SEMESTER 3

BIOMEDICAL ENGINEERING

SEMESTER S3

MATHEMATICS FOR ELECTRICAL SCIENCE AND PHYSICAL SCIENCE – 3

(Common to Group B & C)

Course Code	**GYMAT301**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Basic knowledge in complex numbers.	**Course Type**	BSC

Course Objectives:

1. To introduce the concept and applications of Fourier transforms in various engineering fields.
2. To introduce the basic theory of functions of a complex variable, including residue integration and conformal transformation, and their applications.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Fourier Integral, From Fourier series to Fourier Integral, Fourier Cosine and Sine integrals, Fourier Cosine and Sine Transform, Linearity, Transforms of Derivatives, Fourier Transform and its inverse, Linearity, Transforms of Derivative. **(Text 1: Relevant topics from sections 11.7, 11.8, 11.9)**	**9**
2	Complex Function, Limit, Continuity, Derivative, Analytic functions, Cauchy-Riemann Equations (without proof), Laplace's Equations, Harmonic functions, Finding harmonic conjugate, Conformal mapping, Mappings of $w= z^2$, $w=e^z$, $w=\frac{1}{z}$, $w=\sin z$. **(Text 1: Relevant topics from sections 13.3, 13.4, 17.1, 17.2, 17.4)**	**9**
3	Complex Integration: Line integrals in the complex plane (Definition & Basic properties), First evaluation method, Second evaluation method, Cauchy's integral theorem (without proof) on simply connected domain, Independence of path, Cauchy integral theorem on multiply connected domain (without proof), Cauchy Integral formula (without proof).	**9**

	(Text 1: Relevant topics from sections 14.1, 14.2, 14.3)	
4	Taylor series and Maclaurin series, Laurent series (without proof), Singularities and Zeros – Isolated Singularity, Poles, Essential Singularities, Removable singularities, Zeros of Analytic functions – Poles and Zeros, Formulas for Residues, Residue theorem (without proof), Residue Integration- Integral of Rational Functions of $cos\theta$ and $sin\theta$. **(Text 1: Relevant topics from sections 15.4, 16.1, 16.2, 16.3, 16.4)**	**9**

Course Assessment Method
(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination-2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Determine the Fourier transforms of functions and apply them to solve problems arising in engineering.	**K3**
CO2	Understand the analyticity of complex functions and apply it in conformal mapping.	**K3**
CO3	Compute complex integrals using Cauchy's integral theorem and Cauchy's integral formula.	**K3**
CO4	Understand the series expansion of complex function about a singularity and apply residue theorem to compute real integrals.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	-	2	-	-	-	-	-	-	-	2
CO2	3	3	-	2	-	-	-	-	-	-	-	2
CO3	3	3	-	2	-	-	-	-	-	-	-	2
CO4	3	3	-	2	-	-	-	-	-	-	-	2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Advanced Engineering Mathematics	Erwin Kreyszig	John Wiley & Sons	10^{th} edition, 2016

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Complex Analysis	Dennis G. Zill, Patrick D. Shanahan	Jones & Bartlett	3rd edition, 2015
2	Higher Engineering Mathematics	B. V. Ramana	McGraw-Hill Education	39th edition, 2023
3	Higher Engineering Mathematics	B.S. Grewal	Khanna Publishers	44th edition, 2018
4	Fast Fourier Transform - Algorithms and Applications	K.R. Rao, Do Nyeon Kim, Jae Jeong Hwang	Springer	1st edition, 2011

SEMESTER S3

ANALOG ELECTRONICS

Course Code	**PCBMT302**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3-1-0-0	**ESE Marks**	60
Credits	4	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	GYEST104	**Course Type**	PC

Course Objectives:

1. Develops a basic understanding of the fundamentals and principles of analog circuits and electronic devices.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Wave shaping circuits: Sinusoidal and non-sinusoidal wave shapes, Principle and working of RC differentiating and integrating circuits, Clipping circuits - Positive, negative and biased clipper Transistor biasing: Introduction, operating point, concept of load line, fixed bias, self-bias and voltage divider bias. h-parameter model of BJT.	**11**
2	Amplifiers: Classification of amplifiers, RC coupled amplifier –frequency response. Analysis for mid frequency gain. Typical examples. . Power Amplifiers: Definitions and classification. Typical circuits of Class A, Class B, Class AB and Class C Amplifiers. Analysis for conversion efficiency of B and AB. Simple examples.	**11**
3	Operational amplifiers: Block Diagram, ideal characteristics. Op-Amp Basics, Parameters like gain, bandwidth, slew rate, CMRR, offset voltage and offset current. IC741 op- amp characteristics. Simple op- amp circuits: Inverting amplifier, non-inverting amplifier, summing amplifier, integrator, difference amplifier.	**11**

	Op-Amp Applications: Instrumentation amplifier, Schmitt trigger, precision rectifiers, Comparators, zero crossing detector, level detector. Active Filters: Design of LPF, HPF, BPF and Notch filters.	
4	Oscillators: Feedback Concepts, Basic configurations, Effect of negative feedback on amplifiers. Oscillators: classification, criterion for oscillation, RC phase shift and Wien bridge oscillator (both using BJT). Design equations and working of the circuits (analysis not required). Regulated power supplies: Simple zener voltage regulator, series voltage regulator, IC 723 regulators: block diagram, typical low/high voltage circuits. 3 pin regulators: 78XX and 79XX	**11**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Realize simple circuits using diodes, resistors and capacitors	**K2**
CO2	Analyze various BJT biasing circuits	**K2**
CO3	Analyze voltage amplifier circuits using BJT	**K3**
CO4	Explain the working of different classes of power amplifiers.	**K3**
CO5	Design various op-amp circuits for linear applications	**K3**
CO6	Understand the concept of feedback and working of oscillators based on this principle.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping od Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3										2
CO2	3	3			2							2
CO3	3	3			2			3	3			2
CO4	3	3			2			3	3			2
CO5	3	3			2			3	3			2
CO6	3	3			2			3	3			2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Electronic Devices and Circuit Theory	R L Boylestad and Nachelsky	Pearson	11th Edition
2	Design And Analysis of Electronic Circuits	Dr. K. Gopakumar	Phasor Books	Third Reprint, 2017
3	Op-Amps and Linear Integrated Circuits	Ramakant A Gayakwad	PHI	2000
4	Linear Integrated Circuits	D. Roy Choudhry, Shail Jain	New Age International Pvt. Ltd.	2000

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Micro electric Circuits	Adel S. Sedra, Kenneth C. Smith	Oxford	7th Edition
2	Millman's Electronic Devices & Circuits	Jacob Milman, Christos C Halkias and SatyabrataJit	Tata McGraw-Hill	4th Edition
3	Electronic Devices and Circuits,	Theodore F. Bogart:	Tata McGraw-Hill	6th Edition
4	Design with Operational Amplifiers and Analog Integrated Circuits	Sergio Franco	Tata McGraw-Hill	3rd Edition

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/108/102/108102095/
2	https://nptel.ac.in/courses/108102112
3	https://archive.nptel.ac.in/courses/108/108/108108114/

SEMESTER S3

MEDICAL PHYSICS

Course Code	**PCBMT303**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:1:0:0	**ESE Marks**	60
Credits	4	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	PC

Course Objectives:

1. Understand the mechanism of cell potentials, generation and propagation of neuronal impulses.
2. To study about the generation characteristics and principles of acquisition of various bio potentials.
3. To study the basic engineering principles of diagnostic equipment's.
4. Helps to gain knowledge about the different types of radiation as well as their useful and harmful effects in human beings

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Cells - Excitable cells, Polarized state, Action Potential, Nernst potential, resting potential, Resting to Action Potential mechanism, Goldman Hodgkin Katz equation. Synapses& Neuronal Integration: Synapses – electrical & chemical synapses, excitatory & inhibitory synapses. Synaptic potentials – EPSP & IPSP. Post synaptic integration – types, Neurotransmitters – types.	**11**
2	Electrocardiogram: Generation of ECG, waveforms and their significance, Pacemakers – natural & ectopic. Lead systems in ECG. ECG machine – Block diagram - Artifacts in ECG recording- Application of ECG Arrhythmias – rate abnormalities, AV conduction block, premature contractions, flutter, fibrillation.	**11**

3	Electroencephalogram: brain waves, Abnormal EEGs – epilepsy. Measurement of EEG - 10-20 electrode system, block diagram of EEG machine. Applications of EEG. Electromyogram: Measurement of EMG - block diagram of EMG machine. Applications of EMG - myoelectric control system. Electrodes for measurement of bio potentials– ECG, EEG & EMG electrodes, Basics of other potentials – Evoked Potential, EGG, EOG, ENG, ERG.	11
4	Radioactivity: units of Radioactivity - law of radioactive decay, half life period, measurement methods - interaction of radiation with matter, applications. X rays – Production – discharge tube and Coolidge tube methods, factors determining the x-ray emission. Electromagnetic radiation and applications, Radiation therapies (cyber knife, Intensity-modulated radiation therapy, Stereotactic radio surgery, Image-guided radiation therapy.) –uses, types and side effects	11

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination-2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand the mechanism of cell potentials, generation and propagation of neuronal impulses.	**K2**
CO2	To study about the generation characteristics and principles of acquisition of various bio potentials.	**K2**
CO3	To study the basic engineering principles of diagnostic equipment's.	**K1**
CO4	Helps to gain knowledge about the different types of radiation as well as their useful and harmful effects in human beings.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping od Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3		1			1	1		1			2
CO2	3		1		3	1	1		1			3
CO3	3		1		2	1	1		1			3
CO4	3		1		3	1	1		1			3

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Textbook of Medical Physiology	Arthur C. Guyton	Prism Books (Pvt) Ltd & W.B. Saunders Company	1991
2	Handbook of Medical Instrumentation	R S Khandpur	Tata McGraw Hill, New Delhi	2005

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Fundamental Physics of radiology	W.J. Meredith & J.B. Massey	Varghese Publishing House, Bombay	1992
2	Medical Instrumentation - Application and Design	John G. Webster	Houghton Mifflin Co., Boston	1992
3	Principles of Applied Biomedical Instrumentation	Geddes & Baker	John Wiley 3 rd Edition	1989
4	The Physiology of Excitable cells	D.J. Aidley	Cambridge University Press	1998
5	The Physics of Medical Imaging	Webb, S. (ed)	Institute of Physics Publishing, Bristol	1992

SEMESTER S3

DIGITAL ELECTRONICS

Course Code	**PBBMT304**	**CIE Marks**	60
Teaching Hours/Week (L: T:P: R)	3:0:0:1	**ESE Marks**	40
Credits	4	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	PC-PBL

Course Objectives:

1. Understanding of the fundamental principles of digital electronics, including Boolean algebra, logic gates, and binary arithmetic, logic families etc.
2. Design and Implement various Combinational and Sequential logic circuits.
3. Apply theoretical knowledge to practical projects by designing, implementing, and testing a digital system including thorough planning, documentation, and effective presentation of project outcomes

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Number system**: Binary, Octal, Hexadecimal and conversions, Binary codes: BCD, XS-3 Gray code, Binary addition, subtraction **Boolean algebra**: Boolean laws & Theorems, Logic gates - Basic gates and Universal gates, Realization of different gates using Universal gates, SOP & POS- minterm and maxterm expansion **Minimization technique**: Algebraic and Karnaugh map (upto 4 variables), Don't care conditions.	9
2	**Combinational logic circuit & design**: Adders, Subtractors, Ripple carry and Carry look ahead adders, Code Converters, Multiplexers, Demultiplexers, Decoder and Encoder. **Sequential logic circuits & design**: Latches –SR latch, Flip Flops-SR, JK, T and D Flip flops, master slave JK flip flop, conversion between flip flops.	9
3	**Shift registers**: SISO, SIPO, PISO, PIPO, bidirectional and universal shift registers.	9

	Counters: Asynchronous Counters – Modulus of a counter, Up/Down Counters, mod-N counters, Ring counter, Johnson Counter, counters, Design of Synchronous counters.	
4	**Introduction to State Machines**: - Mealy and Moore machines-comparison. **Logic families**: Characteristics- threshold voltage, propagation delay, power dissipation, noise margin, logic voltage level, fan-in, fan-out, speed, operating temperature, TTL: Basic working principle of TTL NAND gate, totem pole and open collector gate o/p, Tristate logic configuration.	**9**

Suggestion on Project Topics (8 hrs)

1.Literature Review and Presentation on Digital Electronics Applications

● Choose a specific application of digital electronics preferably in biomedical field(e.g., ECG monitoring, pulse oximetry, temperature sensing, digital health monitoring etc)

● Conduct a literature review on the chosen application, highlighting key concepts, recent advancements, and real-world implementations

2. Selection of Digital Electronics Components

● Teams of preferably 4 members select specific digital electronic components relevant to their chosen application (e.g., microcontrollers, FPGA boards, digital sensors, actuators).

● Justify the selection based on technical specifications, cost, and compatibility with biomedical requirements.

3. Analysis and Presentation of Digital Electronic Components

● Analyze the working principles, characteristics, and application considerations of the selected digital electronic components.

● Present findings to the class, focusing on how these components contribute to achieving project objectives.

4. Design, Development, and Testing of Digital Electronics System

● Design and develop a comprehensive digital electronics system based on the selected components and application.

● Implement necessary digital logic circuits, firmware/software programming, and interface design as per project requirements

5. Implementation of Digital Electronics Project

● Implement necessary digital logic circuits, firmware/software programming, and interface design as per project requirements.

● Collaboratively create a fully functional digital electronics project.

● Document the design process, including schematic diagrams, code snippets, testing procedures, and results.

● Prepare a detailed project report outlining methodology, challenges faced, solutions implemented, and future improvements

6. Project Evaluation

● Mid-term Evaluation (After one month): Assess progress, adherence to timeline, and initial project outcomes.

● Final Evaluation (End of Course): Evaluate the completed digital electronics project based on functionality, innovation, presentation, and documentation quality. Conduct a final presentation to demonstrate the project to the class

Course Assessment Method
(CIE: 60 marks, ESE: 40 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Project	Internal Ex-1	Internal Ex-2	Total
5	30	12.5	12.5	60

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 2 marks **(8x2 =16 marks)**	2 questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of 2 sub divisions. Each question carries 6 marks. **(4x6 = 24 marks)**	**40**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Perform various binary arithmetic operations	**K2**
CO2	Apply Boolean principles to minimize logical expressions	**K3**
CO3	Design and Implement various Combinational circuits using logic gates.	**K3**
CO4	Design and Implement various Sequential circuits using logic gates.	**K3**
CO5	Design and develop projects by applying the digital principles.	**K4**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2							2			2
CO2	3	2	2						2			2
CO3	3	2	2						2			2
CO4	3	2							2			2
CO5	3	3	3	2	2				3	3		3

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Digital Fundamentals	T. L. Floyd	Pearson International Publications	10^{th} Edition, 2011
2	Fundamentals of Digital Circuits	Anandkumar	PHI Learning Private Limited	4^{th} Edition 2016.
3	Logic system design	Dr. K. Gopakumar, Dr. Aswathy G P	Owl Books.	2022
4	Digital Electronics	S. Salivahanan and S. Arivazhagan	Vikas Publishing House pvt Ltd	1^{st} Edition, 2012
5	Digital Electronics-An Introduction to Theory and Practice	*W H Gothmann*	PHI	2^{nd} Edition, 2012

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Fundamentals of Logic design	Charles. H. Roth	Thomson Learning	6^{th} Edition,2013
2	Modern Digital Electronics	R.P Jain	Tata Mc Graw Hill	4^{th} Edition ,2009
3	Digital Logic and Computer Design	M Morris Mano	Prentice Hall Publication	5^{th} Edition ,2014
4	Digital Logic & State Machine Design	David J. Comer	Oxford University Press	Third Indian Edition

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/117106086
2	https://onlinecourses.nptel.ac.in/noc22_ee55/preview

PBL Course Elements

L: Lecture (3 Hrs.)	**R: Project (1 Hr.), 2 Faculty Members**		
	Tutorial	**Practical**	**Presentation**
Lecture delivery	Project identification	Simulation/ Laboratory Work/ Workshops	Presentation (Progress and Final Presentations)
Group discussion	Project Analysis	Data Collection	Evaluation
Question answer Sessions/ Brainstorming Sessions	Analytical thinking and self-learning	Testing	Project Milestone Reviews, Feedback, Project reformation (If required)
Guest Speakers (Industry Experts)	Case Study/ Field Survey Report	Prototyping	Poster Presentation/ Video Presentation: Students present their results in a 2 to 5 minutes video

Assessment and Evaluation for Project Activity

Sl. No	Evaluation for	Allotted Marks
1	Project Planning and Proposal	5
2	Contribution in Progress Presentations and Question Answer Sessions	4
3	Involvement in the project work and Team Work	3
4	Execution and Implementation	10
5	Final Presentations	5
6	Project Quality, Innovation and Creativity	3
Total		**30**

1. **Project Planning and Proposal (5 Marks)**
   - Clarity and feasibility of the project plan
   - Research and background understanding
   - Defined objectives and methodology

2. **Contribution in Progress Presentation and Question Answer Sessions (4 Marks)**
    - Individual contribution to the presentation
    - Effectiveness in answering questions and handling feedback
3. **Involvement in the Project Work and Team Work (3 Marks)**
    - Active participation and individual contribution
4. Teamwork and collaboration **Execution and Implementation (10 Marks)**
    - Adherence to the project timeline and milestones
    - Application of theoretical knowledge and problem-solving
    - Final Result
5. **Final Presentation (5 Marks)**
    - Quality and clarity of the overall presentation
    - Individual contribution to the presentation
    - Effectiveness in answering questions
6. **Project Quality, Innovation, and Creativity (3 Marks)**
    - Overall quality and technical excellence of the project
    - Innovation and originality in the project
    - Completeness, clarity, and accuracy of the lab record submitted

SEMESTER S3

INTRODUCTION TO ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Course Code	**GNEST305**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:1:0:0	**ESE Marks**	60
Credits	4	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	ESC

Course Objectives:

1. Demonstrate a solid understanding of advanced linear algebra concepts, machine learning algorithms and statistical analysis techniques relevant to engineering applications, principles and algorithms.
2. Apply theoretical concepts to solve practical engineering problems, analyze data to extract meaningful insights, and implement appropriate mathematical and computational techniques for AI and data science applications.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to AI and Machine Learning**: Basics of Machine Learning - types of Machine Learning systems-challenges in ML- Supervised learning model example- regression models- Classification model example- Logistic regression-unsupervised model example- K-means clustering. Artificial Neural Network- Perceptron- Universal Approximation Theorem (statement only)- Multi-Layer Perceptron- Deep Neural Network- demonstration of regression and classification problems using MLP.(Text-2)	**11**
2	**Mathematical Foundations of AI and Data science**: Role of linear algebra in Data representation and analysis – Matrix decomposition- Singular Value Decomposition (SVD)- Spectral decomposition- Dimensionality reduction technique-Principal Component Analysis (PCA). (Text-1)	**11**
3	**Applied Probability and Statistics for AI and Data Science**: Basics of probability-random variables and statistical measures - rules in probability-	**11**

	Bayes theorem and its applications- statistical estimation-Maximum Likelihood Estimator (MLE) - statistical summaries- Correlation analysis- linear correlation (direct problems only)- regression analysis- linear regression (using least square method) (Text book 4)	
4	**Basics of Data Science**: Benefits of data science-use of statistics and Machine Learning in Data Science- data science process - applications of Machine Learning in Data Science- modelling process- demonstration of ML applications in data science- Big Data and Data Science. (For visualization the software tools like Tableau, PowerBI, R or Python can be used. For Machine Learning implementation, Python, MATLAB or R can be used.)(Text book-5)	**11**

Course Assessment Method
(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination-2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
● 2 Questions from each module. ● Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	● Each question carries 9 marks. ● Two questions will be given from each module, out of which 1 question should be answered. ● Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Apply the concept of machine learning algorithms including neural networks and supervised/unsupervised learning techniques for engineering applications.	**K3**
CO2	Apply advanced mathematical concepts such as matrix operations, singular values, and principal component analysis to analyze and solve engineering problems.	**K3**
CO3	Analyze and interpret data using statistical methods including descriptive statistics, correlation, and regression analysis to derive meaningful insights and make informed decisions.	**K3**
CO4	Integrate statistical approaches and machine learning techniques to ensure practically feasible solutions in engineering contexts.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**	**3**	**3**	**3**								
CO2	**3**	**3**	**3**	**3**								
CO3	**3**	**3**	**3**	**3**								
CO4	**3**	**3**	**3**	**3**								
CO5	**3**	**3**	**3**	**3**								

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Introduction to Linear Algebra	Gilbert Strang	Wellesley-Cambridge Press	6th edition, 2023
2	Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow	Aurélien Géron	O'Reilly Media, Inc.	2nd edition,2022
3	Mathematics for machine learning	Deisenroth, Marc Peter, A. Aldo Faisal, and Cheng Soon Ong	Cambridge University Press	1st edition. 2020
4	Fundamentals of mathematical statistics	Gupta, S. C., and V. K. Kapoor	Sultan Chand & Sons	9th edition, 2020
5	Introducing data science: big data, machine learning, and more, using Python tools	Cielen, Davy, and Arno Meysman	Simon and Schuster	1st edition, 2016

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Data science: concepts and practice	Kotu, Vijay, and Bala Deshpande	Morgan Kaufmann	2nd edition, 2018
2	Probability and Statistics for Data Science	Carlos Fernandez-Granda	Center for Data Science in NYU	1st edition, 2017
3	Foundations of Data Science	Avrim Blum, John Hopcroft, and Ravi Kannan	Cambridge University Press	1st edition, 2020
4	Statistics For Data Science	James D. Miller	Packt Publishing	1st edition, 2019
5	Probability and Statistics - The Science of Uncertainty	Michael J. Evans and Jeffrey S. Rosenthal	University of Toronto	1st edition, 2009
6	An Introduction to the Science of Statistics: From Theory to Implementation	Joseph C. Watkins	chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.math.arizo	Preliminary Edition.

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/106/106/106106198/
2	https://archive.nptel.ac.in/courses/106/106/106106198/ https://ocw.mit.edu/courses/18-06-linear-algebra-spring-2010/resources/lecture-29-singular-value-decomposition/
3	https://ocw.mit.edu/courses/18-650-statistics-for-applications-fall-2016/resources/lecture-19-video/
4	https://archive.nptel.ac.in/courses/106/106/106106198/

SEMESTER S3

ECONOMICS FOR ENGINEERS

(Common to All Branches)

Course Code	**UCHUT346**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	2:0:0:0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	HMC

Course Objectives:

1. Understanding of finance and costing for engineering operation, budgetary planning and control
2. Provide fundamental concept of micro and macroeconomics related to engineering industry
3. Deliver the basic concepts of Value Engineering.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Basic Economics Concepts - Basic economic problems – Production Possibility Curve – Utility – Law of diminishing marginal utility – Law of Demand - Law of supply – Elasticity - measurement of elasticity and its applications – Equilibrium- Changes in demand and supply and its effects Production function - Law of variable proportion – Economies of Scale – Internal and External Economies – Cobb-Douglas Production Function	**6**
2	Cost concepts – Social cost, private cost – Explicit and implicit cost – Sunk cost - Opportunity cost - short run cost curves - Revenue concepts Firms and their objectives – Types of firms – Markets - Perfect Competition – Monopoly - Monopolistic Competition - Oligopoly (features and equilibrium of a firm)	**6**

3	Monetary System – Money – Functions - Central Banking –Inflation - Causes and Effects – Measures to Control Inflation - Monetary and Fiscal policies – Deflation Taxation – Direct and Indirect taxes (merits and demerits) - GST National income – Concepts - Circular Flow – Methods of Estimation and Difficulties - Stock Market – Functions- Problems faced by the Indian stock market-Demat Account and Trading Account – Stock market Indicators-SENSEX and NIFTY	**6**
4	Value Analysis and value Engineering - Cost Value, Exchange Value, Use Value, Esteem Value - Aims, Advantages and Application areas of Value Engineering - Value Engineering Procedure - Break-even Analysis - Cost-Benefit Analysis - Capital Budgeting - Process planning	**6**

Course Assessment Method
(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Case Study/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
10	**15**	**12.5**	**12.5**	**50**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• Minimum 1 and Maximum 2 Questions from each module. • Total of 6 Questions, each carrying 3 marks **(6x3 =18marks)**	• 2 questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of 2 sub divisions. Each question carries 8 marks. **(4x8 = 32 marks)**	**50**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the fundamentals of various economic issues using laws and learn the concepts of demand, supply, elasticity and production function.	**K2**
CO2	Develop decision making capability by applying concepts relating to costs and revenue, and acquire knowledge regarding the functioning of firms in different market situations.	**K3**
CO3	Outline the macroeconomic principles of monetary and fiscal systems, national income and stock market.	**K2**
CO4	Make use of the possibilities of value analysis and engineering, and solve simple business problems using break even analysis, cost benefit analysis and capital budgeting techniques.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	1	-	-	-	-	1	-
CO2	-	-	-	-	-	1	1	-	-	-	1	-
CO3	-	-	-	-	1	-	-	-	-	-	2	-
CO4	-	-	-	-	1	1	-	-	-	-	2	-

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Managerial Economics	Geetika, Piyali Ghosh and Chodhury	Tata McGraw Hill,	2015
2	Engineering Economy	H. G. Thuesen, W. J. Fabrycky	PHI	1966
3	Engineering Economics	R. Paneerselvam	PHI	2012

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Engineering Economy	Leland Blank P.E, Anthony Tarquin P. E.	Mc Graw Hill	7^{TH} Edition
2	Indian Financial System	Khan M. Y.	Tata McGraw Hill	2011
3	Engineering Economics and analysis	Donald G. Newman, Jerome P. Lavelle	Engg. Press, Texas	2002
4	Contemporary Engineering Economics	Chan S. Park	Prentice Hall of India Ltd	2001

SEMESTER S3

ENGINEERING ETHICS AND SUSTAINABLE DEVELOPMENT

Course Code	**UCHUT347**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	2:0:0:0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. Equip with the knowledge and skills to make ethical decisions and implement gender-sensitive practices in their professional lives.
2. Develop a holistic and comprehensive interdisciplinary approach to understanding engineering ethics principles from a perspective of environment protection and sustainable development.
3. Develop the ability to find strategies for implementing sustainable engineering solutions.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Fundamentals of ethics -** Personal vs. professional ethics, Civic Virtue, Respect for others, **Profession and Professionalism,** Ingenuity, diligence and responsibility, Integrity in design, development, and research domains, Plagiarism, a balanced outlook on law - challenges - case studies, **Technology and digital revolution**-Data, information, and knowledge, Cybertrust and cybersecurity, Data collection & management, **High technologies: connecting people and places-**accessibility and social impacts, **Managing conflict**, Collective bargaining, **Confidentiality**, Role of confidentiality in moral integrity, **Codes of Ethics**. **Basic concepts in Gender Studies -** sex, gender, sexuality, gender spectrum: beyond the binary, gender identity, gender expression, gender stereotypes, **Gender disparity and discrimination in education**, employment and everyday life, History of women in Science & Technology, Gendered	**6**

	technologies & innovations**, Ethical values and practices in connection with gender** - equity, diversity & gender justice, **Gender policy and women/transgender empowerment initiatives.**	
2	**Introduction to Environmental Ethics:** Definition, importance and historical development of environmental ethics, key philosophical theories (anthropocentrism, biocentrism, ecocentrism). **Sustainable Engineering Principles:** Definition and scope, triple bottom line (economic, social and environmental sustainability), life cycle analysis and sustainability metrics. **Ecosystems and Biodiversity:** Basics of ecosystems and their functions, Importance of biodiversity and its conservation, Human impact on ecosystems and biodiversity loss, An overview of various ecosystems in Kerala/India, and its significance. **Landscape and Urban Ecology:** Principles of landscape ecology, Urbanization and its environmental impact, Sustainable urban planning and green infrastructure.	**6**
3	**Hydrology and Water Management:** Basics of hydrology and water cycle, Water scarcity and pollution issues, Sustainable water management practices, Environmental flow, disruptions and disasters. **Zero Waste Concepts and Practices:** Definition of zero waste and its principles, Strategies for waste reduction, reuse, reduce and recycling, Case studies of successful zero waste initiatives. **Circular Economy and Degrowth:** Introduction to the circular economy model, Differences between linear and circular economies, degrowth principles, Strategies for implementing circular economy practices and degrowth principles in engineering. **Mobility and Sustainable Transportation:** Impacts of transportation on the environment and climate, Basic tenets of a Sustainable Transportation design, Sustainable urban mobility solutions, Integrated mobility systems, E-Mobility, Existing and upcoming models of sustainable mobility solutions.	**6**
4	**Renewable Energy and Sustainable Technologies:** Overview of renewable energy sources (solar, wind, hydro, biomass), Sustainable technologies in energy production and consumption, Challenges and opportunities in renewable energy adoption. **Climate Change and Engineering Solutions:** Basics of climate change science, Impact of climate change on natural and human systems, Kerala/India and the Climate crisis, Engineering solutions to mitigate, adapt and build resilience to climate change. **Environmental Policies and Regulations:** Overview of key environmental policies and regulations (national and international), Role of engineers in policy	**6**

	implementation and compliance, Ethical considerations in environmental policy-making. **Case Studies and Future Directions:** Analysis of real-world case studies, Emerging trends and future directions in environmental ethics and sustainability, Discussion on the role of engineers in promoting a sustainable future.	

Course Assessment Method
(CIE: 50 marks , ESE: 50)

Continuous Internal Evaluation Marks (CIE):

Continuous internal evaluation will be based on individual and group activities undertaken throughout the course and the portfolio created documenting their work and learning. The portfolio will include reflections, project reports, case studies, and all other relevant materials.

- The students should be grouped into groups of size 4 to 6 at the beginning of the semester. These groups can be the same ones they have formed in the previous semester.
- Activities are to be distributed between 2 class hours and 3 Self-study hours.
- The portfolio and reflective journal should be carried forward and displayed during the 7th Semester Seminar course as a part of the experience sharing regarding the skills developed through various courses.

Sl. No.	Item	Particulars	Group/ Individual (G/I)	Marks
1	Reflective Journal	Weekly entries reflecting on what was learned, personal insights, and how it can be applied to local contexts.	I	5
2	Micro project (Detailed documentation of the project, including methodologies, findings, and reflections)	1 a) Perform an Engineering Ethics Case Study analysis and prepare a report 1 b) Conduct a literature survey on 'Code of Ethics for Engineers' and prepare a sample code of ethics	G	8
		2. Listen to a TED talk on a Gender-related topic, do a literature survey on that topic and make a report citing the relevant papers with a specific analysis of the Kerala context	G	5
		3. Undertake a project study based on the concepts of sustainable development* - Module II, Module III & Module IV	G	12

3	Activities	2. One activity* each from Module II, Module III & Module IV	G	15
4	Final Presentation	A comprehensive presentation summarising the key takeaways from the course, personal reflections, and proposed future actions based on the learnings.	G	5
		Total Marks		**50**

*Can be taken from the given sample activities/projects

Evaluation Criteria:

- **Depth of Analysis**: Quality and depth of reflections and analysis in project reports and case studies.
- **Application of Concepts**: Ability to apply course concepts to real-world problems and local contexts.
- **Creativity**: Innovative approaches and creative solutions proposed in projects and reflections.
- **Presentation Skills**: Clarity, coherence, and professionalism in the final presentation.

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Develop the ability to apply the principles of engineering ethics in their professional life.	**K3**
CO2	Develop the ability to exercise gender-sensitive practices in their professional lives	**K4**
CO3	Develop the ability to explore contemporary environmental issues and sustainable practices.	**K5**
CO4	Develop the ability to analyse the role of engineers in promoting sustainability and climate resilience.	**K4**
CO5	Develop interest and skills in addressing pertinent environmental and climate-related challenges through a sustainable engineering approach.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1						3	2	3	3	2		2
CO2		1				3	2	3	3	2		2
CO3						3	3	2	3	2		2
CO4		1				3	3	2	3	2		2
CO5						3	3	2	3	2		2

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Ethics in Engineering Practice and Research	Caroline Whitbeck	Cambridge University Press & Assessment	2nd edition & August 2011
2	Virtue Ethics and Professional Roles	Justin Oakley	Cambridge University Press & Assessment	November 2006
3	Sustainability Science	Bert J. M. de Vries	Cambridge University Press & Assessment	2nd edition & December 2023
4	Sustainable Engineering Principles and Practice	Bhavik R. Bakshi,	Cambridge University Press & Assessmen	2019
5	Engineering Ethics	M Govindarajan, S Natarajan and V S Senthil Kumar	PHI Learning Private Ltd, New Delhi	2012
6	Professional ethics and human values	RS Naagarazan	New age international (P) limited New Delhi	2006.
7	Ethics in Engineering	Mike W Martin and Roland Schinzinger,	Tata McGraw Hill Publishing Company Pvt Ltd, New Delhi	4" edition, 2014

Suggested Activities/Projects:

Module-II

- Write a reflection on a local environmental issue (e.g., plastic waste in Kerala backwaters or oceans) from different ethical perspectives (anthropocentric, biocentric, ecocentric).
- Write a life cycle analysis report of a common product used in Kerala (e.g., a coconut, bamboo or rubber-based product) and present findings on its sustainability.
- Create a sustainability report for a local business, assessing its environmental, social, and economic impacts
- Presentation on biodiversity in a nearby area (e.g., a local park, a wetland, mangroves, college campus etc) and propose conservation strategies to protect it.
- Develop a conservation plan for an endangered species found in Kerala.
- Analyze the green spaces in a local urban area and propose a plan to enhance urban ecology using native plants and sustainable design.
- Create a model of a sustainable urban landscape for a chosen locality in Kerala.

Module-III

- Study a local water body (e.g., a river or lake) for signs of pollution or natural flow disruption and suggest sustainable management and restoration practices.
- Analyse the effectiveness of water management in the college campus and propose improvements - calculate the water footprint, how to reduce the footprint, how to increase supply through rainwater harvesting, and how to decrease the supply-demand ratio
- Implement a zero waste initiative on the college campus for one week and document the challenges and outcomes.
- Develop a waste audit report for the campus. Suggest a plan for a zero-waste approach.
- Create a circular economy model for a common product used in Kerala (e.g., coconut oil, cloth etc).
- Design a product or service based on circular economy and degrowth principles and present a business plan.
- Develop a plan to improve pedestrian and cycling infrastructure in a chosen locality in Kerala

Module-IV

- Evaluate the potential for installing solar panels on the college campus including cost-benefit analysis and feasibility study.
- Analyse the energy consumption patterns of the college campus and propose sustainable alternatives to reduce consumption - What gadgets are being used? How can we reduce demand using energy-saving gadgets?
- Analyse a local infrastructure project for its climate resilience and suggest improvements.

- Analyse a specific environmental regulation in India (e.g., Coastal Regulation Zone) and its impact on local communities and ecosystems.
- Research and present a case study of a successful sustainable engineering project in Kerala/India (e.g., sustainable building design, water management project, infrastructure project).
- Research and present a case study of an unsustainable engineering project in Kerala/India highlighting design and implementation faults and possible corrections/alternatives (e.g., a housing complex with water logging, a water management project causing frequent floods, infrastructure project that affects surrounding landscapes or ecosystems).

SEMESTER S3

ANALOG ELECTRONICS LAB

Course Code	**PCBML307**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	0:0:3:0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	PCL

Course Objectives:

1. To verify practical principles, basic operations and applications of various analog circuits using diodes, BJT, JFET & MOSFET.
2. To verify practical principles, basic operations and applications of various circuits using op-amp 741 IC

Expt. No.	Experiments
1	Diode characteristics (Silicon, Zener)
2	BJT characteristics CE configuration
3	JFET/ MOSFET characteristics CS configuration
4	RC coupled amplifier
5	RC phase shift oscillator
6	RC differentiator and integrator
7	Basic OPAMP circuits inverting and non-inverting, Voltage follower, summing amplifier etc
8	Voltage comparator
9	Schmitt trigger
10	Active filters and frequency response
11	Precision rectifiers
12	Astable, monostable multivibrators (using IC 555/ Op Amp)

Course Assessment Method
(CIE: 50 marks, ESE: 50 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Preparation/Pre-Lab Work experiments, Viva and Timely completion of Lab Reports / Record (Continuous Assessment)	Internal Examination	Total
5	25	20	50

End Semester Examination Marks (ESE):

Procedure/ Preparatory work/Design/ Algorithm	Conduct of experiment/ Execution of work/ troubleshooting/ Programming	Result with valid inference/ Quality of Output	Viva voce	Record	Total
10	15	10	10	5	50

- ***Submission of Record: Students shall be allowed for the end semester examination only upon submitting the duly certified record.***
- ***Endorsement by External Examiner:*** *The external examiner shall endorse the record*

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Learn the characteristics of transistor	**K3**
CO2	Design electronic the circuits using discrete components.	**K3**
CO3	Familiarise & design the circuit using ICs.	**K3**
CO4	Student will be able to simulate the response of the basic circuit in simple simulation tools	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO- PO Mapping (Mapping of Course Outcomes with Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3					2	2		1
CO2	3	2	3	3					2	2		1
CO3	3	2	3	3					2	2		1
CO4	3	2	3	3					2	2		1
CO5												

1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Basic Electronics – Principles and Applications,	ChinmoySaha, ArindhamHalder and DebaratiGanguly	Cambridge University Press	2018
2	Electronic Devices and Circuit Theory	R L Boylestad and Nachelsky	Pearson	11^{th} Edition
3	Design And Analysis of Electronic Circuits	K. Gopakumar	Phasor Books	Third Reprint, 2017

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Micro electric Circuits	Adel S. Sedra, Kenneth C. Smith	Oxford	7^{th} Edition
2	Electronic Devices and Circuits	David A. bell		5^{th} edition
3	Integrated Electronics:Analog and Digital Circuits and Systems	J. Millman and C. Halkias	McGraw Hill	1985

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc22_ee11/preview
2	https://onlinecourses.nptel.ac.in/noc23_ee65/preview

Continuous Assessment (25 Marks)

1. **Preparation and Pre-Lab Work (7 Marks)**
   - Pre-Lab Assignments: Assessment of pre-lab assignments or quizzes that test understanding of the upcoming experiment.
   - Understanding of Theory: Evaluation based on students' preparation and understanding of the theoretical background related to the experiments.
2. **Conduct of Experiments (7 Marks)**
   - Procedure and Execution: Adherence to correct procedures, accurate execution of experiments, and following safety protocols.
   - Skill Proficiency: Proficiency in handling equipment, accuracy in observations, and troubleshooting skills during the experiments.
   - Teamwork: Collaboration and participation in group experiments.
3. **Lab Reports and Record Keeping (6 Marks)**
   - Quality of Reports: Clarity, completeness and accuracy of lab reports. Proper documentation of experiments, data analysis and conclusions.
   - Timely Submission: Adhering to deadlines for submitting lab reports/rough record and maintaining a well-organized fair record.
4. **Viva Voce (5 Marks)**
   - Oral Examination: Ability to explain the experiment, results and underlying principles during a viva voce session.

