14 hrs
Unit-IV	**Unit IV: Analog Circuits** Analog IC Multipliers and applications Comparators, regenerative comparators, input - output Characteristics, Astable and Monostable multivibrator, Triangular wave- generators; 555 Timer functional diagram, monostable and astable operation, applications; Voltage Regulator Series op amp regulator, Three terminal IC voltage regulator exercise problems. IC 723 general purpose regulator, Switching Regulator. **Phase Locked Loop and Oscillators** Block diagram of PLL and its function, PLL types, characteristics/parameters of PLL, and different applications of PLL. Oscillators principle, types and frequency stability, design of phase shift, wein bridge, Quadrature, voltage-controlled oscillators.	8 hrs

Internal assessment		
Part A	CIA-I: Unit I, and II	20 Marks
	CIA-II: Unit III, and IV	20 Marks
Part B	EoSE: Term Exam	60 Marks

Text/Reference Books:

1. J. Millman & A. Grabel,Microelectronics,TataMcGraw-Hill, 2001.
2. Millman and Halkias, Integrated Electronics, Tata McGraw-Hill, 2001.
3. R. A. Gayakwad, Op amp and Linear Integrated Circuits, Prentice-Hall (India), 1983.
4. B. S. Sonde, Power Supplies and Regulators, Tata Mc-Graw Hill,1980.
5. Schilling and Belove, Electronics Circuits, Tata Mc-Graw Hill, 2002.
6. Robert Boylestad, Electronics Devices and Circuits, 9 th ed., Dorling Kindersley (India) Pvt Ltd, 2009.
7. David Bell, Electronics: Devices and Circuits, 4 th ed., Prentice-Hall (India), 1999. IC Voltage Regulators: National Semiconductor Data Book.

BME304: Invasive And Non-Invasive Medical Diagnostic Techniques		
Teaching Scheme	**Examination Scheme**	**Credits allocated**
Theory 3 hrs/week	End of semester Examination: 60 marks Internal assessment: 40 marks	Theory-3
Course Prerequisite: NA		
Course Objective: 1. To have an overview of Invasive and Non-Invasive diagnostic techniques 2. To study the principles and application of Invasive Medical Diagnostic techniques. 3. To study about principles and application of Invasive Medical Diagnostic techniques.		
Course Outcomes: On completion of this course, students will be able to		
1. Learn about Invasive and Non-Invasive diagnostic techniques 2. Learn about principles and application of Invasive Medical Diagnostic techniques. 3. Learn about principles and application of Invasive Medical Diagnostic techniques.		
	Course Content	
Unit -I	Introduction of Invasive and non-invasive Medical Diagnostic Techniques: Definition of Invasive and Non-invasive technique and measurements, Minimally Invasive medical measurement. Invasive Medical Diagnostic Techniques**:** working principle and application of Transesophageal, Echocardiogram, Cardiac Catheterization, Balloon Angioplasty, atherectomy, Coronary Stent, Peripheral Angiogram, Endogenous Ablation, Ambulatory Phlebectomy and Sclerotherapy.	10 hrs

Unit-II	Non-invasive Techniques**:** working principle and application of Electrocardiography, Radiography – routine and specialized areas like CT and MRI, Stress testing – tread mill test, stress related and other nuclear techniques, Holter monitoring for arrhythmias and ischemic disorders, Echocardiography – M-mode, two dimensional, Doppler, Color flow imaging, transesophageal echocardiography and echo directed hemodynamic studies.	10 hrs
Unit-III	Techniques related to Gynaecology, ophthalmology, ENT, orthopaedics etc, Rapid diagnostic tests and kits, Laboratory Measurements: Apparatus and Principles, Photometry, Laboratory Mathematics, Quality Assurance in the Clinical Laboratory, Automation in the Clinical Laboratory. ECG, EEG, EMG signal acquisition and interpretation, X-RAY, CT-Scan, MRI, USG imaging and image analysis and interpretation.	10 hrs
Assessment		
Part A	CIA-I: Unit I	**20 Marks**
	CIA-II: Unit II, III	**20 Marks**
Part B	End Semester Exam	**60 Marks**

ESSENTIAL READINGS

1. R. S. Khandpur, Biomedical Instrumentation 3rd Edition (India Professional Science &Technology Electrical Engineering), McGraw Hill Education; Third edition (4 August 2014).
2. Robert B. Northrop, Non-Invasive Instrumentation and Measurement in Medical Diagnosis, CRC Press, 2017.
3. Alberto Benchimol, Non-Invasive Diagnostic Techniques in Cardiology, Williams & Wilkins; Reprint edition (1 June 1977).
4. Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer, Biomedical Instrumentation and Measurements, Prentice- Hall Inc.
5. Emma P. Corcoles, Mortyn G Boutelle, Biosensors and Invasive Monitoring in Clinical Applications, Springer International Publishing AG.
6. John G. Webster, Medical Instrumentation Application and Design, John Wiley & Sons Inc.
7. J. Wesley Todd, Invasive Diagnostic Techniques: Volume 2 (Todd's Cardiovascular Review), Createspace Independent Pub; 5th edition (26 June 2013).

