Vel Tech
Rangarajan Dr. Sagunthala
R&D Institute of Science and Technology
(Deemed to be University Estd. u/s 3 of UGC Act, 1956)

Accredited by NAAC with the HIGHEST GRADE A++

Recognised as CATEGORY-1 DEEMED TO BE UNIVERSITY by the UGC University Grants Commission

SCHOOL OF ELECTRICAL AND COMMUNICATION

CURRICULUM AND SYLLABI

B. Tech – Biomedical Engineering

Vel Tech Dr. RR & Dr. SR University
Chennai · 1997 · India

REGULATION VTR UGE 2021

Department of Biomedical Engineering

VISION & MISSION OF THE DEPARTMENT

VISION:

"To be recognized as an excellent centre in Biomedical Engineering for imparting quality technical education that leads to transformative advancements in healthcare industries"

MISSION:

M1: *To infuse **critical thinking skills** by providing a strong foundation that enables the students for continuing education*

M2: *To create an ambience of academic excellence with **state-of-the-art** laboratories to compete globally*

M3: *To establish a **dynamic research environment** that integrates advanced healthcare technologies for innovation and progress*

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

After 3-4 years of graduation, the undergraduates will be able to

PEO1: *Exhibit **Proficiency in designing and analyzing** healthcare solutions to cater to the needs of the medical industry and societal needs.*

PEO2: *Demonstrate **professional networking** in a diverse team setting and **collaborate** among peers with ethical practices in the workplace, ensuring integrity*

PEO3: *Reinforce **lifelong learning** practices for professional advancement not limited to higher studies and research*

PROGRAM OUTCOMES (POs)

PO1: **Engineering Knowledge:** Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop to the solution of complex engineering problems.

PO2: **Problem Analysis:** Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development.

PO3: **Design/Development of Solutions:** Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required.

PO4: **Conduct Investigations of Complex Problems:** Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions.

PO5: **Engineering Tool Usage:** Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems.

PO6: **The Engineer and The World:** Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment.

PO7: **Ethics:** Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws.

PO8: **Individual and Collaborative Team work:** Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.

PO9: **Communication:** Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.

PO10: **Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.

PO11: **Life-Long Learning:** Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSOs)

Graduates will be able to

PSO1: *Apply critical reasoning to analyse, identify and solve solutions for problems related to Brain-Computer Interface (BCI)*

PSO2: *Design an effective interface between biological and electronic systems*

PSO3: *Apply the knowledge of Artificial intelligence in healthcare engineering to solve real-time problems*

Minimum credits required for regular students in various course categories to complete B-tech Biomedical Engineering under VTR UGE 2021

Course Category	Minimum Credits Required
Foundation Courses (FC)	56
Programme Core (PC	58
Programme Elective (PE)	18
Open Elective (OE)	12
Independent Learning (IL)	14
Industry/Higher Institute Learning Interaction (IHL)	2
Professional Proficiency Courses (PPC)	4
Total	***164***

Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Technology
Department of Biomedical Engineering
L-Lecture, T-Tutorial, P-Practical, C-Credit

Foundation Courses of VTR UGE 2021						
Sl. No.	**Course Code**	**Course Name**	**Class distribution per week**			**C**
			L	**T**	**P**	
1	10210PH102	Physics of Materials	3	0	0	3
2	10210CH102	Biochemistry (2021-2022 & 2022-2023 batch)	3	0	0	3
	10210CH106	Biochemistry (2023-2024 batch onwards)	3	0	0	3
3	10210CS101	Problem Solving using C	3	0	0	3
4	10210ME101	Design thinking	2	0	0	2
5	10210MA201	Matrices & Calculus	2	0	2	3
6	10210EN201	Professional Communication - I	1	0	2	2
7	10210ME201	Engineering Graphics	1	0	4	3
8	10210CH301	Engineering Chemistry Lab	0	0	2	1
9	10210EE301	Engineering Products Lab	0	0	2	1
10	10210CS301	Problem Solving using C Lab	0	0	2	1
11	10210PH103	Applied Physics	2	0	0	2
12	10210BM101	Biology for Engineers	2	0	0	2
13	10210MA203	Vector Calculus & Complex variable	2	0	2	3
14	10210EN202	Professional Communication - II	1	0	2	2
15	10210EE202	Basic Electrical & Instrumentation Engineering	2	0	2	3
16	10210EE204	Introduction to Engineering	1	0	4	3
17	10210CS201	Python Programming	1	0	2	2
18	10210PH302	Applied Physics Laboratory	0	0	2	1
19	10210CS303	IT Workshop (2021-2022 admitted batch)	0	0	2	1
20	10210MA104	Fourier Series & Transform techniques	3	0	0	3
21	10210CH103	Environmental Studies (2021-2022 batch)	2	0	0	2
	10210CH104	Environmental Science and Sustainability (2022-2023 batch onwards)	3	0	0	3
22	10210ME102	Universal Human Values	3	0	0	3
23	10210ME103	Innovation & Entrepreneurship	2	0	0	2
24	10210ME104	Project Management & Finance	2	0	0	2
25	10210MA107	Statistics and Numerical Methods	3	0	0	3
			Total			**56**
Mandatory Courses						
26	10217GE902	Constitution of India	1	0	0	M
27	10217GE901	Engineer and Society	1	0	0	M

S. No	**Course Code**	**Program Core**	**Class distribution per week**			**C**
			L	**T**	**P**	
1	10211BM101	Anatomy and Human Physiology	3	0	0	3
2	10211BM102	Analog and Digital Integrated Circuits	2	1	0	3
3	10211BM103	Electric Circuit Theory	2	1	0	3

4	10211BM104	Engineering Mechanics (2021-2022, 2022-2023 batch)	2	1	0	3
5	10211BM105	Bio Sensors and Transducers	3	0	0	3
6	10211BM106	Control systems	3	1	0	4
7	10211BM107	Microcontroller and Digital Signal Processor	2	1	0	3
8	10211BM108	Digital Signal Processing	2	1	0	3
9	10211BM109	Biomaterials (2021-2022, 2022-2023 batch)	3	0	0	3
10	10211BM110	Biomedical Instrumentation	3	0	0	3
11	10211BM111	Diagnostic and Therapeutic Equipments	3	0	0	3
12	10211BM112	Radiological Equipments	3	0	0	3
13	10211BM113	Biomaterials Applications (2023-2024 onwards)	3	0	0	3
14	10211BM114	Engineering Mechanics and its Applications (2023-2024 batch onwards)	2	1	0	3
				Total		37
Program Core Integrated Courses						
15	10211BM201	Pathology and Microbiology	2	0	2	3
16	10211BM202	Artificial Neural Networks	3	0	2	4
17	10211BM203	Biomechanics	2	0	2	3
18	10211BM204	Image Processing	3	0	2	4
				Total		14
Laboratory Courses						
19	10211BM301	Biochemistry and Physiology Laboratory	0	0	2	1
20	10211BM302	Analog and Digital Integrated Circuits Laboratory	0	0	2	1
21	10211BM303	Sensors and Transducers Laboratory	0	0	2	1
22	10211BM304	Microcontrollers and DSP Processor Laboratory	0	0	2	1
23	10211BM305	Digital Signal Processing Laboratory	0	0	2	1
24	10211BM306	Biomedical Instrumentation Laboratory	0	0	2	1
25	10211BM307	Diagnostic and Therapeutic Equipments Laboratory	0	0	2	1
				Total		7
				Total Credits		**58**

S.No	**Course Code**	**Program Electives (18 Credits)**	**Class distribution per week**			**C**
			L	**T**	**P**	
1	10212BM101	Hospital Management	3	0	0	3
2	10212BM102	Telehealth Technology	3	0	0	3
3	10212BM103	Medical Ethics	3	0	0	3
4	10212BM104	Body Area Networks	3	0	0	3
5	10212BM105	Introduction to Nanotechnology	3	0	0	3
6	10212BM106	Rehabilitation Engineering	3	0	0	3

7	10212BM107	Robotics in Medicine	3	0	0	3
8	10212BM108	Biomedical Informatics	3	0	0	3
9	10212BM119	Medical optics	3	0	0	3
10	10212BM120	Medical Device Regulatory Affairs	3	0	0	3
11	10212BM121	Tissue Engineering	3	0	0	3
12	10212BM124	Biomimetic Engineering	3	0	0	3
Program Elective Integrated Courses						
13	10212BM201	Digital Imaging and Communication in Medicine	1	0	4	3
14	10212BM202	Brain-Computer Interface	1	0	4	3
15	10212BM203	Biomedical Computational Modelling	1	0	4	3

S.No	**Course Code**	**Specialization Electives (18 Credits)**	**Class distribution per week**			**C**
			L	**T**	**P**	
(AI in Healthcare Technology)						
1	10212BM109	Introduction to Machine Learning	3	1	0	4
2	10212BM204	Introduction to Deep Learning (2021-2022 batch)	3	0	2	4
3	10212BM110	Natural Language Processing (2021-2022 & 2022-2023 batch)	3	0	0	3
4	10212BM304	Essential Python Modules for Machine Learning Laboratory (2021-2022 & 2022-2023 batch)	0	0	2	1
5	10212BM122	High-Performance Computing (2021-2022 batch)	3	0	0	3
6	10212BM123	Computer Vision (2021-2022 batch and 2022-2023 batch)	3	0	0	3
7	10212BM206	Deep Learning Fundamentals (2022-2023 onwards)	3	0	2	4
8	10212BM207	Programming Essentials in Python (2023-2024 onwards)	1	0	2	2
9	10212BM208	Introduction to Computer Vision (2023-2024 onwards)	3	0	2	4
10	10212BM209	GPU Architecture and Programming (2023-2024 onwards)	3	0	2	4
11	10212BM125	Computing Architecture of Deep Learning (2022-2023)	3	0	0	3
S.No	**Course Code**	**Honors Electives (18 Credits)**	**Class distribution per week**			**C**
			L	**T**	**P**	
(Precision Healthcare Technology)						
1	10212BM205	Foundations of Data Science and R	3	0	2	4

2	10212BM111	Inferential Analysis and Machine Learning	3	0	0	3
3	10212BM112	Precision Medicine in Chronic Diseases	3	0	0	3
4	10212BM301	Inferential Medical Data Analytics Using R	0	0	4	2
5	10212BM113	Predictive Analysis of Medical Data (2021-2022 batch)	3	0	0	3
6	10212BM114	Healthcare Operations Research	3	0	0	3
7	10212BM115	Medical Data Analytics (2022-2023 onwards)	3	0	0	3
S.No	**Course Code**	**Minor Degree (18 Credits)**	**Class distribution per week**			**C**
			L	**T**	**P**	
(Brain-Computer Interface)						
1	10213BM110	Neurophysiology	2	0	0	2
2	10213BM111	Introduction to BCI and Signal Acquisition Methods	3	0	0	3
3	10213BM112	Digital Signal Processing	3	1	0	4
4	10213BM203	BCI Feature Extraction & Translation	3	0	2	4
5	10213BM302	BCI Data Analysis with MNE	0	0	2	1
6	10213BM113	BCI-Applications and Ethics	3	0	0	3
7	10213BM303	EEG Recording & Analysis Laboratory	0	0	2	1
			Total			18

S.No	**Course Code**	**Independent Learning (14 Credits)**	**Class distribution per week**			**C**
			L	**T**	**P**	
1	10214BM501	Community Service Project	-	-	30	1
2	10214BM601	Minor Project 1	-	-	60	2
3	10214BM602	Minor Project 2	-	-	60	2
4	10214BM701	Major Project	-	-	270	9

S.No	**Course Code**	**Industry/Higher Institute Learning Interaction (IHL)**	**Class distribution per week**			**C**
			L	**T**	**P**	
1	10215BM8XX	In-Plant Training	-	-	30/ 60	1/2

2	10215BM9XX	Industry/Higher Learning Institute Interaction	15/ 30	-	-	1/2

S. No	Course Code	Open Electives (12 Credits)	Class distribution per week			C
			L	T	P	
1	10213BM201	Bio Signal Processing Instrumentation	2	0	2	3
2	10213BM202	Brain Computer Interface	2	0	2	3
3	10213BM101	Body Area Networks	3	0	0	3
4	10213BM102	Environmental Conservation	3	0	0	3
5	10213BM103	Remote Health Technology	3	0	0	3
6	10213BM104	Medical Instrumentation	3	0	0	3
7	10213BM105	Drone in Healthcare	3	0	0	3
8	10213BM301	Biomedical Lab	0	0	2	1
9	10213BM114	Biomimicry	3	0	0	3
10	10213BM117	Drone Technology in Healthcare	3	0	0	3
11	10213BM118	Human-Computer Interface	3	0	0	3
MOOC						
PROGRAM ELECTIVE/SPECIALIZATION ELECTIVE						
1	10212BM401	Affective Computing	-	-	-	3
2	10212BM402	Implant, Sensors & Rodents Studies in Biomedical Applications	-	-	-	3
3	10212BM403	Optical Spectroscopy and Microscopy: Fundamentals of optical measurements and instrumentation	-	-	-	3
4	10212BM404	Fundamentals of Micro and Nanofabrication	-	-	-	3
5	10212BM405	Deep Learning for Computer Vision	-	-	-	3
OPEN ELECTIVE						
1	10213BM401	Design & Implementation of Human-Computer Interfaces	-	-	-	3
2	10213BM402	Nanomaterials and their Properties	-	-	-	3
3	10213BM403	Introduction to Biomedical Imaging system	-	-	-	3
4	10213BM404	Strength & Conditioning for Indian Population	-	-	-	3
5	10213BM405	Human Computer Interaction	-	-	-	3

6	10213BM406	Medical Law	-	-	-	2
7	10213BM407	Psychology of stress health and well-being	-	-	-	3

Course Code	Course Title	L	T	P	C
10211BM101	Anatomy and Human Physiology	3	0	0	3

a) Course Category

Program core

b) Preamble

Knowledge of Human anatomy and physiology is essential for a biomedical engineer in order to design any biomedical instruments. This course gives a basic knowledge about human anatomy

c) Prerequisite

10210BM101 - Biology for Engineers

d) Related Courses

10211BM201 - Pathology and Microbiology

e) Course Outcomes

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

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Summarize the basic structural and functional elements of the human body	K2
CO2	Analyze the mechanics of respiration with respect to various respiratory parameters	K3
CO3	Illustrate the mechanics of the circulatory system	K2
CO4	Interpret the functional significance of the kidney, eye, and ear	K2
CO5	Classify the types of the nervous system based on its function	K2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	-	-	1	-	-	-	-	-	-	-	1	-
CO2	3	2	-	-	-	-	-	1	1	-	-	-	1	-
CO3	3	1	-	-	-	-	-	1	1	-	-	-	1	-
CO4	3	1	-	-	-	-	-	1	1	-	-	-	1	-
CO5	3	1	-	-	-	-	-	1	1	-	-	2	1	-

f) Course content

UNIT I INTRODUCTION TO TISSUE STRUCTURE 9 Hrs

Tissue – epithelial, connective, muscle-skeletal muscle – structure, contractile elements, properties, smooth muscle – structure and types.

Introduction to Skeletal system – types of bones and joints, membranes and cavities of the body

UNIT II RESPIRATORY SYSTEM 9 Hrs

Components of respiratory system- organs of respiration, non-respiratory functions of the lung – filtration of air. Respiratory Mechanics – respiratory movements, muscles of respiration, movement of lungs and thoracic cage, respiratory pressures, compliance. Lung volumes, capacities and its measurements. Ventilation – pulmonary, alveolar, dead space. Gas exchange – internal and external, Transport of respiratory gases, Regulation of respiration..

UNIT III CARDIOVASCULAR SYSTEM 9 Hrs

Blood – plasma, formed elements, erythropoiesis. Blood vessels – types and structure, Structure of heart – internal and external, Properties of cardiac muscle. Cardiac cycle – atrial and ventricular events, pressure changes during cardiac cycle, cardiac output. Pulse – Arterial and venous pulse, Heart sound, Blood pressure – Arterial, venous and capillary pressure, Circulation of blood.

UNIT IV URINARY AND SPECIAL SENSORY SYSTEM 9 Hrs

Urinary system: Structure of kidney and nephron, juxtaglomerular apparatus, Renal circulation – auto regulation and special features. Mechanism of Urine formation: Glomerular filtration, tubular reabsorption, tubular secretion, acidification of urine, micturition.

Special senses: Eye – structure of eye, intraocular pressure, ocular muscle and movements, function of rods and cones. Ear – structure of ear, auditory pathway.

UNIT V NERVOUS SYSTEM 9 Hrs

Structure of a Neuron – Types of Nerve. Synapse and neurotransmitters. Conduction of action potential in neuron. Brain – Cerebrum – brain stem –cerebellum. Spinal cord – Tracts of spinal cord, Autonomic nervous system.

Total: 45 Hrs.

g) Learning Resources

Text Books

1. K. Sembulingam and Prema Sembulingam “Essentials of Medical Physiology”, 8th edition , 2019, Jaypee Brothers Medical Publishers.
2. Anne Waugh and Allison Grant, Ross and Wilson “Anatomy and Human Physiology in Health and Illness” 13th edition, 2018, Elsevier Publishers.

Reference Books

1. Gillian Pocock, Christopher D. Richards, The human Body – An introduction for Biomedical and Health Sciences, 5th edition, 2017, Oxford University Press.
2. William F.Ganong, “Review of Medical Physiology”, 26th Edition, 2019, Mc Graw Hill, New Delhi.

Course Code	Course Title	L	T	P	C
10211BM102	Analog and Digital Integrated Circuits	2	1	0	3

a) Course Category

Program core

b) Preamble

Every medical instrument whether it is diagnostic or therapeutic does not come without basic electronics circuits like an Instrumentation amplifier. This course gives an insight into the design of such equipment

c) Prerequisite

None

d) Related Courses

10211BM107 – Microcontroller and Digital Signal Processor, 10211BM105 – Bio Sensors and Transducers, 10211BM103 – Electric Circuit Theory.

e) Course Outcomes

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Design Biasing circuits for Transistor Design simple mathematical circuits using opamp	K3
CO2	Design various wave shaping circuits with op amp and 555 timers	K3
CO3	Solve problems on number system Use Boolean algebra to simplify digital circuits	K3
CO4	Apply the concept of counters, flip flops, registers and combinational logic in digital circuits	K3
CO5	Solve problems on A/D and D/A converters	K3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	-	-	-	-	-	-	-	-	2	-	-
CO2	3	2	1	-	-	-	-	-	-	-	-	2	-	-
CO3	3	1	1	-	-	-	-	-	-	-	-	1	-	-
CO4	3	2	1	-	1	-	-	-	-	1	-	1	-	-
CO5	3	1	1	-	1	-	-	-	1	-	-	1	-	-

f) Course content

UNIT I Introduction to OP-AMP **9 Hrs**

VI Characteristics of BJT, FET and MOSFET; Transistor as an amplifier, Transistor as an amplifier, Methods of Transistor biasing- fixed bias, voltage divider, Emitter feedback bias and Bias stability. Characteristics and applications of operational amplifiers - difference amplifier, adder, subtractor, integrator, differentiator, instrumentation amplifier.

UNIT II Oscillators and 555 Timer **9 Hrs**

Oscillators- Classification of Oscillators, Barkhausen Criterion, General form of an LC Oscillator, Hartley oscillator, Colpitts oscillator, RC oscillator, Wein-Bridge Oscillator, Introduction to 555 timer; Astable and monostable operation of 555 timer, Schmitt Trigger using 555 timer, Applications of 555 in Astable and Monostable operation

UNIT III Number system & Boolean algebra **10 Hrs**

Number system; Base conversion methods; compliments- 1's and 2's compliment, Codes- BCD-2421- Excess 3- Gray and ASCII, Boolean Algebra: Basic theorems and properties- Boolean laws and De-Morgan's theorem, Canonical & Standard form, Boolean algebraic simplification and realizing using logic gates, K-Map.

UNIT IV Combinational Logic, Sequential Machine and Circuit Analysis **10 Hrs**

Combinational Logic: Introduction- Arithmetic circuits, Comparators, Decoders and encoders, Multiplexers and De-multiplexers. Fundamentals of sequential machine operation, Storage elements- Latches & Flip-flops (D-Flip-flop, T-Flip-flop, J-K flip-flop and Clocked flip-flops), Counters- ripple counter, ring counters, Registers- Shift register sequences. State Diagram.

UNIT V Signal Conversion **7 Hrs**

A/D and D/A converters: Weighted-resistor D/A converter; R-2R Ladder D/A converter; Parallel comparator A/D converter; Successive-approximation A/D converter.

Total: 45 Hrs

g) Learning Resources

Text Books

1. Electronic Devices and Circuits – S Salivahanan, N Suresh Kumar. Mc Graw Hill Education, 2022, 5th edition.
2. D. Roy Chowdary, Sheil B Jani- Linear Integrated circuits- new age publication, 2021, 6th edition.
3. M. Morris Mano- Digital Design. Global Edition, Pearson, 2018, 6th edition.

Reference Books

1. 1. Jacob Millman and Christos Halkias - Electronic Devices and Circuits, McGraw-Hill Education India, 2017, Black edition.
2. 2. Allan Mottershed - Electronic devices and circuits: An introduction- Printis hall of India 2011 edition.
3. 3. Donald P Leach - Digital Principles and Applications - Pearson- Seventh Edition

Course Code	Course Title	L	T	P	C
10211BM103	Electric Circuit Theory	2	1	0	3

a) Course Category

Program core

b) Preamble

Any analog circuit design/debugging needs thorough analysis of current and voltage at each point. This course introduces knowledge background needed for designing any electronic circuit or solving any problems encountered in the electronic circuit

c) Prerequisite

None

d) Links to other courses

Analog Electronics and Integrated Circuits

e) Course Outcomes

Upon successful completion of the course, the students will be able to

CO Nos.	Course outcome	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Solve circuits for current and voltage using simple mesh and node analysis and theorems	K3
CO2	Reduce the complicated circuit to an equivalent simple circuit	K3
CO3	Compute the resonance frequency of series and parallel resonance circuits	K3
CO4	Solve the problems of Coupled circuits	K3
CO5	Solve problems on how RL, RC an RLC circuits behave with respect to time domain for both DC / AC input	K3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	-	-	-	-	-	-	-	-	-	1	-
CO2	3	2	1	-	-	-	-	-	-	-	-	-	1	-
CO3	3	2	1	-	-	-	-	-	-	-	-	-	1	-
CO4	3	2	1	-	-	-	-	-	-	-	-	-	1	-
CO5	3	2	1	-	-	-	-	-	-	-	-	-	1	-

f) Course Content

UNIT-I Basic Circuit Analysis **9 Hrs**

Ohm's Law – Kirchhoff's laws – DC and AC Circuits – Resistors in series and parallel circuits –Mesh current and node voltage method of analysis for D.C Circuits and Fundamental A.C. circuits

UNIT-II Network Reduction and Theorems for DC Circuits **9 Hrs**

Network reduction: voltage and current division in DC circuits, source transformation Technique– star delta conversion. Thevenin's and Norton & Theorem – Superposition Theorem – Maximum power transfer theorem– Reciprocity Theorem.