Final Marks Averaging: The final marks for preparation, conduct of experiments, viva, and record are the average of all the specified experiments in the syllabus.

Evaluation Pattern for End Semester Examination (50 Marks)

1. **Procedure/Preliminary Work/Design/Algorithm (10 Marks)**

- Procedure Understanding and Description: Clarity in explaining the procedure and understanding each step involved.
- Preliminary Work and Planning: Thoroughness in planning and organizing materials/equipment.
- Algorithm Development: Correctness and efficiency of the algorithm related to the experiment.
- Creativity and logic in algorithm or experimental design.

2. **Conduct of Experiment/Execution of Work/Programming (15 Marks)**

- Setup and Execution: Proper setup and accurate execution of the experiment or programming task.

3. **Result with Valid Inference/Quality of Output (10 Marks)**

- Accuracy of Results: Precision and correctness of the obtained results.
- Analysis and Interpretation: Validity of inferences drawn from the experiment or quality of program output.

4. **Viva Voce (10 Marks)**

- Ability to explain the experiment, procedure results and answer related questions
- Proficiency in answering questions related to theoretical and practical aspects of the subject.

5. **Record (5 Marks)**

- Completeness, clarity, and accuracy of the lab record submitted

SEMESTER S3

DIGITAL ELECTRONICS LAB

Course Code	**PCBML308**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	0:0:3:0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Basic knowledge of Digital Electronics is expected.	**Course Type**	PCL

Course Objectives:

1. Designing and testing of digital electronic circuits.
2. Realization and implementation of digital logic gates, combinational and sequential circuits.
3. Software implementation of digital logic circuits

Expt. No.	Experiments
1	Identify different logic ICs, their specifications, and pin configurations.
2	Implementation of basic and universal gates and realization of basic gates using universal gates. Realization of SOP and POS expression using logic gates.
3	Design of 4:1 Multiplexer and 1:4 Demultiplexer circuits using basic gates and study of mux/De-mux ICs.
4	Realization of Multiplexers and De-multiplexers using gates and study their ICs.
5	Analyse the characteristics of TTL gate.
6	Realization of Encoder and Decoder circuits using gates.
7	Implementation of SR, JK, D, T and Master Slave JK flip flops using basic gates.
8	Realization of Ring counter and Johnson Counter using flip flops
9	Design and implementation of 2 bit comparators and code converters using logic gates.
10	Design of following asynchronous counters 1. up and down asynchronous counter 2. up/ down asynchronous counters using mode control.
11	Design of following synchronous counters 1. up and down synchronous counter

	2. up/ down synchronous counters using mode control 3. mod-N synchronous counters
12	Design of following shift registers. (any two) 1. Serial In- Serial Out (SISO) shift registers 2. Serial In- Parallel Out (SIPO) shift registers 3. Parallel In- Serial Out (PISO) shift registers 4. Parallel In- Parallel Out (PIPO) shift registers Serial/Parallel Shift register using mode control
Note*- Familiarization with Verilog HDL coding: Modelling and simulation of basic gates, simple Boolean functions (any two) and combinational circuits (any two) using Verilog (gate level) must be done along with the corresponding experiments. (Mandatory)	

Course Assessment Method
(CIE: 50 marks, ESE: 50 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Preparation/Pre-Lab Work experiments, Viva and Timely completion of Lab Reports / Record (Continuous Assessment)	Internal Examination	Total
5	25	20	50

End Semester Examination Marks (ESE):

Procedure/ Preparatory work/Design/ Algorithm	Conduct of experiment/ Execution of work/ troubleshooting/ Programming	Result with valid inference/ Quality of Output	Viva voce	Record	Total
10	15	10	10	5	50

- ***Submission of Record: Students shall be allowed for the end semester examination only upon submitting the duly certified record.***
- ***Endorsement by External Examiner:*** *The external examiner shall endorse the record*

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Identify different logic ICs, their specifications, and pin configurations.	**K2**
CO2	Design and implement combinational logic circuits.	**K3**
CO3	Design and implement sequential logic circuits.	**K3**
CO4	Design and simulate digital logic circuits using simulation tool.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO- PO Mapping (Mapping of Course Outcomes with Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	-	-	-	-	-	-	3	2	-	-
CO2	3	3	-	-	-	-	-	-	3	2	-	2
CO3	3	3	-	2	-	-	-	-	3	2	-	2
CO4	3	3	-	2	-	-	-	-	3	2	-	2
CO5	3	3	-	2	3	-	-	-	3	2	-	2

Note: 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Digital Fundamentals	T. L. Floyd	Pearson International Publications	10th Edition, 2011
2	Modern Digital Electronics	R.P Jain	Tata Mc Graw Hill	4th Edition ,2009
3	Digital Logic and Computer Design	M Morris Mano	Prentice Hall Publication	5th Edition ,2014

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Fundamentals of Digital Circuits	A.Anandkumar	PHI Learning Private Limited	4^{th} Edition 2016.
2	Electronics Lab Manual Volume 1	K A Navas	College Books (Higher Education Textbooks)	
3	Digital Electronics-An Introduction to Theory and Practice	*W H Gothmann*	PHI	2^{nd} Edition, 2012

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/117106086
2	https://onlinecourses.nptel.ac.in/noc22_ee55/preview

Continuous Assessment (25 Marks)

1. **Preparation and Pre-Lab Work (7 Marks)**

   - Pre-Lab Assignments: Assessment of pre-lab assignments or quizzes that test understanding of the upcoming experiment.
   - Understanding of Theory: Evaluation based on students' preparation and understanding of the theoretical background related to the experiments.

2. **Conduct of Experiments (7 Marks)**

   - Procedure and Execution: Adherence to correct procedures, accurate execution of experiments, and following safety protocols.
   - Skill Proficiency: Proficiency in handling equipment, accuracy in observations, and troubleshooting skills during the experiments.
   - Teamwork: Collaboration and participation in group experiments.

3. **Lab Reports and Record Keeping (6 Marks)**
    - Quality of Reports: Clarity, completeness and accuracy of lab reports. Proper documentation of experiments, data analysis and conclusions.
    - Timely Submission: Adhering to deadlines for submitting lab reports/rough record and maintaining a well-organized fair record.
4. **Viva Voce (5 Marks)**
    - Oral Examination: Ability to explain the experiment, results and underlying principles during a viva voce session.

Final Marks Averaging: The final marks for preparation, conduct of experiments, viva, and record are the average of all the specified experiments in the syllabus.

Evaluation Pattern for End Semester Examination (50 Marks)

1. **Procedure/Preliminary Work/Design/Algorithm (10 Marks)**
    - Procedure Understanding and Description: Clarity in explaining the procedure and understanding each step involved.
    - Preliminary Work and Planning: Thoroughness in planning and organizing materials/equipment.
    - Algorithm Development: Correctness and efficiency of the algorithm related to the experiment.
    - Creativity and logic in algorithm or experimental design.
2. **Conduct of Experiment/Execution of Work/Programming (15 Marks)**
    - Setup and Execution: Proper setup and accurate execution of the experiment or programming task.
3. **Result with Valid Inference/Quality of Output (10 Marks)**
    - Accuracy of Results: Precision and correctness of the obtained results.
    - Analysis and Interpretation: Validity of inferences drawn from the experiment or quality of program output.
4. **Viva Voce (10 Marks)**
    - Ability to explain the experiment, procedure results and answer related questions
    - Proficiency in answering questions related to theoretical and practical aspects of the subject.
5. **Record (5 Marks)**
    - Completeness, clarity, and accuracy of the lab record submitted.

SEMESTER 4

BIOMEDICAL ENGINEERING

SEMESTER S4

MATHEMATICS FOR ELECTRICAL SCIENCE – 4

(B Group)

Course Code	GBMAT401	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	Basic calculus	Course Type	BSC

Course Objectives:

1. To familiarize students with the foundations of probabilistic and statistical analysis mostly used in varied applications in engineering and science.
2. To expose the students to the basics of random processes essential for their subsequent study of analog and digital communication

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Random variables, Discrete random variables and their probability distributions, Cumulative distribution function, Expectation, Mean and variance, Binomial distribution, Poisson distribution, Poisson distribution as a limit of the binomial distribution, Joint pmf of two discrete random variables, Marginal pmf, Independent random variables, Expected value of a function of two discrete variables. **[Text 1: Relevant topics from sections 3.1 to 3.4, 3.6, 5.1, 5.2]**	**9**
2	Continuous random variables and their probability distributions, Cumulative distribution function, Expectation, Mean and variance, Uniform, Normal and Exponential distributions, Joint pdf of two Continuous random variables, Marginal pdf, Independent random variables, Expectation value of a function of two continuous variables. **[Text 1: Relevant topics from sections 3.1, 4.1, 4.2, 4.3, 4.4, 5.1, 5.2]**	**9**
3	Confidence Intervals, Confidence Level, Confidence Intervals and One-side confidence intervals for a Population Mean for large and small samples	**9**

	(normal distribution and t-distribution), Hypotheses and Test Procedures, Type I and Type II error, z Tests for Hypotheses about a Population Mean (for large sample), t Test for Hypotheses about a Population Mean (for small sample), Tests concerning a population proportion for large and small samples. **[Text 1: Relevant topics from 7.1, 7.2, 7.3, 8.1, 8.2, 8.3, 8.4]**	
4	Random process concept, classification of process, Methods of Description of Random process, Special classes, Average Values of Random Process, Stationarity- SSS, WSS, Autocorrelation functions and its properties, Ergodicity, Mean-Ergodic Process, Mean-Ergodic Theorem, Correlation Ergodic Process, Distribution Ergodic Process. **[Text 2: Relevant topics from Chapter 6]**	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Micro project	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the concept, properties and important models of discrete random variables and to apply in suitable random phenomena.	**K3**
CO2	Understand the concept, properties and important models of continuous random variables and to apply in suitable random phenomena.	**K3**
CO3	Estimate population parameters, assess their certainty with confidence intervals, and test hypotheses about population means and proportions using *z*-tests and the one-sample *t*-test.	**K3**
CO4	Analyze random processes by classifying them, describing their properties, utilizing autocorrelation functions, and understanding their applications in areas like signal processing and communication systems.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	-	-	-	-	-	-	-	2
CO2	3	3	2	2	-	-	-	-	-	-	-	2
CO3	3	3	2	2	-	-	-	-	-	-	-	2
CO4	3	3	2	2	-	-	-	-	-	-	-	2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Probability and Statistics for Engineering and the Sciences	Devore J. L	Cengage Learning	9th edition, 2016
2	Probability, Statistics and Random Processes	T Veerarajan	The McGraw-Hill	3rd edition, 2008

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Probability, Random Variables and Stochastic Processes,	Papoulis, A. & Pillai, S.U.,	McGraw Hill.	4th edition, 2002
2	Introduction to Probability and Statistics for Engineers and Scientists	Ross, S. M.	Academic Press	6th edition, 2020
3	Probability and Random Processes	Palaniammal, S.	PHI Learning Private Limited	3rd edition, 2015
4	Introduction to Probability	David F. Anderson, Timo, Benedek	Cambridge	1st edition, 2017

Video Links (NPTEL, SWAYAM…)	
Sl.No	**Link ID**
	https://archive.nptel.ac.in/courses/117/105/117105085/

SEMESTER S4

MICROCONTROLLERS AND INTERFACING

Course Code	**PCBMT402**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:1:0:0	**ESE Marks**	60
Credits	4	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	GBEST204	**Course Type**	PC

Course Objectives:

1. Course aims to equip students with the knowledge and skills required to design, develop, and troubleshoot embedded systems using microcontrollers effectively.
2. It combines theoretical concepts with practical hands-on experience to prepare students for careers in fields such as embedded systems engineering, IoT (Internet of Things) development, and robotics.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Intel 8051: Architecture, Special Function Registers, Pin description, Interrupts, Stack and stack pointer, Addressing modes, Port organization and dual operations of 8051 ports, Instruction format, Counter and Timer operation, Memory organization of 8051.	11
2	Instruction sets of 8051: Data transfer instructions, Arithmetic, logical, compare and rotate instructions- Bit processing instructions- Program flow control instructions. Assembly language programming of 8051, Interfacing with 8051- stepper motor, keyboard& rolling display, ADC & DAC interfacing.	11
3	PIC Microcontrollers :- Overview of PIC 16 Series, Architecture of PIC16F877A, Pin description, Memory organization, Core and	11

	peripheral features, interrupts, Addressing modes, Instruction sets: Arithmetic, logic, branch, call instructions, Basics of serial communication, RS232, SPI overview, I2C for peripheral chip access.	
4	Arduino uno - Overview, Board description, Program structure - Elements of programming, Interfacing sensors-LM35, PIR Sensors, motor control - PWM. Overview of ESP32, Board discriptiuon and programming structure of ESP32, Interfacing: analog sensors, MPU6050	**11**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Micro project	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Describe the architecture of the 8051 ,PIC16F877A, Arduino uno & ESP32 microcontrollers.	**K1,K2**
CO2	Develop Programs for target microcontrollers to do simple computational problems and control.	**K2,K3**
CO3	Interface different devices and peripheral chips to commonly used microcontrollers.	**K2,K3**
CO4	Design simple microcontroller-based system for various applications.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	1	3	1	1		1				2
CO2	3	3	3	3	2	1		1				2
CO3	3	3	3	3	3	1		1				2
CO4	3	3	3	3	3	2		1				2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	The 8051 Microcontroller and Embedded Systems using Assembly and C	Muhammed Ali Mazidi and Janice GillispieMazidi	Pearson Education,	2e
2	The 8051 Microcontroller	Kenneth J Ayala	Cengage Learning	3e
3	Arduino Programming: Step-by-Step Guide to Master Arduino Hardware and Software	Mark Torvalds	ISBN-13: 978-1976097713	2nd edition
4	Arduino Programming From Beginning to Advanced	Muhammad Ali Mazidi, Shujen Chen, EshraghGhaemi	MicroDigitalEd.com	2019
5	ESP32 Programming for the Internet of Things: A step-by-step guide to the ESP32	Sever Spanulescu	CRC Press	2021

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	PIC data sheets and manuals such as PIC18F2455/2550/4455/4550 Data Sheet- Microchip		Microchip	PIC data sheets and manuals such as PIC18F2455/2550/4455/4550 Data Sheet-Microchip
2	Arduino 101 Beginners Guide: How to Get Started with Your Arduino	Erik Savasgard	Createspace Independent Pub	Arduino 101 Beginners Guide: How to Get Started with Your Arduino
3	Internet of Things Projects with ESP32: Build exciting and powerful IoT projects using the all-new Espressif ESP32	Agus Kurniawan	Packt Publishing	Internet of Things Projects with ESP32: Build exciting and powerful IoT projects using the all-new Espressif ESP32

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/108102045
2	https://youtu.be/y9RAhEfLfJs
3	www.digimat.in/nptel/courses/video/108102045/L01.html
4	https://archive.nptel.ac.in/courses/106/105/106105193/

SEMESTER S4

ELECTRICAL AND ELECTRONIC INSTRUMENTATION

Course Code	**PCBMT403**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	4:0:0:0	**ESE Marks**	60
Credits	4	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None/ (Course code**)**	**Course Type**	PC

Course Objectives

1. Equip the students with an understanding of the fundamental principles of measurement systems.

2. Provide an overview of electronic measuring instruments and introduce the working principle and examples of fundamental electronic circuits used in biomedical instruments.

3. Provide an overview of basic instruments used in measurement of electrical parameters.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Electric and Magnetic units, SI units; Types of Errors- Gross erros, Systematic and random errors in measurement; propagation of errors; expression of uncertainty – accuracy, precision, sensitivity, resolution, loading effect. Classification of instruments, secondary instruments–indicating, integrating and recording Operating forces- deflecting, damping, controlling torques. Electromechanical indicating instruments: suspension galvanometer, PMMC mechanism, DC ammeters and voltmeters, Ohmmeter, Multimeters; AC indicating instruments- Dynamometer, Watthour meter, power factor meter.	**11**

2	Bridges for measurement: Wheatstone, Kelvin bridges; AC bridges-Maxwell, Hay and Wein bridges; Measurement of R,L, C. Motors (Basic Concepts only required): Motor Components; DC Motors-DC Shunt Motor, Separately Excited & Self Excited, DC Series Motor, DC Compound Motor; Permanent Magnet DC motor; AC Motors- Synchronous Motor, Three-phase Induction Motor.; Special Electrical Motors- Stepper Motor, Servo Motor, BLDC Motor.	**11**
3	Medical Instrumentation circuits: Analog Active Filters-Sallen and Key, Generalized Impedance Converter AFs for very low frequencies, two-Op Amp ECG amplifier. Instrumentation amplifier, Medical Isolation amplifiers, safety standards in medical electronic amplifiers , Phase sensitive rectifiers, phase detectors, VCO, Phase Locked Loops. Digital Interfaces: Aliasing and the Sampling Theorem -Digital-to-Analog Converters, DAC Designs-Weighted Resistors, R–2R ladder. Analog-to-Digital Converters (Tracking Converters, The Successive Approximation ADC, integratingConverters, Flash Converters, Delta-Sigma converters).	**11**
4	Devices for Measurement and Recording : Cathode ray oscilloscope, Digital storage oscilloscopes-DSO applications. Method of measuring voltage, current, phase, frequency and period using CRO, DSO. Strip chart recorder, X-Y recorder, Plotter, liquid crystal display (LCD) ,Waveform analysing instruments- Distortion meter, Spectrum analyser, Digital spectrum analyser.	**11**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Micro project	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Demonstrate basic concept of Measurement Systems, Instruments and errors in Measurement	**K1,K2**
CO2	Analyze basic bridges for measurements and motors	**K1,K2**
CO3	Appraise various electrical and electronic circuits and systems used in biomedical instrumentation	**K2,K3**
CO4	Outline various electrical recording and measuring devices	**K2,K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	3	1	1	-	-	-	-	-	-
CO2	1	2	3	2	1	2	1	1	1	-	-	2
CO3	1	2	3	2	2	2	2	1	1	1	1	1
CO4	1	2	3	2	2	1	-	-	-	-	-	1

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	A course in Electrical and Electronic Measurements & instrumentation	Sawhney A.K	Dhanpat Rai	2012
2	Modern electronic instrumentation and measurement techniques	Albert D. Helfrick and William D. Cooper Modern	Prentice Hall India	2008
3	Analysis and Application of Analog Electronic Circuits to Biomedical Instrumentation	Robert B. Northrop	CRC Press	2017

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Microelectronic Circuits Theory And Application	Sedra and Smith	Seventh Edition, Oxford University Press	2017
2	Electronic Instrumentation and Measurements	David A. Bell	Third edition, Oxford University Press	2013
3	Liquid Crystal Displays: Fundamental Physics and Technology	Robert H. Chen	Wiley	2012
4	Electric Motors and drivers: Fundamentals, Types and Applications	Austin Hughes and Bill Drury	Newnes	2019

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc24_ee117/preview
2	https://nptel.ac.in/courses/108105153
3	https://nptel.ac.in/courses/108105131

SEMESTER S4

BIOSENSORS & TRANSDUCERS

Course Code	**PBBMT404**	**CIE Marks**	60
Teaching Hours/Week (L: T:P: R)	3:0:0:1	**ESE Marks**	40
Credits	4	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None/ (Course code**)**	**Course Type**	PC-PBL

Course Objectives:

1. **Hands-On Experience**: Gain practical experience through laboratory work and projects, involving the assembly and testing of biosensors and transducers
2. **Understanding Fundamental Concepts**: Grasp the basic principles of biosensors and transducers, including their types, working mechanisms, and applications in biomedical engineering.
3. **Design and Development Skills**: Develop skills in designing biosensors and transducers, focusing on material selection, fabrication techniques, and integration with electronic systems.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to biosensors**: Definition and historical development of biosensors - Overview of biosensor components: biorecognition elements, transducers, signal processors - Applications of biosensors; **Biorecognition Elements:** Enzymes: catalysis, specificity, enzyme-based biosensors -Antibodies: antigen-antibody interactions, immunosensors -Nucleic acids: DNA/RNA hybridization, aptamers-Cells and tissues: whole-cell biosensors, tissue-based biosensors; **Immobilization Techniques:** Physical adsorption, covalent bonding, cross-linking, entrapment-Advantages and limitations of each immobilization method.	**9**
2	**Types of Biosensors:** Electrochemical biosensors: potentiometric, amperometric, conductometric - Optical biosensors: fluorescence, surface plasmon resonance, bioluminescence - Thermal biosensors:	**9**

	calorimetric detection methods - Piezoelectric biosensors: quartz crystal microbalance, surface acoustic wave devices	
3	Fundamentals of Transducers: Types and classification –primary and secondary-active and passive - Electrical Transducers: resistive, capacitive, inductive - Mechanical Transducers: strain gauges, piezoelectric transducer - Thermal Transducers: thermocouples, thermistors - Magnetic Transducers: Hall effect transducers, LVDT Transducer Characteristics: Static Characteristics: accuracy, precision, resolution, sensitivity, linearity - Dynamic Characteristics: response time, frequency response, bandwidth.	**9**
4	**Emerging Trends in Biosensor Technology:** Evolution of microsensors **- Nanotechnology**: use of nanomaterials (nanoparticles, nanotubes, nanowires) in biosensors, nanobiosensors - **Lab-on-a-Chip**: integration of biosensing and microfluidics, advantages of miniaturization – implantable sensors, wearable health sensors.	**9**

Suggestion on Project Topics

Project based learning (8 hours)

1. Literature review and presentation on a selected biosensor application (e.g., glucose monitoring, detection of pollutants in water).
2. Students select a specific type of transducer for the given application.
3. Analyze and present the working principles, characteristics, and application considerations of the selected transducer.
4. Design, develop, and test a comprehensive biosensor system based on the knowledge and skills acquired throughout the course.
5. Students will work in teams to create a fully functional biosensor, document their process, and present their project to the class.
6. There shall be two evaluations - after one month of commencement of classes and at the end of the course.

Course Assessment Method
(CIE: 60 marks, ESE: 40 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Project	Internal Ex-1	Internal Ex-2	Total
5	**30**	**12.5**	**12.5**	**60**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 2 marks **(8x2 =16 marks)**	• 2 questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 2 sub divisions. • Each question carries 6 marks. **(4x6 = 24 marks)**	**40**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand the principle behind the working of biosensors	K2
CO2	Describe the methods of measurement of different biosensors	K5
CO3	Analyse the principle behind various biomedical transducers	K4
CO4	Gain an in-depth understanding of emerging trends and advancements in biosensor technology	K2
CO5	Develop functional prototypes of biosensors or transducer systems and successfully implement project-based solutions to specific biomedical challenges.	K3

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	2			2	2					2
CO2	3	1	1			1	1					1
CO3	3	1	2		1	2	2					1
CO4	3	1	2			1	1					1
CO5	3	3	3	2	2	1	1	1	2	2	2	1

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Biosensors and modern bio-specific analytical techniques, Volume XLIV	L. Gorton	Elsevier	2005
2	Advances in biosensors	B. D. Malhotra & A. P. F. Turner	Elsevier	2003
3	Sensors and transducers	Brindley, Keith	CRC Press ILlc	1988
4	Biosensors: Fundamentals and Applications	Anthony P. F. Turner	Oxford Science Publications	
5	Biosensors and modern bio-specific analytical techniques, Volume XLIV	L. Gorton	Elsevier	2005

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Biomedical Instrumentation and measurement	Leslie Cromwell	Prentice hall of India, New Delhi,	2007
2	Medical Instrumentation Application and Design	JohnG.Webster	John Wiley & Sons	2004
3	Principle of biomedical Instrumentation	Andrewg Webb	Cambridge University Press	2018
4	Applied biosensors	D.L.Wise	Butterworth Publishers, London	1989

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc21_ee32/preview , Optical Sensors - Course (nptel.ac.in)
2	Optical Sensors - Course (nptel.ac.in)
3	Transducers For Instrumentation - Course (nptel.ac.in)
4	A brief introduction of Micro-Sensors - Course (nptel.ac.in)

PBL Course Elements

L: Lecture (3 Hrs.)	**R: Project (1 Hr.), 2 Faculty Members**		
	Tutorial	**Practical**	**Presentation**
Lecture delivery	Project identification	Simulation/ Laboratory Work/ Workshops	Presentation (Progress and Final Presentations)
Group discussion	Project Analysis	Data Collection	Evaluation
Question answer Sessions/ Brainstorming Sessions	Analytical thinking and self-learning	Testing	Project Milestone Reviews, Feedback, Project reformation (If required)
Guest Speakers (Industry Experts)	Case Study/ Field Survey Report	Prototyping	Poster Presentation/ Video Presentation: Students present their results in a 2 to 5 minutes video

Assessment and Evaluation for Project Activity

Sl. No	Evaluation for	Allotted Marks
1	Project Planning and Proposal	5
2	Contribution in Progress Presentations and Question Answer Sessions	4
3	Involvement in the project work and Team Work	3
4	Execution and Implementation	10
5	Final Presentations	5
6	Project Quality, Innovation and Creativity	3
Total		**30**

1. **Project Planning and Proposal (5 Marks)**
    - Clarity and feasibility of the project plan
    - Research and background understanding
    - Defined objectives and methodology

2. **Contribution in Progress Presentation and Question Answer Sessions (4 Marks)**
    - Individual contribution to the presentation
    - Effectiveness in answering questions and handling feedback

3. **Involvement in the Project Work and Team Work (3 Marks)**
    - Active participation and individual contribution
    - Teamwork and collaboration

4. **Execution and Implementation (10 Marks)**
    - Adherence to the project timeline and milestones
    - Application of theoretical knowledge and problem-solving
    - Final Result

5. **Final Presentation (5 Marks)**
    - Quality and clarity of the overall presentation
    - Individual contribution to the presentation
    - Effectiveness in answering questions

6. **Project Quality, Innovation, and Creativity (3 Marks)**
    - Overall quality and technical excellence of the project
    - Innovation and originality in the project
    - Creativity in solutions and approaches

SEMESTER S4

POWER ELECTRONICS AND APPLICATIONS

Course Code	**PEBMT 411**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3-0-0-0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	PE

Course Objectives:

1. The purpose of learning this course is to describe various power electronic devices so that the learner will be able to meet technical demands concerning power electronics and its applications.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to Power Electronics-**Scope and applications-power electronics vs signal electronics. **Power electronics devices-** Power diodes, Power transistors, MOSFETS and IGBTs. Structure, fabrication, Regions of operations, switching characteristics, Safe operating area. **Thyristor family**: SCRs, VI characteristics, dynamic characteristics, turn-on methods, thyristor protection, two transistor analogy, latching current and holding current. DIAC and TRIAC (basic concepts only)	**9**
2	**AC-DC converters**: Single phase-controlled rectifiers – half wave, full-wave, half-controlled and fully controlled with R, RL and RLE with freewheeling diodes-typical waveforms and output equations. Three phase half-wave and full-wave controlled rectifier with R load-typical waveforms and output equations	**9**
3	**DC-DC converters**: Step down and step-up choppers –classification, time ratio control & current limit control in dc-dc converters, Buck, Boost and Buck-Boost converters.	**9**

	DC-AC Inverters, Square wave operations, single-phase half bridge and full bridge inverters with R and RL loads, three-phase bridge inverter with R load- 120° and 180° conduction modes, Carrier based unipolar and bipolar PWM inverters, Effect of harmonics and its elimination, Sinusoidal PWM inverters.	
4	Gate driver circuits-Isolated and non-isolated types, Applications-residential and industrial applications, SMPS-flyback converter, push-pull converter, half-bridge converter and full bridge converter, static switches-single phase AC switches and DC switches, solid state relays- AC and DC solid state relays, microelectronic relays.	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Micro project	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Describe basic operation and compare performance of various power semiconductor devices.	**K1, K2**
CO2	Analyze the performance of power converter circuits	**K3 ,K4**
CO3	Design and implement chopper circuits suitable for various applications.	**K3**
CO4	Describe the working of various types of inverters including PWM inverter.	**K2**
CO5	Implement various drive circuits and application of power electronics	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2		1							2
CO2	3	3	2		1							2
CO3	3	3	3		1							2
CO4	3	3	1		1							2
CO5	3	3	3		1		2					2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Power Electronics - Essentials and applications	L. Umanand	Wiley	2009
2	Power Electronics Circuits, Devices and Applications	Muhammad H. Rashid	Pearson Education	4th edition, 2013
3	Power Electronics	Dr. P. S. Bimbhra	Khanna Publishers	2012
4	Power Electronics	M.D. Singh, K.B. Khanchandani	TataMcgraw Hill	3rd edition, 2008

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Power electronics: converters, applications, and design	Ned Mohan, Tore M. Undeland	John Wiley & Sons	1989
2	Power Electronics.	Daniel. W. Hart	Pearson Education	2010

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://youtube.com/playlist?list=PLTFstmhqwXp-OEjDuBKmaPac-qJzdfvol&si=ayJx_RL7unspjbsa
2	https://archive.nptel.ac.in/courses/108/105/108105066/
3	https://youtube.com/playlist?list=PLwdnzlV3ogoWVgA9fHBV36L_bxWZlpa7X&si=tBAT_LFK2SmeUBY1
4	https://youtu.be/tI2OJWOQSTg?si=LKrRWYMf3FiGlKf6

SEMESTER S4

IOT AND BIOMEDICAL APPLICATIONS

Course Code	**PEBMT 412**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	PE

Course Objectives:

1. Teach the internet concepts and design methodology
2. Teach importance of embedded and IoT in health care

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Internet Concepts And Infrastructure-**Broad Band Transmission facilities, Open Interconnection standards, Local Area Networks, Wide Area Networks, Network management, Network Security, Cluster computers. Internet concepts, Capabilities and limitations of the internet. Interfacing Internet server applications to corporate databases HTML and XML Web page design through programming and the use of active components.Data analytics in medical data processing	**9**
2	**Design Methology And Protocols-**Introduction, Characteristics, Physical design, Protocols, Logical design, Enabling technologies, IoT Levels, Domain Specific IoTs, IoT vs M2M. IOT design methodology, IoT systems management, IoT Design Methodology Specifications Integration and Application Development.	**9**
3	**Ethical Issues In Health Care-**Ethical implications of digital health technologies- privacy, confidentiality and security of personal health dataethical framework and guidelines in digital health, principles of biomedical ethics	**9**

4	**IoT In Health Care Applications**-IoT based health care-physiological parameter monitoring system- future challenges in health care- health care echo system with IoT- IoT for personalized health care- wearable device characteristics-analysis of power aware protocols. Artificial intelligence in health monitoring.	9

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Micro project	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Acquire the knowledge & concepts of IoT	K2
CO2	Explain the basic concepts of IoT Protocols.	K2
CO3	. Categorize the importance of digital health	K4
CO4	Develop an application based on IoT in health care	K3

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	3									2
CO2	2	3	3									2
CO3	2	3	3									2
CO4	2	3	3									2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	A Clinical Microsystems Approach.	Eugene C Nelson Paul B Betalden Majorie M Godfrey	John Wiley & sons ISBN	2007
2	Requirements Engineering for Digital Health,	Samuel A. Fricker, ChristophThuemmler, AnastasiusGavras	Springer.	2015

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	"Designing the Internet of Things	Adrian Mc Ewen, Hakim Cassimally,	Wiley, 2013.	2013
2	"Data and computer communications",	Stallings, William,	Pearson Education Pvt Ltd, New Delhi, 2007	2007
3	"Computer Networks",	Andrew S Tanenbaum	Pearson Education Pvt Ltd, New Delhi, 4th Edition, 2012.	2012

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc22_cs53/preview
2	https://onlinecourses.nptel.ac.in/noc22_cs53/preview
3	https://elearn.nptel.ac.in/shop/iit-workshops/completed/healthcare-applications-role-relevance-of-ehrs-in-healthcare/?v=c86ee0d9d7ed
4	https://elearn.nptel.ac.in/shop/iit-workshops/completed/healthcare-applications-role-relevance-of-ehrs-in-healthcare/?v=c86ee0d9d7ed

SEMESTER S4

CLINICAL ENGINEERING

Course Code	**PEBMT413**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	PE

Course Objectives:

1. Understand the design of infrastructural facilities of hospital.
2. Different functions of a biomedical engineer: planning, procurement, maintenance of medical equipment and record keeping.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Role and responsibilities:** Definition – Bio-engineering, Biomedical engineering, Clinical engineering & Hospital Engineering. **Hospital Architecture:** Planning and design of various department – Radiology, ICU, Central Sterilization and Operation Theatres. **Accreditation protocols:** NABH, JCI and AERB certification.	9
2	**Electrical power systems in hospitals:** Stabilized and uninterrupted power supply systems, Protective systems- over voltage and over current protectors, circuit protectors, Surge protectors, EMI filters. Effect of electrical current in human body, Leakage current and its types, electric shock- micro & macro shock. Safety measures: Gas, fire, electric, and radiation.	9
3	**Hospital Gas Supply Systems:** Centralized gas supply system- air, oxygen, nitrous oxide and vacuum –functions, Manifold room, principle of production of liquid oxygen.	9

	Sterilization systems in hospitals: principles & techniques of sterilization systems, steam & EO sterilization, Autoclaves & Incinerators.	
4	**Procurement & Maintenance of medical equipment:** Contract procedures- CMC & AMC , preventive maintenance and its types. Training of medical staff. **IT networking with medical technology:** Hospital Information Systems (HIS) & Radiology Information systems (RIS), Architecture of PACS(Picture Archival & Communication Systems)	9

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Micro project	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Appreciate the role of biomedical engineering hospital.	**K2**
CO2	Understand the design & architecture of main departments in hospital.	**K2**
CO3	Review the electrical systems in hospital.	**K2**
CO4	Analyse the gas supply and sterilizations systems in hospital.	**K2**
CO5	Understand the procurement & maintenance of medical equipment in hospital.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	1				1		2				3
CO2	2	1				1		2				3
CO3	2	1				1		2				3
CO4	2	1				1	3	2				3
CO5	2	1				1		2				3

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Handbook of clinical engineering	B N Feinberg	CRC press	1980
2	Electrical power substation engineering	John Douglas Mcdonald	CRC press	2003
3	Standard handbook of biomedical engineering & Design	Kutz Myer	Mc Graw Hill	

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Hospital & Health care facility Design	Richard L Miller, Earl S Swensson	Norton & company	2^{nd} edition, 2002
2	Medical equipment maintenance programme overview	WHO medical device technical series		2011

SEMESTER S4

BIOSTATISTICS

Course Code	**PEBMT414**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	2:1:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	PE

Course Objectives:

1. Summarize and describe the main features of a data set using appropriate descriptive statistical measures.
2. Apply the basic concepts of probability and probability distributions to model random phenomena and make statistical inferences.
3. Utilize estimation techniques and hypothesis testing methods to make inferences about populations based on sample data.
4. Examine relationships between variables and compare means across multiple groups using advanced statistical methods.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**DESCRIPTIVE STATISTICS:** • **Measures of Location**: Arithmetic Mean, Median, Mode, Geometric Mean, Harmonic Mean • **Measures of Spread**: Variance, Standard Deviation, Coefficient of Variation • **Properties of Arithmetic Mean and Variance** • **Grouped Data** **Graphic Methods**: Bar graph, Box plots, Scatter plots	9

2	**PROBABILITY AND PROBABILITY DISTRIBUTIONS** • **Probability**: Notations and laws of probability, Bayes' rule and screening tests, Bayesian inference, ROC curves, Random variables. • **Discrete Probability Distributions**: Probability mass function, Expected value, Variance, Cumulative distribution, Binomial distribution, Poisson distribution **Continuous Probability Distributions**: Normal distribution, Properties of standard normal distribution	**9**
3	**ESTIMATION AND HYPOTHESIS TESTING** • **Estimation**: Relationship between Population and Sample, Random number trials, clinical trials, Estimation of Mean, Variance, One-sided confidence intervals • **Hypothesis Testing**: One sample inference: One sample test for the mean of a normal distribution, one- and two-sided alternatives. Categorical data: Fisher's Exact Test, Chi-Square Goodness-of-Fit Test • **Nonparametric Methods**: The Sign Test, The Wilcoxon Signed-Rank Test	**9**
4	**REGRESSION, CORRELATION, AND MULTISAMPLE INFERENCE** • **Regression and Correlation Methods**: Fitting regression lines: Method of least squares, Inference about parameters from regression lines, Interval estimation for linear regression, Correlation coefficient, Multiple regression **Multisample Inference**: Introduction to ANOVA (Analysis of Variance)	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Micro project	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Summarize and describe the main features of a data set using appropriate descriptive statistical measures.	**K2**
CO2	Apply the basic concepts of probability and probability distributions to model random phenomena and make statistical inferences.	**K3**
CO3	Utilize estimation techniques and hypothesis testing methods to make inferences about populations based on sample data.	**K4**
CO4	Examine relationships between variables and compare means across multiple groups using advanced statistical methods.	**K4**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3									2		2
CO2	3	2								2		2
CO3	3	3		2								2
CO4	3	3		2								2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Fundamentals of Biostatistics	Bernard Rosner	**Duxbury Press**	Seventh and 2011
2	Introduction to Biostatistics and Research Methods	PSS Sunder Rao and J Richard	PHI Learning	Fifth and 2012

Reference Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Fundamentals of Biostatistics	Irfan A. Khan, Atiya Khanum	Ukaaz, 2004	Second and 2004
2	Introduction to the Practice of Statistics	Moore, McCabe, and Craig’s	W.H. Freeman and Company New York	Sixth and 2009
3	Principles of Biostatistics	Marcello Pagano and Kimberlee Gauvreau	Chapman and Hall/CRC	Second and 2018

Video Links (NPTEL, SWAYAM…)

Module No.	Link ID
1	https://archive.nptel.ac.in/courses/111/104/111104120/
2	https://nptel.ac.in/courses/102106051
3	https://nptel.ac.in/courses/110107114
4	https://archive.nptel.ac.in/courses/102/106/102106051/