BME- 305 Immunotechnology laboratory		
Teaching Scheme	**Examination Scheme**	**Credits allocated**

Practical 2 hrs/week	End of semester Examination: 60 marks Internal assessment: 40 marks	Practicals-2
Course Prerequisite: NA		
Course Objective: To provide hands-on training on immuno assay and related techniques.		
Course Outcomes: On completion of this course, students will be able to 1. To perform different immuno assays that are used in clinical diagnostics and research. 2. To design immuno assay as per the requirement.		
Course Content		
• Isolation of serum from blood and heat inactivation • Purification of antibody from serum, agglutination assay • In vitro assay of macrophage activation by bacterial polysaccharide 4-Immunocytochemistry, Immunohistochemistry • 5-ELISA, Western blot, 6-Flow cytometry, • Immunodiffusion, • Immunoelectrophoresis		
Assessment		
Part A	CIA-I	**20 Marks**
	CIA-II	**20 Marks**
Part B	End Semester Exam	**60 Marks**

BME 306: Analog Electronics Lab		
Teaching Scheme	Examination Scheme	Credits allocated
Lab 2 hrs/week	End of semester Examination-60 marks	Lab-1
Course Prerequisite: 10+2 Math, Linear Algebra, Fourier and Laplace Transforms.		
Course Objective: To enhance the details knowledge on communication systems, various experiments have been incorporated. The main objective of this lab course is to enhance the details knowledge on different Amplifiers (Power, Operational, Tuned, etc.).		
Course Outcomes: On completion this course, students will be able to		
CO1: Understand and analyze the op-amp and their comparative study **CO2:** Develop the experimental skills to compare the strengths andweaknesses of various analog electronics systems **CO3:** Have knowledge on circuit implementation on Multisim software.		
Level	Bachelor	
List of Experiments		

1. To study the operation of single-stage and multi-stage RC-Coupled Amplifiers.
2. To calculate Av, AI, Zin and Zout of CE RC-Coupled amplifiers with potential divider biasing.
3. To plot the frequency response of an RC-Coupled amplifier.
4. To study the effect of load resistance and source resistance on operation of an Amplifier.
5. To calculate the current gain and input impedance of Darlington pair & β of a transistor.
6. To calculate the voltage gain of the Darlington pair using voltage divider biasing.
7. Observing the functioning of voltage follower i.e. buffer.
8. Observing Op amp as inverting summer, average, differentiator, and integrator.
9. To study the operation of class A, B and C amplifiers.
10. To study the operation of a Differential Amplifier.

Internal assessment		
Part A	CIA-I	20 Marks
	CIA-II	20 Marks
Part B	EoSE: Term Exam	60 Marks

Text/Reference Books:

1. J. Millman & A. Grabel,Microelectronics,TataMcGraw-Hill, 2001.
2. Millman and Halkias, Integrated Electronics, Tata McGraw-Hill, 2001.
3. R. A. Gayakwad, Op amp and Linear Integrated Circuits, Prentice-Hall (India), 1983.
4. B. S. Sonde, Power Supplies and Regulators, Tata Mc-Graw Hill,1980.
5. Schilling and Belove, Electronics Circuits, Tata Mc-Graw Hill, 2002.
6. Robert Boylestad, Electronics Devices and Circuits, 9 th ed., Dorling Kindersley (India) Pvt Ltd, 2009.

BME 307 - Biomedical Imaging Laboratory		
Teaching Scheme	**Examination Scheme**	**Credits allocated**
Practical 2 hrs/week	End of semester Examination: 60 marks Internal assessment: 40 marks	Practicals-2

Course Prerequisite: NA

Course Objective:

• To expertise the students through handling different medical imaging instruments and analyze it more precisely.

Course Outcomes: On completion of this course, students will be able to

- After completing the course the student will able to operate the image equipment individually.
- Student can able to differentiate a diseased and normal images more accurately.
- Imaging and diagnostic data and its images also be analyzed by the students.

Course Content

- X-ray images of chest, fracture bone and its image analysis
- CT image of lungs
- Mammogram

- NMR and MRI images
- Ultrasonography of fetus and its image analysis
- Doppler effects
- To represent basic signals (Unit step, unit impulse, ramp, exponential, sine and cosine).
- To develop a program for obtaining Fourier transform & inverse Fourier transform.
- To develop a program for obtaining Laplace transform & inverse Laplace transform.
- To develop a program for obtaining z- transform & inverse z-transform.
- To develop a program for discrete convolution.
- To develop a program for discrete correlation.
- To develop a program for converting an RGB image to GRAY scale.
- To develop a program for obtaining a histogram of image.
- To develop a program for adding & removing salt n pepper noise.
- To develop a program for performing filtering operations on images.
- To develop a program for blurring & sharpening of an image.

Assessment		
Part A	CIA-I	**20 Marks**
	CIA-II	**20 Marks**
Part B	End Semester Exam	**60 Marks**

SEMESTER-VI

BME 308: Measurements and Instrumentations		
Teaching Scheme	**Examination Scheme**	**Credits allocated**
Theory 3 hrs/week	End of semester Examination: 60 marks Internal assessment: 40 marks	Theory-3
Course Prerequisite: Basic Knowledge of Instrumentation and mathematics		
Course Objective: To understand the occurrence of errors while measuring a physical quantity.		
Course Outcomes: On completion this course, students will be able to		
CO1: Understand fundamentals of measuring instruments theoretically as well as practically. CO2: Study of cathode ray oscilloscope in detail with its applications and probe compensation. CO3: Attain basic knowledge about analog instruments. CO4: Study measurement of low resistances, voltage, current, phase frequency etc. CO5: Understand compensation, calibration and testing of measuring instruments. CO6: Gain knowledge about A.C. bridges and its applications.		
	Course Content	
Unit -I	**Fundamentals of Measuring Instruments** Fundamental methods of measurement, classification of measuring instruments, static and dynamic characteristics, error classification and analysis, standards for displacement, force, time, frequency, temperature and electrical standards. IEEE standards.	15 hrs
Unit-II	**Unit 2. Cathode Ray Oscilloscope** Construction and operation, measurement of amplitude, phase and frequency with CRO, lissajous patterns. Fundamentals of EMI, RF measurements techniques, network analysers, noise reduction techniques, compatibility of measuring instruments.	12 hrs
Unit-III	**Analog Instruments** Analog indicating type instruments based on various operating principles, ammeters, voltmeters, ohmmeters. Extension of instrument range, instrument transformers. **Calibration and Testing of Instruments** Measurement of low resistances, voltage, current, phase, frequency, power and energy, Q factor, resistance, noise etc., compensation, calibration and testing of measuring instruments.	12 hrs
Unit-IV	**A.C. Bridges** A.C bridges for measurement of inductance, capacitance, Q factor and loss angle, universal impedance bridge. Design aspects. Design aspects of digital multimeter and panel meters. Distortion and spectrum analysis.	12 hrs
Assessment		
Part A	CIA-I: Unit I and II	20 Marks
	CIA-II: Unit III, and IV	20 Marks
Part B	EoSE: Term Exam	60 Marks