UNIT-III Resonance Circuits **9 Hrs**

Introduction to Resonance circuits, Resonant Tuned Circuits, Series and parallel resonance-resonant frequency- quality factor- bandwidth, Comparison of series and parallel resonant circuits.

UNIT-IV Coupled Circuits **9 Hrs**

Introduction to Coupled Circuits, Self-Inductance, Mutual Inductance, Modeling of coupled circuits, Dot convention in coupled coils, Series connection of coupled coils, Parallel connection of coupled coils, Equivalent T-network for mutually coupled circuits.

UNIT-V Transient Response **9 Hrs**

Transient response of RL, RC and RLC Circuits using Laplace transform for DC input and A.C. with sinusoidal input**.**

Total: 45 Hrs

g) Learning Resources

Text Books

1. Arumugam and PremKumar " Electric Circuit Theory", Khanna Publishers, 2000
2. Joseph Edminister, "Electric Circuits" Schaum's outline series, Tata McGraw Hill Book Company, Third Edition, 2013
3. Kothari DP and I.J Nagrath, "Basic Electrical and Electronics Engineering", McGraw Hill Education, 2014.
4. Hayt JackKemmerly, Steven Durbin, "Engineering Circuit Analysis",Mc Graw Hill education, 9th Edition, 2018.

Reference Books

1. A.Chakrabarti," Circuit Theory – Analysis and Synthesis", Dhanpat Rai & Co. New Delhi, Fifth Edition 2006
2. 2. Charles.K.Alexander, Mathew N.O.Sadiku," Fundamentals of Electric Circuits", McGraw Hill, 5th Edition, 2012.
3. 3. David Bell, "Fundamentals of Electric Circuits", Oxford University press, 7 th Edition, 2009.
4. 4. John O Mallay, Schaum's Outlines "Basic Circuit Analysis", The Mc Graw Hill companies, 2nd Edition, 2011.

Course Code	Course Title	L	T	P	C
10211BM104	Engineering Mechanics	2	1	0	3

a) Course Category

Program core

b) Preamble

This course provides an introduction to the basic concepts of forces, inertias, centroids, and moments of area and techniques of finding their effects on motion. It introduces the phenomenon of friction and its effects. It introduces students to cognitive learning in applied mechanics and develops problem-solving skills in both theoretical and engineering oriented problems.

c) Pre-Requisite

10210MA203-Vector Calculus & Complex variable

d) Related Courses

None

e) Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Solve engineering problems using the principles of statics of particles	K2
CO2	Illustrate the forces and moments acting on rigid bodies	K2
CO3	Determine the sectional properties of standard geometries	K3
CO4	Solve engineering problems in fluid mechanics and relate them to biofluids.	K3
CO5	Apply the principles of particle dynamics and friction to analyze the mechanical system.	K2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	3	-	-	-	-	-	-	-	-	-	1	-
CO2	3	1	3	-	-	-	-	-	-	-	-	-	1	-
CO3	3	1	3	-	-	-	-	-	-	-	-	-	1	-
CO4	3	1	3	-	-	-	-	-	-	-	-	-	1	-
CO5	3	1	3	-	-	-	-	-	-	-	-	-	1	-

f) Course Content

UNIT I BASICS & STATICS OF PARTICLES **9 Hrs**

Introduction – Units and Dimensions – Laws of Mechanics – Lami's theorem, Parallelogram and Triangular Law of forces – Vectors – Vectorial representation of forces and couples – Vector operations: additions, subtraction, dot product, cross product – Coplanar Forces – Resolution and Composition of forces – Equilibrium of a particle – Equivalent systems of forces – Principle of transmissibility – Single equivalent force.

UNIT II EQUILIBRIUM OF RIGID BODIES **9 Hrs**

Free body diagram – Types of supports and their reactions – requirements of stable equilibrium – Moments and Couples – Moment of a force about a point and about an axis – Scalar components of a moment – Varignon's theorem – Equilibrium of Rigid bodies in two dimensions

UNIT III PROPERTIES OF SURFACES AND SOLIDS **9 Hrs**

Determination of Areas and Volumes – First moment of area and the Centroid of sections – Second and product moments of plane area – Parallel axis theorem and perpendicular axis theorem

UNIT IV BASICS OF MECHANICS OF FLUIDS **9 Hrs**

Fluids – density – pressure – blood pressure and gravity – buoyancy – moments of force and stability –movement in water –Newton's laws of viscosity – Definitions and simple problems on Newtonian fluid, Non - Newtonian fluid.

UNIT V DYNAMICS OF PRACTICLES & FRICTION **9 Hrs**

Frictional force – Laws of Coulomb friction – simple contact friction – Belt friction – Roller friction. Translation and Rotation of Rigid Bodies – General Plane motion.

Total : 45 Hrs

g) Learning Resources

Text Books

1. R.S.Khurmi, A Text Book of Engineering Mechanics, S Chand and Company (P) Ltd., New Delhi. Revised Edition, 2019.
2. Dr. R. K. Bansal, A Text Book of Fluid Mechanics, Laxmi Publications (P) Ltd., New Delhi. 2018
3. Hibbeller, R.C., Engineering Mechanics, Vol. 1 Statics, Vol. 2 Dynamics, Pearson Education Asia Pvt. Ltd., 2019.
4. S.Timoshenko, D.H.Young, J.V.Rao, Sukumar Pati, Engineering Mechanics, McGraw Hill Education (India) Private Limited., 2018.

References Books

1. Palanichamy, M. S., and Nagan, S., Engineering Mechanics (Statics and Dynamics), Tata McGraw Hill, New Delhi 2012.
2. Kumar, K. L., Engineering Mechanics, Tata McGraw- Hill, New Delhi, 2019.
3. Shames, I. H., and Krishna Mohana Rao, G., Engineering Mechanics (Statics and Dynamics), Dorling Kindersley India) Pvt. Ltd. (Pearson Education), 2019.
4. Beer, F. P., and Johnston, E. R., Vector Mechanics for Engineers – Dynamics and Statics, Tata McGraw-Hill, New Delhi, 2011.
5. Natarajan, K.V., Engineering Mechanics, Dhanalakshmi Publishers, 2011.
6. Lee Waite, ―Bio fluid Mechanics in Cardiovascular Systems‖, The McGraw-Hill Companies, 2016.

Course Code	Course Title	L	T	P	C
10211BM105	Bio Sensors and Transducers	3	0	0	3

a) Course Category

Program core

b) Preamble

The student should be able to explain how physiological parameters are being measured.

c) Prerequisite

None

d) Related Courses

10211BM110 - Biomedical Instrumentation

e) Course Outcomes

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

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Illustrate the principles of electrodes and their applications	K2
CO2	Apply direct and indirect pressure measurement methods in biosensors	K3
CO3	Summarize the fluid and gas flow measurements	K2
CO4	Differentiate the techniques employed in motion and force measurement	K2
CO5	Choose a suitable device to measure temperature in biomedical applications	K3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	-	-	-	1	1	-	-	-	-	2	3	-
CO2	3	1	1	-	-	2	-	-	-	-	-	-	3	-
CO3	3	1	-	-	-	2	-	-	-	-	-	-	3	-
CO4	3	1	-	-	-	2	-	-	-	-	-	-	3	-
CO5	3	1	-	-	-	2	-	-	-	-	-	-	3	-

f) Course content

UNIT I INTRODUCTION TO SENSORS AND TRANSDUCER 9 Hrs

Transducer and Measurement system - Static Characteristics – Dynamic Characteristics – Standards and Calibration – Types of Error.Bioelectric and Biomagnetic Measurement: Bioelectric events, Biomangetic events. Electrode theory – Electrode-Electrolyte interface – Liquid junction potentials –Double layer – Electrode potenials. Surface Potential Electrodes: ECG electrodes – EMG electrodes – ECG electrodes. Glass electrodes – Metal Electrodes – Suction electrodes. Bio Magnetism: Biomagnetic fields – Magnetopneumography.

UNIT II PRESSURE MEASUREMENTS 9 Hrs

Requirements of pressure measurements, Direct pressure measurement: Catheters and diaphragm type pressure measurement – Catheter tip pressure transducer, Pressure measurement in small vessels - Servo controlled, Pressure measurement in collapsible vessels – Interstitial pressure measurement – Differential pressure measurement. Indirect pressure measurement – Systolic, Diastolic and Mean blood pressure – Auscultatory and Oscillometric method.

UNIT III FLOW MEASUREMENT 9 Hrs

Requirements of flow measurement, Blood flow meters in single vessel – Electromagnetic flow meter – Ultrasound flow meter – Indicator dilution method. Tissue blood flow meter – Venous Occlusion plethysmography. Respiratory Gas flow measurements – Gas flow sensors - Lung plethysmography.

UNIT IV MOTION AND FORCE MEASUREMENTS 9 Hrs

Objects of Measurements, Motion Measurements: Displacement and rotation measurements by contact transducers - Displacement and rotation measurements of body in extracted tissue – Displacement measurement in vivo, Non contact measurement of displacement and rotation. Force measurements: Muscle contraction measurement – Force measurements in isolated muscles – In vivo measurement of muscle contraction.

UNIT V TEMPERATURE MEASUREMENT 9 Hrs

Requirements of temperature measurement, Temperature transducers – Thermistor - Thermocouple– Thin film thermo resistive element – p-n junction diodes and transistors. Clinical thermometers: Indwelling thermometer probes – Rectal, Esophageal and Bladder temperature measurement, Tymphanic thermometer, Zero heat flow thermometer.

Total: 45 Hrs

g) Learning Resources

Text Books

1. Tatsuo Togawa, Toshiyo Tamura, P. Ake Oberg, “Biomedical Sensors and Instruments”, 2nd Edition, CRC Press, 2011.
2. John G. Webster and Amit J. Nimunkar, “Medical Instrumentation - Application and Design, An Indian Adaptation”, 5th Edition, John Wiley and sons, 2021.
3. A K Sawhney, “A Course in Electrical and Electronic Measurements and Instrumentation”, Sree Hari Publications, 2021.

Reference Books

1. Ernest O Doebelin and Dhanesh N Manik, Measurement systems, Application and design, 5th edition, McGraw-Hill, 2007.
2. Khandpur R.S, “Handbook of Biomedical Instrumentation”, Tata McGraw-Hill, 2003.

3. Leslie Cromwell, “Biomedical Instrumentation and measurement”, 2nd Edition, Prentice hall of India, 2015.
4. L.A Geddas and L.E.Baker, “Principles of Applied Biomedical Instrumentation”, 3rd Edition, John Wiley and Sons, 2008.
5. Albert D.Helfrick and William D. Cooper. Modern Electronic Instrumentation and Measurement Techniques”, Prentice Hall of India, 2007

Online Resources/Links

- https://sl-coep.vlabs.ac.in/exp/temperature-sensor/
- http://vlabs.iitkgp.ac.in/ctrl/index.html

Course Code	Course Title	L	T	P	C
10211BM106	**Control systems**	**3**	**1**	**0**	**4**

a) Course Category

Program core

b) Preamble

This course will give comprehension of the essentials of control frameworks beginning from the rudiments of control hypothesis to certain instances of biomedical designing applications

c) Prerequisite

10210MA104- Fourier Series & Transform techniques

d) Related Courses

10211BM203 - Biomechanics, 10211BM108 – Digital Signal Processing

e) Course Outcomes

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

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Classify the different types of systems , and derive the transfer function of linear systems using block diagram reduction and signal flow graph methods (Mason's Gain Formula).	K3
CO2	Compute and interpret the time response of various systems and discuss the concept of system stability.	K3
CO3	Plot and Interpret the frequency response characteristics of various systems.	K3
CO4	Identify controller types, their applications, and standard tuning methods for performance requirements	K2
CO5	Illustrate closed-loop control concepts in human physiological systems such as cardiac output regulation, insulin regulation, and respiratory control mechanisms	K2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	-	-	-	-	-	-	-	-	-	-	1	-
CO2	3	2	-	-	-	-	-	-	-	-	-	-	1	-
CO3	3	2	-	-	-	-	-	-	-	-	-	-	1	-
CO4	3	2	2	-	-	-	-	-	-	-	-	-	1	-
CO5	3	2	2	-	1	-	-	-	-	-	-	-	1	-

f) Course Content

UNIT-1: INTRODUCTION **12 Hrs**

Basic Control Definitions, Fundamental Control Concepts, Analysis and Design Objectives, Design Process, Reduction of block diagram and signal flow graph. Mathematical modelling of linear systems: Continuous Time-Linear Systems- Linear and Time Invariant Systems- Laplace Transform- Discrete-Time Linear Systems- Z-Transform- Continuous and Discrete Transfer Functions.

UNIT-II: TIME DOMAIN ANALYSIS OF CONTINUOUS & DISCRETE SYSTEMS **14 Hrs**

Continuous Transient Response Analysis, First Order System Response, Second Order System Response: Second Order system with distinct real roots- Second order systems with repeated real roots- second order system with conjugate complex roots, System Identification: First order system identification- Second order system identification, Discrete Transient Response analysis, Mapping from *S*-plane to *Z*-plane, Continuous and Discrete systems stability.

UNIT-III: FREQUENCY DOMAIN ANALYSIS OF CONTINUOUS & DISCRETE SYSTEMS **14 Hrs**

Frequency Response Analysis of Continuous systems, Bode Diagrams of Continuous systems, Frequency Response Analysis of Discrete-Time systems, Bode Diagrams of Discrete-Time Systems, Relation between Transient and Frequency Response, Relative stability of Continuous and Discrete Time systems in the frequency domain, Root locus Analysis of Continuous and Discrete Systems.

UNIT-IV: CONTROL SYSTEM DESIGN **10 Hrs**

PID continuous controller: Proportional Control- Integral Control- Derivative Control, Discretization of Continuous Controller, Tuning PID Controllers, Ziegler-Nichols Technique in Open loop and Closed loop.

UNIT-V: APPLICATIONS IN THE FIELD OF BIOMEDICAL ENGINEERING **10 Hrs**

Regulation of Cardiac Output: The cardiac output curve- The venous return curve- Closed loop Analysis: Heart and Systemic Circulation, Regulation of Insulin, Model of Cheyne-stokes Breathing.

Total: 60 Hrs

g) Learning Resources

Text Books

1. J.Nagrath and M.Gopal, “Control System Engineering”, New Age International Publishers, 7thEdition, 2021.
2. Michael C K Khoo, “Physiological control systems”, IEEE Press, Prentice Hall of India, 2005
3. A Nagoorkani, “Control Systems”,5th Edition,RBA Publications,2020.
4. Milsum John H, "Biological Control System Analysis", 2nd Edition, McGraw Hill Publications, 1996
5. John Enderly, Joseph Bronzino, “Introduction to Biomedical Engineering”, Third Edition, Academic Press Series in Biomedical Engineering, 2012.

Reference Books

1. Norman S. Nise. “Control Systems Engineering” John Wiley & Sons, Inc., Seventh Edition,2015.
2. Ogata Katsuhika, Modern Control Engineering, Fifth Edition, Pearson Publisher Prentice Hall of India,2010.
3. Richard C.Dorf & Robert H. Bishop, “Modern Control Systems”, Pearson Education, 13th Edition,2017
4. Joseph J.Di Stefano, Allen R. Stubberud, Schaum's, “Outline of Feedback and Control Systems”, McGraw-Hill Education, 3 r d Edition, 2013.
5. M. Gopal, “Control System, Principles and Design”, McGraw-Hill, 2012

Course Code	Course Title	L	T	P	C
10211BM107	Microcontroller and Digital Signal Processor	2	1	0	3

a) Course Category

Program core

b) Preamble

Microcontrollers are the basic building blocks of all embedded systems and DSPs are the core of many multimedia devices existing today. This course gives primary knowledge required to design such devices. This course assumes no prior knowledge of DSP

c) Prerequisite

10211BM102-Analog and Digital Integrated Circuits

d) Related Courses

Digital Signal Processing, Image Processing

e) Course Outcomes

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

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Solve simple arithmetic and logic functions using 8085 ALP	K3
CO2	Sketch the architecture of MSP430 and write c codes for simple applications with MSP430	K3
CO3	Develop MSP430 code to configure ADC & DAC	K3
CO4	Compare the architecture of MSP430 and DSP	K3
CO5	Develop a C program for interfacing the peripheral hardware with DSP	K3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	-	-	1	-	-	-	-	-	-	1	1	1
CO2	3	1	1	-	-	-	-	-	-	-	-	1	1	1
CO3	3	1	-	2	-	-	-	-	-	-	-	1	1	1
CO4	3	1	-	1	-	-	-	-	-	-	-	1	1	1
CO5	3	1	-	1	-	-	-	-	-	-	-	1	1	1

f) Course Content

UNIT-I 8085 architecture and programming 9 Hrs

Introduction to 8085 Architecture, Addressing Modes, Instruction Formats, and Instruction Set. Introduction to 8086 Architecture, Features, Signals, I/O & Memory Interfacing, Addressing Modes, Instruction Formats, Instruction Set, Assembler Directives, Interrupts, Minimum Mode & Maximum Mode Operation,

UNIT-II TI MSP430 Launchpad and programming 11 Hrs

General Layout, CPU, Memory, I/O ports, clock, timer and watchdog timer module, ADC and comparator module, other module, interrupts, interrupt vectors, port interrupts, ISR, Introduction, addressing modes, stack, simple programs, Digital I/O Registers, coding practices for digital I/O.

UNIT-III Mixed signal system 7 Hrs

Analog and digital signals, the comparator, A/D conversion, D/A conversion, ADC 10 and application.

UNIT-IV DSP Architecture and Programming 9 Hrs

Architecture and Memory organization, addressing modes, instruction set, assembler directives, Programming Examples Using C code

.

UNIT-V DSP 9 Hrs

The analog interface circuit, interrupts and peripherals, External/Flash Memory and I/O with 16-bit Stereo Audio Codec, Programming Examples Using C code

Total: 45 Hrs

g) Learning Resources

Text Books

1. Ramesh S Gaonkar, Microprocessor Architecture, Programming and application with 8085, 6th Edition, Penram International Publishing
2. P. Lapsley, J. Bier, A. Shoham, E.A. Lee, "DSP Processor Fundamentals - Architectures and Features", IEEE Press, New York, 1997, cap. 1. 4.

3. K. Hintz, D. Tabak, "Microcontrollers - Architecture, Implementation and Programming", Mc Graw - Hill, 1992, par. 1.1.4, pp. 16-26.

Reference Books

1. Barry B.Brey, “The Intel Microprocessors”
2. Adrian Fernandez, Dung Dang” Getting Started with the MSP430 Launchpad

Web Resources

1. https://www.ti.com/lit/ug/slau318g/slau318g.pdf?ts=1624954174860&ref_url=https%253A%252F%252Fwww.google.com%252F
2. http://embeddedtechnosolutions.com/wp-content/uploads/2016/11/MSP430-Tutorial.pdf

Course Code	Course Title	L	T	P	C
10211BM108	Digital Signal Processing	2	1	0	3

a) Course Category

Program core

b) Preamble

This course provides the basic knowledge on the required mathematics for the process of analog and digital signals

c) Prerequisite

10210MA104-Fourier Series & Transform Techniques

d) Related Courses

Microprocessor and Microcontroller, Image Processing

e) Course Outcomes

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Classify the continuous/discrete time signals/systems from the given equation according to their properties	K3
CO2	1. Compute the spectrum of periodic and aperiodic signals using continuous and Discrete Fourier transform. 2. Analyze the given Discrete system using Z-transform.	K3
CO3	Solve problems on analog to digital signal conversion, Aliasing and identify the signal using Fourier transform	K3
CO4	Design FIR filter for the given specification	K3
CO5	Design IIR filter for the given specification	K3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	-	-	-	-	-	-	-	-	1	-	-
CO2	3	2	1	-	-	-	-	-	-	-	-	1	-	1
CO3	3	2	1	1	-	-	-	-	-	-	-	1	-	1
CO4	3	2	1	1	-	-	-	-	-	-	-	1	-	1

CO5	3	2	1	-	-	-	-	-	-	-	-	1	-	1

f) Course Content

UNIT-I Classification of signals and systems **9 Hrs**

Continuous Time signals (CT signals) – Discrete Time signals (DT signals) – Elementary CT signals and DT signals – Basic properties of signals , Classification of CT and DT signals – Basic properties of systems – Classification CT systems and DT systems – Linear time invariant systems and properties

UNIT-II Signal and system analysis (CT and DT) **9 Hrs**

Fourier Transform in signal analysis and system analysis, convolution integral and impulse response, Fourier transform of discrete sequence, Z-transform and its properties, inverse z-transforms; Stability analysis, frequency response – Convolution..

UNIT-III Representation of discrete time signals and FFT **9 Hrs**

Sampling of Continuous Time signals and aliasing –z transform in Discrete Time signal analysis, Discrete Fourier Transform, (DFT), DFT for periodic sequence, Fast Fourier Transform (FFT), Butterfly Diagram, Convolution through FFT

UNIT-IV Design of FIR Filters **9 Hrs**

FIR design: Windowing Techniques - Rectangular, Hamming, Hanning – Need and choice of windows – Linear phase characteristics.

UNIT-V Design of IIR Filters **9 Hrs**

IIR design: Analog filter design - Butterworth filter design using impulse invariant and bilinear transformation - Warping, prewarping - Frequency transformation..