SEMESTER S4

DESIGN OF LOGIC SYSTEM

Course Code	PEBMT416	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	2:1:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	PCBMT303	Course Type	PE

Course Objectives:

1. The objective of the course is to design and construct the combinational modules and sequential circuits. The course also deals with basic HDL programming and different types of programmable logic devices.
2. A thorough knowledge of digital circuits and systems is expected from the students.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Review of digital system** Binary decoder- decoder networks, encoders-priority encoder, Multiplexers-multiplexer trees, demultiplexers, shifters —barrel shifter. Implementation of combinational circuits using Multiplexers and Decoders. Adder modules- ripple carry adder, carry look ahead adder (CLA),Carry-Save Adder (CSA), Carry-Save Adder (CSA), Comparator module.	**9**
2	**Sequential network Design** General model for sequential network, State tables, State graphs, Derivations of state graph. State reduction-equivalence classes and and state assignment. Design examples using the FSM approach-serial adder, modulo —p counter, pattern recognizer. *3pattern recognizer.*	**9**
3	**Timing characteristics and Hazards** Impediments to synchronous design- Clock skew,jitter, gating the clock,Asynchronous inputs, synchronizer failure and metastability.	**9**

	Data synchronizer. Timing hazard-Static hazard, dynamic hazard, essential hazard and designing hazard free circuits.	
4	**Introduction to digital design methodology using HDL and Programmable devices.** Fundamentals-, basic language elements —data object, data types, identifiers. Process statement-signal assignment vs variable assignment . Programmable Array Logic-combinational PLDs (Eg:PAL 12H6) PLDs((Eg PAL12H6), 3 Sequential PLDs (Eg: PAL16R8), Simple PLD (Eg: PAL16R8) Complex Programmable Logic Devices- Xilinx XC 9500 CPLD family. 4	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Micro project	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Design and implementation of combinational modules.	**K1**
CO2	Design and implementation of sequential circuits.	**K1**
CO3	Describe the timing related issues in sequential circuits.	**K2**
CO4	Implementation of logic circuits using VHDL and Interpret the architecture of programmable logic devices.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	1	3							1
CO2	3	3	3	1	3							1
CO3	3	3	3	1	3							1
CO4	3	2	3	1	3							1
CO5												

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Digital Design: Principles & Practices	John F Wakerly	Pearson Education	4th edition 2005
2	Digital Logic: Applications and Design	John M.Yarbough	Cengage Learning India	1st edition, 1996
3	Digital Principles and design	Donald G Givone	Tata McGraw Hill	2003
4	A VHDL Synthesis Primer	J. Bhasker	B.S. Publications	2001

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Fundamentals of logic design	Charles Roth	Cengage Learning	7th edition, 2013
2	Fundamentals of Digital logic with VHDL desig	Stephen Brown & Zvonko Vranesic	McGraw Hill	3rd edition, 2008
3	Digital fundamentals	Thomas. L Floyd	Pearson,l0/e	2011

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/108/106/108106177/ [NOC: Electrical Engineering (IIT Ropar)]
2	https://archive.nptel.ac.in/courses/108/105/108105132/ [NOC: Electrical Engineering (IIT Kharagpur)]

SEMESTER S4

QUANTITATIVE PHYSIOLOGY

Course Code	PEBMT415	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	5/3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	PE

Course Objectives:

1. To be able to describe a physiologic system in a quantitative way.
2. To be able to analyze physiologic measurements and use them for parameter estimation.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to Quantitative Physiology**: Importance of analytical and quantitative approach in Physiology. **The Origin of the Resting Membrane Potential:** Equilibrium Potential and the Balance Between Electrical Force and Diffusion, K+ Negative, Integration of the Nernst-Planck Electrodiffusion Equation and The Goldman-Hodgkin-Katz Equation, Slope Conductance, Chord Conductance and the Current Convention. **Action Potential**: Voltage-Dependent Changes in Ion Conductance and the Action Potential, Dependency on the Number and State of the Channels, Patch Clamp Experiments, Hodgkin-Huxley Model of the Action Potential. **Propagation Of The Action Potential**: Time Course and Distance of Electrotonic Spread Dependency, Cable Properties, Jumping. **Problem Solving for Module 1**	9

2	**The Neuromuscular Junction and Excitation-** Contraction Coupling: Action Potentials Origination, Neuromuscular Junction, Release of Acetylcholine to Excite Muscles, Action Potential into an Intracellular Ca^{2+} Signal. **Muscle Energetics**: Muscular Activity and ATP Consumption, Glucose and Glycogen as Fuel for Muscle, Lactic Acid Production and Oxidation. **Cardiovascular System and the Blood:** Circulatory System as a Transport System, Circulation and Diffusion, Pressure Drives Blood Flow, Vessels and Compliance, Blood Consists of Cells Suspended in Plasma, Hemostasis Defends the Integrity of the Vascular Volume. **Plasma and Red Blood Cells:** Plasma Proteins and Electrolytes, Plasma Proteins and Ions Buffer Changes in Plasma pH, Control Of Erythropoiesis By Erythropoietin. **White Blood Cells And Inflammation:** Leukocytes, White Blood Cells And Pluripotent Stem Cells, Monocytes And Tissue Macrophages **Problem Solving for Module 2**	**9**
3	**The Heart As A Pump:** Law Of Laplace For Thin-Walled Spheres And Thick-Walled Spheres, Contractile Events In The Cardiac Cycle, Automatic Electrical System Controls The Contraction Of The Heart **Cardiac Action Potential**: Resting Membrane Potential and Action Potential of Cardiac Cells, Autonomic Nerves, Ionic Basis, Electrocardiogram and Cardiac Dipole. **Cellular Basis Of Cardiac Contractility:** Calcium-Induced Calcium Release Couples Excitation to Contraction in Cardiac Muscle, Regulation of Cardiac Contractility. **Cardiac Function Curve:** Integral of The Pressure-Volume Loop and The PV Work, Frank- Starling Law of the Heart, Ventricular Function Curve, Fick’s Principle, Indicator Dilution Method, Thermal Dilution Method **Problem Solving for Module 3**	**9**

4	**Body Fluid Compartments:** Determination of Body Fluid Compartments And Fick's Dilution Principle, Inulin/ Evans' Blue Dye Marks, Fluid Compartments, Macroscopic Electroneutrality, Darrow-Yannet Diagrams, Kidneys and Plasma. **Functional Anatomy of the Kidneys and Overview of Kidney Function:** Nephrons, Juxtaglomerular Apparatus and Renin, Non excretory Functions of the Kidney. **Glomerular Filtration:** Clearance of Inulin and Glomerular Filtration Rate, Clearance of Para Amino Hippuric Acid and Renal Plasma Flow, Clearance of Various Substance, Basement Membrane, Slit Membrane, Sieving Coefficient, Starling Forces and Ultrafiltration. **Problem Solving for Module 4**	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	*Internal Ex*	*Evaluate*	*Analyse*	*Total*
5	**15**	**10**	**10**	**40**

Criteria for Evaluation (Evaluate and Analyse): 20 marks

Students should evaluate and analyse quantitative modelling techniques for biomedical applications, assess the case and provide the most appropriate solution for the problem.

Criteria for evaluation:

1. ***Problem Definition (K4 - 5 points)***
    a. *Clearly defines the problem.*
    b. *Examine and identifies relevant factors.*
2. ***Problem Analysis (K4 - 5 points)***
    a. *Break-down and presents a well-reasoned solution approach.*
3. ***Evaluate (K5 - 5 points)***
    a. *Thoroughly evaluate the proposed solutions.*
4. ***Conclusion (K3- 3 points, K5 – 2 points)***
    a. *Summarizes findings and insights. State which solution is most appropriate for the problem*

Scoring:

1. ***Accomplished (4 points)****: Exceptional analysis, and depth of understanding.*
2. ***Competent (3 points)****: Solid performance with minor areas for improvement.*
3. ***Developing (2 points)****: Adequate effort but lacks depth or clarity.*
4. ***Minimal (1 point)****: Incomplete or significantly flawed.*

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Quantitatively analyze the physiology of nerve conduction.	**K3**
CO2	Apply the quantitative physiological understanding of the skeletal muscle.	**K2**
CO3	Apply quantitative knowledge about blood and circulatory systems.	**K2**
CO4	Analyze the physiology of the heart in a quantitative approach.	**K3**
CO5	Quantitatively evaluate the physiology of body fluid volumes, glomerular filtration and clearance.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2					2		2
CO2	3	3	2	2	2					2		2
CO3	3	3	2	2	2					2		2
CO4	3	3	2	2	2					2		2
CO5	3	3	2	2	2					2		2

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Quantitative Human Physiology: An Introduction	Joseph J Feher	Academic Press	2nd edition, 2017
2	Quantitative Physiology: Systems Approach	Shangbin Chen and Alexey Zaikin	Springer	2020 edition, 2021

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Interdisciplinary Applied Mathematics: Mathematical Physiology	Bruce M. Koeppen and Bruce A. Stanton	Mosby	6th updated Edition, 2009
2	Interdisciplinary Applied Mathematics: Mathematical Physiology	James Keener and James Sneyd	Springer	2nd edition, 2009

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/127/106/127106001/ (Neuroscience of Human Movements (IIT Madras))
2	https://archive.nptel.ac.in/courses/102/104/102104058/ (NOC:Animal Physiology (IIT Kanpur))
3	https://archive.nptel.ac.in/courses/102/104/102104058/ (NOC:Animal Physiology (IIT Kanpur))
4	https://archive.nptel.ac.in/courses/102/104/102104058/ (NOC:Animal Physiology (IIT Kanpur))

SEMESTER S4

ECONOMICS FOR ENGINEERS

(Common to All Branches)

Course Code	**UCHUT346**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	2:0:0:0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs.30 Min.
Prerequisites (if any)	None	**Course Type**	HMC

Course Objectives:

1. Understanding of finance and costing for engineering operation, budgetary planning and control
2. Provide fundamental concept of micro and macroeconomics related to engineering industry
3. Deliver the basic concepts of Value Engineering.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Basic Economics Concepts - Basic economic problems – Production Possibility Curve – Utility – Law of diminishing marginal utility – Law of Demand - Law of supply – Elasticity - measurement of elasticity and its applications – Equilibrium- Changes in demand and supply and its effects Production function - Law of variable proportion – Economies of Scale – Internal and External Economies – Cobb-Douglas Production Function	**6**
2	Cost concepts – Social cost, private cost – Explicit and implicit cost – Sunk cost - Opportunity cost - short run cost curves - Revenue concepts Firms and their objectives – Types of firms – Markets - Perfect Competition – Monopoly - Monopolistic Competition - Oligopoly (features and equilibrium of a firm)	**6**

3	Monetary System – Money – Functions - Central Banking –Inflation - Causes and Effects – Measures to Control Inflation - Monetary and Fiscal policies – Deflation Taxation – Direct and Indirect taxes (merits and demerits) - GST National income – Concepts - Circular Flow – Methods of Estimation and Difficulties - Stock Market – Functions- Problems faced by the Indian stock market-Demat Account and Trading Account – Stock market Indicators- SENSEX and NIFTY	6
4	Value Analysis and value Engineering - Cost Value, Exchange Value, Use Value, Esteem Value - Aims, Advantages and Application areas of Value Engineering - Value Engineering Procedure - Break-even Analysis - Cost-Benefit Analysis - Capital Budgeting - Process planning	6

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Case study/ Micro project	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
10	**15**	**12.5**	**12.5**	**50**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• Minimum 1 and Maximum 2 Questions from each module. • Total of 6 Questions, each carrying 3 marks **(6x3 =18marks)**	• 2 questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 2 sub divisions. • Each question carries 8 marks. **(4x8 = 32 marks)**	**50**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand the fundamentals of various economic issues using laws and learn the concepts of demand, supply, elasticity and production function.	**K2**
CO2	Develop decision making capability by applying concepts relating to costs and revenue, and acquire knowledge regarding the functioning of firms in different market situations.	**K3**
CO3	Outline the macroeconomic principles of monetary and fiscal systems, national income and stock market.	**K2**
CO4	Make use of the possibilities of value analysis and engineering, and solve simple business problems using break even analysis, cost benefit analysis and capital budgeting techniques.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	-	-	-	-	-	1	-	-	-	-	1	-
CO2	-	-	-	-	-	1	1	-	-	-	1	-
CO3	-	-	-	-	1	-	-	-	-	-	2	-
CO4	-	-	-	-	1	1	-	-	-	-	2	-

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Managerial Economics	Geetika, Piyali Ghosh and Chodhury	Tata McGraw Hill,	2015
2	Engineering Economy	H. G. Thuesen, W. J. Fabrycky	PHI	1966
3	Engineering Economics	R. Paneerselvam	PHI	2012

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Engineering Economy	Leland Blank P.E, Anthony Tarquin P. E.	Mc Graw Hill	7^{TH} Edition
2	Indian Financial System	Khan M. Y.	Tata McGraw Hill	2011
3	Engineering Economics and analysis	Donald G. Newman, Jerome P. Lavelle	Engg. Press, Texas	2002
4	Contemporary Engineering Economics	Chan S. Park	Prentice Hall of India Ltd	2001

SEMESTER S3/S4

ENGINEERING ETHICS AND SUSTAINABLE DEVELOPMENT

Course Code	**UCHUT347**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	2:0:0:0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. Equip with the knowledge and skills to make ethical decisions and implement gender-sensitive practices in their professional lives.
2. Develop a holistic and comprehensive interdisciplinary approach to understanding engineering ethics principles from a perspective of environment protection and sustainable development.
3. Develop the ability to find strategies for implementing sustainable engineering solutions.

SYLLABUS

Module No.	**Syllabus Description**	**Contact Hours**
1	**Fundamentals of ethics -** Personal vs. professional ethics, Civic Virtue, Respect for others, **Profession and Professionalism,** Ingenuity, diligence and responsibility, Integrity in design, development, and research domains, Plagiarism, a balanced outlook on law - challenges - case studies, **Technology and digital revolution**-Data, information, and knowledge, Cybertrust and cybersecurity, Data collection & management, **High technologies: connecting people and places**-accessibility and social impacts, **Managing conflict**, Collective bargaining, **Confidentiality**, Role of confidentiality in moral integrity, **Codes of Ethics**. **Basic concepts in Gender Studies -** sex, gender, sexuality, gender spectrum: beyond the binary, gender identity, gender expression, gender stereotypes, **Gender disparity and discrimination in education**, employment and	**6**

	everyday life, History of women in Science & Technology, Gendered technologies & innovations**, Ethical values and practices in connection with gender -** equity, diversity & gender justice, **Gender policy and women/transgender empowerment initiatives.**	
2	**Introduction to Environmental Ethics:** Definition, importance and historical development of environmental ethics, key philosophical theories (anthropocentrism, biocentrism, ecocentrism). **Sustainable Engineering Principles:** Definition and scope, triple bottom line (economic, social and environmental sustainability), life cycle analysis and sustainability metrics. **Ecosystems and Biodiversity:** Basics of ecosystems and their functions, Importance of biodiversity and its conservation, Human impact on ecosystems and biodiversity loss, An overview of various ecosystems in Kerala/India, and its significance. **Landscape and Urban Ecology:** Principles of landscape ecology, Urbanization and its environmental impact, Sustainable urban planning and green infrastructure.	**6**
3	**Hydrology and Water Management:** Basics of hydrology and water cycle, Water scarcity and pollution issues, Sustainable water management practices, Environmental flow, disruptions and disasters. **Zero Waste Concepts and Practices:** Definition of zero waste and its principles, Strategies for waste reduction, reuse, reduce and recycling, Case studies of successful zero waste initiatives. **Circular Economy and Degrowth:** Introduction to the circular economy model, Differences between linear and circular economies, degrowth principles, Strategies for implementing circular economy practices and degrowth principles in engineering. **Mobility and Sustainable Transportation:** Impacts of transportation on the environment and climate, Basic tenets of a Sustainable Transportation design, Sustainable urban mobility solutions, Integrated mobility systems, E-Mobility, Existing and upcoming models of sustainable mobility solutions.	**6**
4	**Renewable Energy and Sustainable Technologies:** Overview of renewable energy sources (solar, wind, hydro, biomass), Sustainable technologies in energy production and consumption, Challenges and opportunities in renewable energy adoption. **Climate Change and Engineering Solutions:** Basics of climate change science, Impact of climate change on natural and human systems, Kerala/India and the Climate crisis, Engineering solutions to mitigate, adapt and build resilience to climate change. **Environmental Policies and Regulations:** Overview of key environmental policies and	**6**

	regulations (national and international), Role of engineers in policy implementation and compliance, Ethical considerations in environmental policy-making. **Case Studies and Future Directions:** Analysis of real-world case studies, Emerging trends and future directions in environmental ethics and sustainability, Discussion on the role of engineers in promoting a sustainable future.	

Course Assessment Method
(CIE: 50 marks , ESE: 50)

Continuous Internal Evaluation Marks (CIE):

Continuous internal evaluation will be based on individual and group activities undertaken throughout the course and the portfolio created documenting their work and learning. The portfolio will include reflections, project reports, case studies, and all other relevant materials.

- The students should be grouped into groups of size 4 to 6 at the beginning of the semester. These groups can be the same ones they have formed in the previous semester.
- Activities are to be distributed between 2 class hours and 3 Self-study hours.
- The portfolio and reflective journal should be carried forward and displayed during the 7th Semester Seminar course as a part of the experience sharing regarding the skills developed through various courses.

Sl. No.	Item	Particulars	Group/ Individual (G/I)	Marks
1	Reflective Journal	Weekly entries reflecting on what was learned, personal insights, and how it can be applied to local contexts.	I	5
2	Micro project (Detailed documentation of the project, including methodologies, findings, and reflections)	1 a) Perform an Engineering Ethics Case Study analysis and prepare a report 1 b) Conduct a literature survey on ‘Code of Ethics for Engineers’ and prepare a sample code of ethics	G	8
		2. Listen to a TED talk on a Gender-related topic, do a literature survey on that topic and make a report citing the relevant papers with a specific analysis of the Kerala context	G	5
		3. Undertake a project study based on the concepts of sustainable development* - Module II, Module III & Module IV	G	12

3	Activities	2. One activity* each from Module II, Module III & Module IV	G	15
4	Final Presentation	A comprehensive presentation summarising the key takeaways from the course, personal reflections, and proposed future actions based on the learnings.	G	5
		Total Marks		**50**

*Can be taken from the given sample activities/projects

Evaluation Criteria:

- **Depth of Analysis**: Quality and depth of reflections and analysis in project reports and case studies.
- **Application of Concepts**: Ability to apply course concepts to real-world problems and local contexts.
- **Creativity**: Innovative approaches and creative solutions proposed in projects and reflections.
- **Presentation Skills**: Clarity, coherence, and professionalism in the final presentation.

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Develop the ability to apply the principles of engineering ethics in their professional life.	**K3**
CO2	Develop the ability to exercise gender-sensitive practices in their professional lives	**K4**
CO3	Develop the ability to explore contemporary environmental issues and sustainable practices.	**K5**
CO4	Develop the ability to analyse the role of engineers in promoting sustainability and climate resilience.	**K4**
CO5	Develop interest and skills in addressing pertinent environmental and climate-related challenges through a sustainable engineering approach.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1						3	2	3	3	2		2
CO2		1				3	2	3	3	2		2
CO3						3	3	2	3	2		2
CO4		1				3	3	2	3	2		2
CO5						3	3	2	3	2		2

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Ethics in Engineering Practice and Research	Caroline Whitbeck	Cambridge University Press & Assessment	2nd edition & August 2011
2	Virtue Ethics and Professional Roles	Justin Oakley	Cambridge University Press & Assessment	November 2006
3	Sustainability Science	Bert J. M. de Vries	Cambridge University Press & Assessment	2nd edition & December 2023
4	Sustainable Engineering Principles and Practice	Bhavik R. Bakshi,	Cambridge University Press & Assessmen	2019
5	Engineering Ethics	M Govindarajan, S Natarajan and V S Senthil Kumar	PHI Learning Private Ltd, New Delhi	2012
6	Professional ethics and human values	RS Naagarazan	New age international (P) limited New Delhi	2006.
7	Ethics in Engineering	Mike W Martin and Roland Schinzinger,	Tata McGraw Hill Publishing Company Pvt Ltd, New Delhi	4" edition, 2014

Suggested Activities/Projects:

Module-II

- Write a reflection on a local environmental issue (e.g., plastic waste in Kerala backwaters or oceans) from different ethical perspectives (anthropocentric, biocentric, ecocentric).
- Write a life cycle analysis report of a common product used in Kerala (e.g., a coconut, bamboo or rubber-based product) and present findings on its sustainability.
- Create a sustainability report for a local business, assessing its environmental, social, and economic impacts
- Presentation on biodiversity in a nearby area (e.g., a local park, a wetland, mangroves, college campus etc) and propose conservation strategies to protect it.
- Develop a conservation plan for an endangered species found in Kerala.
- Analyze the green spaces in a local urban area and propose a plan to enhance urban ecology using native plants and sustainable design.
- Create a model of a sustainable urban landscape for a chosen locality in Kerala.

Module-III

- Study a local water body (e.g., a river or lake) for signs of pollution or natural flow disruption and suggest sustainable management and restoration practices.
- Analyse the effectiveness of water management in the college campus and propose improvements - calculate the water footprint, how to reduce the footprint, how to increase supply through rainwater harvesting, and how to decrease the supply-demand ratio
- Implement a zero waste initiative on the college campus for one week and document the challenges and outcomes.
- Develop a waste audit report for the campus. Suggest a plan for a zero-waste approach.
- Create a circular economy model for a common product used in Kerala (e.g., coconut oil, cloth etc).
- Design a product or service based on circular economy and degrowth principles and present a business plan.
- Develop a plan to improve pedestrian and cycling infrastructure in a chosen locality in Kerala

Module-IV

- Evaluate the potential for installing solar panels on the college campus including cost-benefit analysis and feasibility study.
- Analyse the energy consumption patterns of the college campus and propose sustainable alternatives to reduce consumption - What gadgets are being used? How can we reduce demand using energy-saving gadgets?
- Analyse a local infrastructure project for its climate resilience and suggest improvements.

- Analyse a specific environmental regulation in India (e.g., Coastal Regulation Zone) and its impact on local communities and ecosystems.
- Research and present a case study of a successful sustainable engineering project in Kerala/India (e.g., sustainable building design, water management project, infrastructure project).
- Research and present a case study of an unsustainable engineering project in Kerala/India highlighting design and implementation faults and possible corrections/alternatives (e.g., a housing complex with water logging, a water management project causing frequent floods, infrastructure project that affects surrounding landscapes or ecosystems).

SEMESTER S4

MICROCONTROLLERS AND INTERFACING LAB

Course Code	**PCBML407**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	0:0:3:0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	GBEST204 (Programming in C)	**Course Type**	PCL

Course Objectives:

1. Develop simple assembly level programs for 8051 Microcontrollers
2. Demonstrate high level programming proficiency using the various addressing modes and data transfer instructions of the PIC microcontroller.
3. Design simple computational systems using target Microcontrollers
4. Design and implement systems with peripheral control using target Microcontrollers

Expt. No.	Experiments
1	Familiarization with 8051 based kit, programming
2	8051 - arithmetic operations/ logical operations
3	8051 - Bit manipulation.
4	8051 – Data format conversion
5	8051 - Sorting array.
6	8051 - Finding largest/ smallest elements in an array

7	8051 - Data sequence generation
8	Interfacing 8051 - Stepper motor/DC motor
9	Familiarization of MPLAB IDE and PIC16F series.
10	Design logic functions like Addition, Subtraction, and Multiplication using the microcontroller PIC16F.
11	Interfacing stepper motor with PIC16F.
12	Array sorting and manipulations using the microcontroller PIC16F

Course Assessment Method
(CIE: 50 marks, ESE: 50 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Preparation/Pre-Lab Work experiments, Viva and Timely completion of Lab Reports / Record (Continuous Assessment)	Internal Examination	Total
10	20	20	50

End Semester Examination Marks (ESE):

Procedure/ Preparatory work/Design/ Algorithm	Conduct of experiment/ Execution of work/ troubleshooting/ Programming	Result with valid inference/ Quality of Output	Viva voce	Record	Total
10	15	10	10	5	50

- ***Submission of Record: Students shall be allowed for the end semester examination only upon submitting the duly certified record.***
- ***Endorsement by External Examiner:*** *The external examiner shall endorse the record*

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Develop simple assembly level programs for 8051 Microcontrollers	**K1**
CO2	Demonstrate high level programming proficiency using the various addressing modes and data transfer instructions of the PIC microcontroller.	**K3**
CO3	Design simple computational systems using target Microcontrollers	**K3**
CO4	Design and implement systems with peripheral control using target Microcontrollers	**K5**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO- PO Mapping (Mapping of Course Outcomes with Program Outcomes)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	3	3				3	3		3
CO2	3	3	3	3	3				3	3		3
CO3	3	3	3	3	3				3	3		3
CO4	3	3	3	3	3				3	3		3

1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	"The 8051 Microcontroller"	Kenneth J Ayala	Cengage Learning,	Third edition
2	"Design with PIC microcontrollers"	John B. Peatman	Pearson Education	ISBN: 978-81-7758-551-3
3	"Arduino Programming: Step-by-Step Guide to Master Arduino Hardware and Software",	Mark Torvalds	Kindle Edition	2nd edition, ISBN-13: 978-1976097713.

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	The 8051 Microcontroller and Embedded Systems using Assembly and C,	Muhammed Ali Mazidi and Janice GillispieMazidi	Pearson Education	2002
2	PIC micro MCU - An introduction to programming the Microchip PIC in CCS C	Nigel Gardner	Bluebird Electronics	2002 (e book)

Continuous Assessment (25 Marks)

1. **Preparation and Pre-Lab Work (7 Marks)**

    - Pre-Lab Assignments: Assessment of pre-lab assignments or quizzes that test understanding of the upcoming experiment.
    - Understanding of Theory: Evaluation based on students' preparation and understanding of the theoretical background related to the experiments.

2. **Conduct of Experiments (7 Marks)**

    - Procedure and Execution: Adherence to correct procedures, accurate execution of experiments, and following safety protocols.
    - Skill Proficiency: Proficiency in handling equipment, accuracy in observations, and troubleshooting skills during the experiments.
    - Teamwork: Collaboration and participation in group experiments.

3. **Lab Reports and Record Keeping (6 Marks)**

    - Quality of Reports: Clarity, completeness and accuracy of lab reports. Proper documentation of experiments, data analysis and conclusions.
    - Timely Submission: Adhering to deadlines for submitting lab reports/rough record and maintaining a well-organized fair record.

4. **Viva Voce (5 Marks)**

   - Oral Examination: Ability to explain the experiment, results and underlying principles during a viva voce session.

Final Marks Averaging: The final marks for preparation, conduct of experiments, viva, and record are the average of all the specified experiments in the syllabus.

Evaluation Pattern for End Semester Examination (50 Marks)

1. **Procedure/Preliminary Work/Design/Algorithm (10 Marks)**

   - Procedure Understanding and Description: Clarity in explaining the procedure and understanding each step involved.
   - Preliminary Work and Planning: Thoroughness in planning and organizing materials/equipment.
   - Algorithm Development: Correctness and efficiency of the algorithm related to the experiment.
   - Creativity and logic in algorithm or experimental design.

2. **Conduct of Experiment/Execution of Work/Programming (15 Marks)**

   - Setup and Execution: Proper setup and accurate execution of the experiment or programming task.

3. **Result with Valid Inference/Quality of Output (10 Marks)**

   - Accuracy of Results: Precision and correctness of the obtained results.
   - Analysis and Interpretation: Validity of inferences drawn from the experiment or quality of program output.

4. **Viva Voce (10 Marks)**

   - Ability to explain the experiment, procedure results and answer related questions
   - Proficiency in answering questions related to theoretical and practical aspects of the subject.

5. **Record (5 Marks)**

   - Completeness, clarity, and accuracy of the lab record submitted.

SEMESTER S4

BIOMEDICAL ELECTRONICS LAB

Course Code	**PCBML408**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	0:0:3:0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Basic Knowledge of Electronic components required	**Course Type**	PCL

Course Objectives:

1. Acquire comprehensive knowledge and practical skills in designing and implementing biomedical signal processing techniques
2. Gain proficiency in using and characterizing biomedical sensors and integrated circuits

Expt. No.	Experiments
1	Bioamplifier
2	Notch Filter
3	Phase Detector
4	VCO using 565
5	Flash ADC
6	R2R Ladder DAC
7	Threshold Detector
8	Thermistor Characteristics
9	PLL using 4046
10	V to F, F to V converters
11	Skin contact impedance measurement
12	LDR Characteristics
13	Design of pacemaker circuit and characteristics

14	Study of IC 4051 and its applications
15	Study of medical equipment 1. ECG Machine 2. Sphygmomanometer 3. Patient Monitor

* A minimum of 12 experiments is to be completed.

Course Assessment Method
(CIE: 50 marks, ESE: 50 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Preparation/Pre-Lab Work experiments, Viva and Timely completion of Lab Reports / Record (Continuous Assessment)	Internal Examination	Total
5	25	20	50

End Semester Examination Marks (ESE):

Procedure/ Preparatory work/Design/ Algorithm	Conduct of experiment/ Execution of work/ troubleshooting/ Programming	Result with valid inference/ Quality of Output	Viva voce	Record	Total
10	15	10	10	5	50

- ***Submission of Record: Students shall be allowed for the end semester examination only upon submitting the duly certified record.***
- ***Endorsement by External Examiner:*** *The external examiner shall endorse the record*

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Design of Op-Amp based electronic Circuits for Biomedical Applications	**K2**
CO2	Design circuits using transducers for biomedical applications	**K3**
CO3	Identify basic biomedical instruments and their working	**K3**
CO4	Troubleshooting of biomedical circuits after assembly	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO- PO Mapping (Mapping of Course Outcomes with Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3					3	3	3		2
CO2	3	1	3						3	3		
CO3	3							3	3	3		2
CO4	3	1	3						3	3		3

1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Electronics Lab Manual Volume 2	K A Navas	College Books (Higher Education Textbooks	
2	Linear Integrated Circuits	D.Roy Chowdary	New age	6th

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Electronic Devices & Circuit Theory	Boylestead&Neshelsky	Prentice Hall of India.	2003
2	Electronic Devices & Circuits	Millman&Halkias	Tata McGraw Hill, New Delhi	1996
3	Op-Amp and Linear Integrated Circuits	Ramakant A. Gayakwad	Pearson Education Asia.	4thed.

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://youtu.be/VKK_xafQME4?si=dl43_lOWMCI0rK8K
2	https://youtu.be/kMGap-0XwGs?si=CnlMjjP7jySBLbFq
3	https://youtu.be/2I7aKFBWzGE?si=LJ2GVROFVTSQeTXw
4	https://youtu.be/jL9L8Pd5HDM?si=wE7Y1beXhmLsitBJ

Continuous Assessment (25 Marks)

1. **Preparation and Pre-Lab Work (7 Marks)**
   - Pre-Lab Assignments: Assessment of pre-lab assignments or quizzes that test understanding of the upcoming experiment.
   - Understanding of Theory: Evaluation based on students' preparation and understanding of the theoretical background related to the experiments.

2. **Conduct of Experiments (7 Marks)**
   - Procedure and Execution: Adherence to correct procedures, accurate execution of experiments, and following safety protocols.
   - Skill Proficiency: Proficiency in handling equipment, accuracy in observations, and troubleshooting skills during the experiments.
   - Teamwork: Collaboration and participation in group experiments.
3. **Lab Reports and Record Keeping (6 Marks)**
   - Quality of Reports: Clarity, completeness and accuracy of lab reports. Proper documentation of experiments, data analysis and conclusions.
   - Timely Submission: Adhering to deadlines for submitting lab reports/rough record and maintaining a well-organized fair record.

4. **Viva Voce (5 Marks)**
   - Oral Examination: Ability to explain the experiment, results and underlying principles during a viva voce session.

Final Marks Averaging: The final marks for preparation, conduct of experiments, viva, and record are the average of all the specified experiments in the syllabus.

Evaluation Pattern for End Semester Examination (50 Marks)

1. Procedure/Preliminary Work/Design/Algorithm (10 Marks)

- Procedure Understanding and Description: Clarity in explaining the procedure and understanding each step involved.
- Preliminary Work and Planning: Thoroughness in planning and organizing materials/equipment.
- Algorithm Development: Correctness and efficiency of the algorithm related to the experiment.
- Creativity and logic in algorithm or experimental design.

2. **Conduct of Experiment/Execution of Work/Programming (15 Marks)**

- Setup and Execution: Proper setup and accurate execution of the experiment or programming task.

3. Result with Valid Inference/Quality of Output (10 Marks)

- Accuracy of Results: Precision and correctness of the obtained results.
- Analysis and Interpretation: Validity of inferences drawn from the experiment or quality of program output.

4. Viva Voce (10 Marks)

- Ability to explain the experiment, procedure results and answer related questions
- Proficiency in answering questions related to theoretical and practical aspects of the subject.