Text book

1. A.k. sawhney, electrical & electronic measurement & instrumentation, dhanpat rai, 2015.

Reference Books

1. W. D. Cooper, Electronic Instrumentation and Measurement, Prentice Hall, 1985.

BME 309: Sensors & Transducers in Healthcare		
Teaching Scheme	**Examination Scheme**	**Credits allocated**
Theory 3 hrs/week	End of semester Examination: 60 marks Internal assessment: 40 marks	Theory-4
Course Prerequisite: 10+2 knowledge in physics, chemistry and biology		
Course Objective: 1. To study different classes of sensors used in healthcare and analyze the shortcomings of the biological sensors in real life applications. 2. To learn about different classes of transducers. 3. To understand fundamentals of biological receptors and its applications in sensor development. 4. To learn engineering principles necessary for healthcare-based sensors.		
Course Outcomes: On completion this course, students will be able to		
1. Apply principles and concepts of biology and engineering to design biosensors 2. Apply principles and concepts of electronics and electrochemistry to design electrochemical biosensors 3. Recognize different types of transducers, and their application in biosensor design. 4. Apply principles and concepts of sensing and engineering to design biosensors for detection of markers in biofluids.		
	Course Content	
Unit -I	**Introduction And Classes Of Biosensors Used In Healthcare** Biosensors- Advantages and limitations, various components of biosensors Biocatalysis based biosensors, Bioaffinity based biosensors & Microorganisms based biosensors, Biologically active material and analyte. Types of membranes used in biosensor constructions. Displacement sensors: Resistive sensors, strain sensors, bridge circuits, Inductive, capacitive, piezo-electric sensors; Temperature sensors: thermoelectric, radiation thermometry, thermistors, fiber-optic sensors;	15 hrs
Unit-II	**Transducers In Biosensors** Various types of transducers; principles, characteristics, accuracy, precision and applications - Calorimetric, Optical, Potentiometric / Amperometric, Conductometric / Resistometric, Piezoelectric, Semiconductor, Impedimetric, Chemiluminiscene - based Biosensors.	12 hrs
Unit-III	**Biosensors - Physiological Receptors - J Receptors And Bioelectronics**	12 hrs

	Chemoreceptors, Baroreceptors, Touch receptors, Biosensors - Working Principle and Types, Biopotentials: Origin of biopotentials, Cell, nerve and muscle protentials, Action potential, resting potential, Membrane structure and Nernst Equation, Nerve cell.	
Unit-IV	**Application And Uses Of Biosensors:** Biosensors in clinical chemistry, medicine and health care, Application of enzymes in analysis and diagnostics; design of enzyme electrodes and their application as biosensors in healthcare industry. Biopotential electrodes and biopotential amplifiers, ECG principle, sensing, 12-Lead ECG PQRS characteristics.	12 hrs
Assessment		
Part A	CIA-I: Unit I and II	20 Marks
	CIA-II: Unit III, and IV	20 Marks
Part B	EoSE: Term Exam	60 Marks

Text/Reference Books:

1. Medical Instrumentation Application and Design, John Webster Ed. John Wiley & Sons 2009.
2. Operational Amplifiers and linear ICs,R. A. Gayakwad, Phi Learning, 2009.3. Additional research papers distributed in class.
3. Brian R Eggins - Biosensors an Introduction , First edition, John Wiley & Sons Publishers, 1996.
4. Loic J Blum, Pierre R Coulet - Biosensors Principles and Applications, First edition, Marcel Dekker,Inc, 1991.
5. Donald G. Buerk - Biosensors Theory and Applications, First Edition Technomic Publishing. Co, Inc, 1993.
6. Elizabeth A Hall - Biosensors, First Edition, Open University, Milton Keynes, 1990.
7. Graham Ramsay - Commercial Biosensors, First edition, John Wiley & Sons, Inc. 1998.
8. Tran Minh Canh - Sensor Physics & Technology - Biosensors , First Edition, Champan & Hall, 1993

List of Experiments:

1. Implementation of signal conditioning circuits
2. To study the characteristics of resistometric transducers
3. Sensor design, fabrication and characterization
4. To study the characteristics of strain gauge
5. To study the characteristics of resistance temperature detector
6. Blood pressure measurement using sphygmomanometer.
7. Design of instrumentation amplifier.
8. Measurement pH using pH meter.
9. Galvanic Skin resistance measurement.
10. Recording of ECG using ECG simulator.
11. Recording of EEG using EEG simulator.
12. Recording of EMG using EMG simulator.

BME 310: Microcontroller and Embedded System		
Teaching Scheme	Examination Scheme	Credits allocated
Theory 3 hrs/week	End of semester Examination-60 marks	Theory-3
Course Prerequisite: An undergraduate level course on Digital Electronics and C programming Language.		
Course Objective: This course introduces the basics of microcontrollers and embedded systems to the students which focused on introductory study of embedded systems using 8051 microcontroller and its interfacing to different components covering daily life problems to industrial problems. The course is heavily oriented towards the programming and interfacing of different input/output devices to 8051 microcontroller and their practical applications.		
Course Outcomes: On completion this course, students will be able to		
CO1: Implement and use 8051 microcontrollers for embedded systems **CO2:** Apply Embedded system concepts to solve real word problems and can present solution to automated systems using microcontrollers for real-life situations. **CO3:** Apply concepts of embedded systems and microcontroller to enhance existing systems by effectively implementing data handling and processing. **CO4:** Ability to develop concepts, logics towards solving unknown problem in research and industry using microcontrollers and embedded systems.		
Level	Bachelor	
Course Content:		
Unit -I	Introduction to Embedded Systems: Overview of Embedded systems, Design Process in Embedded systems and System Integration, Challenges in Embedded System Design, IoT	10 hrs
Unit-II	Embedded System Architecture: Instruction Set Architecture,	10 hrs