Total: 45 Hrs

g) Learning Resources

Text Books

1. C. Ramesh Babu Durai, " Digital Signal Processing", 2nd Edition, Laxmi Publications, 2020.
2. Dr. Shaila D. Apte, "Digital Signal Processing", 2nd Edition, Wiley India, 2020.
3. Emmanuel Ifeachor, Barry Jervis, "Digital Signal Processing, 2/e", 2nd Edition, Pearson Education, 2018.

Reference Books

1. Lizhe Tan, Jean Jiang, "Digital Signal Processing: Fundamentals and Applications", 3rd Edition, Academic Press, 2018.
2. R. Anand, "Digital Signal Processing", 1st Edition, Oxford University Press, 2018.

Course Code	Course Title	L	T	P	C
10211BM109	Biomaterials	3	0	0	3

a) Course Category

Program core

b) Preamble

Knowledge on different biomaterials is essential for a biomedical engineer in order to make any biomedical products such as implants. This course gives an introductory knowledge about biomaterials, types, and its properties

c) Prerequisite

None

d) Related Courses

10212BM105 - Introduction to Nanotechnology

e) Course Outcomes

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Classify biomaterials based on their composition, structure, and functional properties	K2
CO2	Differentiate between hard tissue and soft tissue implant materials based on structure and application.	K2
CO3	Summarize various polymeric biomaterials and their basic composition used in biomedical engineering.	K2
CO4	Compare various ceramic biomaterials and their basic structure for biomedical applications.	K2
CO5	Summarize how the structure of composite biomaterials relates to their biomedical applications.	K2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	-	-	-	-	-	-	1	1	-	-	3	-
CO2	3	2	-	-	-	-	-	-	1	1	-	-	3	-
CO3	3	2	-	-	-	-	-	-	1	1	-	-	3	-

CO4	3	2	-	-	-	-	-	-	1	1	-	-	3	-
CO5	3	2	-	-	-	-	-	-	1	1	-	-	3	-

f) Course content

Unit 1 Biomaterials – Introduction, Properties and Biocompatibility 10 Hrs

Introduction to biomaterials, basic criteria for biomaterials, classification of biomaterials, selection and performance of biomaterials, biological responses - surface and physical properties, mechanical properties, stress-strain behaviour & hardness, mechanical failures, fatigue, electrical, optical and magnetic properties - introduction to biocompatibility, blood compatibility and tissue compatibility, and rejections.

Unit 2 Metallic Biomaterials 8 Hrs

Stainless Steels, Cobalt (Co)-Chromium (Cr) Alloys, Titanium (Ti) Alloys, Corrosion of Metallic Implants – Stress and Cracking. Hard Tissue Replacement Materials: Orthopaedic Implants and Dental Implants. Soft Tissue Replacement Materials: Percutaneous and Skin Implants, Vascular Implants, and Heart Valve Implants.

Unit 3 Polymeric Biomaterials 9 Hrs

Polymerization and basic structure, Polymeric biomaterials: Polyolefin (Polyethylene (PE), Polypropylene (PP)), polyamides (Nylon), acrylic polymers (Plolymethylmetacrylate (PMMA)), fluorocarbon polymers (Polytetrafluoroethylene (PTFE)), Silicone Rubber, Hydrogels, Biodegradable Polymers - Classification according to Thermosets, Thermoplastics (Polyetherether ketone (PEEK)) and Elastomers. Natural bio-polymers: Collagen, Elastin and chitin. Biomedical Applications.

Unit 4 Ceramic Biomaterials 8 Hrs

Definition of Bioceramics - Non-absorbable materials: Alumina, Carbons, Zirconia. Biodegradable Ceramics: Calcium phosphate, Aluminum-Calcium-Phosphate (ALCAP) Ceramics. Bioactive ceramics: Glass ceramics and Hydroxyapatite. Biomedical applications.

Unit 5 Composite Biomaterials & Sterilization in Biomaterials 10 Hrs

Properties and Types of Composites - Mechanics of Improvement of properties by incorporating different elements - Composite Theory of Fibre reinforcement (short and long fibres, fibres pull out) - Polymers Filled with Osteogenic Fillers (e.g. Hydroxyapatite). Biomedical applications. Sterilization procedures: ETO, gamma radiation, autoclaving, Effects of sterilization on material properties.

Total: 45 Hrs

g) Learning Resources

Test Books

1. Sujata V. Bhat, Biomaterials, Narosa Publishing House, 2005.
2. Bronzino JD, ed. The Biomedical Engineering Handbook, Second Edition, Vol-II, CRC Press

3. Sreeram Ramakrishna, Biomaterials: A Nano Approach, CRC Press, 2010
4. William Wagner, Biomaterials Science- An Introduction to Materials in Medicine - 4th Edition - 2020

Reference Books

1. Jonathan Black, Biological Performance of materials, Marcel Decker
2. C.P.Sharma & M.Szycher, Blood compatible materials and devices, Tech.Pub.Co. Ltd..
3. Piskin and A S Hoffmann, Polymeric Biomaterials (Eds), Martinus Nijhoff Publishers.
4. Eugene D. Goldbera , Biomedical Ploymers, Akio Nakajima.
5. L. Hench & E. C. Ethridge, Biomaterials - An Interfacial approach.
6. Buddy D.Ratner, Allan S. Hoffman, Biomaterial Sciences – Int. to Materials in Medicine
7. Frederick H. Silver, Biomaterials, Medical devices and Tissue Engineering, Chapman & Hall
8. J B Park, Biomaterials - Science and Engineering, Plenum Press, 1984.

Course Code	Course Title	L	T	P	C
10211BM110	Biomedical Instrumentation	3	0	0	3

a) Course Category

Program core

b) Preamble

To make the student to acquire knowledge on how to record and measure bio signals and to design bio amplifiers.

c) Prerequisite

10211BM102-Analog Digital Integrated Circuits

d) Related Courses

10211BM105 - Bio Sensors and Transducers

e) Course Outcomes

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Compare the different types of electrodes and draw its equivalent circuit.	K2
CO2	Summarize the procedure for recording various biosignals	K2
CO3	Categorize different bioamplifiers and apply them for the measurement of physiological biosignals.	K4
CO4	Classify blood cell counting methods including microscopic, automatic optical, and Coulter counter techniques. Differentiate electrical shock hazards such as microcurrent shock and leakage currents.	K2
CO5	Identify the physiological significance of pH, pCO_2, and pO_2 in clinical diagnostics.	K2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	-	-	-	-	-	-	-	-	-	1	2	-
CO2	3	1		1	-	-	1	-	-	-	-	1	2	-
CO3	2	2	2	1	-	2	1	-	-	-	-	1	2	-

CO4	3	1	-	-	-	-	2	-	-	-	-	1	2	-
CO5	3	-	-	-	-	-	-	-	-	-	-	-	1	-

f) Course content

UNIT I BIO POTENTIAL ELECTRODES 9 Hrs

Origin of bio potential and its propagation. Electrode-electrolyte interface, electrode–skin interface, half cell potential, impedance, polarization effects of electrode – nonpolarizable electrodes. Types of electrodes - surface, needle and micro electrodes and their equivalent circuits. Recording problems - measurement with two electrodes.

UNIT II BIO SIGNAL RECORDING 10 Hrs

ECG: origin, waveforms and their characteristics, Einthoven triangle, lead configurations, electrocardiograph, 12 lead ECG machine circuit, common mode and interference reduction circuits, Vector cardiograph, Recording of EMG, EEG : origin, waveforms and their characteristics, 10-20 electrode placement system, Electro encephalogram, Magneto encephalogram, EOG & ERG: origin, measurement of EOG, electroretinogram, Heart sounds: origin, phonocardiography.

UNIT III BIO AMPLIFIERS 9 Hrs

Need for bio-amplifier - single ended bio-amplifier, differential bio-amplifier – right leg driven ECG amplifier. Band pass filtering, isolation amplifiers – transformer and optical isolation - isolated DC amplifier and AC carrier amplifier. Chopper amplifier. Power line interference.

UNIT IV BIO ANALITICAL EQUIPMENTS AND PATIENT SAFETY 10 Hrs

Blood cell counters –microscopic method, automatic optical, method, coulter counter, automatic recognition and differential counting of cells, flow cytometer, Selective ion electrodes, ion analyzer, Electric shock hazards, micro current shock, leakage currents, Precautions to minimize electric hazards, safety codes for electro medical equipment, electrical safety analyzer.

UNIT V BIO CHEMICAL MEASUREMENTS 7 Hrs

Identify the physiological significance of pH, pCO_2, and pO_2 in clinical diagnostics.

Total:45 Hrs.

g) Learning Resources

Text Books

1. John G. Webster, "Medical Instrumentation Application and Design", Fifth Edition, 2020, John Wiley and sons, New York.
2. Khandpur R.S, "Handbook of Biomedical Instrumentation", Tata McGraw-Hill, New Delhi, 2003.(Units II & IV)

Reference Books

1. Leslie Cromwell, "Biomedical Instrumentation and measurement", Prentice hall of India, New Delhi, 2007.

2. Myer Kutz, “Standard Handbook of Biomedical Engineering and Design”, McGraw Hill Publisher, 2003.
3. Joseph J. Carr and John M. Brown, “Introduction to Biomedical Equipment Technology”, 4th Edition, 2019, Pearson Education.

Course Code	Course Title	L	T	P	C
10211BM111	Diagnostic and Therapeutic Equipments	3	0	0	3

a) Course Category

Program core

b) Preamble

This course deals with the medical devices used for the measurement of biological parameters and the methods of continuous monitoring and treating them

c) Prerequisite

None

d) Related Courses

10211BM110-Biomedical Instrumentation and 10211BM112-Radiological Equipments.

e) Course Outcomes

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Apply the principles of artificial ventilation and pulmonary function measurement to select an appropriate device for clinical scenarios.	K3
CO2	Identify and classify audiological tests including audiograms, pure tone, speech, and evoked response audiometry. Comprehend the working principles and applications of implantable and external cardiac rhythm control devices	K2
CO3	Summarize the concept of diathermy and their application. Identify electrodiagnostic apparatus used for neuromuscular and physiological assessments.	K2
CO4	a) Compare the operating principles of different ultrasound modes used in diagnostic applications. b) Differentiate the various drug delivery systems.	K2
CO5	Summarize the importance of Extra corporeal devices	K2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	-	-	-	2	-	-	-	-	-	-	3	-
CO2	3	2	-	-	-	2	-	-	-	-	-	-	3	-
CO3	3	2	-	-	-	2	-	-	-	-	-	-	3	-
CO4	3	2	-	-	-	2	-	-	1	-	-	-	3	-
CO5	3	2	-	-	-	2	-	-	1	-	-	-	3	-

f) Course content

UNIT I RESPIRATORY MEASUREMENT SYSTEM 8 Hrs

Artificial ventilation, ventilators-types of ventilators, pressure-volume-flow diagrams, modern ventilators , humidifiers, nebulizers and aspirators. Pulmonary function measurements - spirometry, pulmonary function analysers, Anaesthesia- Need for anaesthesia, anaesthesia machine

UNIT II ASSIST DEVICES 11 Hrs

Common tests – audiograms, air conduction, bone conduction, masking techniques, Pure tone, Speech, Evoked response audiometry, Hearing aids – principles, DSP based hearing aids.
Cardiac Pacemaker- Internal and External Pacemaker, Pacemaker Standard Codes, AC and DC Defibrillator ,Cardiotocograph-Methods of Monitoring Foetal Heart Rate, Monitoring Labour Activity, Recording System. Intra-aortic ballon pump.

UNIT III DIATHERMY & STIMULATORS 9 Hrs

Principle of Surgical diathermy-surgical diathermy machine, short wave diathermy, micro wave diathermy, ultrasonic therapy unit, High frequency heat therapy, Electrodiagnostic apparatus, pain relif through electrical stimulation bladder stimulators, cerebellar stimulators. Functional Electrical Stimulation, FES system controlled by EMG signal.

UNIT IV ULTRASONIC TECHNIQUE & DRUG DELIVERY SYSTEMS 8 Hrs

Diagnostic Ultrasound, physics of ultrasonic waves, medical ultrasound, basic pulse-echo apparatus, A- Scan, Echocardiograph (M-Mode), B- Scanner, Biological effects of ultrasound, Real time ultrasonic imaging systems. Infusion Pumps, Components of Drugs Infusion Systems, Implantable Infusion Systems.

UNIT V EXTRA CORPOREAL DEVICES AND SPECIAL DIAGNOSTIC EQUIPMENTS 9 Hrs

Haemodialysis Machines- Function of Kidneys, Artificial Kidney, Dialyzers, Membranes for Haemodialysis, Haemodialysis machine, Portable kidney machines. Lithotriptors- Introduction, First lithotriptor machine, Modern Lithotriptor System. Heart-lung machine, ECMO ,Oxygenator.

Total:45 Hrs.

g) Learning Resources

Text Books

1. R S Khandpur, “Handbook of Bio-Medical Instrumentation”, 3rd Edition, McGraw Hill Education (India) Private Limited, 2014
2. Anthony Y K Chan, “Biomedical Device Technology: Principles and Design”, 2nd Edition, 2016 Charles C Thomas Publisher Ltd.

Reference Books

1. R S Khandpur, “Compendium of Biomedical Instrumentation”, 1st Edition, John Wiley & Sons Ltd, 2020
2. Joseph J. Carr, John M. Brown, “Introduction to Biomedical Equipment Technology”, 4th Edition, 2008
3. Joseph D. Bronzino, Donald R. Peterson, “The Biomedical Engineering- Handbook”, 4th Edition, IEEE Press.

Course Code	Course Title	L	T	P	C
10211BM112	**Radiological Equipments**	**3**	**0**	**0**	**3**

a) Course Category
Program core

b) Preamble
The course gives the basic knowledge on how radiological equipment are used for measuring physiological parameters and what are the safety measures need to be followed

c) Prerequisite
10211BM101 - Anatomy and Human Physiology

d) Related Courses
10211BM105 - Bio Sensors and Transducers

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Identify the fundamental mechanism involve in the generation of X-rays	K2
CO2	Apply principles of sectional imaging and CT reconstruction techniques, use 3D Slicer for CT image visualization, and list safety concerns in computed tomography systems.	K3
CO3	Summarize the underlying principles of NMR and its components.	K2
CO4	Comprehend the application of radionuclides in medical field	K2
CO5	Explain how body heat can be used as a diagnostic tool	K2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	-	-	-	2	1	1	1	-	-	-	3	-
CO2	3	2	-	-	2	2	1	1	1	-	-	-	3	-
CO3	3	2	-	-	2	2	1	1	1	-	-	-	3	-
CO4	3	1	-	-	-	2	1	1	1	-	-	-	3	-
CO5	3	1	-	-	-	2	1	1	1	-	-	-	3	-

f) Course content

UNIT I DIAGNOSTIC X RAYS 9 Hrs

Production of X-Rays – X-ray tubes, Visualization of x-rays – Fluorescent screen, Image intensifiers – construction and working principle. Digital radiography. Harmful X-ray Risks.

UNIT II X-RAY COMPUTED TOMOGRAPHY 9 Hrs

Principles of sectional imaging – scanner configurations, line integrals, projection sets. Image reconstruction techniques – overview of back projection and iteration methods – Exercise Problems. CT image Visualization using 3D slicer tool. Safety Concerns in Computed Tomography.

UNIT III MAGNETIC RESONANCE IMAGING 9 Hrs

Principles of MRI – interaction of nuclei and static magnetic field and radio frequency wave, rotation and precision, induction of magnetic resonance signal, bulk magnetization. Components of MRI – Magnets, magnetic field gradients, RF system, transmit and receive coils, receiver and detection system. Safety Precautions.

UNIT IV NUCLEAR MEDICINE 9 Hrs

Types of radioactive decay, Radiation detectors – gas detectors, Scintillation detectors, Semiconductor detectors. Gamma camera – principle of operation, Radiopharmaceuticals, Principles of PET and SPECT. Health Effects.

UNIT V THERMOGRAPHY 9 Hrs

IR imaging system – pyroelectric imaging system, temperature measurement. Clinical thermography – physiological factors, applications. safety precautions

Total: 45 Hrs.

g) Learning Resources

Text Books

1. M Flower, “Webbs Physics of Medical Imaging (Series in Medical Physics and Biomedical Engineering)”, 2nd Edition, CRC Press, 2012.
2. Khandpur R.S, “Handbook of Biomedical Instrumentation”, 3rd Edition, Tata McGraw-Hill, 2014.
3. Bethe A. Scalettar and James R. Abney, Introductory Biomedical Imaging, CRC Press, 2024.

Reference Books

1. Gopal B. Saha “Physics and Radiobiology of Nuclear Medicine”, 3rd Edition Springer, 2006.
2. B.H.Brown, PV Lawford, R H Small wood , D R Hose, D C Barber, “Medical physics and biomedical Engineering”, - CRC Press, 2017.
3. Myer Kutz, “Standard handbook of Biomedical Engineering and design”, McGraw Hill, 2003.

Online Resources/Links

- https://training.slicer.org/
- https://www.radiologyinfo.org/en/info/safety-mr
- https://vmi.tamu.edu/lab_1.html
- https://www.spellmanhv.com/en/Technical-Resources/Application Notes-X-Ray-Generators/AN-02#Low-kV/High-mA-Emissi
- https://www.hopkinsmedicine.org/health/treatment-tests-and-therapies/computed-tomography-ct-scan
- https://www.brighamandwomens.org/assets/bwh/radiology/pdfs/basic-approach-to-evaluating-a-headct.pdf

Course Code	Course Title	L	T	P	C
10211BM113	Biomaterials Applications	3	0	0	3

a) Course Category

Program core

b) Preamble

Knowledge on different biomaterials is essential for a biomedical engineer in order to make any biomedical products such as implants. This course gives an introductory knowledge about biomaterials, types, and its properties

c) Prerequisite

None

d) Related Courses

10212BM105-Introduction to Nanotechnology

e) Course Outcomes

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Classify the biomaterials based on their properties	K2
CO2	Summarize metallic biomaterials and compare various ceramic biomaterials for utilization in biomedical applications.	K2
CO3	Classify different polymeric biomaterials and describe their composition and function for use in biomedical applications	K2
CO4	Categorized composite materials based on their properties and how to improve the mechanical properties	K2
CO5	Comprehend about different replacement biomaterials and discuss the biomaterial sterilization procedures	K2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	-	-	-	-	-	-	1	1	-	-	3	-

CO2	3	2	-	-	-	-	-	-	1	1	-	-	3	-
CO3	3	2	-	-	-	-	-	-	1	1	-	-	3	-
CO4	3	2	-	-	-	-	-	-	1	1	-	-	3	-
CO5	3	2	-	-	-	-	-	-	1	1	-	-	3	-

f) Course content

Unit 1 Biomaterials – Introduction, Properties and Biocompatibility 10 Hrs

Introduction to Biomaterials, Basic Criteria for Biomaterials, Classification of Biomaterials, Selection and Performance of Biomaterials, Biological Responses - Surface and Physical Properties, Mechanical Properties, Stress-Strain Behaviour & Hardness, Mechanical Failures, Fatigue, Electrical, Optical and Magnetic Properties - Introduction To Biocompatibility, Blood Compatibility and Tissue Compatibility, In vitro and In vivo Testing, and Rejections.

Unit 2 Metallic Biomaterials and Bio-Ceramics 10 Hrs

Metals: Stainless Steels, Cobalt (Co)-Chromium (Cr) Alloys, Titanium (Ti) Alloys, Corrosion of Metallic Implants – Stress and Cracking. Bio-Ceramics: Definition and classification - Non-absorbable Ceramics: Alumina, Carbons, Zirconia. Biodegradable Ceramics: Calcium phosphate. Bioactive ceramics: Glass ceramics and Hydroxyapatite. Biomedical applications.

Unit 3 Polymeric Biomaterials 9 Hrs

Polymerization and basic structure, Polymeric biomaterials: Polyolefin (Polyethylene (PE), Polypropylene (PP)), polyamides (Nylon), acrylic polymers (Polymethylmetacrylate (PMMA)), fluorocarbon polymers (Polytetrafluoroethylene (PTFE)), Silicone Rubber, Hydrogels, Biodegradable Polymers - Classification according to Thermosets, Thermoplastics (Polyetherether ketone (PEEK)) and Elastomers. Natural bio-polymers: Collagen, Elastin and chitin. Biomedical Applications.

Unit 4 Composite Materials 7 Hrs

Properties and Types of Composites - Mechanics of Improvement of properties by incorporating different elements - Composite Theory of Fibre reinforcement (short and long fibres, fibres pull out) - Polymers Filled with Osteogenic Fillers (e.g. Hydroxyapatite). Biomedical applications.

Unit 5 Replacement Biomaterials & Sterilization in Biomaterials 9 Hrs

Hard Tissue Replacement Materials: Orthopaedic Implants and Dental Implants. Soft Tissue Replacement Materials: Percutaneous and Skin Implants, Vascular Implants, and Heart Valve Implants. Sterilization procedures: ETO, gamma radiation, autoclaving, Effects of sterilization on material properties.

Total: 45 Hrs

g) Learning Resources

Test Books

1. Sujata V. Bhat, Biomaterials, Narosa Publishing House, 2005.
2. Bronzino JD, ed. The Biomedical Engineering Handbook, Second Edition, Vol-II, CRC Press
3. Sreeram Ramakrishna, Biomaterials: A Nano Approach, CRC Press, 2010
4. William Wagner, Biomaterials Science- An Introduction to Materials in Medicine - 4th Edition - 2020

Reference Books

1. Jonathan Black, Biological Performance of materials, Marcel Decker
2. C.P.Sharma & M.Szycher, Blood compatible materials and devices, Tech.Pub.Co. Ltd..
3. Piskin and A S Hoffmann, Polymeric Biomaterials (Eds), Martinus Nijhoff Publishers.
4. Eugene D. Goldbera , Biomedical Ploymers, Akio Nakajima.
5. L. Hench & E. C. Ethridge, Biomaterials - An Interfacial approach.
6. Buddy D.Ratner, Allan S. Hoffman, Biomaterial Sciences – Int. to Materials in Medicine
7. Frederick H. Silver, Biomaterials, Medical devices and Tissue Engineering, Chapman & Hall
8. J B Park, Biomaterials - Science and Engineering, Plenum Press, 1984.