5. Record (5 Marks)

- Completeness, clarity, and accuracy of the lab record submitted

SEMESTER 5

BIOMEDICAL ENGINEERING

SEMESTER S5

BIOMEDICAL SIGNAL PROCESSING

Course Code	PCBMT501	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:1:0:0	ESE Marks	60
Credits	4	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	PC

Course Objectives:

1. To enable the students to learn about widely used signal processing techniques, emphasizing biomedical applications.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Signals and Signal Processing-** Characterization and Classification of Signals- Elementary Signals , Typical signal Processing Operations, Examples of Biomedical Signals , Analog-to-Digital Conversion (block diagram only) **Discrete-Time Signals** –Typical Sequences and Sequence-Representation, Discrete-Time Systems-Classification of Discrete-Time Systems	11
2	**Discrete-Time Fourier Transform (DTFT**)-Definition, Properties **Discrete Fourier Transform (DFT)-**Definition, Properties **Fast Fourier Transform (FFT)-**Decimation-in-Time, Decimation-in-Frequency. **z Transform-** Properties of the z-Transform, Poles and Zeros, Inversion of the z-Transform Using partial fraction expansion, Analysis of Linear Time-Invariant Systems in the z-Domain, Transfer function, Frequency response	11
3	**LTI systems as frequency selective filters-** Ideal filter characteristics, Simple Digital Filter Design-Preliminary Considerations, Design of linear-phase FIR Filter using windows (Bartlett) and frequency sampling method **IIR Filter Design-** Approximation of Derivatives, Impulse invariance, Bilinear Transform Method, Analog filter approximation -Butterworth approximation, Frequency Transformations (Analog and Digital domain)	11

4	**Periodogram-** Averaged periodogram, QRS detection in ECG, Analysis of Heart Rate Variability using periodogram **Adaptive Filters-** Principle of Wiener Filters, Principle of adaptive filtering, Principle of adaptive noise cancellation, Cancellation of 50-Hz interference in ECG	**11**

Course Assessment Method
(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Demonstrate the fundamentals of discrete-time signals and systems.	**K2**
CO2	Apply domain transformation techniques in discrete-time signals.	**K4**
CO3	Design digital filters and apply the concepts in biomedical scenarios.	**K4**
CO4	Apply different power spectrum estimation and noise cancellation techniques for biomedical applications.	**K4**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3							2		2
CO2	3	3	3	3	3					2		2
CO3	3	3	3	3	3					2		3
CO4	3	3	3	3	3					2		3

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Biomedical signal processing: principles and techniques	Reddy, D. C.	McGraw-Hill	2005
2	Digital Signal Processing Principles, Algorithms and Applications	John G Proakis& Dimitris G Manolakis	Prentice Hall of India	2005
3	Biomedical signal processing	Akay Metin.	Academic press	2012
4	Biomedical digital signal processing	Tompkins Willis J.	Editorial Prentice Hall	1993
5	"Digital signal processing (Book, 598 p)." Research supported by the Massachusetts Institute of Technology, Bell Telephone Laboratories, and Guggenheim Foundation	Oppenheim Alan V Ronald W. Schafer.	Englewood Cliffs, N. J., Prentice-Hall, Inc	1975
6	Biomedical signal processing: principles and techniques	Reddy, D. C.	McGraw-Hill	2005
7	Digital Signal Processing Principles, Algorithms and Applications	John G Proakis& Dimitris G Manolakis	Prentice Hall of India	2005

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Digital signal processing: a computer-based approach. Vol. 2	Mitra, Sanjit Kumar YonghongKuo	New York: McGraw-Hill	2006
2	Signals and systems for bioengineers: a MATLAB-based introduction	John Semmlow	Academic Press	2011
3	Biomedical Signal Analysis	Rangaraj M Rangayyan	John Wiley	2002

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/108/104/108104100/
2	https://nptel.ac.in/courses/117102060
3	https://nptel.ac.in/courses/117102060

SEMESTER S 5

THERAPEUTIC EQUIPMENTS

Course Code	**PCBMT502**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	4-0-0-0	**ESE Marks**	60
Credits	4	**Exam Hours**	2 Hrs.30 Min.
Prerequisites (if any)	PBBMT304, PCBMT403	**Course Type**	PC

Course Objectives:

1. To understand the principles and working mechanisms of various therapeutic equipment used in medical practice
2. To study the design and development of therapeutic devices.
3. To explore the clinical applications and safety considerations of therapeutic equipment.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Fundamentals of Therapeutic Equipments**:**Introduction to Therapeutic Equipment-**Definition and classification-Historical development and evolution-Regulatory standards and safety guidelines; **Electrical Stimulation Devices-**Principles of electrical stimulation-Types of stimulators: TENS, FES, and EMS-Applications in pain management, muscle rehabilitation, and neurological disorders-Design and safety considerations	**11**
2	**Cardiopulmonary and Renal Therapeutic Equipments:Cardiac Therapy Equipment-**Pacemakers: Types, working principles, and implantation techniques- Defibrillators: External and implantable, mechanisms of defibrillation- Cardiac resynchronization therapy (CRT) devices-monitoring and maintenance of cardiac devices; **Respiratory Therapy Devices-**Mechanical ventilators: Types, modes of operation, and patient interfaces-CPAP and BiPAP machines: Principles and clinical applications-Nebulizers	**11**

	and humidifiers ; **Renal Therapy Equipment:** Hemodialysis machines: Working principles, components, and operation-Peritoneal dialysis: Techniques and equipment-Continuous renal replacement therapy (CRRT) devices.	
3	**Physiotherapy, Rehabilitation, and Radiotherapy Equipment**: **Physiotherapy and Rehabilitation Equipment:** Therapeutic ultrasound: Mechanism and clinical applications-Laser therapy devices: Types and therapeutic uses-Electromagnetic therapy: Principles and equipment-Robotic rehabilitation devices and exoskeletons; **Radiotherapy Equipment-** Principles of radiotherapy and types of radiation-Linear accelerators: Design and function-Brachytherapy: Techniques and equipment-Safety protocols and radiation protection.	**11**
4	**Surgical Equipment and Emerging Technologies: Surgical Therapeutic Equipment-**Electrosurgical units: Types and applications-Laser surgical systems: Principles and uses-Ultrasonic surgical devices-Safety and efficacy in surgical environments; **Emerging Therapeutic Technologies-** Nanotechnology in therapy: Devices and applications-Gene therapy delivery systems-Bioelectronic medicine and neural interfaces-Innovations in personalized and precision medicine	**11**

Course Assessment Method
(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
● 2 Questions from each module. ● Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	● Each question carries 9 marks. ● Two questions will be given from each module, out of which 1 question should be answered. ● Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Explain the fundamental principles and classifications of therapeutic devices.	Understand
CO2	Design and analyse therapeutic devices considering both technical specifications and clinical requirements.	Analyze
CO3	Demonstrate effective application and operation of therapeutic equipment.	Apply
CO4	Understand safety standards, regulations, and ethical considerations.	Understand
CO5	Get familiarised with the latest advancements and emerging technologies in therapeutic equipment.	Understand

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			1	1							2
CO2	3	3	2	1	1	2						2
CO3	3	1	1	1	2	2						2
CO4	3			3	1	1						2
CO5	3	1	1	1	2	3						2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Medical instrumentation: application and design	Webster, John G., ed.	John Wiley & Sons	2009
2	Joseph J. Carr, John M. Brown	Introduction to Biomedical Equipment Technology,	Pearson Education (Singapore) Pvt. Ltd.	2001
3	Principles of biomedical engineering	Sundararajan V. Madihally	Boston: Artech House	2010
4	Handbook of biomedical instrumentation.	Khandpur, Raghbir Singh.	McGraw-Hill Education	2004

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Introduction to Biomedical Equipment Technology	Joseph J. Carr, John M. Brown	Pearson Education (Singapore) Pvt. Ltd.	2001
2	Principles of Applied Biomedical Instrumentation	Gddes & Baker	CRC Press	1995
3	Medical Ventilator System Basics: A Clinical Guide	Lei, Yuan.	Oxford University Press	2017
4	Handbook of medical technology.	Kramme, Rüdiger, Klaus-Peter Hoffmann, and Robert Steven Pozos, eds.	Springer Science & Business Media	2011

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	Drug Delivery: Principles and Engineering - Course (nptel.ac.in) (https://onlinecourses.nptel.ac.in/noc19_bt23/preview)
2	https://onlinecourses.nptel.ac.in/noc19_bt23/preview

SEMESTER S5

MEDICAL IMAGING TECHNIQUES

Course Code	**PCBMT503**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	PC

Course Objectives:

1. To learn about medical and biological imaging techniques

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Diagnostic Ultrasound Imaging:** Ultrasound interaction with tissue (Basics only) – Ultrasound waves and propagation, attenuation, reflection, scattering, refraction. Pulsed ultrasound and imaging - Pulsed ultrasound, pulse echo principle, Principles of image formation, A-mode, B-mode & M-mode scanning. Transducer principle, Ultrasound instrumentation – block diagram, Image artifacts, Doppler ultrasound & Colour Doppler	9
2	**Magnetic Resonance Imaging:** Basic principles of magnetic resonance – magnetic moment, FID, excitation and emission - principles of image formation, MRI instrumentation – magnets, gradient system, shim system, RF system, console & MRI suit, MRI Pulse Sequences types (Basics only), Selective Applications of MRI for the Brain - Functional MRI (fMRI), MR Angiography, Diffusion MRI, MRI Fourier Reconstruction	9

3	**Computed Tomography:** Basics of X-ray - Properties & production – X-ray tube – Fixed anode type and rotating anode type, Principles of sectional imaging, generations of CT, spiral & multi slice CT, detectors used in CT, data acquisition system, conversion of x-ray data into scan image, 2D image reconstruction techniques - Iteration and Fourier methods	9
4	**Nuclear Imaging:** Concept of nuclear imaging, radiation detectors, Gamma camera, Emission computed tomography - SPECT & PET **Hybrid Imaging** - MR-PET Instrumentation MR-PET system architecture **Infrared Imaging** – Basic principle of thermal imaging, Physics of thermography – IR detectors **Principles of Tactile Imaging and Photoacoustic Imaging**	9

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand the principle and instrumentation of diagnostic Ultrasound imaging	**K2**
CO2	Apply the principles of Nuclear Magnetic Resonance in medical imaging	**K3**
CO3	Explain the imaging methods used in Computed tomography	**K3**
CO4	Elucidate the concepts of multimodal imaging	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1			1			1	1		2
CO2	3	2	1			1			1	1		2
CO3	3	2	1			1			1	1		2
CO4	3	2	1			1			1	1		2
CO5	3	2	1			1			1	1		2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	The Physics and Technology of Diagnostic Ultrasound	Dr Robert Gill	National library of Australia	2nd Edition 2020
2	Diagnostic ultrasound Physics and Equipment	Hoskins, Peter R , Kevin Martin , Abigail Thrush	CRC Press	2019
3	MRI Basic Principles and Applications	Mark A Brown Richard C Semelka	Wiley-Liss Publication	3rd Edition 2003
4	Webb's Physics of Medical Imaging	M Flower	Taylor & Francis	2016
5	Computed Tomography-E-Book: Physical Principles, Clinical Applications, and Quality Control	Seeram, Euclid	Elsevier Health Sciences	2015
6	Handbook of Biomedical Instrumentation	R. S. Khandpur	Tata Mac Graw-Hill	3rd Edition 2014

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Nuclear Medicine Textbook, Methodology and Clinical Applications	Duccio Volterrani, Paola Anna Erba, Ignasi Carrio, H. William Strauss, Giuliano Mariani	Springer	2019
2	Ultrasound imaging and therapy	Fenster, Aaron, James C. Lacefield	Taylor & Francis	2015
3	MRI Made easy	Hans H Schild	Berlex Laboratories	2012
4	Principles of Computerized Tomographic Imaging	Avinashi C Kak, Malcolm Slaney	Purdue University	2001

Video Links (NPTEL, SWAYAM…)	
Sl No	**Link ID**
1	https://archive.nptel.ac.in/courses/108/105/108105091/
2	https://onlinecourses.nptel.ac.in/noc21_bt50/preview
3	http://acl.digimat.in/nptel/courses/video/104101137/L39.html

SEMESTER S5

ANALYTICAL AND DIAGNOSTIC EQUIPMENT

Course Code	**PBBMT504**	**CIE Marks**	60
Teaching Hours/Week (L: T:P: R)	3:0:0:1	**ESE Marks**	40
Credits	4	**Exam Hours**	2 Hrs.30 Min.
Prerequisites (if any)	Nil	**Course Type**	PC-PBL

Course Objectives:

1. **Understanding Fundamental Concepts**: Aim to guide advancements in medical equipment and analytical techniques, focusing on improving healthcare outcomes through enhanced diagnostic capabilities, efficiency, and reliability.
2. **Design and Development Skills**: Develop skills in designing analytical & diagnostic equipments and also biomedical recorders & monitors, focusing on material selection, fabrication techniques, and integration with electronic systems.
3. **Hands-On Experience**: Gain practical experience through laboratory work and projects, involving the assembly and testing of analytical & diagnostic equipments and also biomedical recorders & monitors.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to medical equipment, Analytical equipment used in the clinical environment .Beer-Lambert's Law-Deviation, Colorimeters-Single beam & Double beam instruments. UV &Visible spectroscopy: Instrumentation (sources, Monochromators, detectors). Clinical flame photometer-emission system, optical system, recording system, schematic diagram. Lab On a Chip (LOC) biochemical sensor, glucometer, Pulse Oximeter- Instrumentation. Point of Care Test equipment (POCT)	9
2	Automated clinical analyzers-Semi & Automated. Antibody based analytical techniques-Radioimmunoassay (RIA) -Enzyme Linked Immuno Sorbent Assay (ELISA/CLIA)-Applications. Immunoprecipitation-Immunofluorescence- Polymerase Chain Reaction (PCR)- RT-PCR	9

	instrumentation. Chromatography – Gas-high-pressure liquid and paper chromatography - principle and applications. Flow Cytometry-Block Diagram-Applications, Blood cell counters-Coulter Counters.	
3	Phonocardiograph–Instrumentation. Patient monitoring systems -ECG-NIBP-PPG-Temperature. Cardiac stress testing, Arrhythmia monitors-Block Diagram, Ambulatory recorders-Holter monitors. Sleep studies-Polysomnography, Sleep apnea monitors. Impedance Techniques: detection of physiological activities using impedance techniques - respiratory activity-Impedance Cardiography- Impedance Plethysmography.	**9**
4	Audiometers – pure tone, speech audiometers and impedance audiometry. Cardiac output measurement- Fick method Dilution Methods-Doppler method. Spirometry – Basic system and applications- Pulmonary function measurements. Blood flow meters - Electromagnetic – Ultrasonic sonic blood flow meters-NMR blood flow meter-Laser blood flow meter. Introduction to wearable health monitors.	**9**

Suggestion on Project Topics

Students will work in teams to design analytical or diagnostic equipment and or any biomedical recorders & monitors, document their process, and present their project to the class.

1. Students select a specific topic on any analytical or diagnostic equipment or any biomedical recorders & monitors.
2. Literature review and presentation on a selected topic.
3. Analyze and present the working principles, characteristics, and application considerations of the selected topic.
4. Design, develop and test the specified project, based on the knowledge and skills acquired throughout the course.

Course Assessment Method
(CIE: 60 marks, ESE: 40 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Project	Internal Ex-1	Internal Ex-2	Total
5	30	12.5	12.5	60

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
● 2 Questions from each module. ● Total of 8 Questions, each carrying 2 marks **(8x2 =16 marks)**	2 questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of 2 sub divisions. Each question carries 6 marks. **(4x6 = 24 marks)**	**40**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Familiarize the instrumentation of various analytical equipments used in clinical laboratory.	**K1**
CO2	Recognize the principle and applications of biochemistry equipment used in clinical environment	**K3**
CO3	Analyze the working of diagnostic equipments for cardiac parameter measurements, impedance measurement concepts and related measurements.	**K2**
CO4	Interpret the principles related to respiratory, blood flow and audiometric measurements.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	2	2							2		2
CO2	3	2	2							2		2
CO3	3	2	2							2		2
CO4	3	2	2							2		2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Handbook of Bio-Medical Instrumentation	Khandpur R S	Tata McGraw Hill	2nd Ed, 2003
2	Analytical Techniques in Biochemistry	Basha, Mahin	Humana Press	2020
3	"Technology in Medicine: Its Role and Significance in Terms of Health Policy."	Kramme, Rüdiger, and Heike Kramme	In Springer Handbook of Medical Technology, pp. 3-6. Springer, Berlin, Heidelberg	2011
4	Principles of biomedical instrumentation.	Webb, Andrew G	Cambridge University Press	2018
5	Biomedical device technology: principles and design	Chan, Anthony YK	Charles C Thomas Publisher	2016
6	Principles of Instrumental Analysis	Skoog A Dogulas, F. James Holler, Stanley R Crouch		6th Edition, 2014

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Elements of electronic instrumentation and measurement.	Carr, Joseph J	Pearson College Division,	1996
2	Medical instrumentation: application and design.	Webster, John G., ed.	John Wiley & Sons	2009

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/104105084
2	https://nptel.ac.in/courses/104105084
3	https://nptel.ac.in/courses/104105084
4	https://nptel.ac.in/courses/104105084

PBL Course Elements

L: Lecture (3 Hrs.)	R: Project (1 Hr.), 2 Faculty Members		
	Tutorial	**Practical**	**Presentation**
Lecture delivery	Project identification	Simulation/ Laboratory Work/ Workshops	Presentation (Progress and Final Presentations)
Group discussion	Project Analysis	Data Collection	Evaluation
Question answer Sessions/ Brainstorming Sessions	Analytical thinking and self-learning	Testing	Project Milestone Reviews, Feedback, Project reformation (If required)
Guest Speakers (Industry Experts)	Case Study/ Field Survey Report	Prototyping	Poster Presentation/ Video Presentation: Students present their results in a 2 to 5 minutes video

Assessment and Evaluation for Project Activity

Sl. No	Evaluation for	Allotted Marks
1	Project Planning and Proposal	5
2	Contribution in Progress Presentations and Question Answer Sessions	4
3	Involvement in the project work and Team Work	3
4	Execution and Implementation	10
5	Final Presentations	5
6	Project Quality, Innovation and Creativity	3
Total		**30**

1. **Project Planning and Proposal (5 Marks)**
    - Clarity and feasibility of the project plan
    - Research and background understanding
    - Defined objectives and methodology

2. **Contribution in Progress Presentation and Question Answer Sessions (4 Marks)**

   - Individual contribution to the presentation
   - Effectiveness in answering questions and handling feedback

3. **Involvement in the Project Work and Team Work (3 Marks)**

   - Active participation and individual contribution
   - Teamwork and collaboration

4. **Execution and Implementation (10 Marks)**

   - Adherence to the project timeline and milestones
   - Application of theoretical knowledge and problem-solving
   - Final Result

5. **Final Presentation (5 Marks)**

   - Quality and clarity of the overall presentation
   - Individual contribution to the presentation
   - Effectiveness in answering questions

6. **Project Quality, Innovation, and Creativity (3 Marks)**

   - Overall quality and technical excellence of the project
   - Innovation and originality in the project

   Creativity in solutions and approaches

SEMESTER S5

CONTROL SYSTEMS ENGINEERING

Course Code	**PEBMT521**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	2:1:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Basic skill in applying Laplace transform	**Course Type**	PE

Course Objectives: The main objectives of the course are:

1. Understand the fundamental concepts of control systems and their applications in biomedical engineering.
2. Mathematical modelling of simple electrical and mechanical systems.
3. Analyse system behaviour and stability in time domain and frequency domain.
4. Represent systems in state-space form and understand the relationship between state-space and transfer function models

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to Control System** – Concepts of control system- Applications, Examples (including physiological control systems), Open loop and closed loop control systems, Control system design process. Review of Laplace Transforms, Transfer function, **Mathematical modelling** of simple electrical and mechanical systems. Block diagram reduction, Signal flow graphs-Mason's Gain Formula.	9
2	**Time domain analysis-** Standard test signals, Transient and steady state response, time response of first order system, Time domain specifications, step response of second order systems, Steady state error and static error coefficients. Concept of stability, Effect of location of poles on stability.	9
3	**Stability Analysis in s-Domain**: Routh-Hurwitz's stability criterion, Root locus -construction of root locus **Frequency domain analysis-**Frequency domain specifications, Stability in	9

	Frequency Domain: Frequency response plots: Polar plots, Bode plots - determination of Phase margin and Gain margin, minimum phase and non-minimum phase systems.	
4	**State space modelling** – Concepts of state, state variables, state space and state model, State space representation of nth order differential equation, State model of simple mechanical and electrical systems, State-Space representation of Transfer Function, Transfer function from state model, **State transition matrix**-properties of state transition matrix, computation of state transition matrix using Laplace method, Controllability and Observability.	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Represent control systems in s domain and analyse it.	**K2**
CO2	Apply time domain analysis to investigate transient and steady state performance of a system.	**K3**
CO3	Analyse the nature of stability of a system by employing different types of frequency domain techniques.	**K3**
CO4	Illustrate state space models of mechanical and electrical systems.	**K3**
CO5	Compute state transition matrix and analyse the controllability & observability of systems.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2										1
CO2	3	2			2							1
CO3	3	2			2							2
CO4	3	2										1
CO5	3	2										1

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Control Systems Engineering	Nagarath, I.J. and Gopal, M	New Age International Publishers	2017
2	Control Systems Engineering	Nagoor Kani	CBS Publishers & Distributors Pvt. Ltd	5/e, 2020
3	Automatic Control Systems	S. Hasan Saeed	KATSON BOOKS	2018
4	Linear Control Systems with MATLAB Applications	B.S. Manke	Khanna Publishers	13/e, 2019
5	Control System: Principle and design	M. Gopal	McGraw Hill Education India Education	4/e, 2012

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Modern Control Engineering	Katsuhiko Ogata	Pearson	6/e,2015
2	Modern Control Systems	Richard C. Dorf and Bishop, R.H.	Pearson Education	2009.
3	Control Systems Theory and Applications	S. K Bhattacharya	Pearson	

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/107/106/107106081
2	https://archive.nptel.ac.in/courses/108/106/108106098
3	https://nptel.ac.in/courses/108102043

SEMESTER S5

BIOMEDICAL OPTICS & BIOPHOTONICS

Course Code	**PEBMT 522**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	PE

Course Objectives:

1. To know the different applications of lasers in medical field.
2. To understand the working principles of different lasers used in medicine.
3. To learn the optical properties of tissue and the opto-thermal interaction of the tissue.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Basic optics: polarized waves-linear, circular and elliptical, propagation of a light wave through a quarter wave plate, reflection at a plane interface, two beam interference, concept of coherence. Basic characteristics of optical fibres: numerical aperture, coherent bundle, attenuation in optical fibres, pulse dispersion in step index optical fibres, loss mechanisms: absorptive losses, radiative losses.	**9**
2	Introduction to Lasers: principle, construction and classification of Lasers - Nd-YAG. Fibre optics and Medical Applications - Endoscopic imaging: formation, resolution, signal to noise ratio – Optical coherence tomography. Minimally Invasive cardio-vascular technologies- Angioplasty, Stents, Aneurysm treatment, Embolic filters, Cardiac ablation catheters.	**9**

3	Optical Micromanipulation tools: Laser tweezer and Laser scissor: principle of working. Applications- Manipulation of single DNA molecules, molecular motors, protein-protein interaction. Biosensor- an introduction, Fiber - Optic biosensors, Planar waveguide biosensors, Evanescent wave biosensors, Interferometric biosensors, Surface plasmon resonance biosensors. Photobiology: Interaction of light with tissues–Optical biopsy- Tissue Engineering and light activation: Laser tissue contouring and restructuring, Laser tissue welding, and regeneration.	**9**
4	Thermal therapy- mechanism, Image guided thermal therapy: device placement, thermometry, assessment of thermal damage. Photodynamic therapy - basic principle, mechanism of photodynamic action, applications. Light irradiation for photodynamic therapy: laser source, laser dosimetry, light delivery. Interface of nanotechnology and photonics, Biomaterials for Photonics – an introduction.	**9**

Course Assessment Method
(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
● 2 Questions from each module. ● Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	● Each question carries 9 marks. ● Two questions will be given from each module, out of which 1 question should be answered. ● Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Get an exposure to the basics of optics and characteristics of optical fibre.	**K1**
CO2	Understand the importance of fibre optics in medical applications.	**K2**
CO3	Acquire the knowledge on micromanipulation tools and biosensor.	**K3**
CO4	Evaluate the interaction of light with tissues and mechanism of thermal therapy.	**K5**
CO5	Introduce the therapeutic applications of laser in medical field.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2							2		2
CO2	3	2	2							2		2
CO3	3	2	2							2		2
CO4	3	2	2							2		2
CO5	3	2	2							2		2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Fiber Optics	Ghattak & Thyagarajan	Cambridge University Press	1989
2	Introduction to Biomedical Photonics	Paras N Prasad	John Wiley	2003
3	BIOMEDICAL TECHNOLOGY and DEVICES HANDBOOK	James Moore and George Zouridakis	CRC Press	

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Biomechatronics in Medicine and Health Care	Raymond K. Y. Tong	Pan Stanford Publishing Pvt. Ltd.	
2	Biomedical Photonics Handbook	Taun Vo-Dinh	CRC Press	
3	Biomedical Engineering and Design Handbook	Myer Kutz	McGraw Hill	Vol 2
4	Advances in Biomedical Engineering	Pascal Verdonck	Elsevier	
5	Biomedical Applications of Light Scattering	Adam Wax and VadimBackman	McGraw Hill	

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/108106135
2	https://nptel.ac.in/courses/108106135
3	https://nptel.ac.in/courses/112103312

SEMESTER S5

RADIOLOGICAL EQUIPMENTS

Course Code	**PEBMT 523**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs.30 Min.
Prerequisites (if any)	Basic knowledge of medical physics and medical imaging techniques	**Course Type**	PE

Course Objectives:

1. To provides an in-depth understanding of various radiological equipment used in medical imaging and therapy.
2. To cover the principles, design, operation, and applications of various imaging modalities and radiotherapy machines.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to Radiological Equipment** Overview of radiological equipment- Historical development of radiological devices- Basic principles of medical imaging and radiotherapy- Regulatory standards and guidelines. Review of contemporary imaging modalities (X-Ray, CT, MRI,ultrasound Nuclear medicineand PET)	**9**
2	**Radiotheraphy Equipment** Linear accelerators (LINAC) and their components-Cobalt-60 teletherapy units- Brachytherapy sources and applicators- Gamma Knife- Cyber Knife-Proton therapy and heavy ion therapy systems-Clinical applications and quality assurance in radiotherapy	**9**
3	**Advanced Imaging Techniques** Dual-energy X-ray absorptiometry (DEXA)-Mammography and breast imaging systems-Interventional radiology equipment-Hybrid imaging systems (PET/CT, SPECT/CT, PET/MRI).	**9**

	Emerging Technologies in Radiotherapy Adaptive radiotherapy-Stereotactic radiosurgery (SRS) and stereotactic body radiotherapy (SBRT)-Image-guided radiotherapy (IGRT)-Intraoperative radiotherapy (IORT)-Future trends and research in radiotherapy equipment	
4	**Radiation Protection and Safety** Principles of radiation protection- Radiation protection in radiotherapy-Radiation measuring instruments-Dosimeter, film Badges, Thermo Luminescent dosimeters- electronic dosimeter.Regulatory requirements and guidelines-Quality assurance and control in radiotherapy-Maintenance and calibration of radiotherapy equipment	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/Microproject	Internal examination-1 (Written)	Internal examination-2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE):

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	2 questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of 3 sub divisions. Each question carries 9 marks. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Describe the basic principles of medical imaging and radiotherapy.	**K1**
CO2	Explain the radiation therapy techniques, equipment, and quality assurance measures.	**K2**
CO3	Discuss a variety of advanced imaging techniques and emerging technologies in the field of radiotherapy.	**K2**
CO4	Explain the regulatory aspects and protection measures of radiation safety and the utilization of radiology information systems in healthcare environments.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping od Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3					2						1
CO2	3	2		2		2						2
CO3	3		2		2	2						1
CO4	3					2		2				2
CO5	3					2						1

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Radiation Therapy Physics	Faiz M. Khan and John P. Gibbons	Wolters Kluwer Health	2014
2	Radiologic Science for Technologists: Physics, Biology, and Protection	Stewart C. Bushong	Elsevier	11th edition, 2017
3	Physics for Diagnostic Radiology	Philip Palin Dendy and Brian Heaton	Crc press	3rd Edition,2011
4	Principles and Practice of Radiation Therapy	Charles M. Washington and Dennis T. Leaver	Elsevier Health Sciences	2015
5	Fundamentals of Diagnostic Radiology,	Jeffrey S Klein, William E Brant, Clyde A Helms, Emily N Vinson	Wolters Kluwer	Fifth Edition,2019.

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Handbook of radiotherapy physics: theory and practice	P Mayles, A Nahum, JC Rosenwald	CRC Press	2007
2	Introduction to Radiologic and Imaging Sciences and Patient Care	Arlene Adler, Richard Carlton	Elsevier	Seventh Edition, 2019
3	Radiation Detectors for Medical Imaging,	Jan S Iwanczyk	CRC Press Taylor & Francis Group	1st Edition,2016

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc21_bt50/preview

SEMESTER S5

IMPLANTS AND PROSTHETIC ENGINEERING

Course Code	**PEBMT 524**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3-0-0-0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	NONE	**Course Type**	PE

Course Objectives:

1. This course gives an overview of various types of prostheses with specific emphasis on visual and auditory implants and neural prostheses.
2. To illustrate the technical design characteristics of the main components that go into forming a smart prosthetic arm for adults.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Microelectronic visual implant technologies: Retinal stimulation and retinal implant - Epiretinal, Subretinal and Extraocular implants, Visual stimulation in the brain, Optic Nerve Stimulation, Engineering challenges in the development of visual prostheses, Stimulation microelectrode arrays - types and electrode materials, optic nerve stimulation using penetrating microelectrode arrays, Neural electrical stimulator, DSP-based image processing system for visual prostheses.	9
2	Modern Cochlear Implant: System Review - Architecture and functional block diagram of a modern cochlear implants, External unit, RF link, Internal unit, Electrodes, Safety Considerations, Auditory Prosthesis Using Deep Brain Stimulation: Development and Implementation – Design considerations, approaches for implementation, Electrode technologies, Stimulation strategies.	9

3	Signals and Signal Processing for Myoelectric Control: Brief history of artificial hands - Origin and nature of the myoelectric signal, Anatomy, Contraction Process, Connections to the CNS, Fibre membrane and the action potential, Measurement of the potentials associated with depolarization, Spatial variation in the arrangement of motor units, Muscle force mediation, Myoelectric Signal - Acquisition, Processing, Control of prosthetic function, Terminal device electronics	**9**
4	Upper Limb Prosthetics: Pre-prosthetic Assessment, Prosthetic Options, Components for the Upper Limb Prosthesis – Hands and Work Hands (Terminal Devices), Pinch Force, Weight, Work Hands, Cosmetic/Protective Covers, Electric wrist rotation, Wrist Flexion, Electronic Controllers, proportional Versus Digital control, Elbow components, All electric alternatives control Systems, Interface designs, Indications and contraindications, Training and outcome measurement Mechatronic hands: prosthetic and robotic design Myoelectrically controlled hand - Mechanisms - Materials, actuators, Sensors - instrumentation, Control - finger position, object slip, EMG reference control, Artificial prehension, Brain control and sensing of artificial limbs.	**9**

Course Assessment Method
(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Describes state-of-the-art advances in techniques associated with implantable neural prosthetic devices and their applications	**K2, K3**
CO2	Understand the concepts of cochlear implants and auditory prosthetics.	**K2, K4**
CO3	Analyse the concept of Signals and Signal Processing for Myoelectric Control.	**K2, K3**
CO4	Design and implementation of upper limb prostheses and smart prosthetic hands	**K2, K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3		2				2		2
CO2	3	3	3	3		2				2		2
CO3	3	3	3	3		2				2		2
CO4	3	3	3	3		2				2		2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Implantable Neural Prostheses 1: Devices and Applications	David D. Zhou Elias Greenbaum	Springer	**2009**
2	Powered Upper Limb Prostheses: Control, Implementation and Clinical Application	L. McLean, R. N.Scott, Ashok Muzumdar	Springer	**2012**
3	Mechatronic Hands Prosthetic and Robotic Design	Paul H. Chappell	The Institution of Engineering and Technology	**2016**

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Orthotics And Prosthetics In Rehabilitation	Kevin Chui Milagros Jorge, Sheng-Che Yen, Michel M. Lusardi	Elsevier	Fourth Edition
2	Active Above-Knee Prosthesis – A Guide to a Smart Prosthetic Leg	Zlata Jelacic, Remzo Dedic, Haris Dindo	Elsevier	2020
3	Mechanics of Biomaterials Fundamental Principles for Implant Design	Lisa A. Pruitt and Ayyana M. Chakravartula	Cambridge University Press	2011

SEMESTER S5

FUNDAMENTALS OF BIOMEMS AND MICROFLUIDS

Course Code	**PEBMT 526**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3-0-0-0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	PE

Course Objectives:

1. To understand fundamentals of BioMEMS.
2. To understand the concepts of micro-systems.
3. To study various diagnostic and therapeutic applications including intelligent biochips and sensors.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Overview of MEMS and Microsystems: MEMS and microsystems, Typical MEMS and microsystem products. Materials for MEMS - active substrate materials-Silicon and its compounds, Silicon piezoresistors, Gallium Arsenide, quartz, polymers. Fabrication- Micromachining photolithography, thin film deposition, doping, etching, bulk machining, wafer bonding, LIGA.	**9**
2	Mechanical Sensors and Actuators: Mechanical sensors and actuators – beam and cantilever –microplates, strain, pressure and flow measurements Thermal sensors and actuators: actuator based on thermal expansion, thermal couples, thermal resistors. Electrostatic sensors and actuators- Inertia sensor, Pressure sensor, flow sensor. Piezoelectric sensors and actuators: Properties of piezoelectric materials, Piezoelectric sensor and actuator – inchworm motor, inertia sensor, flow sensor.	**9**

3	Microfluidic Systems: Fluid dynamics, continuity equation, momentum equation, equation of motion, laminar flow in circular conduits, fluid flow in micro conduits, in submicrometer and nanoscale. Microscale fluid, expression for liquid flow in a channel, fluid actuation methods, dielectrophoresis, microfluid dispenser, microneedle, micropumps	**9**
4	Application of BioMEMS: CAD for MEMS, Drug delivery, micro total analysis systems (MicroTAS) detection and measurement, microsystem approaches to polymerase chain reaction (PCR), MEMS based drug delivery.	**9**

Course Assessment Method
(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Analyse concept of MEMS and BioMEMS.	**K1, K2**
CO2	Describe various materials used for MEMS fabrication.	**K2, K3**
CO3	Compare different types of sensors and actuators and their principles of operation.	**K2, K3**
CO4	Analyse the concept of microfluidic systems.	**K2, K4**
CO5	Explore the application of MEMS in healthcare.	**K2, K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2							2		2
CO2	3	3	2							2		2
CO3	3	3	2							2		2
CO4	3	3	2							2		2
CO5	3	3	2							2		2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	MEMS and Microsystems Design and Manufacture	Tai Ran Hsu	Tata McGraw Hill Publishing Company, New Delhi	First edition, 2017
2	BioMEMS: Technologies and Applications	Wanjun Wang, Stephen A. Soper	CRC Press, New York	First edition, 2007
3	Fundamentals of BioMEMS and Medical Microdevices	Steven S. Saliterman	Wiley Blackwell	First edition, 2006

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	An introduction to Microelectromechanical Systems Engineering	Nadim Maluf, Kirt Williams	Artech House Inc, MA	Second edition, 2004
2	Fundamentals of Microfabrication: the Science of Miniaturization	Marc J. Madou	CRC Press	Second edition, 2002
3	Introduction to BioMEMS	Folch Albert	CRC Press	First edition. 2016
4	Electromechanics and MEMS	Thomas B. Jones	Cambridge University Press	First edition. 2013

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://www.youtube.com/watch?v=j9y0gfN9WMg&list=PL5873EDBDFB69BAD8&index=1&pp=iAQB
2	https://www.youtube.com/watch?v=9qh_7spq6sw&list=PL5873EDBDFB69BAD8&index=16&pp=iAQB
3	https://www.youtube.com/watch?v=Vb1ca8fSFxw&list=PLbMVogVj5nJTzzBpZgmCsGV6kTPrUrGdG&index=1&pp=iAQB
4	https://www.youtube.com/watch?v=tOg1ClLF2Gk

SEMESTER S5

ARTIFICIAL NEURAL NETWORKS

Course Code	**PEBMT525**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	5/3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	PE

Course Objectives:

1. To understand the key concepts of neural networks, their architecture, and learning paradigms.
2. To analyze various neural networks to solve real world problems

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to Artificial neural networks:** Biological neural networks, model of an artificial neuron, architecture, activation functions, learning methods, History of ANN- McCulloch & Pitts model- algorithm and architecture	**9**
2	**Types of networks**: Hebb network - algorithm and problems, Perceptron network, ADALINE, MADALINE, Back Propagation Network - architecture, training algorithm, Problems. Competitive network: Maxent.	**9**
3	**Associative memory networks**: Hetero associative networks, Auto associative memory networks, Discrete Hopfield nets, Bidirectional associative memory networks. Practical issues in neural network training - The Problem of Overfitting, Vanishing and exploding gradient problems, Difficulties in convergence, Local and spurious Optima, Computational Challenges	**9**
4	**Introduction to Convolutional Neural Networks** (CNN) –convolution operation,pooling, ReLU layer, structure of CNN(basic concepts only) **Recurrent Neural Networks-** (RNN) basic concept and simple architecture with practical examples, LSTM, GRU. Case studies of application of neural networks in healthcare	**9**

Course Assessment Method
(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Internal Ex	Evaluate	Analyse	Total
5	15	10	10	40

Criteria for Evaluation (Evaluate and Analyse): 20 marks

Students should evaluate and analyse neural networks for biomedical applications, assess the case and provide the most appropriate solution for the problem.

Criteria for evaluation:

1. ***Problem Definition (K4 - 5 points)***
   a. *Clearly defines the problem.*
   b. *Examine and identifies relevant factors.*
2. ***Problem Analysis (K4 - 5 points)***
   a. *Break-down and presents a well-reasoned solution approach.*
3. ***Evaluate (K5 - 5 points)***
   a. *Thoroughly evaluate the proposed solutions.*
4. ***Conclusion (K3- 3 points, K5 – 2 points)***
   a. *Summarizes findings and insights. State which solution is most appropriate for the problem*

Scoring:

1. ***Accomplished (4 points)****: Exceptional analysis, and depth of understanding.*
2. ***Competent (3 points)****: Solid performance with minor areas for improvement.*
3. ***Developing (2 points)****: Adequate effort but lacks depth or clarity.*
4. ***Minimal (1 point)****: Incomplete or significantly flawed.*

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Explain the fundamental concepts of Neural Networks.	**K3**
CO2	Analyse the behaviour of various basic neural network types.	**K3**
CO3	Construct models of associative neural networks. Identify training issues along with their solutions in artificial neural networks.	**K3**
CO4	Assess the principles and applications of Convolution Neural Networks and Recurrent Neural Networks.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1										
CO2	3	3	2		2	1			2			2
CO3	3	3	2		2	1			2			2
CO4	3	1	2		2	1						3

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Fundamentals of neural networks: architectures, algorithms and applications	Laurene V. Fausett	Pearson Education India	2006
2	Neural Networks and Deep Learning	Charu C Aggarwal	Springer International Publishing AG, part of Springer Nature 2018	2018
3	Neural networks, fuzzy logic and genetic algorithm: synthesis and applications	S. Rajasekaran, G.A. VijayalakshmiPai	PHI Learning Pvt. Ltd.	2003

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Deep Learning	Ian Goodfellow, YoshuaBengio, Aaron Courville	MIT Press	2015
2	Elements of Artificial Neural Networks	Kishan Mehrotra, Chilukuri K. Mohan and Sanjay Ranka	MIT Press	1996

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/106106184
2	https://nptel.ac.in/courses/106105215
3	https://nptel.ac.in/courses/106105215
4	https://nptel.ac.in/courses/106105215

SEMESTER S5

BIOMEDICAL SIGNAL PROCESSING LAB

Course Code	**PCBML507**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	0:0:3:0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs.30 Min.
Prerequisites (if any)	None	**Course Type**	PCL

Course Objectives:

1. To enable the students to acquire knowledge on image and signal fundamentals and mathematical transforms.
2. To enable the students to process and analyse signals and to perform useful operations such as signal enhancement, signal filtering, data compression, feature extraction etc.

Expt. No.	Experiments (Any 12 Mandatory)
1	Acquisition and basic operations of bio signals using standard signal acquisition systems.
2	Implementation of I/D sampling rate converters.
3	Impulse response of first order and second order systems.
4	Implement DCT/IDCT computation using MATLAB
5	Implementation of FIR & IIR Butterworth filters using MATLAB.
6	Implement DFT and FFT on simulated discrete-time signals using MATLAB.
7	Perform (i) Addition (ii) Multiplication (iii) Scaling (iv) Linear Convolution (v) Circular Convolution using MATLAB.
8	Implement FFT and power spectrum of ECG /EMG/EEG using MATLAB.
9	Implement medical data compression (Lossy v/s Loss less signals)
10	Perform spectral modelling and analysis of PCG signals.
11	Design of 50 Hz notch filter for ECG signal and display PSD.
12	Detection of events & waves of EEG signals.
13	Detection of events and heart rate measurement from PPG and ECG.
14	Processing of ECG signals for acquiring parameters like heart rate, QRS complex, P wave etc.
15	Medical data compression Lossy vs. Loss less signals

Course Assessment Method
(CIE: 50 marks, ESE: 50 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Preparation/Pre-Lab Work experiments, Viva and Timely completion of Lab Reports / Record (Continuous Assessment)	Internal Examination	Total
5	25	20	50

End Semester Examination Marks (ESE):

Procedure/ Preparatory work/Design/ Algorithm	Conduct of experiment/ Execution of work/ troubleshooting/ Programming	Result with valid inference/ Quality of Output	Viva voce	Record	Total
10	15	10	10	5	50

- ***Submission of Record: Students shall be allowed for the end semester examination only upon submitting the duly certified record.***
- ***Endorsement by External Examiner:*** *The external examiner shall endorse the record*

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Implement different operations on signals and systems.	**K3**
CO2	Apply suitable signal processing algorithms for biomedical signal analysis and feature extraction.	**K3**
CO3	Design solutions to address the issues during bio signal acquisition and processing.	**K4**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO- PO Mapping (Mapping of Course Outcomes with Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3				3	2		2
CO2	3	3	3	3	3				3	2		2
CO3	3	3	3	3	3				3	2		2

1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Biomedical Signal Analysis	Rangaraj M. Rangayyan	John Wiley & Sons	2015
2	Biosignal and Medical Image Processing	John L. Semmlow, Benjamin Griffel	CRC Press	2021
3	Biosignal and Medical Image Processing	John L. Semmlow	CRC Press	2011
	Digital Image Processing	Rafael C. Gonzalez and Richard E. Woods	PHI/Pearson Education	2nd edition, 2002
4	Digital Image Processing-an algorithmic approach	Madhuri. A. Joshi	PHI	1st edition, 2006

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/108/108/108108185/
2	https://onlinecourses.nptel.ac.in/noc20_ee41/preview

Continuous Assessment (25 Marks)

1. **Preparation and Pre-Lab Work (7 Marks)**

- Pre-Lab Assignments: Assessment of pre-lab assignments or quizzes that test understanding of the upcoming experiment.
- Understanding of Theory: Evaluation based on students' preparation and understanding of the theoretical background related to the experiments.

2. **Conduct of Experiments (7 Marks)**

- Procedure and Execution: Adherence to correct procedures, accurate execution of experiments, and following safety protocols.
- Skill Proficiency: Proficiency in handling equipment, accuracy in observations, and troubleshooting skills during the experiments.
- Teamwork: Collaboration and participation in group experiments.