	CISC and RISC instruction set architecture, Basic Embedded Processor/Microcontroller Architecture, 8051/ PIC/AVR microcontrollers, 8051 Microcontroller, pin configuration, I/O ports and pin, counters, timers, serial I/O, interrupts, physical systems, assembly language for 8051, Instruction syntax, assembly language, moving data, logical operations, arithmetic operations, Jump and Call instructions	
Unit-III	Arduino/Raspberry Pi input-output Interfacing and signal conversion: LED, Switch, 7segment display, LED array, LCD, keyboard, buzzer interfacing, serial communication, ADC and DAC interfacing, sensor interfacing and processing	10 hrs
Unit-IV	External memory, RTC, and mechanical interfacing: External memory interface, real-time clock interfacing, interfacing to relay, DC motor, Stepper Motor, servo motor.	10 hrs

Internal assessment		
Part A	CIA-I: Unit I, and II	20 Marks
	CIA-II: Unit III, and IV	20 Marks
Part B	ESE: Term Exam	60 Marks

Text/Reference Books:

1. J.W. Valvano, "Embedded Microcomputer System: Real Time Interfacing", Brooks/Cole, 2000.
2. Jack Ganssle, "The Art of Designing Embedded Systems", Newness, 1999.
3. V.K. Madisetti, "VLSI Digital Signal Processing", IEEE Press (NY, USA), 1995.
4. David Simon, "An Embedded Software Primer", Addison Wesley, 2000.
5. K.J. Ayala, "The 8051 Microcontroller: Architecture, Programming, and Applications", Penram Intl, 1996
6. Muhammad Ali Mazidi**,** Janice Gillespie Mazidi and Rollin D. McKinlay**,** "The 8051 Microcontroller and Embedded Systems using assembly and C"**,** Pearson, 2006.

List of Experiments:

1. Familiarity to 8051 microcontroller and trainer kit
2. 8051/ Arduino C programming, hex generation and programming
3. 8051/ Arduino timer and LED blinking and input port
4. 8051/ Arduino interfacing to LED, LED array
5. 8051/ Arduino interfacing to 7-segment and 7 segment array
6. 8051/ Arduino interfacing to 16 X 2 LCD and switch
7. 8051/ Arduino Serial Communication and interrupts
8. Interfacing with ADC and DAC
9. Interfacing to LDR and Temperature Sensor
10. Interfacing to External Memory and Real-time clock (RTC) Interfacing to DC motor and Stepper Motor.

BME 311: Medical Image Processing		
Teaching Scheme	**Examination Scheme**	**Credits allocated**
Theory 3 hrs/week	End of semester Examination-60 marks	Theory-3
	Internal assessment:40 marks	
Course Prerequisite: Knowledge of Linear Algebra and Bio Imaging.		
Course Objective: 1. To study the basic concepts used in digital image processing. 2. To learn various operations used for processing digital images. 3. To lean various algorithms used in image processing. 4. To learn various post processing methods.		
Course Outcomes: On completion of this course, students will be able to		
CO1: Students can understand the basic concepts of image processing. CO2: Students can apply basic knowledge of linear algebra for image processing. CO3: Students can detect various region of interest in medical images. CO4: Students can segment important regions from medical images.		
	Course Content	
Unit -I	Introduction to digital images. Sampling and quantization of digital images. Format of Medical images. Concept of Pixels and Voxels. Introduction to matrices. Basic operation of matrices. Introduction to grayscale and colour images. Significance of various imaging modalities such as X-ray, CT, MRI, SPET, PET and microscopic images. Significance of 3D images over 2D images. Reconstruction of 3D images. Significance of digital or medical image processing. Introduction of Histogram of an image.	10 hrs
Unit-II	Image enhancement techniques: Image negatives, log transformations, power-law transformations, piecewise linear transformations, histogram equalization technique, smoothing and sharpening of image. Sampling and transformation of sampled function; Filtering in frequency domain; Image smoothing using frequency domain; Image sharpening using frequency domain filter.	10 hrs
Unit-III	Introduction to Image segmentation: Line and edge detection technique; Advance technique of edge detection; Basic Thresholding technique; Otsu's Thresholding; Multiple Thresholding method; Region Based Segmentation; Statistical Based models.	10 hrs
Unit-IV	Introduction to morphological operators; Erosion and Dilation; Duality; Hole filling; Extraction of connected components; Thinning and Thickening; Pruning; Opening and Closing Operators.	10 hrs
Assessment		
Part A	CIA-I: Unit I	**20 Marks**
	CIA-II: Unit II, III	**20**

		Marks
Part B	End Semester Exam	**60 Marks**

Essential Readings

- Digital Image Processing Fourth Edition, by Rafael C Gonzalez and Richard E Woods.
- Fundamental of Digital Image Processing, 1 January 2015, By Anil K Jain

Medical Image Processing Lab

List of Experiment:

1. Power law transformation of image.
2. Image negative of image.
3. Study various matrix operations such as addition, subtraction, multiplication and division.
4. Smoothing of image.
5. Sharpening of image.
6. Application of thresholding of image.
7. Application of K-means algorithm.
8. Application of morphological operators.