Course Code	Course Title	L	T	P	C
10211BM114	Engineering Mechanics and its Applications	2	1	0	3

a) Course Category

Program core

b) Preamble

This course provides an introduction to the basic concepts of forces, inertias, centroids, and moments of area and techniques of finding their effects on motion. It introduces the phenomenon of friction and its effects. It introduces students to cognitive learning in applied mechanics and develops problem-solving skills in both theoretical and engineering oriented problems.

c) Pre-Requisite

10210MA203-Vector Calculus & Complex variable

d) Related Courses

None

e) Course Outcomes

Upon the successful completion of the course, learners will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Solve engineering problems using the principles of statics of particles	K2
CO2	Derive the magnitude of forces and moments acting on rigid bodies	K2
CO3	Determine the sectional properties of standard geometries	K3
CO4	Solve engineering problems on basics of fluid mechanics and relate it to bio-fluids.	K3
CO5	Summarize the principles of dynamics of particles and various types of friction.	K2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	3	-	-	-	-	-	-	-	-	-	1	-
CO2	3	1	3	-	-	-	-	-	-	-	-	-	1	-

CO3	3	1	3	-	-	-	-	-	-	-	-	-	1	-
CO4	3	1	3	-	-	-	-	-	-	-	-	-	1	-
CO5	3	1	3	-	-	-	-	-	-	-	-	-	1	-

f) Course Content

UNIT I BASICS AND STATICS OF PARTICLES **9 Hrs**

Introduction – Units and Dimensions – Laws of Mechanics – Vectors – Vectorial representation of forces and couples – Vector operations: additions, subtraction, dot product, cross product– Resolution and Composition of forces – Equilibrium of a particle – Lami's theorem – Principle of transmissibility – Equivalent systems of forces and simple problems.

UNIT II EQUILIBRIUM OF RIGID BODIES **9 Hrs**

Free body diagram – Types of supports and their reactions – requirements of stable equilibrium – Moments and Couples – Moment of a force and simple problems– Scalar components of a moment – Varignon's theorem.

UNIT III CENTRE OF GRAVITY AND MOMENT OF INERTIA **9 Hrs**

Centroid- Methods of determining the centroid- Centroid of symmetrical sections- Centroid of unsymmetrical sections – Moment of Inertia- Moment of inertia of plane area– Parallel axis theorem- Perpendicular axis theorem.

UNIT IV BASICS OF MECHANICS OF FLUIDS **9 Hrs**

Fluids – density – pressure – blood pressure and gravity – buoyancy –Newton's laws of viscosity – Definitions and simple problems on Newtonian fluid, Non-Newtonian fluid.

UNIT V DYNAMICS OF PRACTICLES & FRICTION **9 Hrs**

Frictional force – Laws of Coulomb friction – simple contact friction – Belt friction – Roller friction.

Total: 45 Hrs

g) Learning Resources

Text Books

1. R.S.Khurmi, A Text Book of Engineering Mechanics, S Chand and Company (P) Ltd., New Delhi. Revised Edition, 2019.
2. S.Timoshenko, D.H.Young, J.V.Rao, Sukumar Pati, Engineering Mechanics, McGraw Hill Education (India) Private Limited., 2018.
3. Dr. R. K. Bansal, A Text Book of Fluid Mechanics, Laxmi Publications (P) Ltd., New Delhi. 2018.
4. Kumar, K. L., Engineering Mechanics, Tata McGraw- Hill, New Delhi, 2019.

Reference Books

1. Palanichamy, M. S., and Nagan, S., Engineering Mechanics (Statics and Dynamics), Tata McGraw Hill, New Delhi 2012.
2. Shames, I. H., and Krishna Mohana Rao, G., Engineering Mechanics (Statics and Dynamics), Dorling Kindersley India) Pvt. Ltd. (Pearson Education), 2019.
3. Beer, F. P., and Johnston, E. R., Vector Mechanics for Engineers – Dynamics and Statics, Tata McGraw-Hill, New Delhi, 2011.
4. Natarajan, K.V., Engineering Mechanics, Dhanalakshmi Publishers, 2011.
5. Lee Waite, ―Bio fluid Mechanics in Cardiovascular Systems‖, The McGraw-Hill Companies, 2016.

Course Code	Course Title	L	T	P	C
10211BM201	Pathology and Microbiology	2	0	2	3

a) Course Category

Program core/Integrated

b) Preamble

To make the student to acquire knowledge on the structural and functional aspects of living organisms and to know the etiology and remedy in treating the pathological diseases

c) Prerequisite

10210BM101-Biology for Engineers

d) Related Courses

10211BM101 - Anatomy and Human Physiology.

e) Course Outcomes

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Relate pathological processes to structural and functional alterations in cells and tissues.	K2
CO2	Classify hematological disorders, including bleeding disorders and leukemias, based on their pathological features.	K2
CO3	Apply different staining techniques to observe microorganisms	K3
CO4	Summarize the growth cycle of microorganisms	K2
CO5	Comprehend basic immunological concepts, immune responses, immunological techniques, and infectious diseases.	K2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	1	-	-	-	-	-	-	-	-	-	-	1	-
CO2	2	1	-	-	-	-	-	-	-	-	-	-	-	-

CO3	2	1	-	-	-	-	1	2	2	-	-	-	2	-
CO4	2	1	-	-	-	-	1	2	2	-	-	-	2	-
CO5	2	1	-	-	-	-	-	-	-	-	-	-	2	-

f) Course content

UNIT I CELL DEGENERATION, REPAIR AND NEOPLASIA 6 Hrs

Cell injury and Necrosis, Apoptosis, Pathological calcification, cellular adaptations of growth and differentiation, Inflammation and fracture healing, Neoplasia, Classification, Benign and Malignant tumours, carcinogenesis, spread of tumours. Autopsy and biopsy.

UNIT II FLUID AND HEMODYNAMIC DERRANGEMENT 6 Hrs

Edema, normal hemostasis, thrombosis, disseminated intravascular coagulation, embolism, infarction, shock. Hematological disorders-Bleeding disorders, Leukaemias

UNIT III MICROSCOPES 6 Hrs

Light microscope – bright field, dark field, phase contrast, fluorescence, Electron microscope (TEM & SEM). Preparation of samples for electron microscope. Staining methods – simple, gram staining and AFB staining.

UNIT IV MICROBIAL CULTURES 6 Hrs

Morphological features and structural organization of bacteria, growth curve, identification of bacteria, culture media and its types , culture techniques and observation of culture.

UNIT V IMMUNOLOGY 6 Hrs

Natural and artificial immunity, opsonization, phagocytosis, Immune deficiency syndrome, antibodies and its types, immunological techniques: immune diffusion, immuno electrophoresis, RIA and ELISA, monoclonal antibodies. Disease caused by bacteria, fungi, protozoa, virus and helminthes.

LIST OF EXPERIMENTS:

1. Urine physical and chemical examination (protein, reducing substances, ketones, bilirubin and blood)
2. Basic staining – Hematoxylin and eosin staining.
3. Special stains – cresyl fast Blue (CFV)- Trichrome – oil red O – PAS.
4. Simple stain.
5. Gram stain.
6. Bleeding time and clotting time.
7. Slides of malarial parasites, micro filaria and leishmania donovani.
8. Haematology slides of anemia and leukemia.

Total: 60 Hrs.

g)

h) Learning Resources

Text Books

1. Ramzi S Cotran, Vinay Kumar & Stanley L Robbins, “Pathologic Basis of Diseases”, 7th edition, WB Saunders Co. 2005 (Units I & II).
2. Prescott, Harley and Klein, “Microbiology”, 5th edition, McGraw Hill, 2002 (Units III,IV & V).

Reference Books

1. Underwood JCE: General and Systematic Pathology Churchill Livingstone, 3rd edition, 2000.
2. Anthanarayanan & Panicker, “Microbiology” Orientblackswan, 2005.
3. Dubey RC and Maheswari DK. “A Text Book of Microbiology” Chand & Company Ltd, 2007

Course Code	Course Title	L	T	P	C
10211BM202	Artificial Neural Networks	3	0	2	4

a) Course Category

Program core/Integrated

b) Preamble

This course gives an introduction to classification using neural networks which is used in most biomedical applications.

c) Prerequisite

None

d) Related Courses

10211BM204 - Image processing, 10211BM108 – Digital Signal processing

e) Course Outcomes

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Represent the given data in a neural network structure, and achieve the target by manual weight and bias updation	K2
CO2	Compare different learning processes and rules used in neural networks	K2
CO3	Solve the Neural Nets for Pattern Classification.	K3
CO4	Apply back propagation in neural network to train a network for a given target.	K3
CO5	Compare different networks and illustrate the biomedical applications of Neural Networks.	K3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	-	-	2	-	1	2	-	-	-	1	-	2
CO2	3	1	-	-	2	-	1	2	-	-	-	1	-	2
CO3	3	1	-	-	2	-	1	2	-	-	-	1	-	2

CO4	3	1	-	-	2	-	1	2	-	-	-	1	-	2
CO5	3	1	-	-	2	-	1	2	-	1	-	1	-	2

f) Course content

UNIT I MODELS, FEEDBACKS AND ARCHITECTURE 9 Hrs

Introduction to neural network-brain, benefits of neural net, Elementary Neurophysiology and Model of neuron, neural networks as directed graphs, Network architecture – Single layer feed forward, multi-layer feed forward. Common activation functions, McCulloch Pitts neuron with examples – Logic gates.

UNIT II LEARNING PROCESS AND COMPETITIVE NEURAL NETWORK 9 Hrs

Basic learning rules – Introduction, Error correction – delta rule, memory based, Hebbian – supervised and unsupervised rule, Competitive Neural Network-Kohonen Self organizing map, Learning Vector Quantisation

UNIT III SIMPLE NEURAL NETS FOR PATTERN CLASSIFICATION 9 Hrs

Adaptive filtering problem, Perceptron-Architecture, Algorithm, Application ,Perceptron Convergence Theorem, Adaline- Architecture, Algorithm, Applications, Madaline

UNIT IV BACK PROPOGATION NETWORK AND ASSOCIATIVE MEMORY 9 Hrs

Back propagation Network, generalized delta rule, Bidirectional Associative memory, Hopfield Network

UNIT V OTHER NETWORKS AND APPLICATIONS 9 Hrs

Radial basis function network, K-means clustering, Adaptive Resonant Theory (ART), Counter Propagation network, Applications of ANN in biomedical signal analysis and medical image analysis

45 Hrs.

LIST OF EXPERIMENTS 30 Hrs.

1. Study of important functions of Python
2. Generation of Activation Functions
3. Mu-Culloch Pitts Neuron Simulation
4. Implementation of Logic gates using Hebb Learning rule
5. Training a network using Perceptron Learning rule.
6. Implementation of Gradient Descent algorithm
7. Implementation of ADALINE
8. Adaptive noise filtration using LMS algorithm
9. Backpropagation
10. K – means clustering

Total: 75 Hrs.

g) Learning Resources

Text Books

1. S. N. Sivanandam, M. Paulraj, "Introduction to Artificial Neural Networks", 1st Edition, Vikas Publishing House, 2018.
2. Alma Y. Alanis, Nancy Arana-Daniel, Carlos López-Franco, "Artificial Neural Networks for Engineering Applications", 1st Edition, Academic Press (Elsevier), 2019.
3. Stuart J. Russell, Peter Norvig, "Artificial Intelligence: A Modern Approach" 4th Edition, Prentice Hall, 2020.

Reference Books

1. Melanie Mitchell, "Artificial Intelligence: A Guide for Thinking Humans", 1st Edition, Farrar, Straus and Giroux, 2019.
2. Igor V. Tetko, Věra Kůrková, Pavel Karpov, "Artificial Neural Networks and Machine Learning – ICANN 2019: Theoretical Neural Computation", 1st Edition, Springer, 2019.

Web sources/videos:

1. https://in.mathworks.com/
2. https://towardsdatascience.com/
3. https://becominghuman.ai/

Course Code	Course Title	L	T	P	C
10211BM203	Biomechanics	2	0	2	3

a) Course Category

Program core/Integrated

b) Preamble

This course provides an introduction to the basic concepts of mechanics of physiological systems, laws of fluid dynamics that are applicable in human body and use of mechanics in medicine. To discover and also predict the mechanics of human bones, joints, orthopedic and cardiovascular implants.

c) Prerequisite

10211BM114- Engineering Mechanics and its Application

d) Related Courses

None

e) Course Outcomes

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Illustrate the importance of biomechanics in medicine	K2
CO2	Apply the laws of fluid dynamic in biological fluid and mechanics of the skeletal system	K3
CO3	Summarize the Muscular consideration for movement	K2
CO4	Comprehend the functional anatomy for lower and upper Extermity	K2
CO5	Demonstrate the models specific to orthopedic applications.	K3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	1	-	-	-	1	-	-	-	-	-	-	-	-
CO2	3	3	-	-	1	-	-	1	1	-	1	-	-	-
CO3	3	2	-	-	-	-	-	1	1	-	1	-	-	-
CO4	3	3	-	-	-	-	-	1	1	-	1	-	1	-
CO5	3	3	1	-	1	2	-	1	1	-	1	-	2	-

f) Course content

UNIT I INTRODUCTION TO BIO MECHANICS 6 Hrs

Biomechanics - Scope of mechanics in medicine - Mechanics of bone structure, Anatomy vs Functional Anatomy - Mechanical loads of the human body - Effects of loading - Movement Description - Basic movements: Specialized movement descriptors, Anatomical movements - Planes and axes

UNIT II BIOMECHANICS OF CIRCULATION AND SKELETAL SYSTEM 6 Hrs

Mechanics of Circulation : Dynamics of circulatory system - Dynamics of fluid flow in cardiovascular system - Rheology of blood and micro vessels

Mechanics of physiological system: Biomechanical characteristics of Bone - Bone modeling and remodeling - strength and stiffness of bone - Biomechanics of joints, Mechanical properties of Joints, Biomechanics of cartilage - Mechanical properties and failure of cartilage

UNIT III MUSCULAR CONSIDERATION FOR MOVEMENT 6 Hrs

Structure of an individual muscle fiber - Types of muscle; Force generation in the muscle - Motor unit, muscle Contraction - Mechanical Model of muscle - The musculo tendinous unit, skeletal muscles servo mechanism, Viscoelastic response of the tendon, Muscle injuries and prevention of injury to muscles.

UNIT IV FUNCTIONAL ANATOMY FOR LOWER AND UPPER EXTERMITY 6 Hrs

Lower Extermity: Structure of Hip joints - Muscular action of Hip - Loads on the Hip - Structure of Knee Joint - Combined movements of Ankle and foot

Upper Extermity: Shoulder complex- The elbow and radioulnar joints - The wrist and fingers, Movement Characteristics of the Elbow, Loads on the elbow, common injuries of upper Extermity

UNIT V BIOMECHANICS APPLICATIONS 6 Hrs

Dynamics and analysis of human locomotion - Gait analysis (determination of instantaneous joint reaction analysis), occupant response to vehicular vibration. Mechanics of knee joint during standing and walking

30 Hrs

LIST OF EXPERIMENTS 30 Hrs.

1. Determine the muscle strain by using dynamometer.
2. To study of neurological functions by using pinchmeter.
3. To measure the ground reaction forces generated by a body standing on, walking or moving across them by using force plates.
4. Determination of muscle elasticity using myometer.
5. Strength determination of using hand load cells.
6. Analysis the posture of feet in static and moving as well as behaviour of knees, hips and joints.

Total: 60 Hrs.

g) Learning Resources

1. Joseph-Hamill-Biomechanical-"Basis of Human-Movement" 2018, 4th Edition, Joseph Hamill, Kathleen M. Knutzen, Timothy R. Derrick
2. Duane Knudson - Fundamentals Of Biomechanics.-Springer (2020)
3. Susan J.Hall, "Basics Bio Mechanics" 2014, 5th Edition, McGraw-Hill Publishing Co, USA.
4. Joseph D.Bronzino, "Biomedical Engineering Fundamentals", Taylor& Francis, 2006.
5. Peter M. McGinnis, "Biomechanics of sports and exercise", Human kinetics, 3rd Edition, 2013.

Course Code	Course Title	L	T	P	C
10211BM204	Image Processing	3	0	2	4

a) Course Category

Program core/Integrated

b) Preamble

To make the student to acquire knowledge on how images are processed digitally

c) Prerequisite

10211BM108 - Digital Signal Processing

d) Related Courses

10211BM112 - Radiological Equipments, 10211BM108 - Digital signal processing.

e) Course Outcomes

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Infer how an image is acquired and how pixels are related with each other	K2
CO2	Explain how image enhancement is done both in Spatial and frequency domains	K2
CO3	Compare the different noise models applicable to image processing and discuss the various restoration methods and segmentation techniques.	K2
CO4	Compare and explain the theory behind lossy and lossless image coding techniques under predictive and transform coding techniques	K2
CO5	Classify different methods used for image representation and description	K2
CO6	Apply image processing techniques to analyze and enhance digital images effectively.	K3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	-	-	-	-	-	-	-	-	-	-	-	1
CO2	3	1	-	-	-	-	-	-	-	-	-	-	-	1
CO3	3	1	-	1	-	-	-	-	-	-	-	-	-	1
CO4	3	1	-	1	-	-	-	-	-	-	-	-	-	1
CO5	3	1	-	1	-	-	-	-	-	-	-	-	-	1
CO6	1	1	3	-	2	-	1	2	3	3	1	-	-	1

f) Course content

UNIT I FUNDAMENTALS OF DIGITAL IMAGING 9 Hrs

Introduction – Origin – Steps in Digital Image Processing – Components – Elements of Visual Perception – Image Sensing and Acquisition – Image Sampling and Quantization – Relationships between pixels – overview of mathematical tools.

UNIT II IMAGE ENHANCEMENT 9 Hrs

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..

UNIT III IMAGE RESTORATION AND IMAGE SEGMENTATION 9 Hrs

Noise models – Mean Filters – Order Statistics – Adaptive filters – Band reject Filters – Band pass Filters – Notch Filters – Optimum Notch Filtering – Inverse Filtering – Wiener filtering

Segmentation: Point detection – Line detection – Edge models and edge detection – Edge Linking and Boundary detection.

UNIT IV WAVELETS AND IMAGE COMPRESSION 9 Hrs

Wavelets – Subband coding - Multiresolution expansions.

Compression: Fundamentals – Image Compression models – Bit-Plane Coding – Lossless Predictive Coding – Lossy Compression – Lossy Predictive Coding – Compression Standards – JPEG, JPEG 2000

UNIT V IMAGE REPRESENTATION AND RECOGNITION 9 Hrs

Boundary representation – Chain Code – Polygonal approximation, signature, boundary segments. Boundary description – Shape number – Fourier Descriptor, moments- Regional Descriptors – Topological feature, Texture - Patterns and Pattern classes - Recognition based on matching.

45 Hrs

LIST OF EXPERIMENTS: **30 Hrs**

1. Conversion between color spaces.
2. Histogram Equalization.
3. Filtering Technique.
4. Edge detection using Operators.
5. Wavelet Decomposition.
6. Image Compression.
7. Image Segmentation
8. Mini Project (Any Application).

Total: 75 Hrs

g) Learning Resources

Text Books

1. Rafael C. Gonzales, Richard E. Woods, "Digital Image Processing", Third Edition, Pearson Education, 2018, Fourth Edition.
2. Anil Jain K. "Fundamentals of Digital Image Processing", PHI Learning Pvt. Ltd., 2015, First Edition
3. Fundamentals of Digital Image Processing: Roger L. Easton, Jr. 22 November 2010

Reference Books

1. Willliam K Pratt, "Digital Image Processing", John Willey, 2007, Fourth Edition
2. Malay K. Pakhira, "Digital Image Processing and Pattern Recognition", PHI Learning Pvt. Ltd., 2014.

Course Code	Course Title	L	T	P	C
10211BM301	Biochemistry and Physiology Laboratory	0	0	2	1

a) Course Category

Program Core/ Laboratory

b) Preamble

Biomedical engineering deals with human physiological parameters. This course gives a hands on for understanding and quantifying the physiological parameters

c) Prerequisite

None

d) Related Courses

10210CH102 - Bio-Chemistry / 10211BM101 - Anatomy and Human Physiology

e) Course Outcomes

Upon successful completion of the course, students will be able to

CO. Nos	Course outcome	Skill Level (Dave'sTaxonomy)
1	Measure physiological parameters to make a primary assessment of the subject	S2
2	Analyze a given sample	S2
3	Quantify the macromolecules present in a sample	S3
4	Demonstrate dissection to show important anatomical parts	S1

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	-	2	-	-	-	3	2	-	2	-	2	-
CO2	3	2	-	2	-	-	-	3	2	-	2	-	1	-
CO3	3	2	-	2	-	-	-	1	2	-	2	-	1	-
CO4	3	-	-	3	1	-	-	1	-	-	2	-	-	-

LIST OF EXPERIMENTS

1. Blood Pressure Measurement
2. Hearing loss test
3. Blood grouping test
4. Study of Histological slides
5. Qualitative Tests For Carbohydrates
6. Quantitative Tests For Carbohydrates
7. Quantitative analysis of protein.
8. Separation of amino acids
9. Body Organization – a) cavities and organs, b) skeleton.
10. Virtual dissection of arteries and vein
11. Virtual dissection to locate joints
12. Visual tests and eye anatomy.

Total: 30 Hrs.