3. **Lab Reports and Record Keeping (6 Marks)**

- Quality of Reports: Clarity, completeness and accuracy of lab reports. Proper documentation of experiments, data analysis and conclusions.
- Timely Submission: Adhering to deadlines for submitting lab reports/rough record and maintaining a well-organized fair record.

4. **Viva Voce (5 Marks)**

- Oral Examination: Ability to explain the experiment, results and underlying principles during a viva voce session.

Final Marks Averaging: The final marks for preparation, conduct of experiments, viva, and record are the average of all the specified experiments in the syllabus.

Evaluation Pattern for End Semester Examination (50 Marks)

1. **Procedure/Preliminary Work/Design/Algorithm (10 Marks)**

- Procedure Understanding and Description: Clarity in explaining the procedure and understanding each step involved.
- Preliminary Work and Planning: Thoroughness in planning and organizing materials/equipment.
- Algorithm Development: Correctness and efficiency of the algorithm related to the experiment.

- Creativity and logic in algorithm or experimental design.

2. **Conduct of Experiment/Execution of Work/Programming (15 Marks)**

- Setup and Execution: Proper setup and accurate execution of the experiment or programming task.

3. **Result with Valid Inference/Quality of Output (10 Marks)**

- Accuracy of Results: Precision and correctness of the obtained results.
- Analysis and Interpretation: Validity of inferences drawn from the experiment or quality of program output.

4. **Viva Voce (10 Marks)**

- Ability to explain the experiment, procedure results and answer related questions
- Proficiency in answering questions related to theoretical and practical aspects of the subject.

5. **Record (5 Marks)**

- Completeness, clarity, and accuracy of the lab record submitted

SEMESTER S5

CLINICAL INSTRUMENTATION LAB

Course Code	**PCBML508**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	0:0:3:0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	PCL

Course Objectives:

1. Students undergoing the course are expected to have a thorough understanding and hands-on expertise on simple Analog Electronic circuits and basic electronic instrumentation for Medical devices.

Expt. No.	**Experiments**
1	Chart Drive circuit
2	QRS Detector circuit
3	Automatic gain compensation circuit
4	Time gain compensation circuit
5	Power amplifier circuit for Stylus movement
6	ESU waveform generator
7	Study of monitoring device - Multiparameter physiological recorders – instrumentation and recording of physiological parameters.
8	Study of therapeutic equipment – Ventilator / Dialysis machine (model kit or demo) / Defibrillator / Heart lung Machine (model kit or demo) – demonstration
9	Study of diagnostic equipment - ECG Machine / Spirometer – instrumentation, operation and calibration.
10	Study of general surgery assisting device - Electrosurgical unit – instrumentation, operation
11	Study of drug delivery devices – Infusion pump / syringe pump – Instrumentation and and operation
12	Study of simulators and analysers – Electrical safety analyser, ECG simulator, and defibrillator analyser

13	Study of basic sensor circuits to acquire and display the physiological parameter: Volumetric measurement using Photoplethysmography or plethysmography / monitoring of body temperature, heart rate and blood pressure / measuring the oxygen saturation using Photoplethysmography / Electronic Stethoscope for characterization of physiological acoustic signals
14	Study of analytical device – Semi-auto analyser / colorimeter / flame photometer - instrumentation, operation and calibration.
15	Testing and calibration of medical equipment - Field visit - Engineering department of hospital (any one equipment)

Course Assessment Method
(CIE: 50 marks, ESE: 50 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Preparation/Pre-Lab Work experiments, Viva and Timely completion of Lab Reports / Record (Continuous Assessment)	Internal Examination	Total
5	25	20	50

End Semester Examination Marks (ESE):

Procedure/ Preparatory work/Design/ Algorithm	Conduct of experiment/ Execution of work/ troubleshooting/ Programming	Result with valid inference/ Quality of Output	Viva voce	Record	Total
10	15	10	10	5	50

- ***Submission of Record: Students shall be allowed for the end semester examination only upon submitting the duly certified record.***
- ***Endorsement by External Examiner:*** *The external examiner shall endorse the record*

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Describe the working principle and operation of different types of medical equipments	**K1**
CO2	Design and implement the instrumentation modules of clinical equipments.	**K2**
CO3	Conduct testing and calibration procedure of different medical equipments	**K2**
CO4	Simulate the electronic instrumentation of common clinical equipments	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO- PO Mapping (Mapping of Course Outcomes with Program Outcomes)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2							3	3		3
CO2	3		3	3	3				3	3		3
CO3	3			3	3				3	3		3
CO4	3		3	3	3				3	3		3

Note: 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Op-Amps and Linear Integrated Circuits	Ramakanth A Gayakwad	Pearson Education	4th edition,2015
2	Analysis and Application of Analog Electronic Circuits to Biomedical Instrumentation	Robert B. Northrop	CRC Press	1st edition,2003
3	Electronic Devices & Circuit Theory	Boylestead& Neshelsky	Prentice Hall of India	2003
4	Handbook of Biomedical Instrumentation	R.S. Khandpur	Second Edition, McGraw-Hill Publishing Company Limited,	2002

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Encyclopaedia of medical devices and instrumentation, volume 1	John G Webster	, Published by John Wiley & Sons, Inc., Hoboken, New Jersey	2006
2	Principles of Transducers & Biomedical Instrumentation: Designs and Applications	Dr. Vibhav Kumar Sachan	Sachan Books	2019
3	Biomedical Transducers and Instruments	Tatsuo Togawa, Toshiyo Tamura, P. Ake Oberg	CRC Press,	1997

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/108106172

Continuous Assessment (25 Marks)

1. Preparation and Pre-Lab Work (7 Marks)

- Pre-Lab Assignments: Assessment of pre-lab assignments or quizzes that test understanding of the upcoming experiment.
- Understanding of Theory: Evaluation based on students' preparation and understanding of the theoretical background related to the experiments.

2. **Conduct of Experiments (7 Marks)**

- Procedure and Execution: Adherence to correct procedures, accurate execution of experiments, and following safety protocols.
- Skill Proficiency: Proficiency in handling equipment, accuracy in observations, and troubleshooting skills during the experiments.
- Teamwork: Collaboration and participation in group experiments.

3. **Lab Reports and Record Keeping (6 Marks)**

- Quality of Reports: Clarity, completeness and accuracy of lab reports. Proper documentation of experiments, data analysis and conclusions.
- Timely Submission: Adhering to deadlines for submitting lab reports/rough record and maintaining a well-organized fair record.

4. **Viva Voce (5 Marks)**

- Oral Examination: Ability to explain the experiment, results and underlying principles during a viva voce session.

Final Marks Averaging: The final marks for preparation, conduct of experiments, viva, and record are the average of all the specified experiments in the syllabus.

Evaluation Pattern for End Semester Examination (50 Marks)

1. **Procedure/Preliminary Work/Design/Algorithm (10 Marks)**

- Procedure Understanding and Description: Clarity in explaining the procedure and understanding each step involved.
- Preliminary Work and Planning: Thoroughness in planning and organizing materials/equipment.
- Algorithm Development: Correctness and efficiency of the algorithm related to the experiment.
- Creativity and logic in algorithm or experimental design.

2. **Conduct of Experiment/Execution of Work/Programming (15 Marks)**

- Setup and Execution: Proper setup and accurate execution of the experiment or programming task.

3. **Result with Valid Inference/Quality of Output (10 Marks)**

- Accuracy of Results: Precision and correctness of the obtained results.
- Analysis and Interpretation: Validity of inferences drawn from the experiment or quality of program output.

4. Viva Voce (10 Marks)

- Ability to explain the experiment, procedure results and answer related questions
- Proficiency in answering questions related to theoretical and practical aspects of the subject.

5. Record (5 Marks)

- Completeness, clarity, and accuracy of the lab record submitted

SEMESTER 6

BIOMEDICAL ENGINEERING

SEMESTER S6

BIOMECHANICS

Course Code	PCBMT601	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	4:0:0:0	ESE Marks	60
Credits	4	Exam Hours	2 Hrs.30 Min.
Prerequisites (if any)	None	Course Type	PC

Course Objectives:

1. **T**o provide students with a foundational understanding of biomechanics, focusing on the mechanical properties and behaviors of biological tissues and systems.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to Biomechanics (T1)** ● **Introduction to Biomechanics -** Definition and perspective - Statics of the body and total body equilibrium - Equilibrium of individual body components ● **Kinematic and Kinetic Concepts for Analyzing Human Motion** - Kinematic concepts - Kinetic concepts - Anthropometry ● **Human Bone Biomechanics -** Composition and structure of bone tissue - Bone growth and development - Modeling and remodeling of bones (Wolfe's law of bone remodeling) - Biomechanics of bone fractures and fixation (external and internal fixation) ● **Biomechanics of Human Skeletal Articulations -** Joint architecture and flexibility - Neuromuscular response to stretch - Joint injuries and pathologies	**11**
2	**Muscle Mechanics (T2)** ● **Muscle Architecture and Mechanics** - Muscle fascicles and their arrangement - Fiber architecture in fascicles - Muscle as a fiber-reinforced composite - Muscle centroids and cross-sectional areas	**11**

<table>
<tr><td></td><td>(physiological & anatomical)
● Viscoelasticity of Tissues - Models of viscoelasticity (Kelvin – Voight model and Maxwell model)
● Properties of Tendons and Passive Muscles - Viscoelastic behavior of tendons - Tendon interaction with surrounding tissues - Mechanical properties of passive muscles
● Mechanics of Active Muscle - Muscle force production and transmission - Functional relations (Force-length, Force-velocity curves) - History effects in muscle mechanics - Hill’s model and sliding filament theory</td><td></td></tr>
<tr><td>3</td><td>Biomechanics of the Human Upper and Lower Extremity (T1)

● Loads on the Upper Extremity - Shoulder - Elbow
● Loads on the Lower Extremity - Hip - Knee - Foot
● GAIT Cycle - Components of the swing and stance phase of walking - Temporal factors - Center of mass displacement - Range of motion at the joints - Gait cycle for running
● Biomechanics of the Human Spine - Structure of the spine - Spinal curves and abnormal curvatures (lordosis, kyphosis, scoliosis) - Loads on the spine - Stress fractures</td><td>11</td></tr>
<tr><td>4</td><td>Cardiovascular System Biomechanics (T3)

● Basic Biofluid Mechanics - Properties of blood - Structure of blood vessels - Blood pressure - Flow in curving tubes such as arteries - Measuring flow in blood vessels - Modeling flow in blood vessels - Pressure drops in arteries and resistive vessels - Blood flow rates and speeds
● Models of the Cardiovascular System - Vascular resistance and capacitance - Lumped parameter model of the peripheral circulation - Windkessel simplification - Heart as a pump - Variable capacitor model of the heart</td><td>11</td></tr>
</table>

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
● 2 Questions from each module. ● Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	● Each question carries 9 marks. ● Two questions will be given from each module, out of which 1 question should be answered. ● Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course, students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the fundamental principles of biomechanics, including statics, kinematics, kinetics, viscoelasticity of tissues, bone biomechanics, and joint mechanics.	**K2**
CO2	Comprehend and describe the detailed mechanics of muscles, including muscle architecture, properties of tendons and passive muscles, active muscle mechanics, and muscle coordination.	**K2**
CO3	Apply the principles of biomechanics to the human upper and lower extremities and spine, including load distribution, GAIT cycle, and spinal biomechanics.	**K3**
CO4	Utilize the principles of biofluid mechanics and cardiovascular system modeling, including vascular resistance, capacitance, and heart function, to analyze and solve related problems.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2											
CO2	3	2										
CO3	3	3	2	2		2						
CO4	3	3	2	2		2						

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
T1	Basic Biomechanics	Susan J Hall	McGraw-Hill,	Sixth edition & 2012
T2	Fundamentals of Biomechanics	Nihat O ̈ zkaya, David Goldsheyder, Margareta Nordin	Springer International Publishing Switzerland	Fourth edition & 2017
T3	Physics of the Human Body	Irving P. Herman	Springer	Second edition & 2016

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Biomechanics and Motor Control of Human Movement	David A. Winter	John Wiley & Sons, Inc.	Fourth edition & 2009
2	Fundamentals of Biomechanics	Duane Knudson	Springer Science + Business Media, LLC Springer	Second edition & 2007

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc21_me52
2	https://onlinecourses.nptel.ac.in/noc23_bt04
3	https://onlinecourses.nptel.ac.in/noc21_me52
4	https://onlinecourses.nptel.ac.in/noc23_bt04

SEMESTER S6

BIOMATERIALS

Course Code	PCBMT602	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	GBCYT122	Course Type	PC

Course Objectives:

1. This course provides an in-depth exploration of biomaterials, focusing on their properties, interactions with biological systems, applications in medical devices, and the ethical and regulatory aspects of their development and use.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Properties and Classification of Biomaterials** Definition &Properties of Biomaterials:-Mechanical, Chemical & Biological properties, Classification of biomaterials:- Metalic implant materials: Stainless steel, Co-based alloys, Ti and Ti- based alloys, Ceramic implant materials: Aluminum oxides, Glass ceramics, Carbons - Bio resorbable and bioactive ceramics, polymeric implant materials: Polyolefins, polyamides, acrylic polymers, fluorocarbon polymers, silicone rubbers, acetyls, Collagens, Elastine, Cellulose and derivatives, biodegradable polymers for medical purposes	9
2	**Clinical Applications & Bio compatibility** Clinical applications of biomaterials: Cardiovascular implants, Orthopedic and Dental implants, Spinal implants. Concept of biocompatibility & blood compatibility Tissue-material interactions and biocompatibility assessments:- Tissue-material interactions and biological esponse of host tissue to materials. Factors contributing to biomaterial failure:- Swelling & leaching, corrosion and dissolution. Biocompatibility factors affecting the	9

	biocompatibility:- carcinogenicity, mutagenicity, cytogenicity, toxicity. Hemocompatibility factors affecting hemocarmpatibility.	
3	**Assessment of biocompatibility and Regulatory Standards** In vitro biochemical assays, In vivo testing: Toxicity tests: acute and chronic toxicity studies, sensitization, carcinogenicity, mutagenicity and special test. Regulatory Standards for testing and Manufacturing of biomaterials: International Organization for Standardization guidelines (ISO), American Society for Testing and Materials (ASTM International)	**9**
4	**Fabrication techniques of Biomaterials** Bioimplant fabrication methods: Wrought and cast, Powder metallurgy, Additive manufacturing (Rapid prototyping (RP) technologies and Surface finishing processes.Sintering, electrospinning, and sol-gel processing. Testing of biomaterials:-Mechanical testing (tensile, compression tests),Microscopy techniques (SEM, TEM).Spectroscopy techniques (FTIR, Raman spectroscopy).	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Gain a comprehensive understanding of different types of biomaterials, including metals, ceramics, polymers and their properties	**K1**
CO2	Explore the applications of biomaterials in medical devices, implants, drug delivery systems, and tissue engineering	**K1,K2**
CO3	Understand the concept of biocompatibility, including the interactions between biomaterials and biological systems. Learn how to assess and improve the biocompatibility of material	**K1,K2**
CO4	Learn about the regulatory standards and ethical considerations involved in the development and use of biomaterials	**K2**
CO5	Gain knowledge of various fabrication techniques used to create biomaterials and medical devices, including traditional methods and advanced technologies like 3D printing and electrospinning	**K1,K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1			2	2	2				2
CO2	3	3	2			2	2	2				2
CO3	3	1				2	2	2				2
CO4	3					2	2	3				2
CO5	3	2	2	2	2	2	2	2				2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Biomaterials Science: An Introduction to Materials in Medicine	Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen, and Jack E. Lemons	Academic Press	2020 (fourth edition)
2	Biomaterial Science and engineering,	Joon Bu Park	Plenum Press, New York	1984
3	Biological Responses to Materials	James M Anderson	Annual Review of Materials Research	2001
4	Biomaterials And Bioengineering Handbook Hardcover	Donald L. Wise	Taylor & Francis	2000
5	Biomaterials Fabrication and Processing Handbook	Paul K. Chu and Xiangdong Kong:	CRC Press	2008

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Biomaterials Science: An Introduction to Materials in Medicine	Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons	Academic Press	2004, USA 2. J.B. Park and J.D. TECHNOLOGICAL
2	Biomaterials: Principles and Applications	Bronzino	CRC Press	2002. ISBN: 0849314917
3	Biomaterials	Sujata V. Bhat	Narosa Publishing House	2002
4	Tissue Engineering and Artificial Organs	Joseph D. Bronzino, Donald R. Peterson		2006

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://auece.digimat.in/nptel/courses/video/102106057/L01.html https://archive.nptel.ac.in/courses/113/104/113104009/
2	https://onlinecourses.nptel.ac.in/
3	https://archive.nptel.ac.in/courses/129/105/129105005/ https://archive.nptel.ac.in/courses/127/106/127106136/
4	https://archive.nptel.ac.in/courses/102/106/102106057/ https://link.springer.com/chapter/10.1007/978-981-16-4420-7_24

SEMESTER S6

EMBEDDED SYSTEM DESIGN

Course Code	PEBMT631	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	Nil	Course Type	PE

Course Objectives:

1. Is to enable the students to understand embedded-system programming and apply that knowledge to design and develop embedded solutions.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Overview of Embedded System: Embedded System –architecture - Features -Categories, Requirements -Challenges and Issues. Applications of Embedded Systems in Consumer Electronics and control systems. Applications of Embedded Systems in Instrumentation & Biomedical systems case study of low power mode of MSP430 and its use in embedded systems.	9
2	Hardware Software Co-Design and Program Modelling –Fundamental Issues, Computational Models- Data Flow Graph, Control Data Flow Graph, State Machine. Sequential Model, Concurrent Model, Object oriented model, UML.	9
3	Integration and Testing of Embedded Hardware and Firmware- Embedded firmware design approaches, Embedded System Development Environment – IDEs, Cross Compilers, Disassembles, Decompiles, Simulators, Emulators and Debuggers. Features of Embedded c++ .	9
4	RTOS based Design – Basic operating system services-structure-kernel, process, tasks, and threads. Process management-memory management-device management, Task scheduling algorithms- non-pre-emptive scheduling and Pre emptive scheduling	9

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
● 2 Questions from each module. ● Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	● Each question carries 9 marks. ● Two questions will be given from each module, out of which 1 question should be answered. ● Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO 1	Understand the basic idea regarding the nature of embedded system and its application in different field.	**K2**
CO 2	Analyse and design a model for given operation of embedded system.	**K2**
CO 3	Understand the role of different software modules in the development of an embedded system.	**K3**
CO 4	Study the basics of RTOS for embedded systems. Understand the Inter process communication mechanism and synchronization.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3										2
CO2	3	3									**2**	2
CO3	3	3									**2**	2
CO4	3	3									**2**	2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Programming for Embedded Systems	Dreamtech Software Team	Wiley Dreamtech,	2002
2	Computers as Components: Principles of Embedded Computing System Design	Wayne Wolf	Morgan Kaufman Publishers	2008
3	Introduction to Embedded Systems	Shibu K.V	McGraw Hill Education	2009

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	An Embedded Software Primer	David E. Simon	Pearson Education Asia	2000
2	Embedded / Real time systems: Concepts, Design and Programming	Dr. K. V. K. K. Prasad	Dream Tech press	2003
3	Embedded systems: An Integrated Approach	Lyla B. Das	Lyla B. Das	2012

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc20_cs14/preview
2	https://archive.nptel.ac.in/courses/106/105/106105193/
3	https://onlinecourses.nptel.ac.in/noc20_ee98/preview
4	https://nptel.ac.in/courses/108102045

SEMESTER S6

MEDICAL ROBOTICS

Course Code	**PEBMT 632**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	PE

Course Objectives:

1. This course aims to make students able to understand the engineering aspects of Robots, analyse and design robotic structures and their applications.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Components of robotic system**: History of medical robots, Classification of medical robots, Present status and future trends. Basic components of robotic system. Basic terminology- Accuracy, Repeatability, Resolution, Degree of freedom. Mechanisms and transmission, End effectors, Grippers-different methods of gripping, Mechanical grippers-Slider crank mechanism, Screw type, Rotary actuators, Cam type gripper, Magnetic grippers, Vacuum grippers, Air operated grippers; Specifications of robot.	**9**
2	**Drive systems and Sensors Drive system:** Pneumatic Drives-Hydraulic Drives-Mechanical Drives-Electrical Drives-D.C. Servo Motors, Stepper Motors, A.C. Servo Motors-Salient Features, Applications and Comparison. **Sensors in robots** – Touch sensors, Tactile sensor, Proximity and range sensors, Robotic vision sensor, Force sensor, Light sensors, Pressure sensors.	**9**
3	**Robot kinematics and robot programming:** Forward Kinematics, Inverse Kinematics and Difference; Forward Kinematics and Reverse Kinematics of manipulators with Two, Three Degrees of Freedom (in 2 Dimension), Four Degrees of freedom (in 3 Dimension) Jacobians, Velocity and Forces-Manipulator Dynamics, Trajectory Generator, Manipulator Mechanism Design-Derivations and problems. Lead through Programming, Robot programming Languages-VAL Programming-Motion Commands, Sensor	**9**

	Commands, End Effector commands and simple Programs.	
4	**Robots in healthcare**: Teleoperated Robot-Assisted Minimally Invasive Surgery, Robot design concepts Robot assisted Image-Guided Interventions: CT, MR, Ultrasound, Other applications: Robotic catheters for heart electrophysiology, Humanoids, Micro/nano robots for biomedicine - Delivery, surgery, sensing and detoxification	**9**

Course Assessment Method
(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Introduce the fundamentals of robotics and its components	**K2**
CO2	Understand sensors and drive mechanisms in robotics	**K2**
CO3	Familiarize the Kinematics and robotic programming	**K3**
CO4	Analyse applications of robots in healthcare	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1			1				1		2
CO2	2	2	1			2				1		1
CO3	2	2	1			1				1		1
CO4	3	2	2			1				1		1
CO5	2	2	1			1				1		2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	"Robot Modelling and Control"	Mark W. Spong, Seth Hutchinson, and M. Vidyasagar	John Wiley & Sons	2nd e,2020
2	"Medical robotics- Minimally Invasive surgery"	Paula Gomes	Woodhead	2012
3	Industrial Robotics – Technology, Programming and Applications	Mikell and Groover	McGraw Hill	2/e, 2012
4	Introduction to Robotics. Analysis and control, applications	Saeed B. Niku	Wiley	2010

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	“Introduction to Robotics Mechanics and Control”	Craig J.J.	Pearson Education	2008
2	“Robotics Technology and Flexible Automation”	Deb S.R.	Tata McGraw Hill Book Co.	1994
3	“Medical Robotics”	Achim Schweikard, Floris Ernst	Springer	2015
4	“Medical Robots”	Daniel Faust	Rosen Publishers	2016

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc24_me88/preview

SEMESTER S6

BIO FLUID MECHANICS

Course Code	PEBMT 633	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	Nil	Course Type	PE

Course Objectives:

1. To teach basic fluid mechanics
2. Aware the fluid mechanics in human body

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Basic Fluid Mechanics Concepts**-Fluid Characteristics and Viscosity, Fundamental Method for Measuring Viscosity, Introduction to Pipe Flow, Bernoulli Equation, Fluid Static, The Womersley Number	9
2	**Cardiovascular Structure and Function-** Introduction, Clinical Features, Functional Anatomy, The Heart as a Pump, Cardiac Muscle Heart Valves, Heart Sounds, Coronary Circulation, Microcirculation, Lymphatic Circulation	9
3	**Pulmonary Anatomy,Pulmonary Physiology, and Respiration-** Introduction, Alveolar Ventilation, Ventilation-Perfusion Relationships, Mechanics of Breathing, Work of Breathing, Gas Exchange and Transport, Pulmonary Pathophysiology	9
4	**Hematology and Blood Rheology**, Elements of Blood,Blood Characteristics,Viscosity Measurement Anatomy and Physiology of Blood Vessels- General Structure of Arteries , Mechanics of Arterial Walls, Pulse Wave Velocity and the Moens–Korteweg Equation, Vascular Pathologies, Coronary Artery Bypass Grafting.	9

Course Assessment Method
(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Aware Basic Fluid Mechanics Concepts	**K2**
CO2	Detailed study of Cardiovascular Structure and Function	**K3**
CO3	Explain Pulmonary Anatomy,Pulmonary Physiology, and Respiration	**K2**
CO4	Applications of Hematology and Blood Rheology	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2									2
CO2	3	3	2									2
CO3	3	3	2		2							2
CO4	3	3	2		2							2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Applied fluid mechanics	Lee Waite,Ph.D.,P.E. Jerry Fine,Ph.D.	The McGraw-Hill Compa	2007
2	Fluid Mechanics	Portonovo S._Ayyaswamy	Elsevier Inc. All rights reserved	2016

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Biofluid Mechanics	Jagan N. Mazumdar	World Scientific Pub Co Inc	1992
2	Biofluid Mechanics: An Introduction to Fluid Mechanics, Macrocirculation, and Microcirculation	David Rubenstein, Wei Yin, Mary D. Frame	Academic Press, AP, A. P.	2021
3	Biofluid Mechanics: The Human Circulation	Krishnan B. Chandran (Author); Stanley E. Rittgers (Author); Ajit P. Yoganathan (Author)	CRC Press	2012

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc22_ce85/preview
2	https://onlinecourses.nptel.ac.in/noc22_ce85/preview
3	https://onlinecourses.nptel.ac.in/noc22_ce85/preview
4	https://onlinecourses.nptel.ac.in/noc22_ce85/preview

SEMESTER S6

COMPUTATIONAL METHODS IN BIOMEDICAL ENGINEERING

Course Code	**PEBMT634**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Nil	**Course Type**	PE

Course Objectives:

1. To understand fundamental techniques in numerical methods

2. To apply these techniques to solve problems of in the field of Biomedical engineering.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to numerical Techniques** Approximations - Accuracy and precision, definitions of round off and truncation errors, error propagation, Algebraic equations - Formulation and solution of linear algebraic equations, Gauss elimination method Introduction to Eigenvalue Analysis – Eigenvectors and Eigenvalues, Eigenvalue problems in Biomedical Engineering.	**9**
2	**Interpolation Techniques** Newton-Raphson method and Regula-Falsi method. Interpolation-finite differences, Newton's forward and backward difference method, Newton's divided difference method and Lagrange's method.Cubic spline and quadratic spline interpolation method	**9**
3	**Numeriacal integration and Solution of ODE** Numerical integration-Trapezoidal rule and Simpson's 1/3rd rule,3/8 rule ODE-Taylor's series method,Euler's method,modified Euler's method R-K method of order four	**9**

4	**Finite Element Method** Introduction to Finite Element Method - strong form and weak form equations, test and trial functions, discretization, boundary conditions, numerical assembly and solution Finite Element Method for nonlinear ODEs - Linearization and Newton-Raphson method, numerical assembly and solution	**9**

Course Assessment Method
(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Aware of the use of numerical methods in modern scientific computing.	**K1,K2**
CO2	Apply Numerical Methods to Solve Biomedical Problems.	**K3**
CO3	Familiar with numerical solutions of nonlinear equations, numerical interpolation and approximation of functions, numerical integration and differentiation, numerical solution of ordinary differential equations.	**K1,K2**
CO4	Utilize Optimization Techniques in Biomedical Engineering.	**K2,K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	2	1	1							2
CO2	3	2	2	1	1	2						2
CO3	3	2	2	1	1							2
CO4	3	2	2	1	1							2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Applied Numerical Methods for Engineers using Matlab and C	Robert J. Schilling and Sandra L. Harris	Brooks/Cole, Pacific Grove	2000
2	Numerical Methods for Engineers	Steven C. Chapra and Raymond P Canale	Tata-Mcgraw Hill, New Delhi	2007,5 th edition
3	Numerical Methods in Engineering and Science	B.S. Grewal	Khanna Publishers	2014**.**

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Computational Science and Engineering	Gilbert Strang	Wellesley-Cambridge Press, Wellesley	2007
2	Computational Methods in Engineering	S. P. Venkatesan	Ane Books India, New Delhi	2014
3	Numerical Methods for Engineers	Santhosh K. Gupta	New age international publishers	2012
4	Applied Numerical Methods with MATLAB for Engineers and Scientists	Steven C. Chapra	Tata-Mcgraw Hill, New Delhi	2012,3 rd edition

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc20_ge20/preview
2	https://archive.nptel.ac.in/courses/111/101/111101165/ https://archive.nptel.ac.in/courses/111/107/111107105/ https://archive.nptel.ac.in/courses/103/106/103106074/
3	https://archive.nptel.ac.in/courses/111/104/111104031/ https://archive.nptel.ac.in/courses/111/104/111104031/
4	https://archive.nptel.ac.in/courses/112/104/112104115/ https://onlinecourses.nptel.ac.in/noc21_me109/preview

SEMESTER S6

INTRODUCTION TO BIONANOTECHNOLOGY

Course Code	PEBMT 636	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3-0-0-0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	Nil	Course Type	PE

Course Objectives:

1. To acquire the knowledge of basic sciences required to understand the fundamentals of nanomaterials
2. To get familiarize with the basic concepts of properties of nanomaterials and applications.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	An overview of biomedical applications of nanotechnology, introduction to nanomaterials - Nanometre scale, nanoparticles and types of nanoparticles, nanomaterials, classification of nanomaterials, quantum effects, quantum dots, surfaces, and interfaces of nanomaterials.	9
2	Introduction to nano, Nano-biomimicry, Synthesis of nanomaterials by physical and chemical methods, Synthesis of nanomaterials by biological methods, Characterisation of nanomaterials, different types of nano sensors – an overview	9
3	DNA nanotechnology, Protein & glyco nanotechnology, Lipid nanotechnology, Bio-nanomachines, Carbon nanotube and its bio-applications.	9
4	Nanomaterials for cancer diagnosis, Nanomaterials for cancer therapy, Nanotechnology in tissue engineering, Nano artificial cells, Nanotechnology in organ printing.	9

Course Assessment Method

(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand the concept of bio nanotechnology and nano particles	**K2**
CO2	Explain the various methods of fabrication of nano materials	**K2**
CO3	Explain the various application of nanotechnology in medical application	**K2**
CO 4	Explain the how nanotechnology help in the diagnosis of disease	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3										**2**
CO2	3	3										2
CO3	3	3										2
CO4	3	3										2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Chemistry of Nanomaterials: Fundamentals and Applications	Tahir Iqbal Awan, Almas Bashir, Aqsa Tahseen	Elsevier, Year: 2020,	11th Edition
2	Nano sensors: Physical, Chemical, and Biological	Vinod Kumar Khanna	CRC Press	2021
3	Nano biosensors: From Design to Applications	Aiguo Wu, Waheed S. Khan	Vch Pub, Year	2019

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Biomedical, Nanotechnology	Neelina H. Malsch,	CRS Press	2025
2	Micro- and Nano-Scale Sensors and Transducers	Ezzat G. Bakhoum	CRC PRESS	2015

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/course.html

SEMESTER S6

ADVANCED BIOMEDICAL SIGNAL PROCESSING AND APPLICATIONS

Course Code	**PEBMT635**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	5/3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	PE

Course Objectives:

1. To study some of the most advanced methodological approaches in the signal analysis of biomedical interest.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Interpretative Models in Biological Signal Processing-Mathematical Instruments for Signal Processing- Descriptive Methods, The Black-Box Models, Interpretative Models, Examples-Mathematical Models and Signals in Intensive Care Units, Mathematical Models and Cardiovascular Variability Signals, Mathematical Models and EEG Signals during Epilepsy, Mathematical Models, Electrophysiology, and Functional Neuroimaging.	**9**
2	Wavelet Analysis-The Short-Time Fourier Transform, Time-Frequency Resolution, Multiresolution Analysis, Wavelet Transform, Generalization of the Short-Time Fourier Transform, Wavelet Transform and Discrete Filter Banks, Matching Pursuit, Applications to Biomedical Signals- Analysis of ECG, Analysis of Spectral Variability of Heart Rate, Analysis of a Signal from a Laser Doppler	**9**
3	Geometrical Scaling and Self-Similarity, Measures of Dimension, Self-Similarity and Functions of Time, Theoretical Signals Having Statistical Similarity, Measures of Statistical Similarity for Real Signals, Generation of	**9**

	Synthetic Fractal Signals, Fractional Differencing Models, Example-measurements of local blood flow in the tissues of the heart using a fractal model.	
4	Nonlinear Models of Signals-Nonlinear Signals and Systems: Basic Concepts, Poincare Sections and Return Maps, Chaos, Measures of Nonlinear Signals and Systems, Characteristic Multipliers and Lyapunov Exponents, Estimating the Dimension of Real Data, Tests of Null Hypotheses Based on Surrogate Data, Applications-Bifurcations in a Model of a Cardiac pacemaker Cell.	**9**

Course Assessment Method
(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Internal Ex	Evaluate	Analyse	Total
5	**15**	**10**	**10**	**40**

Criteria for Evaluation (Evaluate and Analyse): 20 marks

Assignment: 20 Marks

Students should evaluate and analyse signal processing techniques for biomedical applications, assess the proposed solutions and implement the chosen solution using necessary software or hardware.

Criteria for evaluation:

1. ***Problem Definition (K4 - 4 points)***
   a. *Clearly defines the problem.*
   b. *Examine and identify relevant factors.*
2. ***Problem Analysis (K4 - 4 points)***
   a. *Break-down and presents a well-reasoned solution approach.*
3. ***Evaluate (K5 - 3 points)***
   a. *Thoroughly evaluate the proposed solutions.*
4. ***Implementation (K5 - 4 points)***
   a. *Successfully translates the chosen solution into software or hardware as necessary.*

5. ***Conclusion (K3- 3 points, K5 – 2 points)***
    a. *Summarizes findings and insights. State which solution is most appropriate for the problem*

Scoring:

1. ***Accomplished (4 points)****: Exceptional analysis, clear implementation, and depth of understanding.*
2. ***Competent (3 points)****: Solid performance with minor areas for improvement.*
3. ***Developing (2 points)****: Adequate effort but lacks depth or clarity.*
4. ***Minimal (1 point)****: Incomplete or significantly flawed.*

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Apply mathematical models in signal processing	**K2**
CO2	Apply wavelet transform in biomedical signal processing applications	**K3**
CO3	Apply nonlinear models in biomedical signal processing	**K3**
CO4	Analyze nonlinear Biomedical systems	**K4**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3		2					2		3
CO2	3	3	3		2					2		3
CO3	3	3	3		2					2		3
CO4	3	3	3		2					2		3

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Advanced Methods of Biomedical Signal Processing	Sergio Cerutti, Carlo Marchesi	IEEE	2011
2	Biomedical Signal Processing and Signal Modeling	Eugene N. Bruce	Wiley	2000

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Digital Signal Processing for Medical Imaging Using Matlab	Gopi, E. S	Springer	2012
2	RSignals and systems in biomedical engineering: signal processing and physiological systems modeling	Devasahayam, S.	Springer.	2012
3	Biomedical Signal Processing Advances in Theory	Ganesh Naik	Springer	2020

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	Digital Image Processing - Course (nptel.ac.in)
2	Digital Image Processing - Course (nptel.ac.in)
3	Digital Image Processing - Course (nptel.ac.in)
4	Digital Image Processing - Course (nptel.ac.in)

SEMESTER S6

PRINCIPLES OF MEDICAL IMAGE PROCESSING

Course Code	**PBBMT604**	**CIE Marks**	60
Teaching Hours/Week (L: T:P: R)	3:0:0:1	**ESE Marks**	40
Credits	4	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Nil	**Course Type**	PC-PBL

Course Objectives:

1. Comprehend Image Perception and Digital Representation.
2. Apply Image Processing Techniques for Enhancement and Analysis
3. Develop Practical Skills through Implementation and Research

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Image perception - Image Perception-Light, Luminance, Brightness and Contrast, Simultaneous Contrast, Mach Bands-monochrome vision models - color vision model - Image sampling and quantization -Two-dimensional sampling theory Representing Digital Images, Basic relationship between pixels	**9**
2	Image transforms -Two-dimensional orthogonal and Unitary Transforms, Properties of Unitary Transforms,2D-DFT, cosine, sine, properties, Haar and Hadamard Transform. Image Enhancement in the Spatial Domain: Point Operations, Contrast Stretching, Clipping and Thresholding, Digital Negative, Intensity Level Slicing, Bit Extraction	**9**

3	Histogram modeling, histogram equalization- modification. Spatial operations - smoothing techniques. Magnification and interpolation. Frequency Domain methods - low pass filtering, high pass filtering, homomorphic filtering-Image restoration- inverse filtering, Wiener filtering. Image Analysis: Edge Detection-Gradient Operators, Laplace Operators and Zero Crossings.	**9**
4	Boundary Representation–Chain Codes. Boundary Extraction-Connectivity, Contour Following-Image Segmentation-Amplitude Thresholding or Window Slicing, Component Labelling, Boundary based Approaches, Region-based Approaches and Clustering.	**9**

Suggestion on Project Topics

- Students should do a literature review and present various applications of image processing techniques on biomedical images
- Identify and summarize key applications, advancements, and challenges associated with each technique.
- Based on the literature review, choose one image processing technique that can be applied to medical images.
- Justify the selection by explaining its relevance and potential impact on biomedical imaging.

Techniques to Choose From:

Image Segmentation: Techniques such as thresholding, region-based segmentation, and edge detection.

Image Enhancement: Methods like histogram equalization, contrast adjustment, and noise reduction.

Image Reconstruction: Methods for reconstructing images from raw data, including CT and MRI reconstruction algorithms.

Feature Extraction: Techniques for identifying and extracting significant features from images, such as texture analysis and morphological operations.

- Implement the selected image processing technique on a set of medical images using Matlab, Python, or C++.
- Develop a codebase that accurately applies the chosen technique to biomedical images.
- Collaborate in teams to document the entire process, from literature review to implementation.

- Prepare a comprehensive project report detailing the methodology, implementation steps, results, and conclusions.
- Present the project and findings to the class, highlighting the technique's effectiveness and potential applications in medical imaging.