VII Semester

BME 401: Digital Signal Processing		
Teaching Scheme	**Examination Scheme**	**Credits allocated**
Theory 3 hrs/week	End of semester Examination: 60 marks Internal assessment: 40 marks	Theory-3
Course Prerequisite: An Undergraduate level course on Signal and Systems		
Course Objective: This course introduces the basics concepts of Discrete fourier transform, digital filter design and application of digital signal processing. The design of IIR and FIR filter, their structure and implementation is also addressed in this course. DSP processor is also discussed in this course.		
Course Outcomes: On completion this course, students will be able to		
CO1: Analyze and study discrete Fourier transform (DFT) and their implementation. CO2: Analyze and implementation of IIR and FIR filters and their implementation. CO3: Application and introduction to digital signal processors.		
	Course Content	
Unit -I	Discrete Fourier Transforms (DFT): Frequency domain sampling and Reconstruction of Discrete Time Signals, The Discrete Fourier Transform, DFT as a linear transformation, 12 hrs Properties of the DFT: Periodicity, Linearity and Symmetry properties, Multiplication of two DFTs and Circular Convolution, Additional DFT properties. Linear filtering methods based on the DFT: Use of DFT in Linear Filtering, Filtering of Long data Sequences, Fast-Fourier-Transform (FFT) algorithms, Efficient Computation of the DFT: Radix2 FFT algorithms for the computation of DFT and IDFT-decimation in-time and decimation-in-frequency algorithms.	10 hrs
Unit-II	Design of FIR Filters: Characteristics of practical frequency - selective filters, Symmetric and Antisymmetric FIR filters, Design of Linear-phase FIR filters using windows- Rectangular, Hamming, Hanning, Bartlett windows. Design of FIR filters using frequency sampling method. Structure for FIR Systems: Direct form, Cascade form and Lattice structures.	10 hrs
Unit-III	IIR Filter Design: Infinite Impulse response Filter Format, Bilinear Transformation Design Method, Analog Filters using Lowpass prototype transformation. Normalized Butterworth Functions, Bilinear Transformation and Frequency Warping, Bilinear Transformation Design Procedure, Digital Butterworth Filter Design using BLT. Realization of IIR Filters in Direct form I and II.	10 hrs
Unit-IV	Digital Signal Processors: DSP Architecture, DSP Hardware Units, Fixed point format, Floating point Format, IFixed point digital signal processors, Floating point processors. Application of Digital Signal Processors.	10 hrs
Assessment		

Part A	CIA-I: Unit I and II	20 Marks
	CIA-II: Unit III, and IV	20 Marks
Part B	EoSE: Term Exam	60 Marks

Textbooks:

1. Proakis & Manolakis, "Digital Signal Processing- Principles Algorithms &Applications", 4th Edition, Pearson education, New Delhi, 2007. ISBN: 81-3171000-9.
2. Oppenheim & Schaffer, "Discrete Time Signal Processing" ,PHI, 2003.
3. Sanjit K Mitra, "Digital Signal Processing, A Computer Based Approach", 4th Edition. McGraw Hill Education, 2013.
4. D.Ganesh Rao and Vineeth P Gejji, "Digital Signal Processing" Cengage India Private Limited, 2017, ISBN: 9386858231

BME402: Biological Control Systems		
Teaching Scheme	Examination Scheme	Credits allocated
Theory 3 hrs/week	End of semester Examination-60 marks	Theory-3
Course Prerequisite: An undergraduate level course on Control Systems		
Course Objective: To understand the basics of Control systems. To apply the knowledge of control systems to biological systems. To understand the various biological networks using control models.		
Course Outcomes: On completion this course, students will be able to		
CO1: Interpreting physiological systems in terms of control systems and summarizing their properties. CO2: Developing a simple respiratory model. CO3: Developing a simple cardiovascular model. CO4: Summarizing various physiological models. CO5: Interpreting different system identification techniques.		
Level	Bachelor	
Course Content:		
Unit -I	Control Systems Perspective for Biological Systems: Introduction to physiological control systems, examples of a physiological control system, differences between engineering and physiological control systems, art of modelling physiological systems, distributed parameters versus lumped parameter models, simple models of muscle stretch reflex action, across and through variables, generalized system properties (viz., impedance, compliance and inertance).	10 hrs
Unit-II	Human Respiratory Modeling Respiratory mechanism, linear	10 hrs

	model of respiratory mechanics, gas exchange and ventilation–perfusion relationships in the lung, chemical regulation of ventilation Cardiovascular System Modeling Theoretical basis- cardiac cycle & pressures-volume loops, cardiac pressure versus time graph, the cardiac output curve, the venous return curve, closed-loop analysis: heart and systemic circulation combined	
Unit-III	Various Physiological Models The Hodgkin-Huxley model. Westheimer's Saccadic eye model, compartmental models, integrated cardiopulmonary model.	10 hrs
Unit-IV	Art of Modeling the Biological Control System Basic problems in physiological system analysis, nonparametric and parametric identification: numerical deconvolution, least square estimation, estimation using correlation functions, estimation in the frequency domain, optimization techniques. Problems in parameter estimation.	10 hrs

Internal assessment		
Part A	CIA-I: Unit I, and II	20 Marks
	CIA-II: Unit III, and IV	20 Marks
Part B	ESE: Term Exam	60 Marks

Text/Reference Books:

1. Michael C.K. Khoo, Physiological control systems: Analysis, Simulation and Estimation, 2nd ed. Wiley-IEEE press, 2018.
2. Frank C., Hoppenstead, Charles,Modelling and Simulation in Medicine and the Life Sciences, Springer, 2002.

Reference

1. John H. Milsum, Biological Control System analysis, McGraw hill, 1966..

BME 403: Neuroscience and Neurotechnology		
Teaching Scheme	**Examination Scheme**	**Credits allocated**
Theory 3 hrs/week	End of semester Examination: 60 marks Internal assessment: 40 marks	Theory-3

Course Prerequisite: Basic knowledge of Anatomy and Physiology of Brain

Course Objective:

1. To study the anatomy and function of brain.
2. To study the structural property of brain.
3. To study the connectome property of brain.

Course Outcomes: On completion of this course, students will be able to

CO1:To study the structure of brain and reason of various brain disorder.

CO2: To understand various diagnosis of disorder in CT and MRI

CO3: To understand the connectome of brain.