Course Code	Course Title	L	T	P	C
10211BM302	**Analog and Digital Integrated Circuits Laboratory**	**0**	**0**	**2**	**1**

a) Course Category

Program Core/ Laboratory

b) Preamble

Biomedical engineering deals with the designing of medical devices. This course gives a hands-on for designing the amplifier and digital circuits for medical devices

c) Prerequisite

None

d) Related Courses

10211BM105 - Bio Sensors and Transducers, 10211BM103 – Electric Circuit Theory, 10211BM102 - Analog and Digital Integrated Circuits

e) Course Outcomes

Upon successful completion of the course, students will be able to

CO. Nos	Course outcome	Skill Level (Dave'sTaxonomy)
1	Design and demonstrate the basic amplifier circuit	S3
2	Design and demonstrate the application of OP amp	S3
3	Design and demonstrate the working of multivibrator	S3
4	Design and demonstrate the combinational circuits using gates	S3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	1	-	1	2	-	-	-	-	-	-
CO2	3	-	-	-	1	-	1	2	-	-	-	1	-	-
CO3	3	-	-	-	1	-	1	2	-	-	-	1	-	-
CO4	3	-	-	-	1	-	1	2	-	-	-	-	-	-

LIST OF EXPERIMENTS

1. Design a differential amplifier using IC 741.
2. Design a Non-Inverting and Inverting Amplifiers using op-amp.
3. Design an Integrator and Differentiator using op-amp.
4. Design a RC oscillator for a desired frequency using op-amp.
5. Astable Multivibrators using IC 555 Timer.
6. Design a Schmitt Trigger using op-amp IC 741.
7. Study of Logic Gates
8. Design and implementation of combinational circuits using basic gates and universal gates for arbitrary functions.
9. Design and implementation of Code converters.
10. Design and implementation of multiplexers and Demultiplexers.

Total: 30 Hrs.

Course Code	Course Title	L	T	P	C
10211BM303	Sensors and Transducers Laboratory	0	0	2	1

a) Course Category

Program Core/ Laboratory

b) Preamble

This course gives hands-on experience in working with sensors

c) Prerequisite

10210EE202-Basic Electrical & Instrumentation Engineering

d) Related Course

10211BM105 - Bio Sensors and Transducers, 10211BM110 - Biomedical Instrumentation and 10211BM111 - Diagnostics and Therapeutic Equipments

e) Course Outcomes

Upon successful completion of the course, students will be able to

CO.Nos	Course outcome	Skill Level (Dave's Taxonomy)
1	Apply measurement techniques using sensors and transducers to quantify electrical, mechanical, thermal, and biomedical parameters.	S2
2	Analyze and interpret experimental data to evaluate the characteristics and performance of various measurement systems and sensors.	S3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	-	1	2	2	1	-	-	1	-
CO2	3	2	-	-	-	-	1	2	2	1	-	-	1	-

LIST OF EXPERIMENTS

1. Measurement of Resistance by Bridge
2. Measurement of Capacitance and Inductance
3. Measurement of Pressure Using Bridge and Piezo-Resistivity

4. Measurement of Differential Pressure
5. Displacement Measurement and Piezo-Electric Measurement
6. Measurement of Flow Using Orifice
7. Measurement of Static Characteristics of RTD Sensor
8. Measurement of Characteristics of Thermistor
9. Measurement of Characteristics of Strain Gauge
10. Measurement of Distance using Ultrasound, and Speed using Hall Effect sensor
11. Study of the Working Principle of Photodiodes and Light Dependent Resistor
12. Respiration Rate Measurement

Total: 30 Hrs.

Additional Experiments for Advanced Learners:

- Build a pressure monitoring system and measure the pressure in a tube using MPS20N0040D module and Arduino UNO Board
- Acquire ECG signal by using AD8232 heart rate monitor kit and Arduino UNO Board
- Monitor pulse using pulse sensor module SEN-11574 and Arduino UNO Boa

Course Code	Course Title	L	T	P	C
10211BM304	**Microcontrollers and DSP Processor Laboratory**	**0**	**0**	**2**	**1**

a) Course Category

Program Core/ Laboratory

b) Preamble

Biomedical engineering deals with microprocessors and microcontroller for designing medical devices. This course gives hands-on for programing microprocessors and microcontrollers.

c) Prerequisite

10211BM102 - Analog and Digital Integrated Circuits

d) Related Courses

10211BM108 - Digital Signal Processing

e) Course Outcomes

Upon successful completion of the course, students will be able to

CO.Nos	Course outcome	Skill Level (Dave's Taxonomy)
1	Write assembly language programs for 8085 addressing modes and arithmetic logic operations.	S2
2	Develop embedded C program to configure and control GPIO ports for digital I/O in MSP430	S2
3	Design and demonstrate sensor interfacing with MSP430 microcontrollers.	S3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	3	-	1	2	2	1	-	-	-	1
CO2	3	-	-	-	3	-	1	2	2	1	-	3	2	1
CO3	3	-	3	-	3	-	1	2	2	1	-	3	1	1

LIST OF EXPERIMENTS

1. Demonstration of addressing modes of 8085.
2. Addition of two 8 bit and 16-bit number using 8085 Microprocessor.
3. Multiplication and Division of 8-bit number using 8085.
4. Interface push button switch and flash LED's with MSP430 Microcontroller.
5. GPIO Interrupts programming with MSP430 Microcontroller.
6. Configure watchdog timer in watchdog mode & interval mode.
7. Read body temperature using MSP430 with the help of inbuilt ADC.
8. Use analog comparator to compare the signal threshold level.
9. Serial Communication between MSP430 Launchpad and PC.
10. Master slave communication between MSPs using SPI protocol.

Total: 30 Hrs.

Course Code	Course Title	L	T	P	C
10211BM305	Digital Signal Processing Laboratory	0	0	2	1

a) Course Category

Program Core/ Laboratory

b) Preamble

Biomedical Engineering deals with signals from human body which has to be processed to get useful output. Current technology processes everything in digital. This course provides basic knowledge on preprocessing algorithms like filtering and processors which are used to implement the same

c) Prerequisite

None

d) Related Courses

10211BM107 - Microcontroller and Digital Signal Processor, 10211BM204 - Image Processing

e) Course Outcomes

Upon successful completion of the course, students will be able to

CO. Nos	Course outcome	Skill Level (Dave'sTaxonomy)
1	Generate and perform different operations on discrete signal	S2
2	Design and Analyze filters for biosignals	S3
3	Implement FIR filters using C6713	S3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	2	-	1	2	1	1	-	-	-	-
CO2	3	2	1	-	2	-	1	2	1	1	1	2	-	1
CO3	3	2	1	-	2	-	1	2	1	1	1	2	-	1

LIST OF EXPERIMENTS

1. Waveform Generation
2. Basic operation on DT signal
3. Demonstration of sampling and aliasing
4. Design of EEG signal selection using low pass, high pass, and band pass filter
5. Demonstration of FIR Filter
6. Creating Project Using Ccstudio TMS320C6748 Board
7. Audio Loop back using TMS320C6748
8. FIR filter implement using TMS320C6748
9. Sine Wave generation using TMS320C6748

Total: 30 Hrs.

Course Code	Course Title	L	T	P	C
10211BM306	Biomedical Instrumentation Laboratory	0	0	2	1

a) Course Category

Program Core/ Laboratory

b) Preamble

Biomedical engineering deals with human physiological signals like ECG, EEG etc. This course gives a hands on for recording and measuring such waveforms for the diagnosis.

c) Prerequisite

10211BM302 - Analog and Digital Integrated Circuits Laboratory

d) Related Courses

10211BM110 - Biomedical Instrumentation.

e) Course Outcomes

Upon successful completion of the course, students will be able to

CO. Nos	Course outcome	Skill Level (Dave'sTaxonomy)
1	Record and Measure the bio signals from various regions of the body	S2
2	Design preamplifiers circuit for measuring the bio signals	S3
3	Measure non electrical parameters of the body.	S2
4	Demonstrate biofeedback system with EEG	S3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	-	-	-	1	1	2	1	1	-	1	3	-
CO2	3	1	-	-	-	1	1	2	1	1	-	1	3	-
CO3	3	-	-	-	-	1	1	2	1	1	-	1	3	-
CO4	3	-	-	-	-	1	1	2	1	1	-	1	3	-

LIST OF EXPERIMENTS

1. Measurement of blood pressure
2. Design and testing of preamplifiers for various biomedical instruments
3. Development of ECG amplifiers and filters
4. Recording of ECG signal.
5. Measurement of respiratory parameters using spirometer
6. Recording of EMG-Signal
7. Recording of EEG-Signal.
8. Recording EEG with stimulus.
9. Heart sound measurement using PCG
10. Galvanic skin resistance (GSR) measurement

Total: 30 Hrs.

Course Code	Course Title	L	T	P	C
10211BM307	Diagnostic and Therapeutic Equipments Laboratory	0	0	2	1

a) Course Category

Program Core/ Laboratory

b) Preamble

- To demonstrate recording and analysis of different Bio potentials
- To examine different therapeutic modalities.

c) Prerequisite

10211BM102 - Analog and Digital Integrated Circuits

d) Related Courses

10211BM110 - Biomedical Instrumentation, 10211BM111 - Diagnostic & Therapeutic Equipments

e) Course Outcomes

Upon successful completion of the course, students will be able to

CO. Nos	Course outcome	Skill Level (Dave'sTaxonomy)
1	Measure and interpret various physiological signals	S2
2	Demonstrate the ability to measure and analyze various physiological signals (ECG, EEG, EMG, and audiogram)	S2
3	Comprehend the working principles and clinical applications of medical devices, including electrosurgical units (ESU), infusion pumps, syringe pumps, and ultrasonic blood flowmeters.	S2
4	Interpret the waveforms generated by artificial pacemakers and medical stimulators under various physiological conditions.	S2

5	Design and develop basic biomedical devices	S3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	-	2	1	3	2	-	-	-	3	-
CO2	3	2	1	1	-	2	1	3	2	-	-	-	3	-
CO3	3	2	1	1	-	2	1	3	2	-	-	-	3	-
CO4	3	2	1	1	-	2	1	3	2	-	-	-	3	-
CO5	3	2	2	1	-	2	1	3	2	2	-	-	3	-

LIST OF EXPERIMENTS

1. Measurement of various physiological signals using biotelemetry
2. Study of medical stimulator
3. Analyse the working of ESU–cutting and coagulation modes
4. Recording of Audiogram
5. Analysis of ECG, EEG and EMG signals using the simulator
6. ECG heart rate alarm using patient monitoring.
7. Demonstration of Ultrasonic blood flowmeter.
8. Study of artificial pacemaker with various arrhythmia
9. Designing of Humidifier/Hearing Aid/Ultrasound Sensor/Pressure Sensor/Pulse Sensor/ Functional Electrical Stimulator
10. Study of Ultrasound machine
11. Demonstration of the working principle of infusion and syringe pump

Total: 30 Hrs.

Course Code	Course Title	L	T	P	C
10212BM101	Hospital Management	3	0	0	3

a) Course Category

Programme Elective

b) Preamble

This course covers the conceptual and technical knowledge required to administer a hospital

c) Prerequisite

None

d) Related Courses

None

e) Course Outcomes

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Discuss the factors which differentiates the hospital administration from Industrial administration Comprehend and appreciate the significance and role of this course in the present contemporary world	K2
CO2	Explain how Human resource management is done in hospital environment Summarize the principles, practices and areas of application in Hospital Management	K2
CO3	Apply various business strategies and behavioral models in hospital management	K3
CO4	Discuss the role of different information systems and services in hospital environment	K2
CO5	Apply the relevant quantity standards and accreditation framework to ensure compliance in medical and laboratory practices	K3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	-	-	-	-	2	-	-	-	-	1	-	3	-
CO2	2	-	-	-	-	-	-	-	-	-	-	-	3	-
CO3	2	-	-	-	-	-	-	-	-	-	2	-	3	-
CO4	1	-	-	-	-	2	-	-	-	-	2	-	3	-
CO5	1	-	-	-	-	3	-	-	-	-	3	-	3	-

f) Course content

UNIT-I OVERVIEW OF HOSPITAL ADMINISTRATION 7 Hrs

Distinction between Hospital and Industry, Challenges in Hospital Administration –Hospital Planning – Equipment Planning – Functional Planning - Current Issues in Hospital Management - Telemedicine - Bio-Medical Waste Management

UNIT-II HUMAN RESOURCE MANAGEMENT ON HOSPITAL 9 Hrs

Principles of HRM – Functions of HRM – Profile of HRD Manager – Tools of HRD –Human Resource Inventory – Manpower Planning. Different Departments of Hospital, Recruitment, Selection, Training Guidelines –Methods of Training – Evaluation of Training – Leadership grooming and Training, Promotion – Transfer.

UNIT-III MARKETING RESEARCH & CONSUMER BEHAVIOUR 10 Hrs

Marketing information systems - assessing information needs, developing & disseminating information - Market Research process - Other market research considerations - Consumer Markets & Consumer Buyer Behaviour - Model of consumer behaviour - Types of buying decision behaviour - The buyer decision process - Model of business buyer behaviour - Major types of buying situations - global marketing in the medical sector.

UNIT-IV HOSPITAL INFORMATION SYSTEMS & SUPPORTIVE SERVICES 10 Hrs

Management Decisions and Related Information Requirement - Clinical Information Systems - Administrative Information Systems - Support Service Technical Information Systems – Medical Transcription, Medical Records Department – Central Sterilization and Supply Department – Pharmacy– Food Services - Laundry Services.

UNIT-V QUALITY AND SAFETY ASPECTS IN HOSPITAL 9 Hrs

Quality system – Elements, implementation of quality system, Documentation, Quality auditing, International Standards ISO 9000 – 9004 – Features of ISO 9001 – ISO 14000 – ISO 13485, Environment Management Systems. NABA, JCI, NABL, NABH. Security – Loss Prevention – Fire Safety – Alarm System – Safety Rules. Health Insurance & Managing Health Care - Medical Audit – Hazard and Safety in a hospital Setup.

Total: 45 Hrs.

g) Learning Resources

Text Books

1. R. C. Goyal, ―Hospital Administration and Human Resource Management‖, PHI –Fourth Edition, 2006
2. G. D. Kunders, ―Hospitals – Facilities Planning and Management – TMH, New Delhi - Fifth Reprint 2007

References Books

1. Cesar A. Caceres and Albert Zara, The Practice of Clinical Engineering, Academic Press, New York, 1977
2. Peter Berman - Health Sector Reform in Developing Countries‖ - Harvard University Press
3. Health Care Management - Arnold D. Kalcizony & Stephen M. Shortell

Course Code	Course Title	L	T	P	C
10212BM102	**Telehealth Technology**	**3**	**0**	**0**	**3**

a) Course Category
Programme Elective

b) Preamble
This course helps the students to learn about the E Healthcare with their standards. Also this course gives the detail information about the security, transmission, and storage

c) Prerequisite
None

d) Related Courses
10212BM201- Digital Imaging and Communication in Medicine

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Identify major application areas, benefits, service types, implementation challenges, and applicable standards and guidelines for telemedicine	K2
CO2	Compare the different types of communication and networks	K2
CO3	Solve the ethical & legal issues involved in telemedicine for the given scenarios	K3
CO4	Apply the different types of data storage and communication standards used in telehealth system.	K3
CO5	Analyze the various applications of telemedicine.	K4

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	1	-	-	3	-	-	2	-	-	-	-	-	-	-
CO4	3	-	-	-	-	-	-	-	-	-	-	-	-	1
CO5	3	-	-	-	-	-	-	-	-	-	3	-	-	1

f) Course content

UNIT I History and Fundamentals of Telemedicine 9 Hrs

What is Telemedicine? History, Major Areas of Telemedicine, Benefits of Telemedicine, Types of Telemedicine services, Challenges in Implementing Telemedicine, Telemedicine Standards and Guidelines.

UNIT II Communication & Network 9 Hrs

Principles of Multimedia - Text, Audio, Video, data, Data communications and networks, PSTN, POTS, ANT, ISDN, Internet, Air/ wireless communications: GSM satellite, and Micro wave, Amplitude Modulation (Qualitative Analysis), Communication infrastructure for telemedicine – LAN and WAN technology.

UNIT III Ethical and legal aspects of Telemedicine 9 Hrs

Ethical and legal aspects of Telemedicine (Case study) - Confidentiality, Social and legal issues (Case Study), Safety and regulatory issues (Case Study), Trends in Telemedicine, Delivery Modes in Telemedicine System, Setting up Telemedicine Facility.

UNIT IV Technology of Telemedicine System 9 Hrs

Information Sources in Telemedicine, Data Transmission, Transmission of Still Images, Transmission of Video, Transmission of Audio.

UNIT V Applications of Telemedicine 9 Hrs

Teleradiology, PACS, ChatGPT in telemedicine platforms, Telecardiology, Teleoncology, Telesurgery, Medical Emergencies and Disaster Relief, Tele-Education.

Total: 45 Hrs.

g) Learning Resources

Text Books

1. R.S. Khandpur, “Telemedicine Technology And Applications (Mhealth, Telehealth And Ehealth)”, PHI Learning, 2017.
2. Olga Ferrer-Roca, M.Sosa Ludicissa, “Handbook of Telemedicine”, IOS press 2002.
3. Norris A.C, “Essentials of Telemedicine and Telecare”, John Wiley & Sons, 2002.
4. Wootton R, Craig J, Patterson, “Introduction to Telemedicine” Royal Society of Medicine Press Ltd., (2nd ed.), 2006.

References Books

1. Maheu M. M, Whitten P, Allen A, “E-Health, Telehealth, and Telemedicine” Jossy-Bass, 2001.
2. Keith J, Dreyer, David S, Hirschron, James Thrall H, Amit Mehta, PACS: “A Guide to the Digital Revolution”, 2nd Edition, Springer
3. Huang H K, “PACS and imaging informatics – Basic Principles & application”, Wiley-Blackwell
4. Latifi R, “Current Principles and Practices of Telemedicine and e-Health”. Washington DC: IOHS , 2008.
5. Bashshur R L, Shannon G W, “History of Telemedicine”. New Rochelle. NY, Mary Ann Liebert Publishers, 2009.

Course Code	Course Title	L	T	P	C
10212BM103	**Medical Ethics**	**3**	**0**	**0**	**3**

a) Course Category
Programme Elective

b) Preamble
- To achieve familiarity with some basic ethical framework& understand how these ethical frame works can help us to think through contemporary questions in medical ethics.
- To know about the legal and ethical principles and application of these in medical field.
- Gain knowledge about the medical standards that to be followed in hospitals

c) Prerequisite
None

d) Related Courses
None

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Apply ethical principles governing fundamental professional responsibilities and the doctor–patient relationship in clinical practice.	K2
CO2	Apply the moral values and ethics appropriately in the work environment	K3
CO3	Examine the implications of confidentiality challenges in medical practice and their impact on patient privacy and trust	K3
CO4	Identify and select the relevant accreditation and safety standards for the hospital and patients	K2
CO5	Summarize the ways to minimize hazardous wastage and locate the proper safety measures.	K2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	1	3	-	-	-	-	-	1	-
CO2	3	-	-	-	-	1	3	-	-	-	-	-	1	-
CO3	3	-	-	-	-	1	3	-	-	-	-	-	1	-
CO4	3	-	-	-	-	1	3	-	-	-	-	-	1	-
CO5	3	-	-	-	-	1	3	-	-	-	-	-	1	-

f) Course content

UNIT I INTRODUCTION TO MEDICAL ETHICS 9 Hrs

Definition of Medical ethics, Scope of ethics in medicine, American Medical Association code of ethics, CMA code of ethics- Fundamental Responsibilities, The Doctor and the Patient, The Doctor and the Profession, Professional Independence, The Doctor and Society.

UNIT II ETHICAL THEORIES & MORAL PRINCIPLES 9 Hrs

Theories - Deontology & Utilitarianism, Casuist theory, Virtue theory, The Right Theory. Principles - Non-Maleficence, Beneficence, Autonomy, Veracity, Justice.

UNIT III ETHICAL ISSUES 9 Hrs

Autonomy & Confidentiality issues in medical practice, Ethical Issues in biomedical research, Bioethical issues in Human Genetics & Reproductive Medicine.

UNIT IV HOSPITAL ACCREDITATION AND SAFETY STANDARDS 9 Hrs

Hospital accreditation standards, Accreditation- JCI Accreditation & its Policies. Patient centered standards, Healthcare Organization management standards.

Life Safety Standards- Protecting Occupants, Protecting the Hospital From Fire, Smoke, and Heat, Protecting Individuals From Fire and Smoke, Providing and Maintaining Fire Alarm Systems, Systems for Extinguishing Fires Environment of Care Standards-Minimizing EC Risks, Smoking Prohibitions.

UNIT V WASTE AND SAFETY MANAGEMENT 9 Hrs

Managing Hazardous Material and Waste, Maintaining Fire Safety Equipment, Features, Testing, Maintaining, and Inspecting Medical Equipment.

Total: 45 Hrs.

g) Learning Resources

Text Books

1. Domiel A Vallero “Biomedical Ethics for Engineers”, Elsevier Pub.1st edition, 2007

References Books

1. Biomedical Ethics: A Canadian Focus. Johnna Fisher (ed.), Oxford University Press Canada. 2009
2. Robert M Veatch" Basics of Bio Ethics", Second Edition. Prentice-Hall, Inc. 2003

Course Code	Course Title	L	T	P	C
10212BM104	**Body Area Networks**	**3**	**0**	**0**	**3**

a) Course Category
Program Elective

b) Preamble
This course will help the students to understand about body area networks along with the various hardware used and their applications.

c) Prerequisite
None

d) Related Courses
None

e) Course Outcomes
Upon the **successful** completion of the course, students will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Identify the technical challenges in BAN such as sensor design, biocompatibility and energy supply constraints	K2
CO2	Explain the specialized the processor requirements for sensor node and solve problems on interfacing is it ok?	K2
CO3	Differentiate RF communication properties in the human body and free space with respect to propagation, attenuation, frequency behavior, and safety constraints and explain the various standards used for wireless communication	K2
CO4	Identify transmission interferences, countermeasures, and security issues in BAN systems	K2
CO5	Apply BAN concepts to real-life use cases at an introductory application level.	K3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	-	-	-	2	-	-	-	-	-	-	2	-
CO2	2	3	-	-	-	-	-	-	-	-	-	-	1	-
CO3	3	2	-	-	-	-	-	-	-	-	-	-	-	-
CO4	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	3	-	2	-	-	-	-	-	2	-	-	-	1	-

f) Course content

UNIT I INTRODUCTION **9 Hrs**

Definition, BAN and Healthcare, Technical Challenges- Sensor design, biocompatibility, Energy Supply, optimal node placement, number of nodes, System security and reliability, BSN Architecture –Introduction

UNIT II HARDWARE FOR BAN **9 Hrs**

Processor-Low Power MCUs, Mobile Computing MCUs ,Integrated processor with radio transceiver, Memory, Antenna-PCB antenna, Wire antenna, Ceramic antenna, External antenna, Sensor Interface, Power sources- Batteries and fuel cells for sensor nodes.