Course Assessment Method
(CIE: 60 marks, ESE: 40 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Project	Internal Ex-1	Internal Ex-2	Total
5	**30**	**12.5**	**12.5**	**60**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 2 marks **(8x2 =16 marks)**	2 questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of 2 sub divisions. Each question carries 6 marks. **(4x6 = 24 marks)**	**40**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Identify major processes and terminologies involved in formation of medical images	**K2**
CO2	Apply Image Transforms and Enhancement Techniques	**K3**
CO3	Implement Boundary Representation Techniques	**K2**
CO4	Analyze and Evaluate Segmentation Techniques	**K4**
CO5	Implement and evaluate various image processing techniques and apply them to solve real-world problems in the biomedical domain.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1			1						2
CO2	3	1	2			1						1
CO3	3	1	1			1						1
CO4	3	1	1			1						1
CO5	3	3	3	2	3	2	2	1	3	2	2	1

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Fundamentals of Digital Image Processing	Jain Anil K,	Prentice Hall of India	1989
2	Digital Image Processing	Gonzalez Rafel C, Woods Richard E	Pearson	4th,2018
3	Biomedical signal and image processing	Kayvan Najarian, Robert Splinter	CRC Press	2nd,2012

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Biomedical Image Processing	Thomas M. Deserno	Springer	2011
2	Handbook of Medical Image Processing and Analysis	Isaac Bankman	Academic Press Series in Biomedical Engineering	2nd,2009
3	Digital image processing for medical applications	Dougherty G	Cambridge University Press	2009

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	NPTEL :: Electronics & Communication Engineering - NOC:Digital Image Processing
2	Computer Vision and Image Processing - Fundamentals and Applications - Course (nptel.ac.in)
3	Image Signal Processing - Course (nptel.ac.in)
4	Digital Image Processing - Course (nptel.ac.in)

PBL Course Elements

L: Lecture (3 Hrs.)	R: Project (1 Hr.), 2 Faculty Members		
	Tutorial	**Practical**	**Presentation**
Lecture delivery	Project identification	Simulation/ Laboratory Work/ Workshops	Presentation (Progress and Final Presentations)
Group discussion	Project Analysis	Data Collection	Evaluation
Question answer Sessions/ Brainstorming Sessions	Analytical thinking and self-learning	Testing	Project Milestone Reviews, Feedback, Project reformation (If required)
Guest Speakers (Industry Experts)	Case Study/ Field Survey Report	Prototyping	Poster Presentation/ Video Presentation: Students present their results in a 2 to 5 minutes video

Assessment and Evaluation for Project Activity

Sl. No	Evaluation for	Allotted Marks
1	Project Planning and Proposal	5
2	Contribution in Progress Presentations and Question Answer Sessions	4
3	Involvement in the project work and Team Work	3
4	Execution and Implementation	10
5	Final Presentations	5
6	Project Quality, Innovation and Creativity	3
Total		**30**

1. **Project Planning and Proposal (5 Marks)**

   - Clarity and feasibility of the project plan
   - Research and background understanding
   - Defined objectives and methodology

2. **Contribution in Progress Presentation and Question Answer Sessions (4 Marks)**

   - Individual contribution to the presentation
   - Effectiveness in answering questions and handling feedback

3. **Involvement in the Project Work and Team Work (3 Marks)**

   - Active participation and individual contribution
   - Teamwork and collaboration

4. **Execution and Implementation (10 Marks)**

   - Adherence to the project timeline and milestones
   - Application of theoretical knowledge and problem-solving
   - Final Result

5. **Final Presentation (5 Marks)**

   - Quality and clarity of the overall presentation
   - Individual contribution to the presentation

- Effectiveness in answering questions

6. **Project Quality, Innovation, and Creativity (3 Marks)**

   - Overall quality and technical excellence of the project
   - Innovation and originality in the project

Creativity in solutions and approaches

SEMESTER 6

BIOSENSORS & TRANSDUCERS

Course Code	**OEBMT 611**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	OE

Course Objectives:

1. To understand the principle behind the working of biosensors
2. To describe the methods of measurement of different biosensors
3. To apply MEMS and NEMS techniques for designing sensors

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**General configuration of biosensors**: Introduction to biosensor and classification based on bio recognition element. Immobilization techniques- Enzymatic, DNA, antigen-antibody; Basic principle and instrumentation of different biosensors: electrochemical, optical, acoustic and piezoelectric biosensors.	**9**
2	**Electrochemical Biosensors**: basics of gas, ion and humidity sensors, applications of Nernst Equation in biosensor, Reference electrodes and types. **Optical biosensors-** light interactions with biomolecules, types of optical biosensors, Plasmon band based sensors	**9**
3	**Transducers**–types and classification –primary and secondary-active and passive-characteristics of thermo-resistive transducers-RTD-thermistor, thermoelectric transducers- thermocouple-principle of operation	**9**

4	**Introduction to microsensors:** Evolution of microsensors; Nano biosensors-basic concepts, construction of Nano biosensors, Nanomaterials for new bio sensing applications, optical nano biosensors-basics and applications of BioMEMS	**9**

Course Assessment Method
(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the principle behind the working of biosensors	Understand
CO2	Describe the methods of measurement of different biosensors	Evaluate
CO3	Apply MEMS and NEMS techniques for designing sensors	Application
CO4	Analyse the principle behind various biomedical transducers	Analysis

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	2			2	2					2
CO2	3	1	1			1	1					1
CO3	3	1	2			2	2					1
CO4	3	1	2			1	1					1
CO5	3	1	2			1	1					1

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Biosensors and modern bio-specific analytical techniques, Volume XLIV	L. Gorton	Elsevier	2005
2	Advances in biosensors	B. D. Malhotra & A. P. F. Turner	Elsevier	2003
3	Sensors and transducers	Brindley, Keith	CRC Press ILlc	1988
4	Transducers for biomedical instruments	RS CCobbold	John Wiley & Sons	1974

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Biomedical Instrumentation and measurement	Leslie Cromwell	Prentice hall of India, New Delhi,	2007
2	Medical Instrumentation Application and Design	JohnG.Webster	John Wiley & Sons	2004
3	Principle of biomedical Instrumentation	Andrewg Webb	Cambridge University Press	2018
4	Applied biosensors	D.L.Wise	Butterworth Publishers, London	1989

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	Optical Sensors - Course (nptel.ac.in)
2	A brief introduction of Micro-Sensors - Course (nptel.ac.in)
3	Transducers For Instrumentation - Course (nptel.ac.in)

SEMESTER S6

BIOMECHANICS

Course Code	**OEBMT 612**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	OE

Course Objectives:

1. **T**o provide students with a foundational understanding of biomechanics, focusing on the mechanical properties and behaviors of biological tissues and systems.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to Biomechanics (T1)** • **Introduction to Biomechanics -** Definition and perspective - Statics of the body and total body equilibrium - Equilibrium of individual body components • **Kinematic and Kinetic Concepts for Analyzing Human Motion -** Kinematic concepts - Kinetic concepts - Anthropometry • **Human Bone Biomechanics -** Composition and structure of bone tissue - Bone growth and development - Modeling and remodeling of bones (Wolfe's law of bone remodeling) • **Biomechanics of Human Skeletal Articulations -** Joint architecture and flexibility	9
2	**Muscle Mechanics (T2)** • **Muscle Architecture and Mechanics** - Muscle fascicles and their arrangement - Fiber architecture in fascicles - Muscle as a fiber-reinforced composite - Muscle centroids and cross-sectional areas	9

	(physiological & anatomical) • **Viscoelasticity of Tissues** - Models of viscoelasticity (Kelvin – Voight model and Maxwell model) • **Properties of Tendons and Passive Muscles** - Viscoelastic behavior of tendons • **Mechanics of Active Muscle** - Muscle force production and transmission - Functional relations (Force-length, Force-velocity curves) - Hill's model and sliding filament theory	
3	**Biomechanics of the Human Upper and Lower Extremity (T1)** • **Loads on the Upper Extremity** - Shoulder - Elbow • **Loads on the Lower Extremity** - Hip - Knee - Foot • **GAIT Cycle** - Components of the swing and stance phase of walking - Temporal factors - Center of mass displacement • **Biomechanics of the Human Spine** - Structure of the spine - Loads on the spine	**9**
4	**Cardiovascular System Biomechanics (T3)** • **Basic Biofluid Mechanics** - Properties of blood - Structure of blood vessels - Blood pressure – Measuring flow in blood vessels • **Models of the Cardiovascular System** - Vascular resistance and capacitance - Lumped parameter model of the peripheral circulation - Heart as a pump	**9**

Course Assessment Method
(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course, students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the fundamental principles of biomechanics, including statics, kinematics, kinetics, viscoelasticity of tissues, bone biomechanics, and joint mechanics.	**K2**
CO2	Comprehend and describe the detailed mechanics of muscles, including muscle architecture, properties of tendons and passive muscles, active muscle mechanics, and muscle coordination.	**K2**
CO3	Apply the principles of biomechanics to the human upper and lower extremities and spine, including load distribution, GAIT cycle, and spinal biomechanics.	**K3**
CO4	Utilize the principles of biofluid mechanics and cardiovascular system modeling, including vascular resistance, capacitance, and heart function, to analyze and solve related problems.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2											
CO2	3	2										
CO3	3	3		2		2						
CO4	3	3		2		2						

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
T1	Basic Biomechanics	Susan J Hall	McGraw-Hill,	Sixth edition & 2012
T2	Fundamentals of Biomechanics	Nihat O ¨ zkaya, David Goldsheyder, Margareta Nordin	Springer International Publishing Switzerland	Fourth edition & 2017
T3	Physics of the Human Body	Irving P. Herman	Springer	Second edition & 2016

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Biomechanics and Motor Control of Human Movement	David A. Winter	John Wiley & Sons, Inc.	Fourth edition & 2009
2	Fundamentals of Biomechanics	Duane Knudson	Springer Science + Business Media, LLC Springer	Second edition & 2007

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc21_me52
2	https://onlinecourses.nptel.ac.in/noc23_bt04
3	https://onlinecourses.nptel.ac.in/noc21_me52
4	https://onlinecourses.nptel.ac.in/noc23_bt04

SEMESTER S 6

BIO SIGNALS & SIGNAL PROCESSING

Course Code	**OEBMT 613**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	OE

Course Objectives:

1. To familiarize various kinds of signals and their characteristics.
2. To understand transform techniques.
3. To understand FFT algorithms.
4. To familiarize power spectrum estimation.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Signals – classification of signals continuous & discrete, Energy and Power signals , even and odd signals, Even & odd signals. Introduction to elementary signals - exponential and sinusoidal - unit step and impulse - mathematical representation. Introduction to biomedical signals- ECG, EMG, EEG, , carotid pulse, - properties, characteristics of bio signals - challenges in processing - low amplitude low frequency signals.	9
2	Fourier Series & Transform – Fourier series representation of continuous time signals – properties. Continuous time Fourier transform representation of aperiodic signals- properties. Laplace transform - Region of convergence - The inverse	9

	Laplace transform - Properties of the Laplace transform.	
3	Sampling – Introduction - Representation of a continuous-time signal by its samples - the sampling theorem - Under sampling – effects - aliasing. Fourier Series & Transform- Discrete Fourier Series- properties, Discrete Fourier Transform – Properties FFT Algorithm – Decimation in Time & Decimation in Frequency.	9
4	Z- Transform – Region of Convergence- The inverse Z- Transform- Properties of Z Transform. Periodogram-Averaged periodogram, Blackman-Tukey Spectral estimation, QRS detection in ECG, Analysis of Heart Rate Variability using periodogram.	9

Course Assessment Method
(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Demonstrate the fundamentals of signals.	**K1**
CO2	Apply domain transformation techniques in Continuous-time signals	**K3**
CO3	Understand the process of sampling.	**K2**
CO4	Apply domain transformation techniques in discrete-time signals	**K3**
CO5	Understand different power spectrum estimation techniques.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3							2		2
CO2	3	3	3	3	3					2		2
CO3	3	3	3	3	3					2		2
CO4	3	3	3	3	3					2		3
CO5	3	3	3	3	3					2		3

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Signals and Systems	Alan V Oppenheim, Alan S Willsky	Prentice Hall India, 2/e	2010
2	Digital Signal Processing	P. Ramesh Babu	Scitech Publications, India	2004
3	Biomedical signal processing: principles and techniques	Reddy, D. C.	McGraw-Hill	2005
4	Biomedical signal processing	Akay, Metin	Academic press	2012

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Digital Signal processing- Principles, Algorithms and Applications,	John G Proakis & Dimitris G Manolakis	PHI	
2	Digital Signal Processing	Sanjit K. Mithra	Tata McGraw Hill	3rd ed.
3	Biomedical Signal Analysis	Rangaraj M Rangayyan	John Wiley	2002

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/108104100
2	https://nptel.ac.in/courses/108104100
3	https://nptel.ac.in/courses/108104100
4	https://nptel.ac.in/courses/108104100

SEMESTER: S6

BIOMATERIALS

Course Code	OEBMT 614	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3-0-0-0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Nil	**Course Type**	OE

Course Objectives:

1. Understand the properties, classification and application of Biomaterials.
2. Explain Categorization of Biomaterials.
3. Describe in-depth Study of interactions and biocompatibility
4. Elucidate advanced fabrication techniques and applications of biomaterials, alongside regulatory standards for their testing.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Fundamentals of Materials Science** Introduction to basic concepts of Materials Science: Salient properties of materials -Mechanical Properties: Strength, elasticity, fatigue resistance. Chemical Properties: Corrosion resistance, degradation behavior. Biological Properties: Biocompatibility, bioactivity, toxicity. Physical Properties: Density, porosity, surface properties of the materials:	9
2	**Categories of Biomaterials**	

	Polymeric Biomaterials: Synthetic Polymers: Includes materials such as polyolefins, polyamides, fluorocarbon polymers, silicone rubbers, and acetyls. Natural Polymers: Includes biomolecules like collagen, elastin. Metallic Biomaterials: Comprises metals such as stainless steel, titanium, cobalt-chrome alloys, and nickel-titanium alloys. Ceramic Biomaterials: Encompasses materials like alumina, zirconia, hydroxyapatite, and bio glass. Composite Biomaterials: Combines different material types such as fiber-reinforced polymers, bone cement, biocomposites, and nanocomposites.	**9**
3	**Comprehensive Aspects of Biomaterial Interactions and Biocompatibility** Tissue-material interactions and biological response of host tissue, Factors contributing to biomaterial failure: Swelling & leaching, corrosion, dissolution, Biocompatibility factors: Carcinogenicity, mutagenicity. Hemocompatibility factors, Assessment of biocompatibility: In vitro biochemical assays, in vivo testing (acute and chronic toxicity),Strength and strengthening mechanisms of metals, ceramics, and polymers, Tailor-made composites, bio composites, and nano-biocomposites, Treatment procedures to enhance biocompatibility of implants,	**9**
4	**Bioimplant Fabrication Methods, Regulatory Standards, and Applications** Regulatory standards: ISO guidelines, ASTM International standards. Bioimplant fabrication methods: Wrought and cast, Powder metallurgy, Additive manufacturing (Rapid prototyping (RP) technologies and Surface finishing processes. Applications of Biomaterials: Hard tissue and dental implants-Soft tissue implants-Cardiovascular implants-Ophthalmic implants Conceptual designing of bioimplants (by applying the design engineering concept), Literature study: State of the art applications such as tissue engineering scaffolds, drug delivery vehicles devices in the current research studies.	**9**

Course Assessment Method
(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand the properties, classification and application of Biomaterials.	K1
CO2	Explain Categorization of Biomaterials	K2
CO3	Describe in-depth Study of interactions and biocompatibility	K2
CO4	Elucidate advanced fabrication techniques and applications of biomaterials, alongside regulatory standards for their testing	K2

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3											2
CO2	3											1
CO3	3											2
CO4	3			2								2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Biomaterial Science and engineering	Joon Bu Park	Plenum Press, New York	1984
2	Biomaterials	Sujata V. Bhat	Narosa Publishing House Newdelhi Chennai Mumbai	2022
3	Biological Response to materials	James m Anderson,	Review of materials research Annual Review	2001

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Encyclopaedic Hand Book of Biomaterials and Bioengineering	Donald L. Wise	Taylor & Francis	2000
2	Biomaterials: Principles and Applications.	Bronzino	CRC Press	2022
3	Encyclopedia of medical devices and instrumentation	John G Webster ,	Hoboken	2006

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/102106057
2	https://archive.nptel.ac.in/courses/102/106/102106057/
3	https://nptel.ac.in/courses/113108071

SEMESTER S6

MEDICAL DEVICE TESTING AND DISSECTION LAB

Course Code	PCBML607	CIE Marks	50
Teaching Hours/Week (L: T:P: R)	0-0-3-0	ESE Marks	50
Credits	2	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	PCL

Course Objectives:

1. Fundamental understanding of biomedical equipment and perform testing and calibration on these devices.
2. Dissect and explain the working of various medical devices like defibrillator, ventilator etc.
3. Perform dissection on Biomedical Equipment and label and explain various sub-modules of the equipment.
4. Carryout field visit and prepare a report containing protocols for the workflow, regulatory for the installation and maintenance of biomedical equipment/systems.

Details of Experiment

Expt. No	Experiment (Any 10 experiments mandatory)
1	Gaining familiarity with the tools, symbols utilized in medical devices, and industry standards in the biomedical sector.
2	Become familiar with an Electrical Safety Analyser and perform electrical safety testing on two biomedical devices using it, generating standard (IEC/ANSI/AAMI, etc.) reports on safety, quality, and performance tests for these devices.
3	Dissect and familiarize yourself with the Vital Signs Simulator for assessing and troubleshooting patient monitor performance, adhering to standards (IEC/ANSI/AAMI, etc.) for testing ECG, respiration, invasive and non-invasive blood pressure, and Oxygen Saturation.
4	Gain familiarity with a specific critical care equipment thorough examination, while analyzing safety, quality, and performance standards (such as IEC, ANSI, AAMI) pertinent to

	its operational functions.
5	Dissect and familiarize with an Electrosurgical Unit (ESU) to assess all critical functions, generating a standard (IEC/ANSI/AAMI, etc.) safety, quality, and performance test report.
6	Dissect and Conduct testing on a Defibrillator using a Defibrillator Analyser to ensure it meets performance specifications, and produce a standard (IEC/ANSI/AAMI, etc.) safety, quality, and performance test report.
7	Dissect and Test Syringe and infusion Pump using an analyzer to ensure they meet performance specifications, and generate a standard (IEC/ANSI/AAMI, etc.) safety, quality, and performance test report.
8	Perform dissection study on basic biomedical equipment (ECG machine/Automatic BP Machine)
9	Perform dissection study on defibrillator.
10	Perform dissection study on Neonatal equipment.
11	Perform dissection study on analytical equipment.
12	Conduct a field visit and prepare a report outlining the protocols for workflow, regulatory guidelines for the installation and maintenance of biomedical equipment/systems, and the hospital department facility layout in accordance with these regulatory guidelines.
13	Dissect and familiarize with an ultrasound machine.

Course Assessment Method (CIE: 50 Marks, ESE 50 Marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Preparation/Pre-Lab Work, experiments, Viva and Timely completion of Lab Reports / Record. (Continuous Assessment)	Internal Exam	Total
5	**25**	**20**	**50**

End Semester Examination Marks (ESE):

Procedure/ Preparatory work/Design/ Algorithm	Conduct of experiment/ Execution of work/ troubleshooting/ Programming	Result with valid inference/ Quality of Output	Viva voce	Record	Total
10	15	10	10	5	50

Mandatory requirements for ESE:

- Submission of Record: Students shall be allowed for the end semester examination only upon submitting the duly certified record.
- Endorsement by External Examiner: The external examiner shall endorse the record.

Course Outcomes (COs)

At the end of the course the student will be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Fundamental understanding of biomedical equipment and perform testing and calibration on these devices.	**K2**
CO2	Dissect and explain the working of various medical devices like defibrillator, ventilator etc.	**K3**
CO3	Perform dissection on Biomedical Equipment and able to label and explain various sub-modules of the equipment.	**K4**
CO4	Carryout field visit and prepare a report containing protocols for the workflow, regulatory for the installation and maintenance of biomedical equipment/systems.	**K2**

K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

CO-PO Mapping Table

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3					2						
CO2	3					2						
CO3	3					2	2					
CO4	3					2		2	2	2		

Note:1: Slight (Low),2: Moderate (Medium),3: Substantial (High), : No Correlation

Text Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Medical instrumentation application and design	John G Webster	Wiley India Pvt Ltd, India,	4^{th} Edition 2015
2	Hand Book of Biomedical Instrumentation	R S Khandpur	Tata Mc Graw Hill Publishing CO, Ltd	3^{rd} edition 2014
3	Introduction to biomedical equipment technology	Joseph J Carr and John M Brown	Pearson Education , New Delhi	4^{th} Edition 2004

Reference Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Biomedical Instrumentation and measurements	Leslie Cromwell,Fread J Weibell, Erich A Pfeiffer	Pearson Education , PHI Learning Private Limited, India	2^{nd} edition 2007

Video Links (NPTEL, SWAYAM…)

Sl. No.	Link ID
1	https://nptel.ac.in/courses/102106057
2	https://archive.nptel.ac.in/courses/102/106/102106057/
3	https://nptel.ac.in/courses/113108071

Continuous Assessment (25 Marks)

1. **Preparation and Pre-Lab Work (7 Marks)**

- Pre-Lab Assignments: Assessment of pre-lab assignments or quizzes that test understanding of the upcoming experiment.
- Understanding of Theory: Evaluation based on students' preparation and understanding of the theoretical background related to the experiments.

2. **Conduct of Experiments (7 Marks)**

- Procedure and Execution: Adherence to correct procedures, accurate execution of experiments, and following safety protocols.
- Skill Proficiency: Proficiency in handling equipment, accuracy in observations, and troubleshooting skills during the experiments.
- Teamwork: Collaboration and participation in group experiments.

3. **Lab Reports and Record Keeping (6 Marks)**

- Quality of Reports: Clarity, completeness and accuracy of lab reports. Proper documentation of experiments, data analysis and conclusions.
- Timely Submission: Adhering to deadlines for submitting lab reports/rough record and maintaining a well-organized fair record.

4. **Viva Voce (5 Marks)**

- Oral Examination: Ability to explain the experiment, results and underlying principles during a viva voce session.

Final Marks Averaging: The final marks for preparation, conduct of experiments, viva, and record are the average of all the specified experiments in the syllabus.

Evaluation Pattern for End Semester Examination (50 Marks)

1. **Procedure/Preliminary Work/Design/Algorithm (10 Marks)**

- Procedure Understanding and Description: Clarity in explaining the procedure and understanding each step involved.
- Preliminary Work and Planning: Thoroughness in planning and organizing materials/equipment.

- Algorithm Development: Correctness and efficiency of the algorithm related to the experiment.
- Creativity and logic in algorithm or experimental design.

2. **Conduct of Experiment/Execution of Work/Programming (15 Marks)**

- Setup and Execution: Proper setup and accurate execution of the experiment or programming task.

3. **Result with Valid Inference/Quality of Output (10 Marks)**

- Accuracy of Results: Precision and correctness of the obtained results.
- Analysis and Interpretation: Validity of inferences drawn from the experiment or quality of program output.

4. **Viva Voce (10 Marks)**

- Ability to explain the experiment, procedure results and answer related questions
- Proficiency in answering questions related to theoretical and practical aspects of the subject.

5. **Record (5 Marks)**

- Completeness, clarity, and accuracy of the lab record submitted

SEMESTER 7

BIOMEDICAL ENGINEERING

SEMESTER S7

ADVANCED MICROPROCESSORS AND MICROCONTROLLERS

Course Code	**PEBMT741**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	2:1:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	PCBMT 402	**Course Type**	PE

Course Objectives:

1. Is to enable get the students gives a broad overview of the architecture of basic and advanced microprocessors along with an update of current technology in SOC design and high-performance computing.
2. Students shall be encouraged to review technical manuals of relevant processors and microcontrollers one of the assignments shall be a case study of Medical Embedded application of the latest hardware technology.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Intel 80386 Microprocessor: Architecture - Registers – Descriptors - Real Mode - Protected mode - Virtual 8086 mode - Paging and Segmentation - Comparison with 80486 Microprocessor. Pentium class of processors: RISC and CISC architectures - Superscalar Architecture - MMX technology – SSE – Pipelining - Branch Prediction techniques – FPU - Comparative study of features of Pentium-II, Pentium-III and Pentium-IV processors.	**9**
2	High performance CISC architecture: 80386 - Salient features, Architecture and Signal Description, Register Organization. Real Address mode, Protected mode, Segmentation, Paging & Virtual modes. Pentium - General features, pipelining and super scalar architecture. Introduction to multicore processors: Advantages of multicore, Concept of Hyper-Threading, homogeneous and heterogeneous multicore processors, Internal architecture of Intel Core2 Duo (Simple block diagram level only), Comparison of Core i3, i5 and i7 processors	**9**

3	High performance RISC architecture: ARM Processor Fundamentals: ARM category overview- Classic ARM, ARM Cortex, ARM for Embedded Applications. The Classic ARM programmer's model, ARM Processor Families, ARM Organization - 3-stage and 5-stage pipeline ARM organization, ARM instruction execution, ARM Instruction Set, Thumb Instruction set. Architectural Support for System Development - The ARM memory interface, The Advanced Microcontroller Bus Architecture (AMBA)ARM Classic/Cortex based SOC: Basic system-on-chip (SoC) architecture, Overview of SoC design flow. Raspberry Pi family - Overview and general architecture, accessories. Application and use in healthcare (Case study such as People's Ventilator Project), Feature comparison: Pi 4 vs Pi Pico	**9**
4	**Introduction to high performance computing**: CPU vs GPU, Application areas, GPUs as Parallel Computers, Evolution of Graphics Pipelines, GPU Computing, Parallelism with GPUs - Data parallelism and task parallelism, Feature comparison: Raspberry Pi vs NVIDIA Jetson NANO. **Literature Review:** Smartphone processors (Overview of system functionalities) - Samsung Exynos 5410 SoC and Apple A14	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO 1	Describe the architecture, registers and memory unit in a basic CISC processor-based computing device	**K2**
CO 2	Discuss about advanced RISC platforms and illustrate its usage in a typical Medical Embedded application	**K2**
CO 3	Outline the architecture of high-performance GPUs and their application areas.	**K2**
CO 4	Describe parallelism in supercomputing processors	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3										2
CO2	3	3						2			2	2
CO3	3	3						2			2	2
CO4	3	3						2			2	2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Reliable design of medical devices	Fries, Richard C	Wiley Dreamtech,	2012
2	Medical Device Design Innovation from Concept to Market	Peter Ogrodnik	Elsevier	2013
3	Biomedical devices: materials, design, and manufacturing.	Lam, Raymond HW, and Weiqiang Chen	Springer	2019
4	Design of Biomedical Device and Systems	Paul H. King, Richard C. Fries, Arthur T. Johnson	Third Edition	2015

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Design controls for the medical device industry	Teixeira, Marie B	CRC press	2019
2	Medical devices: regulations, standards and practices	Ramakrishna, Seeram, Lingling Tian, Charlene Wang, Susan Liao, and Wee Eong Teo	Woodhead Publishing	2003
3	Embedded systems: An Integrated Approach	Lyla B. Das	Lyla B. Das	2015

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/108/105/108105102/
2	https://nptel.ac.in/courses/117104072
3	https://archive.nptel.ac.in/courses/106/108/106108100/
4	https://nptel.ac.in/courses/108107029

SEMESTER S7

HUMAN FACTORS IN ENGINEERING AND DESIGN

Course Code	**PEBMT742**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs.30 Min.
Prerequisites (if any)	None	**Course Type**	PE

Course Objectives:

1. To provide an understanding of general and specific Human Factor principles and guidelines for Medical Device Design.

SYLLABUS

Module No.	**Syllabus Description**	**Contact Hours**
1	Introduction to Human factors Engineering – Definition, focus, objective, approach. Process of seeing, Visual capabilities- Accommodation, Visual acuity and Contrast sensitivity. Human Factor Aspects for Visual displays in Medical Device: Display Performance Requirements - Display Viewing Conditions, Spatial Characteristics, Temporal Characteristics, Luminance and Color Characteristics. Display Formatting- Size and Spacing of Displayed Characters. Case Study- selection of display for Cardiac Output Monitor	**9**
2	Medical Device Use Environments: General And Specific Design Guidelines For Space And Physical Constraints, Lighting, Energy Sources, Infection Control, Case Studies - Insulin Infusion Pump. Special Environments: Mobile Medical Device Design Principles - Weight, Moving Parts, Size And Shape, Warnings And Labels, Instructions For Use, Protective Mechanisms, Mounting And Security Mechanisms, Brakes, Wheels, Storage, Materials, Cleanability. Case Studies- Transport Ventilator, Portable Ultrasound Device	**9**

3	Medical Workstation Design- General Considerations- Safety, Usability, User Satisfaction, Special Considerations- Workstation Purposes, Workstation Uses , Use Environment . Design Principles- Operational Factors, User accommodations - Seating, Hospital Beds and Examination Tables. Case studies exemplify the effective application of human factors principles - Anaesthesia Workstation, Ultrasound Imaging Workstation, Hospital Bed.	**9**
4	Medical Device Labeling: General Labeling Requirements, Labels for Device Identification, Human Factors Principles for Designing Medical Device Labels. Specific design guidelines for medical device labels - Label Content, Location Aids and Functional Relationships, Position and Placement, Gestalt Principles, Durable Materials, Legibility, Coding.	**9**

Course Assessment Method

(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Describe human factors aspects of visual displays in Medical Devices	**KL2**
CO2	Analyze human factor aspects for Medical Device Use Environments	**KL3**
CO3	Analyze various human factor guidelines for Medical Workstation and evaluate its effective application through case studies	**KL3**
CO4	Explain general labeling requirements and human factors principles for design of medical device labels	**KL2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2				2			2	2		
CO2	3	2				2			2	2		2
CO3	3	2				2			2	2		2
CO4	3	2				2			2	2		2
CO5	3	2				2			2	2		

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Handbook of Human Factors in Medical Device Design	Matthew B. Weinger Michael E. Wiklund Daryle J. Gardner-Bonneau	CRC Press	2010
2	Human Factors in Engineering and Design	Mark S. Sanders & Ernest J. McCormic	McGraw Hill, International Edition	1993

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Human Factors Engineering in System Design	Terence S. Andre, Aaron W. Schopper	British Columbia Teacher	1997
2	Human Factors Design Handbook	Wesley E. Woodson	McGraw-Hill Professional	2nd edition, 1992

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc22_mg108/preview#:~:text=The%20course%20is%20designed%20to,of%20physical%20environment%2C%20design%20of
2	https://onlinecourses.nptel.ac.in/noc22_mg108/preview#:~:text=The%20course%20is%20designed%20to,of%20physical%20environment%2C%20design%20of
3	https://onlinecourses.nptel.ac.in/noc22_mg108/preview#:~:text=The%20course%20is%20designed%20to,of%20physical%20environment%2C%20design%20of
4	https://onlinecourses.nptel.ac.in/noc22_mg108/preview#:~:text=The%20course%20is%20designed%20to,of%20physical%20environment%2C%20design%20of

SEMESTER S7

NEURAL PROSTHESIS & IMPLANTS

Course Code	**PEBMT743**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3-0-0-0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs.30 Min.
Prerequisites (if any)	None	**Course Type**	PE

Course Objectives:

1. To provide an in-depth understanding of the technologies and engineering principles behind neural prostheses, focusing on visual, auditory, and upper limb prosthetics
2. To equip students with the knowledge and skills to design, analyze, and implement neural prosthetic systems, addressing both technical challenges and practical applications

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Overview of Neural Prosthesis, Retinal implant technologies-Epiretinal, Subretinal and Extraocular implants, Visual stimulation in the brain, Optic Nerve Stimulation, Engineering challenges in the development of visual prosthesis, Neural electrical stimulator, DSP-based image processing system for visual prostheses	9
2	Cochlear implants- Architecture and functional block diagram of a modern cochlear implants, External unit, RF link, Internal unit, Electrodes, Safety Considerations, Auditory Prosthesis Using Deep Brain Stimulation: Development and Implementation – Design and implementation, Electrode technologies, Stimulation strategies.	9
3	Brief history of artificial hands - Origin and nature of the myoelectric signal, Anatomy, Contraction Process, Connections to the CNS, Fibre membrane and the action potential, Measurement of the potentials associated with	9

	depolarization, Muscle force mediation, Myoelectric Signal - Acquisition, Processing, Control of prosthetic function, Terminal device electronics	
4	Upper Limb Prosthetics Pre-prosthetic Assessment, Prosthetic Options, Components for the Upper Limb Prosthesis - Hands and Work Hands, and Cosmetic Covers, Electric wrist rotation, Wrist Flexion, Elbow components, control Systems, Interface designs, Indications and contraindications, Training and outcome measurement Mechatronic hands: prosthetic and robotic design Myoelectrically controlled hand - Mechanisms - Materials, actuators, Sensors, Control - finger position, object slip, EMG reference control, Artificial prehension, Brain control and sensing of artificial limbs	**9**

Course Assessment Method
(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand the principles and technologies of visual prostheses, including retinal implants and neural electrical stimulators.	**K2**
CO2	Analyze the architecture and functional components of modern cochlear implants and auditory prostheses using deep brain stimulation.	**K4**
CO3	Explain the origin and nature of myoelectric signals and their application in artificial hand prosthetics.	**K2**
CO4	Assess and choose appropriate components and control systems for upper limb prosthetics, considering pre-prosthetic assessment and patient-specific needs.	**K2**
CO5	Design and implement control systems for myoelectrically controlled prosthetic hands, incorporating sensors, actuators, and EMG reference control.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2									2
CO2	3	3	2		2							2
CO3	3	2		2								2
CO4	3		3			2						2
CO5	3	2	3									2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Implantable Neural Prostheses 1 Devices and Applications,	David D. Zhou Elias Greenbaum	Springer	2009
2	Powered Upper Limb Prostheses: Control, Implementation and Clinical Application	L. McLean, R. N. Scott (auth.), Ashok Muzumdar	Springer-Verlag Berlin Heidelberg	2004
3	Mechatronic Hands Prosthetic and Robotic Design, The Institution of Engineering and Technology	Paul H. Chappell	ISBN 978-1-78561-155-1 (PDF)	2016,
4	Upper Limb Prosthetics	Alberto Esquenazi, MD	PM&R	2014
5	Implantable Neural Prostheses 1 Devices and Applications,	David D. Zhou Elias Greenbaum	Springer	2009

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Orthotics and prosthetics in rehabilitation	Kevin Chui, Milagros Jorge, Sheng-Che Yen, Michel M. Lusardi	Elsevier	Fourth edition
2	Active Above-Knee Prosthesis - A Guide to a Smart Prosthetic Leg, ,	Zlata Jelacic, Remzo Dedic, Haris Dindo	Elsevier Inc	2020
3	Mechanics of Biomaterials Fundamental Principles for Implant Design,	Lisa A. Pruitt and Ayyana M. Chakravartula	Cambridge University Press	2011
4	Orthotics and prosthetics in rehabilitation	Kevin Chui, Milagros Jorge, Sheng-Che Yen, Michel M. Lusardi	Elsevier	Fourth edition
5	Active Above-Knee Prosthesis - A Guide to a Smart Prosthetic Leg, ,	Zlata Jelacic, Remzo Dedic, Haris Dindo	Elsevier Inc	2020

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	The Electric Eye: A Visual Prosthesis (youtube.com)
2	How Do Cochlear Implants Work? (youtube.com)
3	Kinder Joy BB HW Top Right Logo 20s (Malayalam) (youtube.com)

SEMESTER S7

ASSISTIVE MEDICAL DEVICES

Course Code	**PEBMT744**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs.30 Min.
Prerequisites (if any)	PCBMT205, PBBMT304	**Course Type**	PE

Course Objectives:

1. To equip students with a thorough understanding of the principles, design, and application of assistive medical devices, enabling them to address the needs of individuals with disabilities through innovative engineering solutions.
2. To foster practical skills and innovative thinking in students, preparing them to design, develop, and implement effective assistive devices in real-world clinical settings.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction:** Definition and scope of assistive technologies- **Regulatory and Ethical Considerations - O**verview of FDA, CE Mark, and other regulatory frameworks - Ethical considerations in the development and use of assistive devices - Standards and guidelines for accessibility and usability;**Human Factors and Ergonomics -** Principles of human-cantered design and ergonomics - Techniques for improving user experience and usability.	9
2	**Design and Development of Assistive Devices: Materials and Manufacturing- p**roperties of materials used in assistive devices **-** Manufacturing processes: traditional vs. advanced methods (e.g., 3D printing) - Selection criteria for materials and manufacturing technique**s-**	9

	Biomechanics and Movement Analysis: fundamentals of biomechanics relevant to assistive devices - techniques for gait analysis and movement modelling - Integration of biomechanical data in device design- Integration of sensors into assistive devices for data acquisition and feedback - Data processing and signal interpretation.	
3	**Types of Assistive Devices:** Mobility aids: Wheelchairs, scooters, walkers, prosthetics, and orthotics; Sensory aids: Hearing aids, cochlear implants, visual aids, and Braille devices; Cognitive aids: Augmentative and alternative communication (AAC) devices, memory aids, and software tools : **Neural Prosthetics and Brain-Computer Interface:** Basics of neural prosthetics and their applications - Introduction to brain-computer interfaces (BCIs): technology, mechanisms, and applications - Future trends in neural and BCIs for assistive technology.	**9**
4	**Smart Assistive Technologies -** types of assistive robots: exoskeletons, rehabilitation robots, service robots - Key components and technologies in assistive robotics: sensors, actuators, AI - Challenges and advancements in assistive robotics; Role of the Internet of Things (IoT) in assistive devices - Overview of wearable technology and smart home integration - Developing smart, connected assistive devices.	**9**

Course Assessment Method

(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand the significance of assistive devices and ethical considerations in the development and use of assistive devices.	Understand
CO2	Ability to select appropriate materials and techniques based on device requirements.	Understand
CO3	Evaluate and select appropriate assistive devices for different disabilities and integrate advanced technologies in device design.	Evaluate
CO4	Understand the potential and future trends of smart assistive technologies	Understand

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2		2		2	2	2				3
CO2	3			3		2	2	2				3
CO3	3	3	1	2	2	2	2	2				3
CO4	3	2	2	2	3	2	2	2				3

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Assistive Technologies: Principles and Practice	Albert M. Cook and Janice M. Polgar	Elsevier	2015
2	Assistive Technologies and Applications for Assisted Living Challenges and Solution	Martina Ziefle and Carsten Rcker	IGI Global snippet	2010
3	Rehabilitation Engineering: Principles and practice	Alex Mihalidis and Roger Smith	CBC Press	
4	Assistive Technology: Principles and applications	Albert M. Cook and Janice M. Polgar	Elsevier	2015

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	KEEP IT SIMPLE: A Guide to Assistive Technologies	Ravonne A. Green and Vera Blair	Libraries Unlimited	2011
2	Aural Rehabilitation for People with Disabilities	John M. A. Oyiborhoro	Elsevier, Academic Press,	2005
3	Assistive Technology for People with Disabilities	Diane Pedrotty Bryant, Brian R Bryant	Pearson	2012
4	Choosing Assistive Devices A guide for users and professionals	Helen Pain Lindsay McLellan Sally Gore	Jessica Kingsley Publishers	2003

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	Development of Assistive technology for persons with Disabilities - Course (swayam2.ac.in)
3	Introduction to Assistive Devices for Mobility NPTEL-NOC IITM

SEMESTER S7

ADVANCED COMPUTER PROGRAMMING TECHNIQUES

Course Code	**PEBMT746**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs.30 Min.
Prerequisites (if any)	None	**Course Type**	PE

Course Objectives:

1. To introduce the various programming paradigms.
2. To understand the evolution of programming languages.
3. To understand the concepts of languages, functional languages, logical and scripting languages.
4. To introduce the principles and techniques involved in design and implementation of modern programming languages.
5. To introduce the notations to describe the syntax and semantics of programming languages.