	Course Content	
Unit -I	Structure of Neurons; Synapse and Axons, Anatomy of Normal brain, White matter, Gray Matter, Lateral Ventricle, Some special brain disorders; Parkinson's disease, Alzeimer's disease, Cerebral Stroke, Types of brain tumors, Traumatic brain injury.	12 hrs
Unit-II	Brain under CT and MRI; The anatomy of normal brain under CT and MRI; Visualization of tumors and different types of cerebral stroke in CT and MRI.	12 hrs
Unit-III	Study brain connectome of normal and diseased brain; The concept of connectome; Brain under PET scan and registration of PET and CT scans.	12 hrs
Assessment		
Part A	CIA-I: Unit I	**20 Marks**
	CIA-II: Unit II	**20 Marks**
Part B	End Semester Exam	**60 Marks**

ESSENTIAL READINGS

- The Human Brain Book: An Illustrated Guide to its Structure, Function, and Disorders by Rita Carter.
- Oxford Textbook of Neuroimaging (Oxford Textbooks in Clinical Neurology) by Missimo Flippi.
- Connectome: How the Brain's Wiring Makes Us Who We Are **Paperback – 5 February 2013 by Sebastian Seung**

Elective Subjects

BME 315 Immunotechnology		
Teaching Scheme	**Examination Scheme**	**Credits allocated**
Theory 3 hrs/week	End of semester Examination: 60 marks Internal assessment: 40 marks	Theory-3
Course Prerequisite: NA		
Course Objective: 1. To provide a comprehensive idea about the components, properties and function of immune systems.		
Course Outcomes: On completion of this course, students will be able to		
1. After completing the course, the student will be able 2. to analyze the results of an immuno assay including clinical diagnostic reports. 3. to design immune assay as per the requirement 4. to analyze the immune response by accounting the contribution of participating cells and other factors.		
	Course Content	
Unit -I	Overview of the mammalian immune system, Evolutionary perspective of immunity and self defense, Innate immunity, adaptive immunity and its characteristics, Antigen and immunogen, Antigen presenting cells and antigen presentation, MHC molecules, Humoral immunity: Structure and function of antibody, antibody diversity. Transplantation immunology, Autoimmune disorder, Allergy and hypersensitivity, Antiviral immunity, Immunology of stem cells, Tumor immunology, Immunoassays. Immunopathology.	10 hrs
Unit-II	Adjuvant, Vaccines, Use of antibody in diagnostics and therapy, Antibody (Production and purification), Hybridoma Technology: Production of monoclonal antibody, Immunoassays and related screening techniques: Enzyme linked immunosorbent assay (ELISA), Paper radio immunosorbent test (PRIST), Radio immuno assay (RIA), Immunocytochemistry and Immunohistochemistry (ICC & IHC), Immunoblotting (Western blotting), immune-diffusion and immune-electrophoresis.	10 hrs
Unit-III	Isolation and culture of cells of immune system, In vitro assessment of macrophage activation, Cr51 assay, MACS, Flow cytometry, Adaptive immune cell therapy, Tetramer Technology, Dendritic cell vaccine for cancer, Antibody Engineering, Production of human monoclonal antibody, Xenomouse technology, Antibody phage display library, Lab-on-chip devices for immunoassay, Point-of-care immunoassays, Immunotechnology in transplantation: Tissue typing, Use of immunotherapeutics : Safety, regulation and ethics.	10 hrs
Assessment		
Part A	CIA-I: Unit I	**20 Marks**

	CIA-II: Unit II, III	**20 Marks**
Part B	End Semester Exam	**60 Marks**

ESSENTIAL READINGS

1. J. A. Owen, J. Punt , S.A. Stranford, Kuby Immunology, W.H. Freeman & Company , 7th Edition, 2018
2. P.J. Delves, S.J. Martin , D. R. Burton , I. M. Roitt, Roitt's Essential Immunology, Wiley- Blackwell, , 13th Edition, 2017
3. Sudha Gangal, Subhangi Sontakke, Textbook of Basic and Clinical Immunology, Orient Blackswan Private Limited , 2013, 1st Edition
4. A.K. Chakravarty, Immunology and Immunotechnology, Oxford university press , 2006, 1st Edition.

BME 316-Tissue Engineering and Regenerative Medicine		
Teaching Scheme	**Examination Scheme**	**Credits allocated**
Theory 3 hrs/week	End of semester Examination-60 marks Internal assessment:40 marks	Theory-3
Course Prerequisite: NA		
Course Objective: 3. To study basic concepts of cells, tissues and extracellular matrix. 4. To learn about different types of scaffolds and their synthesis process. 5. To understand the basic techniques used in tissue engineering.		
Course Outcomes: On completion of this course, students will be able to		
1. Students can understand the primary concepts of tissue regeneration and its requirement in the biomedical field. 2. Students can apply basic concepts of biology and engineering to fabricate different types of scaffolds. 3. Students can characterize the different properties of the scaffolds. 4. Students can learn about the cell culture technique.		
	Course Content	
Unit -I	Introduction to tissue engineering, tissue engineering triad, challenges in tissue engineering, sources of cells, cells used to restore the mechanical, metabolic, synthetic, communication and combination defects, cell numbers and growth rate, Tissue organization, Extracellular matrix and Tissue dynamics- epithelial tissue, connective tissue, muscular tissue, nervous tissue, glandular tissue, structure composition and function of extracellular matrix, tissue homeostasis, tissue repair (sequence of events in wound healing) and tissue formation, angiogenesis. Malfunctions in ECM signalling, Malfunctioning morpho-regulatory control loop, Tight junction, Belt desmosomes, Spot desmosomes, Gap junction, Bidirectional nature of cell-cell	10 hrs

	communication, Malfunctions in direct cell-cell contact signalling, Response to mechanical stimuli.	
Unit-III	Bioreactors in tissue engineering- Establish spatially uniform cell distributions on 3D scaffolds, Maintain desired nutrient and gas concentrations in medium, Expose the developing tissue to physical stimuli. Artificial blood vessels – response to injury, Current clinical approaches with limitations, Improvement of existing synthetic grafts**,** Artificial pancreas and Liver tissue engineering- anatomy and functions of pancreas and liver, Current clinical approaches with limitations, Improvement of existing synthetic grafts, Host integration, bioethics, Applications: Skin tissue engineering**,** Applications: Bone tissue engineering, Vascular tissue engineering, and Corneal tissue engineering.	10 hrs
Assessment		
Part A	CIA-I: Unit I	**20 Marks**
	CIA-II: Unit II, III	**20 Marks**
Part B	End Semester Exam	**60 Marks**