UNIT III WIRELESS COMMUNICATION AND NETWORK **9 Hrs**

RF communication in Body, Antenna design and testing, Propagation, Base Station-Network topology-Stand –Alone BAN, Wireless personal Area Network Technologies-IEEE 802.15.1, IEEE P802.15.3, IEEE 802.15.4, Zigbee

UNIT IV COEXISTENCE ISSUES WITH BAN **9 Hrs**

Interferences – Intrinsic - Extrinsic, Effect on transmission, Counter measures- on physical layer and data link layer, Regulatory issues-Medical Device regulation in USA and Asia, Security and Self protection-Bacterial attacks, Virus infection ,Secured protocols, Self protection.

UNIT V APPLICATIONS OF BAN **9 Hrs**

Monitoring patients with chronic disease, Hospital patients, Elderly patients, Cardiac arrhymia monitoring, Multi patient monitoring systems, Multichannel Neural recording, Gait analysis, Sports Medicine, Electronic pill.

Total: 45 Hrs.

g) Learning Resources

Text Books

1. Annalisa Bonfiglio, Danilo De Rossi ,"Wearable Monitoring Systems", Springer, 2011
2. Sandeep K.S. Gupta,Tridib Mukherjee,Krishna Kumar Venkatasubramanian, “Body Area Networks Safety, Security, and Sustainability”, Cambridge University Press, 2013.

3. Guang-Zhong Yang, “Body Sensor Newtorks”, Springer, 2006

Course Code	Course Title	L	T	P	C
10212BM105	**Introduction To Nanotechnology**	**3**	**0**	**0**	**3**

a) Course Category
Program Elective

b) Preamble
The course introduces the underlying principles and applications of the emerging field of nanotechnology. It introduces tools and principles relevant at the nanoscale dimensions. Also it discusses current and future nanotechnology applications in biomedical engineering and electronics.

c) Prerequisite
None

d) Related Courses
None

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

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Summarize the fundamental concepts, nanoscale effects, and quantum principles of nanotechnology.	K2
CO2	Explain how the nanomaterial synthesis and nanofabrication methods employ chemical, physical, and biological approaches.	K2
CO3	Comprehend the major structural, surface and spectroscopic techniques used for nanomaterial characterization.	K2
CO4	Illustrate the examples of nanotechnology-based drug and gene delivery systems using relevant case studies.	K2
CO5	Explain how the nanosystems are used in biomedical diagnostic and therapeutic applications through case studies.	K2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	2	2	-	2	-	-	-	-	-	-	-	-	-	-
CO3	2	-	-	2	-	-	-	-	-	-	-	-	-	-
CO4	1	2	-	2	-	-	-	1	1	-	1	-	3	-
CO5	1	2	-	2	-	-	-	1	1	-	1	-	3	-

f) Course content

UNIT I INTRODUCTION **9 Hrs**

History, background scope and interdisciplinary nature of nanotechnology, scientific revolutions, nano sized effects surface to volume ratio, crystal structure, atomic structure, molecules and phases, energy bands - insulators, semiconductors and conductors, Nanoscale - molecular and atomic size, quantum effects.

UNIT II NANOMATERIALS SYNTHESIS **9 Hrs**

Synthesis and nanofabrication, Bottom-Up and Top-Down approach with examples. Chemical Methods - Precipitation Method, Sol-Gel Method, Sonochemical Synthesis, Hydrothermal, Thermal Decomposition Process. Physical Methods - Ball milling, Physical Vapor deposition (PVD), Chemical Vapor deposition (CVD), Sputter Deposition, Lithography techniques. Biological methods - Synthesis using micro-organisms and bacteria, Synthesis using plant extract, use of proteins and DNA templates.

UNIT III MATERIAL CHARACTERIZATION TECHNIQUES **9 Hrs**

Compositional and Structural Characterization techniques: X-ray, Principles and applications of X-ray diffraction; electron diffraction, Surface characterization Techniques - High resolution microscopy; Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), Atomic force microscopy (AFM). Spectroscopic techniques: Fourier Transform infrared (FTIR) spectroscopy, Raman spectroscopy techniques.

UNIT IV NANO IN DRUG AND GENE DELIVERY **9 Hrs**

Goals of Delivery, Nanocarriers – Liposomes, Niosomes, Polymeric Nanoparticles/Micelles, Dendrimers & Exosomes, Stimuli-Responsiveness (pH, light, sound and magnetic), Targeting (active and passive) and Enhanced Permeation and Retention – PEGylation, Introduction to Chemotherapeutic Drugs (Doxorubicin and Paclitaxel) and Their Delivery to Liver and Brain cancers with Examples – Case Study, Introduction to Therapeutic Genes (siRNA and miRNA) and Their Delivery to Breast Cancer with Examples – Case Study.

UNIT V NANO IN THERAPEUTIC AND DIAGNOSTIC APPLICATION 9 Hrs

Introduction to Biomedical Diagnostic Modalities – Fluorescence, CT, MRI, PET/SPECT, Nanoparticles as Diagnostic agents – Carbon Nanodots, Metal Nanoparticles, Magnetic Nanoparticles and Radionuclides-Conjugated Nanoparticles - Case Study. Biomedical Nano-Therapeutic Modalities – Magnetic Fluid Hyperthermia, Photothermal therapy, Photodynamic Therapy and Sonodynamic Therapy - Case Study.

Total 45 Hrs.

g) Learning Resources

Text Books

1. T. Pradeep , "NANO The Essential , understanding Nanoscience and Nanotechnology". Tata McGraw-Hill Publishing Company Limited, 1st Edition, 2007.
2. Charles P. Poole Jr. and Frank J.Owens, "Introduction to Nanotechnology", Wiley-Interscience, 1st Edition, 2003.
3. C.N.R. Rao, A. Muller and A.K. Cheetham, "The Chemistry of nanomaterials: Synthesis, Properties and Applications, Vol-I", Wiley Publishers, 1st Edition, 2003.
4. Pieter Stroeve and MortezaMahmoudi, "Drug Delivery Systems, World", Scientific Series: From Biomaterials towards Medical Devices, Vol I, 2018.
5. Kishore Cholkar, AbhirupMandal, AshimMitra, "Emerging nanotechnologies for diagnostics, drug delivery and medical devices", Elsevier, 2017.
6. Maxine A Papadakis, "Current Medical Diagnosis and Treatment", McGraw Hill Education, 2017.

Reference Books

1. W. R. Fahrner, "Nanotechnology and Nano Electronics", Springer, 1st Edition, 2005
2. Sulabha K. Kulakarni, "Nanotechnology Principles and Practices", Springer, 3rd Eidtion, 2015.
3. Vladimir Torchillin, "Nanoparticulates as Drug Carriers", Imperial College Press, 2006.
4. Vasant V Ranade and John B, "Drug Delivery Systems", 3rd Edition, CRC Press, 2011

Course Code	Course Title	L	T	P	C
10212BM106	Rehabilitation Engineering	3	0	0	3

a) Course Category
Programme Elective

b) Preamble
Rehabilitation engineering will provide knowledge to design rehabilitation aid and apply them with confidence to help the challenged people.

c) Prerequisite
10211BM101-Anatomy and Human Physiology

d) Related Courses
10211BM111- Diagnostic and Therapeutic Equipments

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Differentiate the various rehabilitation approaches	K3
CO2	Comprehend how different exercises will be used for therapeutic application	K2
CO3	Compare various orthotic & prosthetic devices in healthcare with case study	K3
CO4	Summarize and explain the various assistive technology used for visual aids	K2
CO5	Design hearing aids for the given scenarios	K3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	-	-	-	2	-	-	-	-	-	-	-	-
CO2	3	1	-	-	-	2	-	1	1	-	2	-	-	-

CO3	3	1	1	-	-	2	-	1	1	1	1	1	1	-
CO4	3	1	1	-	-	2	-	1	1	1	2	1	1	-
CO5	3	1	1	-	-	2	-	1	1	1	2	-	-	-

f) Course content

UNIT I INTRODUCTION TO REHABILITATION ENGINEERING 9 Hrs

What is Rehabilitation, Medical Rehabilitation, Preventive Rehabilitation, Impairment disability and handicap, Sociovocational Rehabilitation, Rehabilitation team, Delivery of Rehabilitation care, Community Based Rehabilitation (CBR).

UNIT II THERAPEUTIC EXERCISE TECHNIQUE 9 Hrs

Co-ordination exercises, Frenkels exercises, Gait analyses-Pathological Gaits, Gait Training, Relaxation exercises-Methods for training Relaxation, Strengthening exercises-Strength training, Types of Contraction, Mobilisation exercises, Endurance exercises.

UNIT III - ORTHOTIC & PROSTHETIC DEVICES 9 Hrs

Anatomy of upper & lower extremities, Classification of amputation types, Prosthesis, Components of upper limb prosthesis, Fabrication of prosthesis, Components of lower limb prosthesis ,Orthoses, types – Lower extremity- and upper extremity orthoses.

UNIT IV – VISUAL AIDS 9 Hrs

Anatomy of eye, Categories of visual impairment, Cortical & retinal implants, Ultrasonic and laser canes, Intraocular lens, Braille Reader, Tactile devices for visually challenged, Text voice converter, screen readers.

UNIT V AUDITORY AND SPEECH ASSIST DEVICES 9 Hrs

Anatomy of the ear, Types of deafness, hearing aids, application of DSP in hearing aids, Cochlear implants, Voice synthesizer, speech trainer.

Total: 45 Hrs.

g) Learning Resources

Text Books

1. Sunder, 'Textbook of Rehabilitation', Jaypee Brothers Medical Publishers Pvt. Ltd, New Delhi, 2nd Edition, Reprint 2007
2. Joseph D. Bronzino, The Biomedical Engineering Handbook, Third edition-3 volume set, Taylor & Francis, 2006
3. Rory A Cooper, Hisaichi Ohnabe, Douglas A Hodson, "An Introduction to Rehabilitation Engineering", CRC Press, First edition, 2006.

References Books

1. Horia- Nocholai Teodorecu, L.C.Jain ,Intelligent systems and technologies in rehabilitation Engineering; CRC; December 2000.

2. Keswick. J., What is Rehabilitation Engineering, Annual Reviews of Rehabilitation- Springer- Verlag, New York, 1982.
3. Warren E. Finn,Peter G. LoPresti; Handbook of Neuroprosthetic Methods CRC; edition 2002.
4. Levine.S.N.Editor, Advances in Bio Medical Engineering and Medical Physics, Inter University Publication, New York 1968.
5. Albert M.Cook and Webster J.G, Therapeutic Medical devices, Prentice Hall Inc., NewJersy,1982.
6. Reswick.J, What is Rehabilitation Engineering, Annual review of Rehabilitation-volume2, Springer-Verlag, New York 1982.

Course Code	Course Title	L	T	P	C
10212BM107	Robotics in Medicine	3	0	0	3

a) Course Category:
Program Elective

b) Preamble
This course helps the students to learn about medical robots with their applications. Also this course gives the detail information about the design methodology in health care application.

c) Prerequisite
None

d) Related Courses
10211BM114 - Engineering Mechanics and its Applications

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Summarize the various types of robot in health care application	K2
CO2	Identify and compare the various types of tracking mechanisms for medical robot	K2
CO3	Apply the principle of minimally invasive surgery robotics to subsystem integration	K3
CO4	Identify the appropriate design methodology of medical robots based on their application.	K2
CO5	Illustrate the working principle of Assistive robots.	K3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	-	-	-	-	-	-	-	-	-	-	1	-
CO2	2	1	-	1	-	-	-	1	1	-	-	-	1	-
CO3	2	1	-	1	-	-	-	1	1	-	1	-	1	-

CO4	2	1	-	1	-	-	-	-	-	-	-	1	1	-
CO5	2	1	-	1	-	-	-	-	-	-	1	-	1	-

f) Course content

UNIT I INTRODUCTION 7 Hrs

Types of medical robots - Navigation - Motion Replication - Imaging - Rehabilitation and Prosthetics - State of art of robotics in the field of healthcare.

UNIT II LOCALIZATION AND TRACKING 8 Hrs

Position sensors requirements - Tracking - Mechanical linkages - Optical - Sound-based - Electromagnetic - Impedance-based - In-bore MRI tracking - Video matching - Fiber optic tracking systems - Hybrid systems.

UNIT III SURGICAL ROBOTICS 10 Hrs

Minimally invasive surgery and robotic integration – surgical robotic sub systems - synergistic control. Control Modes - Radiosurgery - Orthopedic Surgery - Urologic Surgery and Robotic Imaging - Cardiac Surgery – Neurosurgery – case studies.

UNIT IV REHABILITATION & DESIGN OF MEDICAL ROBOTS 14 Hrs

Rehabilitation for Limbs - Brain-Machine Interfaces - Steerable Needles – case studies, Characterization of gestures to the design of robots- Design methodologies- Technological choices- Security.

UNIT V ROBOTS IN MEDICAL CARE 6 Hrs

Assistive robots –types of assistive robots – case studies.

Total: 45 Hrs

g) Learning Resources

1. Paolo Dario, “Medical Robotics”, 1st Edition, Springer, 2019.
2. S. Kevin Zhou, “Medical Robotics: Fundamentals and Applications”, 1st Edition, Elsevier, 2020.
3. Jingang Jiang, Dianhao Wu, Yongde Zhang, Xuesong Dai, “Medical Robot Technology”, 1st Edition, Springer Singapore, 2020.

References Books:

1. Paolo Dario, “Medical Robotics: Minimally Invasive Surgery”, 1st Edition, Germany, 2018
2. Jaydev P. Desai, “The Encyclopedia of Medical Robotics”, 1st Edition, Singapore, 2018.

Course Code	Course Title	L	T	P	C
10212BM108	Biomedical Informatics	3	0	0	3

a) Course Category:
Program Elective

b) Preamble
This course gives an ability to learn ICT applications in medicine with an introduction to health informatics. Understand the theories and practices adopted in Hospital Information Systems in the light of medical standards, medical data formats and recent trends in Hospital Information Systems.

c) Prerequisite
None

d) Related Courses
10212BM201 - Digital Imaging and Communication in Medicine, 10212BM102 -Telehealth Technology

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Summarize the concept of various types of informatics and its application	K2
CO2	Classify various medical standards and their roles in the healthcare system	K2
CO3	Illustrate the basic structure and formats of medical storage	K2
CO4	Identify the models of informatics and databases	K2
CO5	Explore and apply current trends and activities in the field of informatics.	K3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	1	-	-	-	-	-	-	1	-
CO2	3	-	-	-	-	1	1	1	1	-	-	-	1	-
CO3	3	-	-	-	-	1	1	-	-	-	-	-	1	-

CO4	3	-	-	-	-	1	-	1	1	-	-	-	1	-
CO5	3	-	-	-	-	1	-	1	1	-	1	-	1	-

f) Course content

UNIT I MEDICAL INFORMATICS **9 Hrs**

Introduction – Medical Informatics – Bioinformatics – Health Informatics - Structure of Medical Informatics –Functional capabilities of Hospital Information System - On-line services and off – line services - Dialogue with the computer, Application.

UNIT II MEDICAL STANDARDS **9 Hrs**

History and Evolution of Medical Standards – IEEE 11073 - HL7 – DICOM – IRMA - LOINC – HIPPA –Electronics Patient Records – Healthcare Standard Organizations – JCAHO (Joint Commission on Accreditation of Healthcare Organization) - JCIA (Joint Commission International Accreditation) - Evidence Based Medicine - Bioethics.

UNIT III MEDICAL DATA STORAGE AND AUTOMATION **9 Hrs**

Representation of Data, Data modeling Techniques, Relational Hierarchical and network Approach, Normalization techniques for Data handling - Plug-in Data Acquisition and Control Boards – Data Acquisition using Serial Interface – Medical Data formats – Signal, Image and Video Formats – Medical Databases - Automation in clinical laboratories - Intelligent Laboratory Information System – PACS and its significances.

UNIT IV HEALTH INFORMATICS **9 Hrs**

Bioinformatics Databases, Bio-information technologies, Semantic web and Bioinformatics, Genome projects, Clinical informatics, Nursing informatics, Public health informatics, Education and Training

UNIT V RECENT TRENDS IN MEDICAL INFORMATICS **9 Hrs**

Medical Expert Systems, Virtual reality applications in medicine, Virtual Environment – Surgical simulation - Radiation therapy and planning – Telemedicine – virtual Hospitals - Smart Medical Homes – Personalized e-health services – Biometrics - GRID and Cloud Computing in Medicine.

Total: 45 Hrs

g) Learning Resources

Text Books

1. R.D.Lele, “Computers in medicine progress in medical informatics”, Tata McGraw Hill Publishing Ltd, 2005 (Units I, III & IV).
2. Mohan Bansal, “Medical informatics”, Tata McGraw Hill Publishing Ltd, 2003 (Units II, IV & V).

References Books

1. Orpita Bosu and Simminder Kaur Thukral, “Bioinformatics Databases, Tools and Algorithms”, Oxford University press, 2007.
2. Yi Ping Phoebe Chen, “Bioinformatics Technologies”, Springer International Edition, New Delhi, 2007.

Course Code	Course Title	L	T	P	C
10212BM119	Medical Optics	3	0	0	3

a) Course Category
Program Elective

b) Preamble
This course deals with the optical devices and various applications of Lasers in diagnosis and therapy.

c) Prerequisite
Basic knowledge of Analog & Digital Electronics & Engineering Physics.

d) Related Courses
Medical Physics.

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Summarize the basic concepts of optical properties and their interaction with the tissues.	K2
CO2	Classify the different measurement techniques and compare how various photonic principles used in medical instrumentation	K2
CO3	Explain how the laser technique is applied in surgery	K2
CO4	Comprehend the various applications of laser in diagnosis and therapy.	K2
CO5	Summarize the uses of laser for specific medical applications	K2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	-	-	-	-	-	-	-	-	-	-	1	-
CO2	3	-	-	-	-	-	-	-	-	-	-	-	1	-
CO3	3	-	-	-	-	-	-	-	-	-	1	-	2	-
CO4	3	2	-	1	-	-	-	-	-	-	-	-	2	-
CO5	3	-	-	-	-	-	2	-	-	-	-	-	2	-

f) Course content

UNIT-I OPTICAL PROPERTIES OF THE TISSUES 9 Hrs

Refraction, Scattering, Absorption, Light transport inside the tissue, Tissue properties, Laser Characteristics as applied to medicine and biology-Laser tissue Interaction-Optothermal interaction- Electromechanical – Photoabalative processes.

UNIT II INSTRUMENTATION IN PHOTONICS 9 Hrs

Instrumentation for absorption, Scattering and emission measurements, excitation light sources - high pressure arc lamp, solid state LEDs, LASERs, Optical filters, polarisers, optical detectors – Time resolved and phase resolved detectors.

UNIT III SURGICAL APPLICATIONS OF LASER 9 Hrs

LASER-Characteristics, Types of Laser, construction and working principle, Laser applications-Lasers in ophthalmology- Dermatology –Dentistry-Urology-Otolaryngology - Tissue welding.

UNIT IV - NON-THERMAL DIAGNOSTIC APPLICATIONS 9 Hrs

Optical coherence tomography, Elastography, Laser Induced Fluorescence (LIF)-Imaging, FLIM Raman Spectroscopy and Imaging, FLIM – Holographic and speckle application of lasers in biology and medicine.

UNIT V - THERAPEUTIC APPLICATIONS 9 Hrs

Phototherapy, Photodynamic therapy (PDT) - Principle and mechanism -Oncological and non-oncological applications of PDT – Bio-stimulation effect – applications - Laser Safety Procedures - Regulatory standards for Radiation Safety.

Total:45 Hrs.

g) Learning Resources

Text Books

1. MarkolfH.Neimz, “Laser tissue interactions-Fundamentals and applications”, Springer, 3rd edition, 2014.

2. Paras N. Prasad, “Introduction to Biophotonics”, A. John Wiley and Sons, Inc. Publications, 2004

Reference Books

1. Abraham Katzir, Lasers and Optical Fibers in Medicine, Academic Press Edition,1998.

2. Tuan VoDirh, Biomedical Photonics – Handbook, CRC Press, Bocaraton, 2003.

3. G.David Baxter, Therapeutic Lasers – Theory and practice, Churchill Livingstone Publications Edition- 2001.

4. Helena Jelinkova, “Lasers for medical applications: Diagnostics, Therapy and Surgery”, Woodhead Publishing, 1st edition, 2013.

Course Code	Course Title	L	T	P	C
10212BM120	Medical Device Regulatory Affairs	3	0	0	3

a) Course Category
Program Elective

b) Preamble
To make the student to acquire knowledge on various regulatory practices in handling biomedical devices

c) Prerequisite
10211BM111- Diagnostic and Therapeutic Equipments

d) Related Courses
10211BM110- Biomedical Instrumentation

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Classify a medical device according to classification guide	K3
CO2	Analyse the risk in using and managing the medical equipment	K3
CO3	Explain the regulatory standards and procedures followed to maintain the quality of medical devices	K2
CO4	Comprehend the various standards involved in Safety testing	K2
CO5	Explain how to test and inspect diagnostic and therapeutic devices.	K2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	-	-	-	-	-	-	-	-	-

CO2	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	3	-	-	-	-	1	1	-	-	-	-	-	-	-
CO4	2	-	-	-	-	1	2	-	-	-	-	-	1	-
CO5	3	-	-	1	-	1	1	-	-	-	-	-	2	-

f) Course content

UNIT I MEDICAL DEVICE CLASSIFICATION 9 Hrs

Overview of Medical Devices, IVD device classifications – class I, II, III, Classification guide, IDE submission and labeling, IEC standards and its significance, India- Regulatory overview and classification, IEC 60601-1 and 2.

UNIT II RISK ANALYSIS AND MANAGEMENT 10 Hrs

ISO 14971, ISO 14971:2007, Risk analysis techniques, Risk management framework and process, corrective and preventive action (CAPA), case studies.