SYLLABUS

Module No.	**Syllabus Description**	**Contact Hours**
1	Preliminary Concepts: Reasons for studying concepts of programming languages, programming domains, language evaluation criteria, influences on language design, language categories, language design trade-offs, implementation methods, programming environments, Evolution of Major Programming Languages. Syntax and Semantics: General problem of describing syntax, formal methods of describing syntax, attribute grammars, describing the meanings of programs	**9**

2	Names, Bindings, and Scopes: Introduction, names, variables, concept of binding, scope, scope and lifetime, referencing environments, named constants. Data types: Introduction, primitive, character, string types, user defined ordinal types, array, associative arrays, record, tuple types, list types, union types, pointer and reference types, type checking, strong typing, type equivalence Expressions and Statements: Arithmetic expressions, overloaded operators, type conversions, relational and Boolean expressions, short- circuit evaluation, assignment statements, mixed mode assignment Control Structures – introduction, selection statements, iterative statements, unconditional branching, guarded commands.	**9**
3	Subprograms: Fundamentals of subprograms, design issues for subprograms, local referencing environments, parameter passing methods, parameters that are subprograms, calling subprograms indirectly, overloaded subprograms, generic subprograms, design issues for functions, user defined overloaded operators, closures, co routines. Implementing subprograms: General semantics of calls and returns, implementing simple subprograms, implementing subprograms with stack-dynamic local variables, nested subprograms, blocks, implementing dynamic scoping. Abstract Data types: The concept of abstraction, introductions to data abstraction, design issues, language examples, parameterized ADT, encapsulation constructs, naming encapsulations	**9**
4	Object Oriented Programming: Design issues for OOP, OOP in Smalltalk, C++, Java, Ada 95, Ruby, Implementation of Object-Oriented constructs. Concurrency: Introduction, introduction to subprogram level concurrency, semaphores, monitors, message passing, Ada support for concurrency, Java threads, concurrency in functional languages, statement level concurrency. Exception Handling and Event Handling: Introduction, exception handling in Ada, C++, Java, introduction to event handling, event handling with Java and C#. Scripting Language: Pragmatics, Key Concepts, Case Study : Python – Values and Types, Variables , Storage and Control, Bindings and Scope, Procedural Abstraction, Data Abstraction, Separate Compilation, Module Library.	**9**

Course Assessment Method

(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand to express syntax and semantics in formal notation	**K2**
CO2	Employ to apply suitable programming paradigm for the application.	**K3**
CO3	Design to program in different language paradigms and evaluate their relative benefits	**K6**
CO4	Understand the programming paradigms of modern programming languages.	**K2**
CO5	Understand the concepts of ADT and OOP	**K2**
CO6	Knowledge to compare the features of various programming languages	**K1**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1					1		2
CO2	3	3	2	2	1					1		2
CO3	3	3	2	2	1					1		2
CO4	3	3	2	2	1					1		2
CO5	3	3	2	2	1					1		2
C06	3	3	2	2	1					1		2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Concepts of Programming Languages	Robert .W. Sebesta	Pearson Education.	10th edition
2	Programming Language Design Concepts	D. A. Watt,	Wiley India Edition	

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Programming Languages	A.B. Tucker, R.E. Noonan	TMH	
2	Programming Languages	K. C. Louden and K A Lambert	Cengage Learning	3rd edition
3	Programming Language Concepts	C Ghezzi and M Jazayeri	Wiley India	
4	Programming Languages	Ravi Sethi	Pearson	2nd Edition

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
Module - II	https://nptel.ac.in/courses/122104019
Module - IV	https://nptel.ac.in/courses/106106210

SEMESTER S7

DEEP LEARNING TECHNIQUES

Course Code	**PEBMT745**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	5/3	**Exam Hours**	2 Hrs.30 Min.
Prerequisites (if any)	None	**Course Type**	PE

Course Objectives:

1. Illustrate the basic concepts of neural networks and its practical issues (Cognitive Knowledge level: Apply)

2. Outline the standard regularization and optimization techniques for deep neural network (Cognitive Knowledge Level: Understand)

3. Implement the foundation layers of CNN (Cognitive Knowledge Level: Apply)

4. Implement a sequence model using recurrent neural networks (Cognitive Knowledge Level: Apply)

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to Neural networks, Perceptron model-Single layer perceptron and Multi-layer perceptron, Activation functions-Sigmoid, Tanh and ReLu, McCulloch & Pitts model, Back propagation, The Problem of Overfitting, Vanishing and exploding gradient problems, Difficulties in convergence, Local and spurious optima.	**9**
2	Introduction to Deep Learning Bayesian Learning, Decision Surfaces , Deep feed forward network, Training deep models, Optimization techniques - Gradient Descent (GD), GD with momentum, Nesterov accelerated GD, Stochastic GD, AdaGrad, RMSProp, Adam. Regularization Techniques - L1 and L2 regularization, Early stopping, Dataset augmentation, Parameter	**9**

	sharing and tying, Injecting noise at input, Ensemble methods, Dropout, Parameter initialization	
3	Introduction to convolution neural networks– Convolution, pooling, architecture, Convolution and Pooling as an infinitely strong prior, variants of convolution functions, structured outputs, data types, efficient convolution algorithms.	**7**
4	Recurrent neural networks – Computational graphs, RNN design, encoder – decoder sequence to sequence architectures, deep recurrent networks, recursive neural networks, modern RNNs LSTM . Recent Trends in Deep Learning Architectures, Residual Network, Skip Connection Network, Fully Connected CNN etc	**11**

Course Assessment Method
(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Internal Ex	Evaluate	Analyse	Total
5	**15**	**10**	**10**	**40**

Criteria for Evaluation(Assignment/microproject):15 marks

Students should Analyse and apply deep learning technique for implementing a network for the application in biomedical field.

Criteria for evaluation

1.Problem Definition(K4- 5 points)

a)Identify the problem

b)Examine the relevant factors causing the problem

2.Problem Analyse(K4-5 points)

a)Find the best solution

3)Apply(K3 -5 points)

a)Apply any deep learning technique for implementing the solution

Scoring

1 Accomplished (4 points) :Analysis and depth of understanding the concept

2 Competent(3 points): Solid performance with minor area for improvement

3 Developing(2 points) :Adequate effort but lacks clarity

4 Minimal(1 point):Incomplete

End Semester Examination Marks (ESE)

In Part A, all 32questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Illustrate the basic concepts of neural networks and its practical issues	**K2**
CO2	Outline the standard regularization and optimization techniques for deep neural network	**K3**
CO3	Outline the standard regularization and optimization techniques for deep neural network	**K3**
CO4	Implement a sequence model using recurrent neural networks	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2		2									1
CO2	2	2	2		1							2
CO3	2		2									
CO4	2	2	2		2							2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Neural Networks and Deep learning	Charu C. Aggarwal	Springer International Publishing	2018
2	Deep Learning	Goodfellow, I., Bengio,Y., and Courville	MIT Press	2016
3	Fundamentals of Deep Learning: Designing Next-Generation Machine Intelligence Algorithms	Nikhil Buduma and Nicholas Locascio		2017

Reference Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Principles of soft computing	Deepa, S. N., and S. N. Sivanandam	WILEY	2011
2	Neural Networks and Deep Learning	Michael Nielsen		2018

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://elearn.nptel.ac.in/shop/nptel/introduction-to-soft-computing/?v=c86ee0d9d7ed
2	https://onlinecourses.nptel.ac.in/noc22_cs124/preview
3	https://elearn.nptel.ac.in/shop/nptel/introduction-to-soft-computing/?v=c86ee0d9d7ed
4	https://onlinecourses.nptel.ac.in/noc22_cs124/preview

SEMESTER S7

COMMUNICATION TECHNIQUES

Course Code	PEBMT751	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs.30 Min.
Prerequisites (if any)	None	Course Type	PE

Course Objectives:

1. This course introduces the fundamentals of electronic communication systems. Topics include the basic Analog and Digital communication techniques, fundamentals of wireless communication, and Internet of Things healthcare applications.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to Electronic Communication, Communication Systems, Types of Electronic Communication, Modulation. Amplitude Modulation-AM Concepts, Expression for AM wave, Modulation Index, AM Power. Sideband Modulation, Amplitude Modulators-Low-Level and High-Level AM, Amplitude Demodulators-Diode Detectors	9
2	Frequency Modulation-Basic Principles of Frequency and Phase Modulation, Expression for FM wave, Modulation Index and Sidebands, Bandwidth., FM modulators: Varactor diode, and reactance modulators. PM to FM and FM to PM conversion. Frequency Demodulators:Slope Detectors.	9
3	Radio transmitters- AM and FM Transmitter fundamentals, Communication Receivers, AM and FM superheterodyne receivers. Intermediate frequency and images-frequency relationship and images, Noise-Signal to Noise Ratio, external noise, internal noise.	8

4	Pulse modulation: Principles and types. Digital communication techniques- Digital transmission of data, parallel and serial transmission, PCM modulation. Multiplexing and Demultiplexing- FDM, TDM, Cell Phone Technologies-Cellular Concepts-, Base Stations and Small Cells..GSM: Principle and block diagram. Wireless Technologies-Wireless LAN, Wi-Fi, Wi MAX, Bluetooth, ZigBee, and Internet of Things Healthcare Applications (Overview Only)	**10**

Course Assessment Method
(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Explain different types of electronic communication systems and the role of modulation and multiplexing in facilitating signal transmission	**K2**
CO2	Describe transmitter and receiver configurations in radio transmission systems.	**K2**
CO3	Discuss different digital communication techniques.	**K2**
CO4	Classify widely used wireless communication technologies and its relevance in healthcare applications.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1										
CO2	2											1
CO3	2	1				1						1
CO4	2	1				1						1

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Principles of Electronic Communication Systems	Louis E. Frenzel Jr	McGraw-Hill Education.	Fourth Edition,
2	Communication Systems.	Simon Haykin, Michael Moher,	John Wiley & Sons	Fifth Edition 2009,
3	Modern Digital and Analog Communication ,.	B.P. Lathi, ZhiDing	University Press	Fourth Systems, edition Oxford,2011

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Electronics communication systems	George Kennedy ,	McGraw-Hill Education	2011
2	Advanced Electronic Communications Systems	Wayne Tomasi,	Pearson	International Edition
3	Communication System Engineering,	John G Proakis	Prentice Hall India	2002

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/117105143
2	https://onlinecourses.nptel.ac.in/noc21_ee74/preview
3	https://archive.nptel.ac.in/courses/117/105/117105144/
4	https://archive.nptel.ac.in/courses/117/102/117102062/

SEMESTER S7

DESIGN OF BIOMEDICAL DEVICES

Course Code	PEBMT752	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs.30 Min.
Prerequisites (if any)	Nil	Course Type	PE

Course Objectives:

1. To Design concepts for a medical device starting from generating ideas, classifying medical devices and understanding the design procedures.
2. To develop product specification, enhance quality in design are very much essential for a product design.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Determining and Documenting device requirements: Idea feasibility and Generating concept: Need identification, prototype development to prove the idea, proof of concept. Device requirements: Product specification, specification review, design specification .Software and / or Hardware requirement specification, Software/Hardware design description, Device Records (Case study-Automatic BP monitor, ECG machine etc.) Medical device classification	9
2	Design Phase – Risk analysis- hazards review, risk trace matrix, Failure Mode and Effects Analysis(FMEA): Design and system FMEA, Hardware design, Software design, design reviews, Design of experiments, safety margin, environmental protection, product misuse, Biocompatibility, sterilization requirements, human factors engineering, Bill of materials preparation (mechanical/electrical/software/system). (Case study: Example	9

	drug infusion system) Computer-Aided Design (CAD), and Computer-Aided Manufacturing (CAM) in biomedical device design.	
3	Design Verification, Product Validation and Design Transfer: Basic concepts, Design verification plan, protocols, design transfer process, software-hardware test plan for medical devices, system testing- subsystem and full device. Risk assessment of medical devices. Manufacturing supply chain: Product manufacturing, Installation Qualification, Operational Qualification and Performance Qualification (IQ/OQ/PQ) protocols, Labelling- Instructions for Use (IFU), design and manufacture process. Quality assurance, audits, post market surveillance. Manufacturing supply chain- process optimization in manufacturing, Rapid prototyping-3D printing (Case study for manufacturing supply chain).	**9**
4	Medical Device Standards and Regulations: Food and Drug Administration (FDA) regulations, Preparing FDA submission (510k process), European standards, International Organisation for Standardisation (ISO)- ISO-13485/14971, International Electrotechnical Commission (IEC)-IEC-60601(1-2), Indian Certification for Medical Devices (ICMED)- ICMED 13485, Safety and essential performance of medical electrical equipment,Intellectual Property (IP)- protection for medical devices. Steps for patent process.	**9**

Course Assessment Method
(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Prepare documentation based on needs identification and specification preparation.	**K2**
CO2	Evaluate the design aspects of biomedical equipment and its safety	**K2,K3**
CO3	Identify steps in the verification and validation of the product design	**K3**
CO4	Assess the quality control and performance in manufacturing supply chain	**K2**
CO5	Familiarise with the standards and regulations for medical devices	**K2,K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	2		3				3		2
CO2	3	3	3	2		3		2		1		2
CO3	3	3	3	2		3				2		2
CO4	3	3	2	1	1	3				2		2
CO5	3	3	3	2		3		1				2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Reliable design of medical devices	Fries, Richard C	CRC Press	2012
2	Medical Device Design Innovation from Concept to Market	PeterOgrodnik	Elsevier	2013
3	Biomedical devices: materials, design, and manufacturing.	Lam, Raymond HW, and Weiqiang Chen.	Springer	2019
4	Design of Biomedical Device and Systems	Paul H. King,Richard C. Fries,Arthur T	CRC Press	2015
5	Introduction to product design and development for engineers	Jamnia, Ali	CRC Press	2018

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Design controls for the medical device industry	Teixeira, Marie B	CRC press,	2019
2	Medical devices: regulations, standards and practices.	Ramakrishna, Seeram, Lingling Tian, Charlene Wang, Susan Liao, and Wee Eong Teo.	Woodhead Publishing	2015
3	Handbook of medical device design	Fries, Richard C	CRC Press	2019
4	Handbook of Medical Device Regulatory Affairs in Asia	JackWong,,RaymondTong	CRC Press	2018
5	Biodesign: the process of innovating medical technologies.	Yock, Paul G., Stefanos Zenios, Josh Makower, Todd J. Brinton, Uday N.Kumar, FT Jay Watkins, Lyn Denend, Thomas M. Krummel, and Christine Q.Kurihara.	Cambridge University Press	2015
6	Medical device software verification, validation and compliance	Vogel, David A.	Artech House	2011

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc24_ee110/preview
2	https://onlinecourses.swayam2.ac.in/nou24_me10/preview

SEMESTER S7

REHABILITATION ENGINEERING

Course Code	PEBMT753	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	PE

Course Objectives:

1. Introduce students to the fundamental principles and concepts of rehabilitation engineering.
2. Familiarize students with a wide range of assistive technologies used to support individuals with various disabilities.
3. Demonstrate how modern technologies, including robotics, web-based tools, and other communication aids, can be applied to rehabilitation engineering.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Rehabilitation Engineering:** Introduction, Clinical rehabilitation engineer Vs. clinical engineer, Service delivery models, Principles of service delivery. **Standards for assistive technology:** organization of national and international industry standards, the role and contribution of rehabilitation engineering in standards development. **Seating biomechanics and systems:** Seating and common pathologies, Seating assessment, Seating systems, Standing systems, Seat elevation systems	9
2	**Aids for blind or visually impaired:** Dimensions of visual impairment and their impact on task performance, General-purpose assistive technology solutions, Task-specific assistive technologies. **Hearing aid:**Types of hearing impairment, Hearing assistance technology solutions, Medical or surgical approaches to restoring function, Assistive listening solutions,	9

	vocational, daily living, and Communication aids	
3	**Wheelchairs:**Manual wheelchairs, Electric power wheelchairs, Multifunctional wheelchairs. **Major Limb Prosthetic Devices:** Components of the upper limb prosthesis, Cosmetic prostheses, Components of the lower limb prosthesis. **Orthotic Devices:**Spinal orthoses, Lower extremity orthoses, Upper extremity orthoses	**9**
4	**Rehabilitation Robotics:** Intelligent Mobility Aids, Robotic Manipulation Aids, Therapeutic Robots. **Telecommunications, Computers, and Web Accessibility:** Conceptual model: telecommunications, computers and the internet, Technology solutions.	**9**

Course Assessment Method

(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Explain the fundamental principles and Standards of rehabilitation engineering.	**K1**
CO2	Work effectively with audiologists, optometrists, occupational therapists, and other healthcare professionals.	**K2**
CO3	Prepare a career in rehabilitation engineering with a focus on wheelchairs and prosthetic devices.	**K3**
CO4	Learn about the role of robotics, computers and other communication aids in rehabilitation therapy.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2		2		2	1	2				3
CO2	3	2	2		2	2	1	2				3
CO3	3	3	3	2	3	2	1	2				3
CO4	3	2	2	2	3	2	1	2				3

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	An Introduction to Rehabilitation engineering	Rory A Cooper,Hisaichi Ohnabe,Douglas A Hobson	CRC press	2006
2	The biomedical engineering handbook - Biomedical Engineering Fundamentals	Joseph D. Bronzino	CRC Press	2006

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Rehabilitation Engineering Applied to Mobility and Manipulation	Rory A Cooper	CRC Press	1995
2	Rehabilitation Engineering	Robinson C.J.	CRC Press	1995
3	Rehabilitation Technology	Ballabio E	IOS Press	1993.

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/102107058 https://onlinecourses.nptel.ac.in/
2	https://archive.nptel.ac.in/course.html https://archive.nptel.ac.in/courses/108/106/108106167/
3	https://onlinecourses.nptel.ac.in/

SEMESTER 7

MEDICAL INFORMATICS

Course Code	**PEBMT754**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3-0-0-0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs.30 Min.
Prerequisites (if any)	PBBMT304/GBEST305	**Course Type**	PE

Course Objectives:

1. To explain the structure and functional capabilities of Hospital Information System.
2. To describe the need of computers in medical imaging and laboratories.
3. To apply the suitable decision support system for automated clinical diagnosis.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction –structure of Medical Informatics- its standards and applications, Hospital management and information system – its functional capabilities, advantages and disadvantages, Internet and medicine-security issues.	9
2	Automated clinical laboratories, Automated methods in cytology, hematology and histology. Intelligent Laboratory Information system, Computerized EEG, ECG and EMG, computer assisted medical imaging-Xray, ultrasound, nuclear medicine.	9
3	Neuro computers and artificial neural network application, computer assisted decision support system- production rule system cognitive model, decision analysis in clinical medicine, computers in care of critically ill patients.	9

4	Virtual reality applications in medicine- virtual endoscopy- computer assisted surgery-surgical simulation.Medical information and health care information, computer assisted patient education and health.	**9**

Course Assessment Method

(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Explain the structure and functional capabilities of Hospital Information System.	**KL2**
CO2	Describe the need of computers in medical imaging and laboratories.	**KL2**
CO3	Apply the suitable decision support system for automated clinical diagnosis.	**KL3**
CO4	Discuss the application of virtual reality.	**KL2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**CO1**	3	2				2		2			
CO2	**CO2**	3	2				2		2			
CO3	**2CO3**	3	2				2		2			
CO4	**2CO4**	3	2				2		2			
CO5												

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Medical Informatics	Mohan Mansal	Tata Mc Graw Hill	2003
2	Computers in medicine progress in Medical Informatics	R. D. Lele	Tata Mc Graw Hill	2005

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Health Informatics	Kathryn J Hannah, Marion J Ball	springer	3rd edition , 2006
2	Computational Intellegence in Medical Informatics	Naresh kumar, Vinith Kumar	Springer nature	2014

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	A BASIC COURSE IN BIOMEDICAL ENGINEERING(nptel.ac.in)
2	COMPUTATIONAL METHODS IN BIOMEDICAL ENGINEERING(nptel.ac.in)
3	BIOMEDICAL INSTRUMENTATION & TRANSDUCERS(nptel.ac.in)

SEMESTER S7

TISSUE ENGINEERING AND BIOFABRICATION TECHNOLOGY

Course Code	**PEBMT756**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs.30 Min.
Prerequisites (if any)	None	**Course Type**	PE

Course Objectives:

1. To gain a comprehensive understanding of the fundamental concepts in tissue engineering, including cell-extracellular matrix interactions and tissue morphogenesis..
2. To learn the design principles and significance of the tissue microenvironment, cellular dynamics, and the role of in vitro studies in engineering functional tissues.
3. To explore the latest advancements in biomaterials, scaffold fabrication techniques, and biofabrication strategies for developing engineered tissues.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Fundamentals of Tissue Engineering (T1)** Cell extracellular matrix interactions (Development and wound healing) - Adhesion and migration - Proliferation - Differentiation – Apoptosis. Signal transduction events during cell-extracellular matrix interactions - Integrin-Mediated Signalling- Type I – type II – type III Interactions- Engineering Tissue morphogenesis - Relevance for tissue engineering	9
2	**The Tissue Microenvironment: Cell Therapy and Bioreactor (T2)** Design Principles - Cellular Function In Vivo: The Tissue Microenvironment and Communication – Cellularity – Dynamics -Size and Geometry. Importance of in vitro studies for engineering functional tissues - Influence of selected in vitro culture parameters on the development and performance of engineered tissues. Bioreactors - Macrobioreactors – Comparison of	9

	commercial Macrobioreactors – design principle. Microbioreactors -design principles.	
3	**Advanced Biomaterials and scaffold fabrication Techniques (T3)** Advances in Antimicrobial and Osteoinductive Biomaterials – Current challenges in biomaterials - Antimicrobial Biomaterials - Osteoinductive Biomaterials - Dual Functional Biomaterials. **Scaffold Fabrication Techniques for Tissue Engineering Applications -** Freeze-Drying - Solvent Casting/Particle Leaching - Phase Separation- Electrospinning- Gas Foaming	9
4	**Biofabrication in Tissue Engineering (T3)** Biofabrication Strategies- Inkjet Bioprinting - Laser-assisted Bioprinting - Extrusion Bioprinting - Melt Electrowriting (MEW). Criteria for Biomaterial Design and Selection – Biocompatibility - Material Properties - Structural Properties - Degradation. Commonly Used Biofabrication Materials - Naturally Derived Biomaterials - Synthetic Biomaterials. Future Perspectives of biofabrication technologies - Multi-scale Biofabrication – Vascularization - Biomaterial Development.	9

Course Assessment Method

(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course, students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand the fundamental concepts of cell-extracellular matrix interactions and their relevance to tissue engineering.	**K2**
CO2	Utilize the knowledge of the tissue microenvironment, and the influence of in vitro culture parameters, to design and evaluate bioreactors for tissue engineering applications.	**K3**
CO3	Apply advanced biomaterials and scaffold fabrication techniques, to develop functional tissues for engineering applications.	**K3**
CO4	Employ biofabrication strategies, and evaluate biomaterial design and selection criteria to create engineered tissues with appropriate biocompatibility, material properties, structural properties, and degradation rates.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2											
CO2	3	2										
CO3	3	3	2	2		2						
CO4	3	3	2	2		2						

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Principles of Tissue Engineering	Robert Lanza, Robert Langer, Joseph P. V, Anthony A	Academic Press	Fifth edition & 2020
2	Introduction to Biomedical Engineering	John Enderle and Joseph Bronzino	Academic Press	Third Edition & 2012
3	Racing for the surface	Bingyun Li, Thomas Fintan Moriarty, Thomas Webster, Malcolm Xing, Guangyu Bao	Springer Nature Switzerland AG	First edition & 2020

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Tissue Engineering	Bernhard O. Palsson and Sangeetha N. Bhatia	Pearson	First edition & 2004
2	Tissue Engineering	John P Fisher, Antonios G Mikos, Joseph D Bronzino	CRC Press	First edition & 2006
3	Biofabrication: Micro- and Nano-fabrication, Printing, Patterning, and Assemblies	Gabor Forgacs and Wei Sun	Elsevier Inc	First edition & 2013

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/102106036
2	https://nptel.ac.in/courses/102106036,
3	https://archive.nptel.ac.in/courses/102/106/102106081
4	https://archive.nptel.ac.in/courses/102/106/102106095

SEMESTER S7

ADVANCED MEDICAL IMAGING AND IMAGE PROCESSING TECHNIQUES

Course Code	**PEBMT755**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	5/3	**Exam Hours**	2 Hrs.30 Min.
Prerequisites (if any)	PBBMT604: Principles of Medical Image Processing	**Course Type**	PE

Course Objectives:

1. To expose the students to advanced image processing techniques for medical images.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Image Fusion**: Pre-processing measures-geometrical transformations and image interpolation, Distortion identification- disparity analysis **Image Registration**- Global Similarity, Transform Identification, Registration Evaluation and Approval. Image Fusion, Image Subtraction and Addition, Vector-Valued Images, Presentation of Vector-Valued Images, Three-Dimensional Data from Two- Dimensional Slices, Panorama Fusion, Stereo Surface Reconstruction, Time Development Analysis, Time Development via Disparity Analysis, Time Development via Optical Flow.	9
2	**Texture in Biomedical Images:** Image intensity versus image texture, Characterizing the Texture, From Markov Random Fields to Fractals, From Markov Random Fields to Gibbs Distributions, Local binary patterns (LBPs), Co-occurrence Matrices, Generalized Co-occurrence Matrices, Orientation	9

	Histograms, Textons, From Spatio-Frequency to Spatio-Structural Space, Statistical Spatio-Structural Space, Monogenic Signal, From Monogenic Signal Back to Gabor Functions. Deep Learning Techniques on Texture Analysis- Lung nodule detection in CT scans.	
3	**Active Shape and Active Appearance Models**: Creating an ASM, Using ASMs for Segmentation, The Active Appearance Model, Deficiencies of Statistical Shape Models, Changing the Parametric Model, Using a Part-Based Model, Using a Non-parametric Model, Physically-Based Shape Models, Mass-Spring Models, Finite Element Models, Shape, Appearance and Pose Priors for Segmentation, Atlas-Based Segmentation, Combining Shape Information with Level Set Segmentation, Solutions Based on Graph Cuts, Graph Cuts on Pre-segmented Images	**9**
4	**Visualization of medical volume data**: Surface rendering, Reconstruction of surfaces from contours, marching cubes, Indirect volume visualisation - surface rendering of unsegmented and segmented volume data, advanced mesh smoothing, mesh simplification and web-based surface rendering. **Image Storage and Transfer**: Image Management: Archiving- Image Storage and Transfer, Information Systems in a Hospital, The DICOM Standard, Establishing DICOM Connectivity, The DICOM File Format, Technical Properties of Medical Images, Displays and Workstations, HL7 Standard Principles of Image Compression for Archiving and Communication- Philosophy of Image Compression, Generic Still-Image Compression System	**9**

Course Assessment Method
(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Internal Ex	Evaluate	Analyse	Total
5	15	10	10	40

Criteria for Evaluation (Evaluate and Analyse): 20 marks

Assignment: 20 Marks

Students should evaluate and analyse image processing techniques for biomedical applications, assess the proposed solutions and implement the chosen solution using necessary software or hardware.

Criteria for evaluation:

1. ***Problem Definition (K4 - 4 points)***
   . *Clearly defines the problem.*
   a. *Examine and identify relevant factors.*
2. ***Problem Analysis (K4 - 4 points)***
   1. *Break-down and presents a well-reasoned solution approach.*

3. Evaluate (K5 - 3 points)

Thoroughly evaluate the proposed solutions.

4. ***Implementation (K5 - 4 points)***

   Successfully translates the chosen solution into software or hardware as necessary.

0. Conclusion (K3- 3 points, K5 – 2 points)

. *Summarizes findings and insights. State which solution is most appropriate for the problem*

Scoring:

1. ***Accomplished (4 points)****: Exceptional analysis, clear implementation, and depth of understanding.*
2. ***Competent (3 points)****: Solid performance with minor areas for improvement.*
3. ***Developing (2 points)****: Adequate effort but lacks depth or clarity.*

4. Minimal (1 point)*: Incomplete or significantly flawed.*

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
● 2 Questions from each module. ● Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	● Each question carries 9 marks. ● Two questions will be given from each module, out of which 1 question should be answered. ● Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Analyse the sequenced steps needed for medical image fusion.	**K4**
CO2	Examine the potential of the texture-based analysis methods for biomedical applications.	**K2**
CO3	Apply the shape and appearance models to augment data-driven segmentation.	**K3**
CO4	Categorize the visualization algorithms used to provide accurate and smooth renditions of the underlying medical image data.	**K3**
CO5	Interpret the way in which the medical images are archived and distributed in a hospital.	**K4**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	2	1	1				1	1		1
CO2	2	3	2	1	1				1	1		1
CO3	2	2	2	1	2				1	1		1
CO4	2	2	2	1	2				1	1		1
CO5	2	2	2	1	2				1	1		1

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Medical Image Processing, Reconstruction and Analysis: Concepts and Methods, J Jan - 2019			2nd edition, 2017
2	Applied Medical Image Processing	Wolfgang Birkfellner	CRC Press	2020 edition, 2021
3	Guide to Medical Image Analysis- Methods and Algorithms	Klaus D. Toennies	Springer	Secon Edition 2017
4	Visual computing for medicine: theory, algorithms, and applications	B Preim, CP Botha		2013
5	Biomedical texture analysis: fundamentals, tools and challenges	A Depeursinge, S Omar, K Al, JR Mitchell		2017

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Digital Image Processing for Medical Applications	Geoff Dougherty	Cambridge University Press	2007
2	Biomedical Imaging- Principles And Applications	Reiner Salzer	John Wiley & Sons, Inc., Publication	2012
3	Webb's Physics of Medical Imaging		Taylor & Francis	Second Edition, 2012

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc22_bt34/preview
2	https://nptel.ac.in/courses/108105091
3	https://onlinecourses.nptel.ac.in/noc22_bt34/preview

SEMESTER /S7

BIOMEDICAL INSTRUMENTATION

Course Code	**OEBMT721**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3-0-0-0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs.30 Min.
Prerequisites (if any)		**Course Type**	OE

Course Objectives:

1. Understand the Fundamentals of biomedical instrumentation
2. Elucidate the measurement of some physiological Parameters
3. Identify the diagnostic and therapeutic instruments.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to Biomedical Instrumentation-Definition - Importance in healthcare- Origin of bioelectric potentials – resting and action potentials - propagation of action potentials –Examples of bioelectric potentials - ECG, EEG, EMG, – Electrodes for measurement of biopotentials.	**9**
2	Cardiovascular System- Electrocardiography (ECG)- Electrical activity of heart, electrocardiogram - lead systems - ECG machine – block diagram- Measurement of heart sounds–phonocardiography. Blood pressure measurement- sphygmomanometer & Oscillo metric methods. Photo plethysmography - for pulse rate measurement - Pulse oximeters.	**9**

3	Respiratory System-Spirometry and lung volume measurements- measurement of respiratory parameters. Nervous System -Electroencephalography (EEG)- Electrical activity of brain - Electro encephalogram – EEG measurement & waveforms - block diagram. Evoked potential -types & applications. Electromyography (EMG)- Electrical activity of Muscle- Types of electrodes	**9**
4	*Diagnostic Imaging Systems*-X-ray radiography - Principles of x-ray generation – Block diagram of x-ray machine. Computed tomography (CT)- Principle of operation. Magnetic resonance imaging (MRI) -Basic principle- Ultrasound imaging– Basic principles - Ultrasonic transducers. *Therapeutic Devices*-pacemakers – internal and external pacemakers, defibrillators – basic principles.	**9**

Course Assessment Method

(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the Fundamentals of biomedical instrumentation.	**K1**
CO2	Elucidate the cardiovascular instrumentation.	**K2**
CO3	Explain measurements of some physiological Parameters.	**K2**
CO4	Identify the diagnostic and therapeutic instruments.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1										2
CO2	2	1										2
CO3	2	1										2
CO4	2	1										2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Medical Instrumentation: Application and Design	John G. Webster	John Wiley	2009
2	Introduction to Biomedical Equipment Technology	Joseph J. Car, John M. Brown	pearson Education (Singapore) Pvt. Ltd.	2012
3	Biomedical Instrumentation and Measurements	Leslie Cromwell	Pearson Education India	2^{nd} edition, 2015
4	Encyclopaedia of Medical Devices and Instrumentation	John G Webster (Ed)	Wiley	2009

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Handbook of Biomedical Instrumentation	R.S Khandpur	Tata McGraw Hill	2004
2	Hand book of Biomedical Engineering	Bronzino	CRC-Press	2000

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/102/105/102105090/
2	https://onlinecourses.nptel.ac.in/noc22_bt56/preview
3	https://archive.nptel.ac.in/courses/102/105/102105090/

SEMESTER S7

ASSISTIVE DEVICES

Course Code	**OEBMT722**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3-0-0-0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs.30 Min.
Prerequisites (if any)	None	**Course Type**	OE

Course Objectives:

1. To equip students with a comprehensive overview of assistive devices and their applications across different fields. of the principles, design, and application of assistive medical devices, enabling them to address the needs of individuals with disabilities through innovative engineering solutions.
2. Develop a basic understanding of the technological components and systems used in assistive devices and explore current trends and innovations in assistive technology.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction:** Definition and scope of assistive technologies - **Regulatory and Ethical Considerations - O**verview of FDA, CE Mark, and other regulatory frameworks - Ethical considerations in the development and use of assistive devices - Standards and guidelines for accessibility and usability.	**9**
2	**Design and Development of Assistive Devices: Materials and Manufacturing - p**roperties of materials used in assistive devices - Manufacturing processes: traditional vs. advanced methods (e.g., 3D printing) - Selection criteria for materials and manufacturing techniques - Integration of sensors into assistive devices for data acquisition and feedback - Data processing and signal interpretation	**9**

3	**Types of Assistive Devices:** Mobility aids: Wheelchairs, scooters, walkers, prosthetics, and orthotics; Sensory aids: Hearing aids, cochlear implants, visual aids, and Braille devices; Cognitive aids: Augmentative and alternative communication (AAC) devices, memory aids, and software tools: **Neural prosthetics:** Basics of neural prosthetics and their applications.	**9**
4	**Smart Assistive Technologies -** types of assistive robots: exoskeletons, rehabilitation robots, service robots - Challenges and advancements in assistive robotics; Role of the Internet of Things (IoT) in assistive devices - Overview of wearable technology and smart home integration - Developing smart, connected assistive devices.	**9**

Course Assessment Method

(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
● 2 Questions from each module. ● Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	● Each question carries 9 marks. ● Two questions will be given from each module, out of which 1 question should be answered. ● Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the principles, design, and application of assistive medical devices	Understand
CO2	Learn about material selection, manufacturing processes, and the integration of sensor technologies.	Understand
CO3	Understand ethical and social issues related to the use and development of assistive devices.	Understand
CO4	Get familiarised with advanced assistive technologies.	Understand

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2		2		2	2	2				3
CO2	3			3		2	2	2				3
CO3	3	3	1	2	2	2	2	2				3
CO4	3	2	2	2	3	2	2	2				3

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Assistive Technologies: Principles and Practice	Albert M. Cook and Janice M. Polgar	Elsevier	2015
2	Assistive Technologies and Applications for Assisted Living Challenges and Solution	Martina Ziefle and Carsten Rcker	IGI Global snippet	2010
3	Rehabilitation Engineering: Principles and practice	Alex Mihalidis and Roger Smith	CBC Press	
4	Assistive Technology: Principles and applications	Albert M. Cook and Janice M. Polgar	Elsevier	2015

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	KEEP IT SIMPLE: A Guide to Assistive Technologies	Ravonne A. Green and Vera Blair	Libraries Unlimited	2011
2	Aural Rehabilitation for People with Disabilities	John M. A. Oyiborhoro	Elsevier, Academic Press,	2005
3	Assistive Technology for People with Disabilities	Diane Pedrotty Bryant, Brian R Bryant	Pearson	2012
4	Choosing Assistive Devices A guide for users and professionals	Helen Pain Lindsay McLellan Sally Gore	Jessica Kingsley Publishers	2003

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	Development of Assistive technology for persons with Disabilities - Course (swayam2.ac.in)
3	Introduction to Assistive Devices for Mobility NPTEL-NOC IITM

SEMESTER S7

MEDICAL IMAGING TECHNIQUES

Course Code	OEBMT723	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	OE

Course Objectives:

1. To expose imaging methods in medicine and biology.
2. Learn the different methods and modalities used for medical imaging.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Diagnostic Ultrasound Imaging:** Ultrasound interaction with tissue (Basics only) – Ultrasound waves and propagation, attenuation, reflection, scattering, refraction. Pulsed ultrasound and imaging - Pulsed ultrasound, pulse echo principle, Principles of image formation, Modes of ultrasound & applications - A-mode, B-mode & M-mode. Transducers-construction.	9
2	**Magnetic Resonance Imaging:** Basic principles of magnetic resonance – magnetic moment, FID, excitation and emission - principles of image formation, MRI instrumentation , Selective Applications of MRI for the Brain - Functional MRI (fMRI), MR Angiography, Diffusion MRI, MRI Fourier Reconstruction	9
3	**Computed Tomography:** Basics of X-ray - Properties & production – X-ray tube – Fixed anode type and rotating anode type, Principles of sectional imaging, generations of CT, spiral & multi slice CT, detectors used in CT, 2D image reconstruction techniques - Iteration and Fourier methods.	9