ESSENTIAL READINGS

1. The Principles of Tissue Engineering (4th edition), by Robert Lanza, Robert Langer, and Joseph P. Vacanti. Academic Press (AP). 2013
2. An Introduction to Tissue-Biomaterial Interactions by K.C. Dee, D.A. Puleo and R. Bizios. Wiley 2002
3. Culture of Animal Cells: A Manual of Basic Technique and Specialized applications (6th edition), by R. Ian Freshney. Wiley-Blackwell. 2010
4. Biomaterials Science: An Introduction toMaterials and Medicine (3rd edition), byBuddy D. Ratner, Allan S. Hoffman,Frederick J. Schoen and Jack E. Lemons.Academic Press (AP). 2012

BME 320 Medical Nanotechnology		
Teaching Scheme	**Examination Scheme**	**Credits allocated**
Theory 3 hrs/week	End of semester Examination-60 marks Internal assessment:40 marks	Theory-3

Course Prerequisite: NA

Course Objective:

1. To understand the current approaches in nano-based medicine and targeted drug delivery.
2. To prepare them an efficient candidate in the field of nano drug formulation for various treatments.

Course Outcomes: On completion of this course, students will be able to

1. Possess sound knowledge in nano-biomedicine formulations and delivery system.
2. Also had an idea about personalized medicines importance in various diseases.

	Course Content	
Unit -I	Nanoparticles- structure and preparation for drug - Liposomes, Cubosomes and Hexosomes, DNA based Nanostructures- DNA-protein nanostructures-Methods- Self assembled DNA nanotubes—Nucleic acid Nanoparticles, DNA as a Biomolecular template-DNA branching-Metallization- Properties. Protein and Peptide based Nanostructures- S-layers- Chemistry and structure, Assembly, recrystalisation, diagnosis- Engineered Nanopores- Methods of production Supported bilayers and membrane arrays- Genetic Approaches- Microbial nanoparticles production- Magnetosomes- Bacteriorhodopsins- Nanoproteomics.	10 hrs
Unit-II	Lipid based Nanoparticles-Liquid nanodispersions- Solid Lipid Nanoparticles (SLP)- Bio functionalsiation of SLP, Charatcterisation- Nanoparticles for crossing biological membranes. Information-Driven Nanoassembly- Energetic-Chemical Transformation- Regulation- Traffic across Membranes- Biomolecular Sensing- Self-Replication- Machine-Phase Nano biotechnology. - Self-Assembled Artificial Transmembrane Ion Channels-types, Methods, Self- Assembling Nanostructures from Coiled-Coil Peptides, Synthesis and Assembly using Bio- Derived Templates- Self-Assembling for Patterned Molecular Assembly.	10 hrs
Unit-III	Introduction to drug delivery systems, their targeting potentials, various delivery systems- Sustained release dosage forms, Prodrug concept, resealed erythrocytes, transdermal Molecular approaches to drug delivery system, Ligand mediated endocytosis, ligand anchoring and designing of colloidal drug delivery systems, Drug delivery large molecules - peptides proteins, nucleic acids, antibodies and siRNA. Fundamentals-Physicochemical Principles of Nanosized Drug Delivery Systems-Nanotubes, Nanorods, Nanofibers, and Fullerenes for Nanoscale Drug Delivery, Carbon nanotubes biocompatibility and drug delivery.	10 hrs
Assessment		
Part A	CIA-I: Unit I	**20 Marks**
	CIA-II: Unit II, III	**20 Marks**
Part B	End Semester Exam	**60 Marks**

ESSENTIAL READINGS

1. Rajeev K. Tyagi, Neeraj Garg, Rahul Shukla, Prakash Singh Bisen 2020. Role of novel Drug Deliery Vehicles in Nanobiomedicine.
2. Nanobiotechnology I: Concepts, applications and perspectives, eds. CM Niemeyer, CA Mirkin, Wiley-VCH Verlag GmbH & Co., KgaA, Weiheim (2015).
3. Nanobiotechnology II: More concepts, applications and perspectives.
4. Bionanotechnology: Lessons from Nature, David S. Goodsell, John Wiley & Sons - Science, ISBN: 978047146958 (2015).
5. Handbook of Biomimetics and Bioinspiration : Biologically-Driven Engineering of Materials, Processes, Devices, and Systems (In 3 Volumes) Edited by: Esmaiel Jabbari, Deok-Ho Kim, Luke P Lee, Amir Ghaemmaghami, Ali Khademhosseini,

Scientific Series in Nanoscience and Nanotechnology: Volumes 9, 2014.
6. Nano Technology, Rakesh Rathi, S.Chand & Company Limited, New Delhi (2009).

BME 411: Artificial Intelligence and Neural Networks in Medicine		
Teaching Scheme	**Examination Scheme**	**Credits allocated**
Theory 3 hrs/week	End of semester Examination: 60 marks Internal assessment: 40 marks	Theory-3
Course Prerequisite: Basic knowledge of Anatomy and Physiology of Brain		
Course Objective: To study the organization of artificial neural network and how to design own network.		
Course Outcomes: On completion of this course, students will be able to		
CO1:To learn building block of neural networks. CO2: To learning about machine vision and machine learning. CO3: To learn about deep learning.		
	Course Content	
Unit -I	Design of artificial neural network. Activation function. Weights. Optimization technique. Bias Variance tradeoff.	12 hrs
Unit-II	Difference between supervised and unsupervised learning. Feature engineering. Basic machine learning methods: K-NN, Decision tree, Random Forest, Support vector machine. Curse of dimensionality.	12 hrs
Unit-III	ConvNets, ConvNet Architectures and Dropout/Regularization/Batchnorm ConvNets: Basic concepts of Convolutional Neural Networks starting from filetering. Convolution and pooling operation and arithmatics of these. ConvNet Architectures: Discussions on famous convnet architectures - AlexNet, ZFNet, VGG, C3D, GoogLeNet, ResNet, MobileNet-v1, MobileNet-v2, EfficientNet, U-Net Discussion on regularization, Dropout, Batchnorm etc.	12 hrs
Assessment		
Part A	CIA-I: Unit I	**20 Marks**
	CIA-II: Unit II	**20 Marks**
Part B	End Semester Exam	**60 Marks**
ESSENTIAL READINGS		
• Deep learning by Ian Goodfellow MIT Press. • Machine Learning by Tom Mitchel TMH publication.		