UNIT III QUALITY MANAGEMENT SYSTEMS 10 Hrs

ISO 13485, Implementing ISO 13485:2003, ISO 13485:2015, 13485:2016

UNIT IV SAFETY TESTING FOR NEW MEDICAL DEVICES 10 Hrs

Directive 2011/65/EU, ISO 10993 – implementation and assessment, 21CFR 210 and 840.

UNIT V INSPECTION AND TESTING OF MEDICAL EQUIPMENTS 6 Hrs

Diagnostic: Patient Monitoring(ECG, BP device, EEG, EMG), Evoked Response equipment
Therapeutic: Defibrillator, Anesthesia, Dialyser, Neonate Incubator Assist - Respirators

Total 45 Hrs.

g) Learning Resources

Text Books

1. Handbook of Medical Device Regulatory Affairs in Asia Second Edition (Jack Wong, Raymond Tong) (z-lib.org)
2. T2 Managing Medical Devices Within a Regulatory Framework (Beth Ann Fiedler) (z-lib.org)
3. T3 Medical devices regulations, standards and practices (Liao, Susan Ramakrishna, Seeram Teo etc.) (z-lib.org)

Reference Books

1. Inspection of Medical Devices For Regulatory Purposes (Almir Badnjević, Mario Cifrek, Ratko Magjarević etc.) (z-lib.org)
2. Medical Regulatory Affairs An International Handbook for Medical Devices and Healthcare Products, 3rd Edition (Taylor Francis Group) (z-lib.org)
3. Regulatory Affairs for Biomaterials and Medical Devices (Stephen F. Amato (ed.) etc.) (z-lib.org)

Course Code	Course Title	L	T	P	C
10212BM121	**Tissue Engineering**	**3**	**0**	**0**	**3**

a) Course Category

Program Elective

b) Preamble

Tissue Engineering combines knowledge and technologies from different fields such as biology, chemistry, medicine, engineering, material science and nanotechnology. It helps biomedical engineers to develop products for repair or replacement of damaged tissues and organs.

c) Prerequisite

10211BM113- Biomaterials Applications

d) Related Courses

10211BM201 - Pathology and microbiology

e) Course Outcomes

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

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Illustrate the fundamentals of tissue engineering, cellular organization, stem cell behavior, extracellular matrix, and mechanobiology.	K2
CO2	Comprehend the biomaterials used in tissue engineering, including polymers, bioceramics, their degradation behavior and biocompatibility.	K2
CO3	Summarize the essential requirements and processes involved in in-vitro tissue engineering and cell culture systems.	K2
CO4	Identify the scaffold fabrication methods and bioreactor systems used in tissue engineering applications.	K2

CO5	Comprehend the scope of in-vivo tissue engineering applications for various tissues along with associated ethical considerations.	K2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	-	-	-	-	-	-	-	-	-	-	-	1
CO2	3	2	-	-	-	-	-	-	-	-	-	-	-	1
CO3	3	2	-	-	-	-	-	-	-	-	-	-	-	3
CO4	3	2	-	-	-	-	-	-	-	-	-	-	-	3
CO5	3	2	-	-	-	-	-	-	-	-	-	-	-	3

f) Course content

Unit 1: Fundamentals **9 Hrs**

Introduction to Tissue engineering, Cells – Basic Molecular Biology and Molecular Organization, Stem Cells – Growth and Differentiation, Tissue Morphogenesis, Tissue Homeostasis and Extracellular matrix (ECM) as a biological scaffold. Mechanobiology - Mechanical forces, Mechano-sensing and Mechanotransduction.

Unit 2: Biomaterials for Engineering **9 Hrs**

Natural Polymers - Polysaccharides, Proteins, Polyhydroxyalkanoates, Properties, Biodegradable Polymers - Mechanism of Polymer Degradation. Bioceramics and their degradation. Biocompatibility of Polymers and Bioceramics

Unit 3: Essentials for In vitro Engineering **9 Hrs**

Engineering Functional Tissues: Key Concepts and Importance. Cell Culture – Harvest, Selection, Expansion, and Differentiation, Cell Nutrition - Cell Culture Media, Directing Cellular Behaviour, Mass Transport, Nutrient Gradients and Strategies to Improve Nutrient Supply –Formation of Vasculature, Bioreactor, and Scaffolds with Nutrient Channels

Unit 4: Scaffolds and Bioreactors **9 Hrs**

Scaffolds – Design, Morphology/Architecture, Fabrication Techniques and Biomaterials, Textile Technologies and Solid-Free Form Fabrication - Systems based on Laser and UV light Sources and Extrusion/Direct Writing, 3D Printing and 3D Bio-printing. Bioreactors – Key Functions, Design and Development, 3D Model Systems and Clinical Applications

Unit 5: In Vivo Applications **9 Hrs**

Tissue Engineering of Cartilage. Tissue Engineering of Bone. Tissue Engineering of Organs – Urogenital Tissues, Liver Tissues, Lung Tissues, Gut and Pancreas Tissues. Ethical issues - Morality, ethics and values.

Total 45 Hrs.

g) Learning Resources

Text Books

1. Robert Lanza, Robert Langer, Joseph Vacanti, Principles of Tissue Engineering, Fifth Edition, 2020, Elsevier
2. Tissue Engineering, Clemens Van Blitterswijk, 2008, Elsevier

Reference Books

1. Robert A. Brown (auth.) - Extreme Tissue Engineering - Concepts and Strategies for Tissue Fabrication (2012, Wiley-Blackwell)
2. Bernhard O. Palsson, Sangeeta N. Bhatia, "Tissue Engineering" Pearson Publishers 2009.
3. W Mark Saltzman, Tissue Engineering: Engineering Principles for the Design of Replacement Organs and Tissues, 2004, Oxford University Press

Course Code	Course Title	L	T	P	C
10212BM124	Biomimetic Engineering	3	0	0	3

a) Course Category
Program Elective

b) Preamble
The course introduces the inspirations for modern-day technologies, including sensors, devices, robots and fabrics from the existing nature.

c) Prerequisite
10211BM101- Anatomy and Human Physiology

d) Related Courses
None

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

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Summarize the fundamentals about biomimetics, biomimetic design and approaches	K2
CO2	Demonstrate how the nature's design is an inspiration for the development of sensors and artificial organs	K2
CO3	Compare the conventional and modern techniques used in tissue engineering	K2
CO4	Extend the nature's design for developing the robots	K2
CO5	Comprehend how human tissues and anatomies are forming basis for medical implants and devices	K2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	-	-	-	-	-	-	-	-	-	-	1	-
CO2	3	1	-	-	-	-	-	-	-	-	-	-	2	-

CO3	3	1	-	-	-	-	-	-	-	-	-	-	2	-
CO4	3	1	-	-	-	-	-	-	-	-	-	1	2	-
CO5	3	1	-	-	-	-	-	-	-	-	-	-	2	-

f) Course Content

Unit – 1 Introduction to Biomimetics **9 Hrs**

Introduction to Biomimetics or Biomimicry - World's Top Olympians – Sprints, High-Altitude Training, Long/High Jump, Swimming and Diving. Biomimetic Materials from Biology to Engineering, Two Aspects of Biomimetics, Biomimetic Design, Classification of Biomimetic Materials – Properties and Applications, General and Special Approaches for Biomimetic Design.

Unit – 2 Biomimetic Sensors and Artificial Organs **10 Hrs**

Senses and Sensors - Chemical Sensors, Auditory and Acoustic Sensors, Mechanical Sensors - Biomimetic Gyroscope, Length and Velocity Sensors, Tactile Sensors and Flow Sensors, Thermal Sensors, Electric Sensors, Biological Inspiration for Potential Biomimetic Sensors. Artificial Organs –Heart, Lung, Pancreas, Blood and Skin.

Unit – 3 Bio-scaffolds: Fabrication and Performance **9 Hrs**

Limitations in Tissue Engineering, Utilizing 3D scaffolds, 3D scaffold requirements, Fabrication of 3D Scaffolds – Conventional Scaffolds - Salt-Leaching Method, Gas-Foaming Method, Textile Fiber Bonding, Rapid Prototyping, and Hydrogels. Nanofibrous Scaffolds – Electrospinning - Blend and composite nanofibers, Centrifugal and coaxial electrospinning, Self-assembly

Unit – 4 Biomimetic Robotics **9 Hrs**

Biomimetic Robotics - Smart Materials and Smart Structures, Biomimetic Sensors and Actuators, Biomimetic and Bio-Inspired Signal Processing, Modelling and Control of Anthropomorphic Manipulators, Shape and Morphing Control, Engineering Applications - Modelling and Control of Robotic Manipulators – Introduction and Modelling of a Multilink Serial Manipulator

Unit – 5 Biomimetic for Medical Implants **9 Hrs**

Structure of Human Tissue – Hard and Soft, Materials Used in Dental Medicine, Load Bearing Implants, Artificial Muscles, Bio-Inspired Medical Implants - Dental Posts and Scaffolds, Degradable Implants in Regenerative Medicine – Root Replica, Bone Augmentation and Cartilage. Anatomical and Inspirational Design Features, Biomimetic Piezoelectric Pump, Coatings and Attachment Devices.

Total: 45 Hrs

g) Learning Resources

Text Books

1. Yoseph Bar-Cohen, "Biomimetics – Nature Based Innovation", CRC Press, 2012.
2. Akhlesh Lakhtakia and Raúl J.Martín-Palma, "Engineered Biomimicry", Elsevier, 2013.

3. Zhenhai Xia, “Biomimetic Principles and Design of Advanced Engineering Materials”, Wiley, 2016.

Reference Books

1. Jay Harman, “The Shark’s Paintbrush: Biomimicry, Nature and Innovation”, White Cloud Press, 2013.
2. Janine M Benyus, “Biomimicry - Innovation Inspired by Nature”, Mariner Books, 2002.

Course Code	Course Title	L	T	P	C
10212BM201	Digital Imaging and Communication In Medicine	1	0	4	3

a) Course Category

Program Elective/ Integrated

b) Preamble

This course gives an introduction to DICOM standards and will discuss the application of various imaging processing techniques to DICOM images.

c) Prerequisite

None

d) Related Courses

10211BM204 - Image Processing

e) Course Outcomes

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

CO Nos.	Course outcomes	Skill Level (Dave'sTaxonomy)
CO1	Interpret the DICOM standards for the given DICOM file	S2
CO2	Demonstrate how medical images can be manipulated in DICOM	S2
CO3	Experiment with recent applications of DICOM	S3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	2	-	-	2	2	-	1	-	1	1
CO2	3	2	-	1	2	-	-	-	1	-	1	-	1	2
CO3	3	1	-	2	2	-	-	-	1	1	1	-	1	3

f) Course content

UNIT I INTRODUCTION TO DICOM **5 Hrs**

What is DICOM? How does DICOM works, DICOM introduction and history, DICOM File Format, PACS, DICOM Security, DICOM Standards

UNIT II PREPROCESSING TECHNIQUE IN MEDICAL IMAGES **5 Hrs**

Resize the Image, Conversion of Images, Noise addition, Noise Removal, Image Enhancement Technique.

UNIT III APPLICATIONS OF DICOM **5 Hrs**

Image Registration, Image Fusion, Performance Evaluation, Image Compression

15 Hrs.

LIST OF EXPERIMENTS: **60 Hrs.**

1. Read and display single and multiple DICOM images
2. Conversion of DICOM image
3. Alter, Add, or Erase metadata in DICOM image
4. Resizing of DICOM image
5. Image enhancement
6. Histogram equalization
7. Reconstruction of the DICOM image
8. Medical Image Registration
9. Medical Image Fusion
10. Performance evaluation of image fusion
11. Feature Extraction in Medical Images
12. Steganography

Total:75 Hrs.

g) Learning Resources

Text Books

1. O.S Pianykh "Digital Imaging and Communication in Medicine (DICOM), Springer 2008.

Course Code	Course Title	L	T	P	C
10212BM202	Brain Computer Interface	1	0	4	3

a) Course Category

Programme Elective/Integrated

b) Preamble

This course helps to design the brain-computer interface system using brain signals.

c) Prerequisite

None

d) Related Courses

Anatomy and Physiology of brain, Signals and systems and Digital signal processing

e) Course Outcomes

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

CO Nos.	Course outcomes	Skill Level (Dave'sTaxonomy)
CO1	Perform the preprocessing of the EEG signals	S2
CO2	Demonstrate feature extraction and Classification techniques used in BCI	S3
CO3	Record EEG signals using open BCI set up	S2
CO4	Perform the feature extraction and visualize it using EEGLAB	S2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	-	-	2	-	-	1	1	1	1	3	-	2
CO2	3	2	-	1	2	-	-	1	1	1	1	3	-	2
CO3	3	2	-	1	2	-	1	1	1	-	1	3	3	-
CO4	2	1	-	1	2	-	-	1	1	-	1	3	-	2

f) Course content

UNIT-I Brain computer interface **5 Hrs**

Fundamentals of BCI – Structure of BCI system – Classification of BCI: Invasive, Non-invasive and Partially invasive BCI, Brain signal acquisition systems- EEG, MEG, fNIRS, fMRI.

UNIT-II EEG features and stimulus design used in BCI **5 Hrs**

EEG-Temporal characteristics, Spatial Characteristics, Oscillatory EEG activity, event-related potentials (ERP), slow cortical potentials (SCP), and neuronal potentials, Motor Imagery, Stimulus design-RSVP, checkerboard.

UNIT-III Signal processing of BCI and Medical applications **5 Hrs**

Signal Processing-Spatial, temporal, spectral, spatio-temporal filters, Feature extraction-ICA, CSP, Classifier-LDA, SVM, Medical applications

15 Hrs.

LIST OF EXPERIMENTS: **60 Hrs.**

1. Study and collection of online EEG datasets
2. Designing of filter
3. Designing of Common Spatial Filter
4. CSP-feature extraction
5. Topoplot for validation
6. Linear Discriminant Analysis
7. LDA and SVM comparison
8. OpenBCI board interface
9. Acquisition of EEG using openBCI board
10. Import the following using EEGLAB-continuous data, event information, channel locations
11. Filter the line noise and bandpass filter the EEG data using EEGLAB
12. Remove the bad channels and bad data using EEGLAB
13. Plot the 2D ERP, 3D ERP, Channel spectra, time-frequency analysis

Total: 75 Hrs.

g) Learning Resources

References:

1. Brain Computer Interfaces, a Review by Luis Fernando Nicolas-Alonso and Jaime Gomez-Gil
2. https://sccn.ucsd.edu/wiki/BCILAB
3. Spatially regularized common spatial patterns for EEG classification." Lotte, Fabien, and Cuntai Guan.
4. Introduction to Statistical Pattern Recognition 2nd Ed - Keinosuke Fukunaga

Course Code	Course Title	L	T	P	C
10212BM203	**Biomedical Computational Modeling**	**1**	**0**	**4**	**3**

a) Course Category

Programme Elective/ Integrated

b) Preamble

This course gives a hands-on using computational modeling tool in biomedical applications

c) Prerequisite

None

d) Related Courses

10211BM114 - Engineering Mechanics and its Applications

e) Course Outcomes

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain fundamentals of finite element method (FEM) and calculate stress and strain	K3
CO2	Apply discretization and shape function in FEM models	K3
CO3	Manipulate material types and apply boundary conditions in FEM models	K3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	-	-	2	-	-	-	-	-	-	-	-	-
CO2	3	1	-	-	2	-	-	-	-	-	-	-	-	-
CO3	3	1	-	-	2	-	-	-	-	-	-	-	1	-

f) Course content

UNIT-I Introduction to Finite Element Method and Analysis **4 Hrs**

Introduction – ordinary and partial differential equations and matrices, Calculation of Strain and Stress - Average Strain and Point Strain, Normal and Shear Strain, Calculation of Stress, Sample Matrix Structural Analysis (MSA), MSA to a Finite Element Mode

UNIT-II Meshing, Elements and Shape Functions **6 Hrs**

Structure Idealization and Discretization, Node, Element – 1D, 2D and 3D Element types, Formation of Finite Element Mesh, Element Shape Functions and [B] Matrix, Isoparametric Formulation and Mesh Quality – Natural Coordinate System, Isoparametric Formulation of 1D and 2D Elements, Stiffness Matrix Formulation – Direct, Strong and Weak Formulation methods

UNIT-III Materials, Boundary Conditions and Multiphysics **5 Hrs**

Material Laws – Linear Elastic, Elastic-Plastic, Hyper-elastic and viscoelastic, Experimental Types for Biological Tissue Testing and List of Common Material Properties of Biological Tissues, Essential and Natural Boundary Conditions, Nodal Constraint and Prescribed Displacement and Natural Boundary/Loading Conditions, Basics of Heat Transfer and Structural Mechanics

15 Hrs.

LIST OF EXPERIMENTS: **60 Hrs.**

1. Making Initial Selections and Getting Familiar with Modelling Environment - Model Builder, Settings and Graphics, Practical Sense of Building Proper Models
2. Create 1D Geometry Models
3. Create 2D Geometry Models using Boolean Operations – A flange with 5 fillets
4. Create 3D Geometry Models using Boolean Operations – 3D heat sink model
5. Create and mesh 2D and 3D Geometry Models having Material Properties
6. Create and mesh a 3D layered Geometry Model having material Properties
7. Steady-State 2D Heat Transfer with Conduction and Convection
8. Axisymmetric 3D Transient Heat Transfer
9. 3D Thick Plate Stress Analysis
10. Microwave Heating of Cancer Tumor
11. Plastic Deformation of a Biomedical Stent
12. Fluid-Structure Interaction in a Network of Blood Vessels

Total: 75 Hrs.

g) Learning Resources

Text Books

1. Basic Finite Element Method As Applied To Injury Biomechanics - King-Hay Yang, Elsevier, 2018.
2. Introduction to Integrative engineering: A computational approach to biomedical problems, Guigen Zhang, CRC press 2017.
3. Heat and Mass Transfer: Fundamentals and Applications, Yunus A Cengel; Afshin J. Ghajar, 4e, 2017

Reference Books/Links

1. https://www.ansys.com/en-in/Case-Studies
2. https://www.comsol.com/learning-center

Course Code	Course Title	L	T	P	C
10212BM109	**Introduction to Machine Learning**	**3**	**1**	**0**	**4**

a) Course Category
Specialization

b) Preamble
This course will make the learner, apply machine learning to solve problems in biomedical engineering

c) Prerequisite
10211BM202-Artificial Neural Networks

d) Related Courses
10211BM108 - Digital Signal Processing, 10211BM204 - Image processing

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Summarize the seven steps of Machine Learning.	K2
CO2	Apply various supervised learning algorithms on the given datasets.	K3
CO3	Analyze and group the unlabeled data items using various clustering techniques.	K4
CO4	Choose the appropriate method of feature selection, model selection and model evaluation.	K3
CO5	Differentiate semi-supervised and reinforcement learning and Apply the same to solve given problems.	K3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	-	-	-	-	-	1	1	1	-	1	-	3
CO2	3	2	-	-	-	-	-	1	1	1	-	1	-	3
CO3	3	2	-	-	-	-	-	1	1	1	-	1	-	3

CO4	3	2	-	-	-	-	-	1	1	1	-	1	-	3
CO5	3	2	-	-	-	-	-	1	1	1	-	1	-	3

f) Course content

UNIT-1: INTRODUCTION TO MACHINE LEARNING 8 Hrs

Machine learning vs Traditional learning, Seven steps of machine learning, Applications of machine learning, Supervised learning, regression, classification, Unsupervised learning, Clustering, Reinforcement learning, Advantages and Disadvantages of Machine learning.

UNIT-II: SUPERVISED LEARNING ALGORITHMS 12 Hrs

Introduction to Supervised learning, Naive Bayes Classifier Algorithm, Decision Tree Algorithm, K-Nearest Neighbour Algorithm, SVM Algorithm, Random Forest Algorithm.

UNIT-III: UNSUPERVISED LEARNING ALGORITHMS 15 Hrs

Introduction to Unsupervised learning, K-means Clustering, Hierarchical Clustering, Association rule learning, Apriori Algorithm, Frequent Pattern (FP) Growth Algorithm, Gaussian Mixture Models (GMMs).

UNIT-IV: INTRODUCTION TO STATISTICAL LEARNING THEORY 16 Hrs

Introduction to Statistical Learning, Feature Selection- Filters (Pearson Correlation, Chi-Squared, LDA (Linear Discriminant Analysis)- Embedded Methods- L1 regularization- L2 regularization- L1/L2 regularization, Model Selection- Resampling Methods (Random split, Time-based split, Bootstrap), Probabilistic measures (Akaike Information Criterion, Minimum Description Length), Model Evaluation- Classification Metrics- (Accuracy, Precision, Recall, F1 Score, AUC curve), Regression Metrics (Mean Squared Error, Root Mean Squared Error, Mean Absolute Error, Root Mean Squared Log Error) - Clustering Metrics (Dunn Index, Silhouette Coefficient, Elbow method).

UNIT-V: SEMI-SUPERVISED LEARNING, REINFORCEMENT LEARNING 9 Hrs

Introduction to Semi-Supervised learning, Markov Decision Process (MDP), Bellman equations, Monte Carlo methods, Q-learning Algorithm, State-Action-Reward-State-Action (SARSA) Algorithm.

Total: 60 Hrs

g) Learning Resources

Text Book

1. Dr. Ruchi Doshi et al, “Machine Learning- Master Supervised and Unsupervised Learning Algorithms with Real Examples”, BPB Publications, India. (2021)

Reference Books

1. Ryan T. White et al, “Practical Discrete Mathematics” Packt Publishing. (2021)
2. Stuart J. Russell and Peter Norvig, “Artificial Intelligence- A Modern Approach ", Fourth Edition, Pearson Education Limited. (2022)

Course Code	Course Title	L	T	P	C
10212BM204	Introduction to Deep Learning	3	0	2	4

a) Course Category
Specialization

b) Preamble
To understand different types of Deep Architectures, including Convolutional Networks and Recurrent Networks

c) Prerequisite
None

d) Related Courses
10212BM206 - Deep Learning Fundamentals

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Choose the relevant activation function for the given problem.	K3
CO2	Compare the different CNN architectures available in the literature.	K3
CO3	Differentiate CNN from RNN and apply RNN for time sequence problems.	K3
CO4	Apply performance-improving techniques to optimize deep learning model accuracy and robustness.	K3
CO5	Utilize standard deep learning models to a real-world application.	K3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	-	-	3	-	-	2	2	-	-	-	-	1
CO2	2	3	-	3	3	-	-	2	2	-	-	-	-	1

CO3	3	2	-	-	3	-	-	2	2	-	-	-	-	1
CO4	3	1	-	-	1	-	-	1	1	-	-	-	-	1
CO5	3	1	-	-	3	-	-	2	2	-	-	-	-	1

f) Course content

UNIT I INTRODUCTION TO DEEP LEARNING 9 Hrs

Machine Learning vs Deep Learning, Representation Learning, Width and Depth of Neural Networks, Learning Algorithms: Capacity - Overfitting - Underfitting - Bayesian Classification - Activation Functions: RELU, LRELU, ERELU, Unsupervised Training of Neural Networks, Restricted and Deep Boltzmann Machines.