4	**Nuclear Imaging:** Concept of nuclear imaging, radiation detectors, Gamma camera, Emission computed tomography - SPECT & PET. **Hybrid Imaging** - MR-PET Instrumentation MR-PET system architecture. **Infrared Imaging** – Basic principle of thermal imaging, Physics of thermography – IR detectors.	**9**

Course Assessment Method

(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the principle and instrumentation of diagnostic Ultrasound imaging	**K2**
CO2	Apply the principles of Nuclear Magnetic Resonance in medical imaging	**K3**
CO3	Explain the imaging methods used in Computed tomography	**K3**
CO4	Elucidate the concepts of multimodal imaging	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1			1			1	1		2
CO2	3	2	1			1			1	1		2
CO3	3	2	1			1			1	1		2
CO4	3	2	1			1			1	1		2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	The Physics and Technology of Diagnostic Ultrasound	Dr Robert Gill	National library of Australia	2nd Edition 2020
2	MRI Basic Principles and Applications	Mark A Brown, Richard C Semelka	Wiley-Liss Publication	3rd Edition 2003
3	Webb's Physics of Medical Imaging	M Flower	Taylor & Francis	2016
4	Computed Tomography-E-Book: Physical Principles, Clinical Applications, and Quality Control	Seeram, Euclid	Elsevier Health Sciences	2015
5	Handbook of Biomedical Instrumentation	R. S. Khandpur	Tata MacGraw-Hill	3rd Edition 2014

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Diagnostic ultrasound Physics and Equipment	Hoskins, Peter R., Kevin Martin, and Abigail Thrush	CRC Press	2019
2	MRI Made easy	Hans H Schild	Berlex Laboratories	2012
3	Principles of Computerized Tomographic Imaging	AvinashiC KakMalcolm Slaney	Purdue University	2001
4	Nuclear Medicine Textbook, Methodology and Clinical Applications	Duccio Volterrani, Paola Anna Erba, Ignasi Carrió, H. William Strauss, Giuliano Mariani	Springer	2019

Video Links (NPTEL, SWAYAM…)	
Sl. No	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc24_bt69/preview
2	https://onlinecourses.nptel.ac.in/noc24_ge45/preview

SEMESTER -7

ARTIFICIAL ORGANS AND IMPLANTS

Course Code	**OEBMT724**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3-0-0-0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	NONE	**Course Type**	OE

Course Objectives:

1. To understand the design, principles and applications of various types of artificial and tissue derived implants.
2. To understand the use of 3D printing technology in implantation.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Basics of artificial organ design process- the hip joint and its artificial replacement-the eye and its artificial replacement-the lung and its artificial replacement, artificial heart-design of heart valves-	**9**
2	Basics of artificial organ design process-Kidney and its artificial replacement-skin and the design of artificial skin-the liver and its artificial replacement-The medical device market and ethical issues of implants-the manufacturing, testing and sterilization of implants.	**9**
3	Applications of Tissue Engineering in artificial organ design - fundamentals of tissue engineering, Engineering biomaterials for tissue engineering-Drug Delivery- Gene Therapy.	**9**
4	Fundamentals of 3D printing and its applications in Biomedical engineering-stages of 3D printing process-3D modeling-printing-post processing-Types of 3D printing technologies-Biomedical applications of 3D printing technology- maxillofacial surgery- upper limb prosthetics.	**9**

Course Assessment Method

(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
● 2 Questions from each module. ● Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	● Each question carries 9 marks. ● Two questions will be given from each module, out of which 1 question should be answered. ● Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Explore different kind of artificial organs	**K2, K3**
CO2	Explore the medical device market and ethical issues of implants	**K2, K4**
CO3	Review the basic principles of Tissue Engineering	**K2, K3**
CO4	Explore the use of 3D printing technology in Biomedical field	**K2, K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3		1				1		3
CO2	3	3	3	3		1				1		3
CO3	3	3	3	3		1				1		3
CO4	3	3	3	3		1				1		3

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Design of artificial human joints & organs	Subrata Pal	Springer	2014
2	Tissue engineering: principles and practices	Fisher JP, Mikos AG, Bronzino JD, Peterson DR	CRC Press	2012
3	3D Printing in Biomedical Engineering	Singh S, Prakash C, Singh R	Springer	2020

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Biomaterials, artificial organs and tissue engineering	Larry L. Hench, Julian R. Jones	Woodhead Publishing Limited	2005
2	Advanced 3D-printed systems and nanosystems for drug delivery and tissue engineering	Du Toit L, Kumar P, Choonara Y, Pillay V	Elsevier	2020

Video Links (NPTEL, SWAYAM…)	
Sl. No	**Link ID**
1	https://www.youtube.com/watch?v=gPjDsJJcYlA&list=PLgMDNELGJ1CaY5lay_oi1xqBGsqgt4Mrm&index=1&pp=iAQB
2	https://www.youtube.com/watch?v=b5HwDYEWul8

SEMESTER 8

BIOMEDICAL ENGINEERING

SEMESTER S8

MEDICAL DEVICE REGULATIONS & STANDARDS

Course Code	**PEBMT861**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	PE

Course Objectives:

1. To provide basic understanding of medical devices, regulatory requirements and approval standards in India

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**OVERVIEW OF MEDICAL DEVICES -** Medical device definition, Need for Medical Devices, Need for regulatory control and standards - History of Medical Device Regulation - Classification of Medical Devices - Medical Device Design - Product Lifecycle of Medical Device, Medical Device development process, Medical Device Design process, Testing – verification and Validation	**9**
2	**MEDICAL DEVICE DIVISION IN INDIA:** Functions of medical device division- Registration and Licensing- Import Procedure- Approval of new medical devices- Constitution of medical advisory committees. Clinical trial regulation - Concerns in clinical trials. Diversity of medical devices.	**9**
3	**AWS AND GUIDELINES FOR HANDLING MEDICAL DEVICES IN INDIA:** Objectives of Drugs & Cosmetic Act 1940 & Rules 1945, Functions of CDSCO, Functions of state licensing authorities **REGULATIONS AND GUIDELINES OF MEDICAL DEVICES IN**	**9**

	WHO AND FDA: Organizational Structure, Purpose and Functions of Regulatory Guidelines - Working Groups, Summary Technical Document (STED), Global Medical Device Nomenclature (GMDN). WHO regulations of Medical Devices, FDA regulations of Medical Devices	
4	**ETHICS AND STANDARDS IN CLINICAL INVESTIGATION OF MEDICAL DEVICES:** Clinical Investigation of Medical Devices- Clinical Investigation Plan for Medical Devices - Good Clinical Practice for Clinical Investigation of medical devices (ISO 14155:2011). **Quality**: Quality System Regulations of Medical Devices - ISO 13485, Quality Risk Management of Medical Devices - ISO 14971, Validation and Verification of Medical devices. - Adverse Event Reporting of Medical devices - Current trends in the use of standards in medical device regulations	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand the basic knowledge about medical devices	**K2**
CO2	Describe the medical devices divisions in India	**K3**
CO3	Discuss the laws and regulations for medical devices in India, and the standards set by the FDA and WHO globally	**K3**
CO4	Explain the ethics and standards of medical devices	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1		1			1		2	1	1		2
CO2	1		1			1		2	1	1		2
CO3	1		1			1		2	1	1		2
CO4	1		1			1		2	1	1		2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Medical Device Quality Assurance and Regulatory Compliance	Richard C Fries	CRC Press LLC	2019
2	Design of Biomedical Device and Systems	Paul H King Richard C Fries	CRC Press	4th Edition 2019
3	Regulation of Medical Devices A step-by-step guide	Eastern mediterranean Series, WHO	WHO Regional Publications	2016
4	Medical Device Development: Regulation and Law	Jonathan S. Kahan Hogan Lovells US LLP	Paraxel	2014
5	Reliable design of Medical Devices	Richard C Fries	CRC Press	2012
6	Medical Product Regulatory Affairs: Pharmaceuticals, Diagnostics, Medical Devices	John J Tobin Gary Walsh	Wiley Blackwell	2008

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Richard C Fries	Handbook of Medical Device Design	CRC Press	2019
2	Handbook of Medical Device Regulatory Affairs in Asia	Jack Wong Raymond Tong	Jenny Stanford Publishing	2nd Edition 2018
3	Regulatory Affairs for Biomaterials and Medical Devices	Stephen F Amato Robert M Ezzell	Woodhead publishing	2014

Video Links (NPTEL, SWAYAM…)	
Sl No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc20_ge14/preview
2	https://archive.nptel.ac.in/courses/127/106/127106136/
3	https://archive.nptel.ac.in/noc/courses/noc19/SEM1/noc19-ge14/
4	https://www.digimat.in/nptel/courses/video/127106010/L11.html

SEMESTER S8

TELEMEDICINE

Course Code	PEBMT862	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	PBBMT404	Course Type	PE

Course Objectives:

1. Introduce the concept of biomedical telemetry system.
2. To understand the scope and benefits, security aspects and applications of telemedicine.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to biomedical telemetry - Typical Biomedical Telemetry System- Challenges in Biomedical Telemetry - Design Considerations of Biomedical Telemetry Device- Energy Transfer Types - Architecture of Inductively Coupled Biomedical Telemetry Devices - Data Transmission Methods - Safety Issues	9
2	Acquisition systems. Cameras, Scanners, Display systems: Analogue devices, LCD, Laser displays, Holographic representations, Virtual screen devices. Computation of storage systems: Computer speed up systems, Magnetic, Mixed, Optical (laser devices) Solid State Disks (SSD) Types of antennas depending on requirements, Integration and operational issues: - system integration, store –and - forward operation, Real-time Telemedicine.	9
3	Internet in telemedicine: The internet - Basic concepts - Security – secure socket layer – Firewalls – proxies. Data Exchange: Network Configuration, circuit and packet switching, H. 320 series (Video phone based ISBN) T. 120, H.324 (Video phone based	9

	PSTN). Video Conferencing. Data security and standards:Encryption,Cryptography.	
4	Telemedicine applications: Teleradiology:Basic part of a teleradiography system, Image acquisition and management, display,communication. Telepathology: Applications, requirements, telequantization at distance. Telecytology: Applications, Telecardiology: Requirements, portable solutions. Ethical and legal aspects of telemedicine: Confidentiality and the law, patient rights and consent, access to medical records, Consent treatment,Intellectual property rights.	**9**

Course Assessment Method

(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Discuss the basic concepts of biomedical telemetry system.	K1
CO2	Recognize the various communication methods.	K2
CO3	Apply the biomedical telemetry principles in various clinical applications.	K3
CO4	Discuss the importance of patient's data privacy and the security issues in biomedical telemetry system.	K2

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1		2	3	2					1		2
CO2	2		2	3	2					1		2
CO3	2		2	3	2					2		2
CO4	2		2	3	2					1		2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Handbook of Biomedical Telemetry	Konstantina S. Nikita	IEEE Press Series on Biomedical Engineering,Wiley,	First Edition,2014
2	Handbook of telemedicine	Olga (EDT), Ferrer – Roca, M. Sosa (EDT), Marcelo C	IOS Press	1998
3	Essentials of Telemedicine and Telecare	A. C. Norris	,John Wiley & Sons	2002

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Telemetry Principles	Patranabis D	TMH, New Delhi	1999
2	Multimedia image and video processing	Ling Guan,	CRC Pree	2000
3	Telemedicine: Medicine and Communication	Thorsten M Buzug, Heinz Handels, Dietrich Holz	Springer Verlag	2001
4	E Healthcare: Harness the power of internet e-commerce and e-care	Douglas V.Goldstein,	Jones and Barlett Publishers.	

Video Links (NPTEL, SWAYAM…)	
Sl No.	**Link ID**
1	https://nptel.ac.in/courses/102106094
2	https://nptel.ac.in/courses/102105090

SEMESTER S8

BIOMEDICAL TRANSPORT PHENOMENA

Course Code	**PEBMT863**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	PE

Course Objectives:

1. This course covers the principles of momentum, mass, and thermal energy transport as they relate to biomedical sciences and engineering.
2. It explores applications ranging from macroscopic analyses of fluid dynamics in physiological systems to microscopic investigations of transport phenomena at cellular and molecular levels within biomedical contexts.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to biomedical transport phenomena. Role of diffusion, convection in physiological systems. Fluid kinematics: control volumes, velocity field, flow rate, acceleration, stream lines, stream tubes and streak lines- conservation relations and boundary conditions. Fluid statics:Surface tension,Membrane and cortical tension-Newtonian and non-Newtonian fluids-Laminar and turbulent flow.	9
2	Rheology of flow of blood: large vessels, small tubes, capillaries- regulation of blood flow- Flow in branching vessels-flow in specific arteries. Trans vascular transport:Introduction,pathways for trans endothelial transport. Rates of transvascular transport:Osmotic pressure –starlings's law of filtration-Kedem-Katchalsky equation. Oxygen-hemoglobin dissociation curve — Oxygen The Hill equation-Dynamics of oxygenation of blood in lung capillaries levels in blood.	9

3	Mechanism of transmembrane transport: Direct diffusion, facilitated transport, Active transport. Quantitative analysis of Glomerular filtration: Hydraulic conductivity of Glomerular Capillaries, Solute transport across Glomerular Capillaries. Quantitative analysis of Tubular Reabsorption: Mass balance equations, Fluxes of passive diffusion & Convection.	**9**
4	Introduction - Drug delivery in cancer treatment - Quantitative analysis of trans vascular transport. Factors that affect drug administration: The Oie-Tozer equation - A model for intravenous injection of drug. Application to the controlled release of drugs by osmotic pumps — Controlled release of drugs from transdermal patches — Controlled release of drug from implantable devices.	**9**

Course Assessment Method

(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand basic engineering principles of momentum, mass, and heat transfer in integrated form through an array of examples and analysis from biological systems.	**K2**
CO2	Formulate differential equations of change for momentum, heat and mass transfer problems.	**K3**
CO3	Solve transportation equations using methods of advanced mathematics.	**K5**
CO4	Apply biotransport fundamentals to the design and interpretation of biomedical systems and experiments.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	2							2		3
CO2	2	3	2							2		3
CO3	2	3	2							2		3
CO4	2	3	2							2		3

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Transport Phenomena in Biological Systems	G.A. Truskey, F. Yuan, D.F. Katz	Pearson Prentice Hall	2nd Edition,2009
2	Basic Transport Phenomena in Biomedical Engineering	Ronald L Fournier, Ph.D,PE	CRC Press	4* edition,2017
3	Fields, Forces, and Flows in Biological Systems	A.J. Grodzinsky	Garland Science	1st edition,2011

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Transport Phenomena	R.B. Bird, W.E. Stewart, E.N. Lightfoot	John Wiley & Sons	2nd Edition.2002
2	Physicochemical Hydrodynamics: An Introduction	R.F. Probstein	Wiley Interscience	2ndEdition,2003
3	Bioengineering Fundamentals	Saterbak, L.V. McIntire, K.-Y. San	Pearson Prentice Hall	2nd edition.2017.

Video Links (NPTEL, SWAYAM…)	
Sl No.	**Link ID**
1	https://nptel.ac.in/courses/102106340
2	https://nptel.ac.in/courses/102105101
3	https://nptel.ac.in/courses/102106083

SEMESTER 8

MODELLING OF PHYSIOLOGICAL SYSTEMS

Course Code	PEBMT864	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs 30 Min.
Prerequisites (if any)	None	Course Type	PE

Course Objectives:

1. To equip students with the knowledge and skills to develop and analyze mathematical models of complex physiological systems, including circulatory, thermoregulatory, ultra-filtration, and respiratory systems, using various modeling techniques

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Modeling concepts:** The techniques of mathematical modeling. Classification of models characteristics of models. Formulation of mathematical model. Physiological complexity and the need for models: Complexity. Different approaches of modeling physiological systems: Linear 3 Modeling - Distributed Modeling - Nonlinear Modeling - Timevarying Modeling - Mathematical approach	**9**
2	**Circulatory System:** Physical, chemical and rheological properties of blood, problems associated with extra corporeal blood flow, dynamics of circulatory system.	**9**
3	**Thermoregulatory system**: Parameters involved, Control system model etc. Biochemistry of digestion, types of heat loss from body, models of heat transfer between subsystem of human body like skin core, etc. and systems like within body, body, environment, etc	**9**

4	**Ultra-Filtration System:** Transport through cells and tubules, diffusion, facilitated diffusion and active transport, methods of waste removal, counter current model of urine formation in nephron, Modeling Henle's loop. **Respiratory System:** Respiratory System: Modelling oxygen uptake by RBC and pulmonary capillaries, Mass balancing by lungs, Gas transport mechanisms of lungs, oxygen and carbon dioxide transport in blood and tissues	9

Course Assessment Method

(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Develop and classify mathematical models for various physiological systems, recognizing their characteristics and the necessity for such models in addressing physiological complexity.	**K3**
CO2	Analyze and model the dynamics of the circulatory system, considering the physical, chemical, and rheological properties of blood and solving problems related to extracorporeal blood flow.	**K4**
CO3	Develop and analyze control system models for the thermoregulatory system, covering the biochemistry of digestion, methods of heat loss, and the dynamics of heat transfer between the human body and its environment.	**K3**
CO4	Develop models for the ultra-filtration and respiratory systems, understanding transport mechanisms, waste removal processes, and gas transport in blood and tissues.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2								2	
CO2	3	3	2								2	
CO3	3	3	2								2	
CO4	3	3	2								2	

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Physiological Control Systems -Analysis, simulation and estimation,	Michel C Khoo,	Prentice Hall of India, .	2001
2	Mathematical Modeling and Simulation: Introduction for Scientists and Engineers	Author(s):Prof. Dr. Kai Velten	Wiley	2008
3	Introduction to Modeling in Physiology and Medicine	Claudio Cobelli and Ewart Carson	Academic Press	2008
4	Advanced Methods of Physiological System Modeling	V.Z. Marmarelis	Springer US	1994
5	Mathematical Modeling of Physiological Systems	Jerry J. Batzel, Mostafa Bachar, Franz Kappel	Springer	2013

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Mathematical Physiology	JamesKeener,James Sneyd	Springer	2009
2	Biophysics of Computation	Christof Koch	Oxford University Press	2004
3	Modeling and Simulation in Medicine and the Life Sciences	F.C. Hoppensteadt and C.S.Peskin	Springer	2002

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc21_me25/preview

SEMESTER S8

ARTIFICIAL ORGANS & IMPLANTS

Course Code	PEBMT866	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	PE

Course Objectives:

1. To understand the design principles and challenges involved in creating functional replacements for various joints and bone fracture-fixation devices
2. To apply knowledge about the design requirements, materials, and techniques for various artificial organs and implants.
3. To implement 3D printing technology to design and develop biomedical applications.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Basics of the artificial organ design process - The Hip joint and Its artificial replacement - The Knee joint and Its artificial replacement- The Ankle Joint and Its Artificial Replacement – The Elbow joint and its artificial replacement - The Wrist Joint and Its Artificial Replacement - The Finger Joint and Its Artificial Replacement - The Design of a Bone Fracture-Fixation Device	9
2	The Eye and its artificial replacement - The Lung and its Artificial Replacement - Dental Implants: Their Design and Manufacture - Dental Implants - Components of Dental Implants - Types of Implants in Use - Biting Force - Implant Shape - Surface Characteristics - Bone Factors - Loading Conditions- The Number, Distribution, Orientation, and Design of Implants - Placement of Implants into Extraction Sites - Clinical and Biomechanical Considerations for Fixed Tooth Replacement. Artificial Pancreas - Intensive Insulin Therapy and Insulin Pump - Bioengineering	9

	Approach to an Artificial Pancreas - Gene Therapy Approach	
3	Design of Total artificial heart - design of heart valves - Kidney and its artificial replacement- Skin and the design of artificial skin - The Liver and its artificial replacement-The medical device market and ethical issues of implants-the manufacturing, testing, and sterilization of implants	**9**
4	Fundamentals of 3D printing and its applications in Biomedical engineering-stages of 3D printing process- 3D modelling- printing-post processing-Types of 3D printing technologies-Biomedical applications of 3D printing technology-applications-maxillofacial surgery- upper limb prosthetics.	**9**

Course Assessment Method

(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course, students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the design principles and challenges involved in creating functional replacements for various joints and bone fracture-fixation devices	**K2**
CO2	Apply knowledge of design requirements and materials to develop functional replacements for organs and joints such as the eye, lung, pancreas, heart, kidney, skin, and liver, while considering clinical and biomechanical factors	**K3**
CO3	Evaluate the market considerations, ethical issues, and processes for manufacturing, testing, and sterilizing medical implants.	**K3**
CO4	Utilize 3D printing technology to design and develop biomedical applications, including prosthetics and scaffolds for tissue engineering, by understanding the stages of the printing process and types of 3D printing technologies.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Creat*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2										
CO2	3	3										
CO3	3	2										
CO4	3	3			3	2		1				3

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Design of artificial human joints & organs	Subrata Pal	Springer	First edition 2014
2	3D Printing in Biomedical Engineering	Singh S, Prakash C, Singh R	Springer	First edition 2020

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Artificial Organs	Gerald E. Miller	Morgan & Claypool	First edition 2006
2	Artificial Organ Engineering	Maria Cristina Annesini, Luigi Marrelli, Vincenzo Piemonte, Luca Turchetti	Springers	First edition and 2017

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://www.futurelearn.com/courses/medtech-orthopaedic-implants
2	https://nptel.ac.in/courses/102106057
3	https://nptel.ac.in/courses/102106057
4	https://archive.nptel.ac.in/courses/102/106/102106095/

SEMESTER S8

AI FOR MEDICAL IMAGE ANALYSIS

Course Code	PEBMT865	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	5/3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	PE

Course Objectives:

1. The overall objective of this course is to equip students with the theoretical and practical fundamentals necessary to design and implement deep learning methods for real-world medical image analysis problems.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Medical Imaging Basics -** Differences between medical images and natural images, Images as functions, Different imaging modalities, e.g., MRI, CT, ultrasound, PET/SPECT, histopathology, Concept of physical coordinate system **Deep Neural Networks and Convolutional Neural Networks (CNN) -** The Convolution Operation, Motivation, Convolution and Pooling as an Infinitely Strong Prior, Variants of the Basic Convolution Function, Structured Outputs, Data Types, Efficient Convolution Algorithms, Random or Supervised Features, The Neuroscientific Basis for Convolutional Networks, Convolutional Networks and history of Deep Learning	9
2	**Image Classification using TensorFlow -** TensorFlow tutorial, Medical applications of image classification, Cross entropy loss, VGG-16, ResNet-101, Image classification with transfer learning **Introduction to Image Segmentation -** Medical applications of image segmentation, Challenges in medical image segmentation	9

	Deep Learning Based Image Segmentation - Transposed convolution, Categorical cross entropy loss vs Dice loss, Fully convolutional networks, U-Net	
3	**Introduction to Image Registration** - Clinical applications of image registration, Linear transforms: rigid, affine, explicit, parameter, implicit Interpolators: nearest neighbour, linear, bilinear, Similarity metrics: sum of squared differences, cross correlation, mutual information, SSIM, Challenges in image registration, 2D Image Registration, Introduction to 3D Image Registration	**9**
4	**Generative Adversarial Network (GAN)** - Defining the Generator Network, Defining the Discriminator Network, Defining loss and optimizer, Training the discriminator, generator and complete network, Inspecting the generated images. **Image-to-image Translation** - Paired vs Unpaired image-to-image translation, Pix2Pix, Cycle-GAN, Geometry-consistent GAN, Medical applications of image-to-image translation	**9**

Course Assessment Method
(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	*Internal Ex*	*Evaluate*	*Analyse*	*Total*
5	**15**	**10**	**10**	**40**

Criteria for Evaluation (Evaluate and Analyse): 20 marks

Students should evaluate and analyse image analysis techniques for biomedical applications, assess the proposed solutions and implement the chosen solution using necessary software or hardware.

Criteria for evaluation:

1. ***Problem Definition (K4 - 4 points)***
   a. *Clearly defines the problem.*
   b. *Examine and identify relevant factors.*
2. ***Problem Analysis (K4 - 4 points)***

. *Break-down and presents a well-reasoned solution approach.*

3. ***Evaluate (K5 - 3 points)***
   . *Thoroughly evaluate the proposed solutions.*
4. ***Implementation (K5 - 4 points)***
   a. *Successfully translates the chosen solution into software or hardware as necessary.*

5. ***Conclusion (K3- 3 points, K5 – 2 points)***

a. *Summarizes findings and insights. State which solution is most appropriate for the problem*

Scoring:

1. ***Accomplished (4 points)***: *Exceptional analysis, clear implementation, and depth of understanding.*
2. ***Competent (3 points)***: *Solid performance with minor areas for improvement.*
3. ***Developing (2 points)***: *Adequate effort but lacks depth or clarity.*

Minimal (1 point): *Incomplete or significantly flawed.*

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand convolutional neural networks (CNN) and can implement CNN in TensorFlow.	**K2**
CO2	Use CNN, transformer networks, and transfer learning for image classification.	**K3**
CO3	Describe generative adversarial networks, self-attention mechanisms, vision transformer, and variational diffusion models.	**K2**
CO4	Apply the pix2pix and the Cycle-GAN for paired and unpaired image-to-image translation tasks.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3								**2**	
CO2	3	3	3								**2**	
CO3	3	3	3								**2**	
CO4	3	3	3								**2**	

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	The essential physics of medical imaging	Bushberg, Jerrold T and Boone, John M	Lippincott Williams & Wilkins	2nd Edition, 2011
2	Deep Learning	Goodfellow, I., Bengio,Y., and Courville	MIT Press	2016
3	Image Registration Principles, Tools and Methods	A. Ardeshir Goshtasby	Springer	2012
4	Deep Learning with PyTorch: A practical approach to building neural network models using PyTorch.	Subramanian, Vishnu	Packt Publishing Ltd	2018
5	Deep Learning for Computer Vision: Expert techniques to train advanced neural networks using TensorFlow and Keras.	Shanmugamani, Rajalingappaa	Packt Publishing Ltd	2018

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Principles of soft computing	Deepa, S. N., and S. N. Sivanandam	WILEY	2011
2	Convolutional neural network architecture for geometric matching	Rocco, Ignacio, Relja Arandjelovic, and Josef Sivic.	Proceedings of the IEEE conference on computer vision and pattern recognition	2017
3	Generative adversarial networks	Goodfellow, Ian	Communications of the ACM 63.11 139-144.	2020
4	U-net: Convolutional networks for biomedical image Segmentation	Ronneberger, Olaf, Philipp Fischer, and Thomas Brox.	International Conference on Medical image computing and computer-assisted intervention. Springer, Cham,	2015

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc22_bt34/preview

SEMESTER S8

IOT & BIOMEDICAL APPLICATIONS

Course Code	**OEBMT831**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3-0-0-0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min**.**
Prerequisites (if any)	None	**Course Type**	OE

Course Objectives:

1. Students will gain an understanding and be able to analyze the definitions, characteristics, and architectural perspectives of the Internet of Things (IoT).
2. Students will explore IoT-based technologies and data processing techniques in medical applications.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to IoT technology: Definitions and Characteristics of IoT, IoT Architectural View, Physical Design of IOT, Logical Design of IoT- IoT Functional blocks, IoT communication models, IoT Enabling Technologies, IoT Levels & Deployment Templates.	9
2	Internet of things in healthcare: Innovative IoT applications in healthcare-Sensors and smart devices, biosensors, patient health portals, Machine learning applications, Blockchain- based initiatives. Internet of health things and artificial intelligence: The architecture of healthcare IoT, Kaa-a leading platform for state-of-the-art medical IoT.	9
3	Internet of Things Technologies: IoT in biomedical engineering, IoMT system architecture, Components of system architecture. Some other use cases of IoT in the healthcare industry: Reducing waiting time in case of emergency, Enhanced medicine management, and Smart beds for patients.	9

4	IoT based image-guided surgery: Role of new-age technologies in clinical surgery, Proposed model- architecture. Medical big data mining and processing in e-healthcare: Introduction of Big data sources, Big data mining and processing. Odontogenic tumors: Prevalence and Demographic distribution through IoT.	**9**

Course Assessment Method

(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Comprehend IoT Fundamentals	**K2**
CO2	Analyze IoT Applications in Healthcare	**K4**
CO3	Understand Healthcare IoT Architecture and Platforms	**K2**
CO4	Explore IoT in Biomedical Engineering and Healthcare Use Cases	**K4**
CO5	Investigate advanced IoT Applications and Data Processing in Healthcare**:**	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3			3		2					2
CO2	3	2	2	2	3	2	2	2		1		3
CO3	3		2	2	3	2	2					2
CO4	3		2	2	3	2	2	2		1		3
CO5	3		2	2	3	2	2					3

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Internet of Things in Biomedical Engineering	Valentina E Balas,Le Hoang Sung, Sudhan Sha	Elsevier Science	2019
2	The Role of the Internet of Things (IoT) in Biomedical Engineering Present Scenario and Challenges	Devendra Kumar Sharma, Korhan Cengiz, Rohit Sharma,	Apple Academic Press	2022
3	, "Internet of Things: A hands-on approach",	Arshadeep Bahga, Vijay Madisetti	University Press	, 2015 (First edition)
4	Internet of Things in Biomedical Engineering	Valentina E Balas,Le Hoang Sung, Sudhan Sha	Elsevier Science	2019
5	The Role of the Internet of Things (IoT) in Biomedical Engineering Present Scenario and Challenges	Devendra Kumar Sharma, Korhan Cengiz, Rohit Sharma,	Apple Academic Press	2022

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	"The Internet of Things – Key applications and Protocols", Wiley, 2012	Olivier Hersent, David Boswarthick, Omar Elloumi	Wiley	2012
2	"Internet of Things: Architecture and Design Principles"	Rajkamal,	McGraw Hill (India) Private Limited	-
3	IOT Applications for health care system		Springer	2022
4	"The Internet of Things – Key applications and Protocols", Wiley, 2012	Olivier Hersent, David Boswarthick, Omar Elloumi	Wiley	2012
5	"Internet of Things: Architecture and Design Principles"	Rajkamal	McGraw Hill (India) Private Limited	-

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	Components And Applications Of Internet Of Things - Course (swayam2.ac.in)
2	Introduction to internet of things - Course (nptel.ac.in)
3	Microsensors, Implantable Devices and Rodent Surgeries for Biomedical Applications - Course (nptel.ac.in)
4	Design for internet of things - Course (nptel.ac.in)

SEMESTER S8

HUMAN FACTORS IN ENGINEERING AND DESIGN

Course Code	**OEBMT832**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	OE

Course Objectives:

1. To provide an overview of Human Factors in Engineering & Design, focusing on optimizing human-system interactions to enhance usability, efficiency, and safety.
2. To understand various human factors aspects essential for designing systems and environments that prioritize user experience, operational efficiency, and workplace safety

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to Human factors Engineering – Definition, Human Factors & Systems. Process of seeing, Visual capabilities- Accommodation, Visual acuity and Contrast sensitivity. Factors affecting visual capabilities. Human factor aspects of hard copy text and computer screen text. Graphic representations of Text & Data. Human factors in designing Symbols & Codes	**9**
2	Visual Displays - Qualitative visual displays, Quantitative visual displays, Signals & Warning lights, Representational Displays. Auditory Displays - Process of hearing. Principles of auditory displays, Auditory Displays for Specific Purposes. Compatibility – Types of Compatibility, Physical arrangement of displays and controls, Rotary controls and rotor displays movement of displays.	**9**

3	Muscle Physiology, Work Physiology. Measure of physiological strain, Physical Workload, Strength & Endurance. Manual Material Handling (MMH), Bio mechanical recommended limits of MMH. Anthropometry, Anthropometric design principles. Work space envelope, Factors in design of workspace surfaces, Principles of seat design, Principles of control panel organization	**9**
4	Errors - Classification of human errors, Dealing with human errors. Accidents - Theories of accident causation. Occupational Safety and Health - Industrial Safety and Health, Compliance with Standards and Codes, Hazards and Control Measures, Warnings and Safety Programs.	**9**

Course Assessment Method

(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Describe visual capabilities and analyse human factor aspects of hardcopy and computer screen text	**K3**
CO2	Analyze the human factor considerations for visual and auditory displays	**K3**
CO3	Understand various human factor considerations for manual material handling and Apply ergonomic guidelines to recommend safe limits for manual material handling tasks.	**K3**
CO4	Discuss health & safety hazards and deal with human errors	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3		2						2	2		
CO2	3		2			2			2	2		
CO3	3		2									2
CO4	3					2		1				2
CO5	3		2						2	2		

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Human Factors in Engineering and Design	Mark S. Sanders & Ernest J. McCormic	McGraw Hill, International Edition,	1993
2	Introduction to Human Factors and Ergonomics for Engineers	Mark R. Lehto, Mark Lehto, Jim Buck	CRC Press	1st Edition,2007

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Human Factors Engineering in System Design	Terence S. Andre, Aaron W. Schopper	British Columbia Teacher	1997
2	Human Factors Design Handbook	Wesley E. Woodson,	McGraw-Hill Professional	2nd edition, 1992

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/110105162

SEMESTER S8

MEDICAL IMAGE PROCESSING

Course Code	OEBMT833	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	Nil	Course Type	OE

Course Objectives:

1. To provide an overview of the fundamentals behind image processing and analysis methods with an emphasis on biomedical applications.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Digital Image Fundamentals** Introduction – Origin – Steps in Digital Image Processing – Components – Elements of Visual Perception – Image Sensing and Acquisition – Image Sampling and Quantization – Relationships between pixels - medical imaging applications	9
2	**Image transforms** 1D-DFT, 2D-DFT, Two dimensional orthogonal and unitary Transforms, Cosine, Sine, Hadamard, Haar and their properties	9
3	**Image Enhancement** Spatial Domain: Gray level transformations – Histogram processing – Basics of Spatial Filtering– Smoothing and Sharpening Spatial Filtering – Frequency Domain: Introduction to Fourier Transform – Smoothing and Sharpening frequency domain filters – Ideal, Butterworth and Gaussian filters., Application of filtering in medical images.	9

4	**Segmentation and Representation** Detection of Discontinuities–Edge Linking and Boundary detection – Region based segmentation - Morphological processing- erosion and dilation, Application of edge detection - Boundary representation – Chain Code	**9**

Course Assessment Method

(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
● 2 Questions from each module. ● Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	● Each question carries 9 marks. ● Two questions will be given from each module, out of which 1 question should be answered. ● Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Describe digital image fundamentals	**K2**
CO2	Discuss the properties of various image transform techniques and their applications	**K2**
CO3	Apply various techniques for image enhancement	**K3**
CO4	Explain how the segmentation and representation of medical images can be carried out	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1											
CO2	1	1			2							
CO3	3	2	2		2				2	2		1
CO4	3	2	2		2				2	2		1

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Fundamentals of Digital Image Processing	Anil K Jain	Prentice Hall of India	1989
2	Digital Image Processing	Gonzalez Rafel C, Woods Richard E	Pearson	4th Edition 2018
3	Biomedical signal and image processing	Kayvan Najarian, Robert Splinter	CRC Press	2nd Edition 2012

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Biomedical Image Processing	Thomas M. Deserno	Springer	2011
2	Handbook of Medical Image Processing and Analysis	Isaac Bankman,	Academic Press Series in Biomedical Engineering	2nd Edition 2009
3	Digital image processing for medical applications	Dougherty G	Cambridge University Press	2009

Video Links (NPTEL, SWAYAM…)	
Sl No.	**Link ID**
1	https://archive.nptel.ac.in/courses/117/105/117105135/
2	https://onlinecourses.nptel.ac.in/noc22_bt34/preview
3	https://nptel.ac.in/courses/117105079

SEMESTER S8

REHABILITATION ENGINEERING

Course Code	OEBMT834	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	OE

Course Objectives:

1. Introduce students to the fundamental principles and concepts of rehabilitation engineering.
2. Familiarize students with a wide range of assistive technologies used to support individuals with various disabilities.
3. Demonstrate how modern technologies, including robotics, web-based tools, and other communication aids, can be applied to rehabilitation engineering.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Rehabilitation Engineering:** Introduction,Clinical rehabilitation engineer Vs. clinical engineer, Service delivery models,Principles of service delivery. **Standards for assistive technology:** organization of national and international industry standards, the role and contribution of rehabilitation engineering in standards development.	9
2	**Aids for blind or visually impaired:** Dimensions of visual impairment and their impact on task performance, General-purpose assistive technology solutions, Task-specific assistive technologies. **Hearing aid:**Types of hearing impairment, Hearing assistance technology solutions,	9

3	**Wheelchairs:**Manual wheelchairs, Electric power wheelchairs, Multifunctional wheelchairs. **Major Limb Prosthetic Devices:**Components of the upper limb prosthesis, Cosmetic prostheses, Components of the lower limb prosthesis. **Orthotic Devices:**Spinal orthoses, Lower extremity orthoses, Upper extremity orthoses	9
4	**Rehabilitation Robotics:** Intelligent Mobility Aids, Robotic Manipulation Aids, Therapeutic Robots.**Telecommunications, Computers, and Web Accessibility:**Conceptual model: telecommunications, computers and the internet, Technology solutions.	9

Course Assessment Method

(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Explain the fundamental principles and Standards of rehabilitation engineering.	**K1**
CO2	Work effectively with audiologists, optometrists, occupational therapists, and other healthcare professionals.	**K1,K2**
CO3	Prepare a career in rehabilitation engineering, with a focus on wheelchairs and prosthetic devices.	**K3**
CO4	Learn about the role of robotics,computers and other communication aids in rehabilitation therapy.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2		2		2	1	2				3
CO2	3	2	2		2	2	1	2				3
CO3	3	3	3	2	3	2	1	2				3
CO4	3	2	2	2	3	2	1	2				3

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	An Introduction to Rehabilitation engineering	Rory A Cooper,Hisaichi Ohnabe,Douglas A Hobson	CRC press	2006
2	The biomedical engineering handbook - Biomedical Engineering Fundamentals	Joseph D. Bronzino	CRC Press	2006

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Rehabilitation Engineering Applied to Mobility and Manipulation	Rory A Cooper	CRC Press	1995
2	Rehabilitation Engineering	Robinson C.J.	CRC Press	1995
3	Rehabilitation Technology	Ballabio E	IOS Press	1993.

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/102107058 https://onlinecourses.nptel.ac.in/
2	https://archive.nptel.ac.in/course.html https://archive.nptel.ac.in/courses/108/106/108106167/
3	https://onlinecourses.nptel.ac.in/