BME 420: Bioinformatics and Drug Discovery		
Teaching Scheme	**Examination Scheme**	**Credits allocated**
Theory 3 hrs/week	End of semester Examination: 60 marks	Theory-3
Course Prerequisite: Knowledge of Bioinformatics and Drug Discovery.		
Course Objective: 1. Introduction to Bioinformatics and Databases 2. To understand the Sequence alignment and the drug discovery methods 3. To address concepts of molecular modeling for Drug Designing 4. To exploit the algorithm for docking used in drug singing		
Course Outcomes: On completion of this course, students will be able to		
1. Knowledge about bioinformatics and bioinformatics databases. 2. Learn various sequence alignment and drug design methods 3. Understand the modeling for drug design. 4. Different modeling used in docking which helps to understand the drug discovery		
	Course Content	
Unit -I	**Introduction to bioinformatics and Databases** Introduction to Bioinformatics, Introduction to Biological databases; Organization and management of databases; Searching and retrieval of information from the NCBI; Structure databases– PDB (Protein Data Bank), Molecular Modeling Databases (MMDB); Primary Databases (NCBL, EMBL, DDBJ); Introduction to Secondary Databases Organization and management of databases (Swissprot, KEGG); Introduction to BioChemical databases-organization and Management of databases(KEGG, BRENDA)	12 hrs
Unit-II	**Multiple Sequence Alignment and Drug Designing** Multiple sequence alignment and phylogenetic analysis. Need for aligning biological sequences, Smith-Watermann algorithm, Needleman-Wunsch algorithm, Multiple Sequence Alignment, Phylogeny, Applications, BLAST, Introduction Drug Discovery issues, Protein Homology modeling, Target and lead identification, Drug and databases, Drug properties and SMILES, Drug solubility and permeability, ADME, Drug-ADME, Drug-blood brain barrier, efflux/drug-likeness	12 hrs
Unit-III	**Molecular Modeling for Drug Designing** Molecular modeling, Molecular mechanics and force field, ODES and numerical methods, Conformational search and MD, Quantum mechanics, Quantitative Structure-Activity and Relationship (QSAR)	10 hrs
Unit-IV	**Docking method** 3D QSAR, Pharmacophore modelling, Target based drug design, Docking, Pharmacokinetics and pharmacodynamics	4 hrs
Assessment		
Part A	CIA-I: Unit I, and II	20 Marks
	CIA-II: Unit III, and IV	20 Marks

Part B	EoSE: Term Exam	60 Marks

Text/Reference Books:

1. Computational Drug Design: A Guide for Computational and Medicinal Chemists, D. C. Young, WileyBlackwell, ISBN: 978-0470126851, 2009.
2. H. H. Rashidi and L. K. Buehler, Bioinformatics Basics Applications in Biological Science and Medicine, CAC Press, 2000.
3. D. Gusfiled, Algorithmson Strings Trees and Sequences, CambridgeUniversityPress, 1997.
4. Understanding Molecular Simulations: From Algorithms to Applications, D. Frenkel and B. Smit, Academic Press, 2002.
5. Molecular modeling Principles and Applications. A. R. Leach. Pearson, ISBN-13: 978-0582382107 2001.
6. An Introduction to Cheminformatics, A. R. Leach., Springer, ISBN: 978-1-4020-6291-9, 2000
7. D. Mount, Bioinformatics: Sequence and Genome Analysis, Cold Spring Harbor laboratory Press (2004), Second Edition

BME 421: Molecular imaging (imaging of chemistry and biology)		
Teaching Scheme	**Examination Scheme**	**Credits allocated**
Theory 3 hrs/week	End of semester Examination: 60 marks	Theory-3

Course Prerequisite: Knowledge of Bioinformatics and Drug Discovery.

Course Objective:

1. To characterization and quantification of biological processes taking place at the cellular and subcellular levels within intact living subjects.
2. To learn about different imaging techniques used in the biomedical discipline.
3. To use the engineering aspects for the detection of diseases.

Course Outcomes: On completion of this course, students will be able to

1. Understand the principles of numerous imaging techniques used in hospitals.
2. Can differentiate and analyze the data obtained from these imaging techniques.
3. Demonstrate the working of the imaging instruments.

	Course Content	
Unit -I	Introduction to Molecular Imaging, Optics (physics): 3D fluorescence imaging: Tissue optics, Chemistry of Fluorescence, Optics Application: Intervital Optical Neuroimaging, Optical Reporter Genes	12 hrs
Unit-II	SPECT Physics, PET Physics, Radiochemistry, PET Imaging of	12 hrs

	Integrin Expression, Imaging of Apoptosis, MR Basic Principles, Cardiovascular MRI/Targeted MRI Contrast Agents, Neuroimaging by MR	
Unit-III	Spectroscopic Techniques: XRD, XPS, EDX, FTIR Microscopic Techniques: SEM, TEM, AFM, CLSM FRET, BRET	10 hrs
Assessment		
Part A	CIA-I: Unit I, and II	20 Marks
	CIA-II: Unit III, and IV	20 Marks
Part B	EoSE: Term Exam	60 Marks

Text/Reference Books:

1. Weissleder R. Molecular imaging: principles and practice. PMPH-USA; 2010.
2. Yao J, Wang LV. Photoacoustic Molecular Imaging: Principles and Practice. InMolecular Imaging 2021 Jan 1 (pp. 233-244). Academic Press.
3. Khalid S. Molecular Imaging-1: methods and protocols. New York, NY: Humana press; 2011.