UNIT II CONVOLUTIONAL NEURAL NETWORKS 9 Hrs

Architectural Overview, Motivation, Layers, dropout, Filters, Parameter sharing, Regularization, Popular CNN Architectures: AlexNet, ResNet and UNet – Applications.

UNIT III RECURRENT AND RECUSIVE NETS 9 Hrs

Recurrent Neural Networks, Bidirectional RNNs, Encoder-decoder sequence to sequence architectures - BPTT for training RNN, Long Short-Term Memory Networks, Computer Vision - Speech Recognition - Natural language Processing, Case studies in classification, Regression and deep networks.

UNIT IV ADVANCED NEURAL NETWORKS 9 Hrs

Deep Feedforward Networks: Gradient based learning - Hidden Units - Architectural design – Back Propagation algorithms - Regularization for deep learning: Dataset Augmentation - Noise Robustness –Semi supervised learning - Multitask learning - Deep Belief networks - Generative Adversarial Networks by Keras MXnet.

UNIT V APPLICATIONS OF DEEP LEARNING 9 Hrs

Images segmentation – Object Detection – Automatic Image Captioning - Case Study: Named Entity Recognition – Opinion Mining using Recurrent Neural Networks – Parsing and Sentiment Analysis using Recursive Neural Networks – Sentence Classification using Convolutional Neural Networks – Dialogue Generation with LSTMs.

Total 45 Hrs.

LIST OF EXPERIMENTS

1. MNIST Handwritten Recognition using Fully Connected Neural Networks
2. American sign language detection using Fully Connected Neural Networks
3. Diabetic Foot Ulcer classification using Alexnet (CNN)
4. Object Detection with CNN
5. Electrocardiogram (ECG) Signal Analysis using RNN
6. Protein Structure Prediction using Recursive Neural Networks
7. Medical Image Generation using GANs

8. Synthetic Data Generation for Privacy-preserving Healthcare

g) Learning Resources

Text Books

1. Ian Goodfellow, Yoshua Bengio, and Aaron Courville, “Deep Learning”, First Edition, MIT Press, 2016.
2. Nikhil Buduma and Nicholas Lacascio, “Fundamentals of Deep Learning”, First Edition, O.Reilly, 2017.

Reference Books

1. Josh Patterson, Adam Gibson "Deep Learning: A Practitioner's Approach", O'Reilly Media, 2017.
2. Laura Graesser, Wah Loon Keng "Foundations of Deep Reinforcement Learning: Theory and Practice in Python" Addison-Wesley Professional -2020.
3. Jon Krohn, Grant Beyleveld, Aglaé Bassens "Deep Learning Illustrated: A Visual, Interactive Guide to Artificial Intelligence", 1st edition Addison-Wesley Professional 2019.

Course Code	Course Title	L	T	P	C
10212BM110	**Natural Language Processing**	**3**	**0**	**0**	**3**

a) Course Category
Specialization

b) Preamble
To understand the fundamentals of Natural Language Processing (NLP).

c) Prerequisite
None

d) Related Courses
10212BM109 – Introduction to Machine Learning

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Summarize the fundamental concepts of speech production and phonetics.	K2
CO2	Develop speech recognition using NLP components	K2
CO3	Apply rule-based system to tackle morphology/syntax of a language	K2
CO4	Identify a tag set to be used for statistical processing for real-time applications	K2
CO5	Identify the use of different statistical approaches for different types of NLP applications	K2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	-	-	-	-	-	-	-	-	-	-	-	1
CO2	3	1	-	-	-	-	-	-	-	-	-	-	-	1
CO3	3	1	-	-	-	-	-	-	-	-	-	-	-	1

CO4	3	2	-	-	-	-	-	-	-	-	-	-	-	1
CO5	3	1	-	-	-	-	-	-	-	-	-	-	-	1

f) Course content

UNIT I SPEECH **9 Hrs**

Speech – Phonetics - Speech Synthesis - Automatic Speech Recognition - Speech Recognition: - Advanced Topics - Computational Phonology

UNIT II INTRODUCTION TO MEDICAL NATURAL LANGUAGE PROCESSING **9 Hrs**

Introduction to Medical Natural Language Processing – Challenges of Big Data in Health – tokenization, normalization – Word sense disambiguation - N-grams - Part-of-Speech – Tagging - Hidden Markov and Maximum Entropy Models.

UNIT III SYNTAX AND TEXT CLASSIFICATION **9 Hrs**

Formal Grammars of English - Syntactic Parsing - Statistical Parsing - Features and Unification - Language and Complexity – Decision trees – Support Vector Machines – Naïve Bayes – Tools: Weka

UNIT IV SEMANTICS AND PRAGMATICS **9 Hrs**

The Representation of Meaning - Computational Semantics - Lexical Semantics - Computational Lexical Semantics - Computational Discourse

UNIT V APPLICATIONS **9 Hrs**

Information Extraction - Question Answering and Summarization – Sentiment analysis – Challenges due to acronyms-polysemy, synonymy – Deep Learning

Total: 45 Hrs.

g) Learning Resources

Text Books

1. Yue Zhang, Zhiyang Teng, Natural Language Processing, 1st Edition, Cambridge University Press, 2020.
2. Palash Goyal, Sumit Pandey, Karan Jain, “Deep Learning for Natural Language Processing: Creating Neural Networks with Python”, 1st Edition, Apress, 2018.
3. Delip Rao, Brian McMahan, “Natural Language Processing with PyTorch: Build Intelligent Language Applications Using Deep Learning”, 1st Edition, O'Reilly Media, 2019.

Reference Books

1. Muskan Garg, Sandeep Kumar, Abdul Khader Jilani Saudagar, “Natural Language Processing in Artificial Intelligence”,Apple Academic Press, 2020.
2. Information Resources Management Association, “Natural Language Processing: Concepts, Methodologies, Tools, and Applications”, 1st Edition, IGI Global 2020.

Course Code	Course Title	L	T	P	C
10212BM304	**Essential Python Modules for Machine Learning Laboratory**	**0**	**0**	**2**	**1**

a) Course Category

Specialization

b) Preamble

The objective of the course is to provide students an insight into Python programming, and develop programming skills to manage the development of software systems. It covers programming environments, data representations, Object Oriented Programming. This course lays the foundation to Machine Learning, and Artificial Intelligence-based applications & tools, Data Science and Data Visualization applications.

c) Prerequisite

10210CS201-Python Programming

d) Related Courses

10211BM204 - Image Processing, 10212BM109 – Introduction to Machine Learning.

e) Course Outcomes

Upon successful completion of the course students will be able to

CO Nos.	Course outcome	Skill Level (Dave's Taxonomy)
1	Write, test and debug python programs and import basic packages.	S2
2	Write programs in python to process data by utilizing the modules Numpy, Pandas etc.	S2
3	Write programs in python for image processing using OpenCV, skimage.	S2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	-	-	3	-	-	-	-	-	-	2	-	3
CO2	2	2	-	-	3	-	-	-	-	-	-	2	-	3
CO3	1	2	3	1	3	-	-	-	2	2	-	3	-	3

LIST OF EXPERIMENTS

1. Implementation of simple python program by installing and exploring python IDE.
2. Import basic packages, libraries and execute programs in python IDE.
3. Write a python program to implement basic data types – Strings, Numeric, List data types and Tuples.
4. Write a python program to create and manipulate one-dimensional and two-dimensional Numpy arrays.
5. Write a pandas program to create and display a DataFrame from a specified dictionary data which has the index labels.
6. Write a pandas program to join and merge data frames.
7. Write a python program to define constants, variables and placeholders using Tensorflow.
8. Write a python program to define functions in Tensorflow.
9. Write a python program to do mathematical operations on Tensor/Matrix.
10. (a) Write a python program to convert image array to a new color space using skimage.

(b) Write a python program for conversions between one color space to another color space using skimage.

Total: 30 Hrs.

Course Code	Course Title	L	T	P	C
10212BM122	**High-Performance Computing**	**3**	**0**	**0**	**3**

a) Course Category

Specialization

b) Preamble

This course explores the basics of programming for heterogeneous architectures. Also, the course introduces different GPU programming models and the issues in mapping algorithms for GPUs.

c) Prerequisite

10210CS301-Problem Solving using C

d) Related Courses

10211BM107 - Microcontroller and Digital Signal Processor

e) Course Outcomes

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Describe GPU hardware and software architecture Solve problems on thread, block, gird associated with software abstraction/model/architecture Analyze how parallel processing is achieved through warps and threads	K3
CO2	Write simple CUDA programs for mathematical operations like addition and multiplication	K3
CO3	Comprehend different types of programming issues with respect to multiprocessor programming with GPU	K2
CO4	Compare the software model with OpenCL and GPU	K2
CO5	Explain how different algorithms written for CPU processing can be parallelized for GPU	K2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	-	-	-	-	-	-	-	-	-	-	-	2
CO2	3	3	-	-	2	-	-	-	2	-	-	-	-	2
CO3	3	-	-	-	-	-	-	-	-	-	-	-	-	2
CO4	3	2	-	-	-	-	-	-	-	-	-	-	-	2
CO5	-	3	1	-	-	-	-	-	-	-	-	-	-	2

f) Course content

UNIT I GPU ARCHITECTURE **12 Hrs**

Evolution of GPU architectures – Understanding Parallelism with GPU –Typical GPU Architecture – CUDA Hardware Overview – Threads, Blocks, Grids, Warps, Scheduling – Memory Handling with CUDA: Shared Memory, Global Memory, Constant Memory and Texture Memory.

UNIT II CUDA PROGRAMMING **8 Hrs**

Using CUDA – Multi GPU – Multi GPU Solutions – Optimizing CUDA Applications: Problem Decomposition, Memory Considerations, Transfers, Thread Usage, Resource Contentions.

UNIT III PROGRAMMING ISSUES **8 Hrs**

Common Problems: CUDA Error Handling, Parallel Programming Issues, Synchronization, Algorithmic Issues, Finding and Avoiding Errors.

UNIT IV OPENCL BASICS **8 Hrs**

OpenCL Standard – Kernels – Host Device Interaction – Execution Environment – Memory Model – Basic OpenCL Examples.

UNIT V ALGORITHMS ON GPU **9 Hrs**

Parallel Patterns: Convolution, Prefix Sum, Sparse Matrix – Matrix Multiplication – Programming Heterogeneous Cluster.

Total 45 Hrs.

g) Learning Resources

Text Books

1. Shane Cook, CUDA Programming: ―A Developer's Guide to Parallel Computing with GPUs (Applications of GPU Computing), First Edition, Morgan Kaufmann, 2012.
2. David R. Kaeli, Perhaad Mistry, Dana Schaa, Dong Ping Zhang, ―Heterogeneous computing with OpenCL, 3rd Edition, Morgan Kauffman, 2015.

Reference Books

1. Nicholas Wilt, ―CUDA Handbook: A Comprehensive Guide to GPU Programming, Addison – Wesley, 2013.
2. Timothy G. Mattson Aaftab Munshi Benedict Gaster Dan Ginsburg James Fung, OpenCL Programming Guide, Addison Wesley 2011
3. David B. Kirk, Wen-mei W. Hwu, Programming Massively Parallel Processors – A Hands-on Approach, Third Edition, Morgan Kaufmann, 2016.
4. Gareth Morgan Thomas, Advanced CUDA Programming: High Performance Computing with GPUs, 1st Edition, Amazon Digital Services LLC – Kdp 2025
5. Matthew Scarpino, OpenCL in Action: How to Accelerate Graphics and Computations, Manning, 1st edition, 2011

Web links:

1. http://www.nvidia.com/object/cuda_home_new.html
2. http://www.openCL.org

Course Code	Course Title	L	T	P	C
10212BM123	Computer Vision	3	0	0	3

a) Course Category:
Specialization

b) Preamble
Computer Vision is a field of AI which deals with understanding and extracting information from digital images and videos. This course provides an outline of important notions in the field of computer vision

c) Prerequisite:
10211BM204 - Image Processing

d) Related Courses
Image analysis and machine vision

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

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Compare the various ways by which image stitching and image aligning algorithm is working	K2
CO2	Explain the need for segmentation in computer vision and compare the different segmentation algorithms applied to computer vision Solve problems on clustering algorithms	K3
CO3	Compare the various ways in which image stitching and image aligning algorithm is working	K2
CO4	Explain how deep learning is applied in computer vision	K3
CO5	Summarize the steps in creating a computer-aided diagnostic tool	K2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	-	-	1	-	-	-	-	-	-	-	-	2
CO2	3	2	-	2	1	-	-	3	-	-	-	-	-	2
CO3	3	-	-	-	-	-	-	-	-	-	-	-	-	2
CO4	3	2	-	-	-	-	-	-	-	-	-	-	-	2
CO5	3	2	-	-	2	-	-	-	-	-	-	-	-	2

f) Course content

UNIT-1 TEXTURE REPRESENTATION 8 Hrs

Computer vision an Introduction, Local texture representation using filters- Spots and bars, Filter output to texture representation, Shape from texture-Shape from texture for planes, shape from texture for curved surfaces, Analysis and synthesis of texture

UNIT-II SEGMENTATION BY CLUSTERING 10 Hrs

Image segmentation by clustering pixels-Basic clustering methods, the watershed algorithm, Segmentation using K means, Clustering and segmentation with mean shift, Segmentation, clustering and graphs-Terminology and facts for graphs, Agglomerative Clustering with a graph, Divisive clustering with the graph

UNIT-III IMAGE ALIGNMENT AND STITCHING 9 Hrs

Pairwise alignment- 2D alignment using least squares, Iterative algorithms, Robust least squares and RANSAC. Image stitching- parametric motion models, Rotational panoramas, Gap closing, cylindrical and spherical coordinates. Global Alignment- bundle adjustment and parallax removal.

UNIT-IV INTRODUCTION TO DEEP LEARNING 10 Hrs

Introduction to Deep Neural Networks- Weights and layers, Activation functions, Regularization and normalization, Loss function, Back propagation. Convolutional Neural Networks- Pooling and Unpooling, Network Architectures, Application of CNN (Digit Classification). Introduction to 3D CNNs.

UNIT-V STEPS IN CREATING A CAD DIAGNOSTIC TOOL 8 Hrs

What is computer vision in healthcare, Key applications in healthcare, issues with medical image database, Data de-identification, Data annotation. Finding a AI Dataset, Computer vision algorithms-DeepNets

Total: 45 Hrs.

g) Learning Resources

Text Books

1. Szeliski, R. (2022). *Computer vision: algorithms and applications*. Springer Nature.
2. David A. Forsyth, Computer vision: a modern approach, Pearson India Education Limited, 2015

Reference Books

1. Steger, C., Ulrich, M., & Wiedemann, C. (2018). Machine vision algorithms and applications. John Wiley & Sons.
2. Raja, R., Kumar, S., Rani, S., & Laxmi, K. R. (Eds.). (2020). Artificial intelligence and machine learning in 2D/3D medical image processing. CRC Press.
3. Gonzalez, R. C. (2009). Digital image processing. Pearson education India.
4. Joseph Howse, Learning OpenCV 4 Computer Vision with Python 3, Packt Publishing; 3rd ed. Edition 2020

Course Code	Course Title	L	T	P	C
10212BM206	Deep Learning Fundamentals	3	0	2	4

a) Course Category
Specialization

b) Preamble
To understand different types of Deep Architectures, including Convolutional Networks and Recurrent Networks

c) Prerequisite
None

d) Related Courses
10212BM206 - Deep Learning Fundamentals

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Choose the relevant activation function for the given problem.	K3
CO2	Compare the different CNN architectures available in the literature.	K3
CO3	Differentiate CNN from RNN and apply RNN for time sequence problems.	K3
CO4	Apply performance-improving techniques to optimize deep learning model accuracy and robustness.	K3
CO5	Utilize standard deep learning models to a real-world application.	K3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	-	-	3	-	-	2	2	-	-	-	-	1
CO2	2	3	-	3	3	-	-	2	2	-	-	-	-	1

CO3	3	2	-	-	3	-	-	2	2	-	-	-	-	1
CO4	3	1	-	-	1	-	-	1	1	-	-	-	-	1
CO5	3	1	-	-	3	-	-	2	2	-	-	-	-	1

f) Course content

UNIT I INTRODUCTION TO DEEP LEARNING 9 Hrs

Machine Learning vs Deep Learning, ML Basics-Representation Learning, Width and Depth of Neural Networks, Learning Algorithms: Capacity - Overfitting – Underfitting- Representation Learning, Width and Depth of Neural Networks, Learning Algorithms: Capacity - Overfitting - Underfitting - Activation Functions: RELU, LRELU, ERELU, Unsupervised Training of Neural Networks, Restricted and Deep Boltzmann Machines.

UNIT II CONVOLUTIONAL NEURAL NETWORKS 9 Hrs

Architectural Overview, Motivation, Layers, dropout, Filters, Parameter sharing, Regularization, Popular CNN Architectures: AlexNet, ResNet and UNet.

UNIT III RECURRENT AND RECURSIVE NETS 9 Hrs

Recurrent Neural Networks, Bidirectional RNNs, Encoder-decoder sequence to sequence architectures - BPTT for training RNN, Long Short-Term Memory Networks- Speech Recognition - Natural language Processing,

UNIT IV ADVANCED NEURAL NETWORKS 9 Hrs

Deep Feedforward Networks: Gradient based learning - Hidden Units - Architectural design – Back Propagation algorithms - Regularization for deep learning: Dataset Augmentation - Noise Robustness –Semi supervised learning - Multitask learning - Deep Belief networks - Generative Adversarial Networks.

UNIT V APPLICATIONS OF DEEP LEARNING 9 Hrs

Images segmentation – Object Detection – Automatic Image Captioning - Case Study: Named Entity Recognition – Opinion Mining using Recurrent Neural Networks – Parsing and Sentiment Analysis using Recursive Neural Networks – Sentence Classification using Convolutional Neural Networks – Dialogue Generation with LSTMs.

Total: 45 Hrs.

LIST OF EXPERIMENTS

1. Getting Started with Deep Learning
2. Manual data fitting
3. Experimenting with activation functions
4. Manual tuning of Edge detection filters
5. Text vectorization and embedding
6. Back propagation

7. Data Augmentation
8. Sentiment analysis
9. Generative Adversarial Network
10. Assignment- AlexNet/VGG/ResNets

g) Learning Resources

Text Books

1. Ian Goodfellow, Yoshua Bengio, and Aaron Courville, “Deep Learning”, First Edition, MIT Press, 2016.
2. Nikhil Buduma and Nicholas Lacascio, “Fundamentals of Deep Learning”, First Edition, O.Reilly, 2017.

Reference Books

1. Josh Patterson, Adam Gibson "Deep Learning: A Practitioner's Approach", O'Reilly Media, 2017.
2. Laura Graesser, Wah Loon Keng "Foundations of Deep Reinforcement Learning: Theory and Practice in Python" Addison-Wesley Professional -2020.
3. Jon Krohn, Grant Beyleveld, Aglaé Bassens "Deep Learning Illustrated: A Visual, Interactive Guide to Artificial Intelligence", 1st edition Addison-Wesley Professional 2019.

Course Code	Course Title	L	T	P	C
10212BM207	**Programming Essentials in Python**	**1**	**0**	**2**	**2**

a) Course Category

Specialization/Integrated

b) Preamble

This course gives an introduction on classification using neural networks which is used in most biomedical applications.

c) Prerequisite

10210CS201-Python Programming

d) Related Courses

10211BM204 - Image Processing, 10212BM109 – Introduction to Machine Learning.

e) Course Outcomes

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Write, test python programs and import basic packages.	K3
CO2	Write programs in python to process data by utilizing the modules Numpy, Pandas etc.	K3
CO3	Write programs in python to process data using program flow controls.	K3
CO4	Write programs in python to create functions and modules.	K3
CO5	Write programs in python to use packages.	K3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	-	-	3	-	-	-	-	-	-	-	2	-
CO2	2	2	-	-	3	-	-	-	-	-	-	-	2	-

CO3	1	2	3	1	3	-	-	-	2	2	-	-	3	-
CO4	2	2	-	-	3	-	-	-	-	-	-	-	2	-
CO5	2	2	-	-	3	-	-	-	-	-	-	-	2	-

f) Course content

UNIT - 1: BASICS OF PYTHON **3 Hrs**

Overview and fundamentals of python, executing simple programs, exploring python variables, operators and comprehend python blocks.

UNIT - 2: DATA TYPE CONVERSIONS **3 Hrs**

Type conversions – Implicit type and Explicit type, list to tuple, tuple to list.

UNIT - 3: PROGRAM FLOW CONTROLS **3 Hrs**

Indentation, conditional blocks, control statements, looping statements, break statements, for loop, while loop – Examples.

UNIT - 4: FUNCTIONS AND MODULES **3 Hrs**

Create your own functions, Functions parameters, Variable Arguments, Scope of a Function, Function Documentations, Lambda Functions & map – Examples, Create a Module, Standard Modules.

UNIT - 5: PACKAGES & DATA ANALYSIS **3 Hrs**

Creating packages, NumPy, SciPy, Pandas, Matplotlib

15 Hrs.

LIST OF EXPERIMENTS

1. Implementation of simple python program by installing and exploring python IDE.
2. Import basic packages, libraries and execute programs in python IDE.
3. Write a python program to implement basic data types – Strings, Numeric, List data types and Tuples.
4. Write a python program to create and manipulate one-dimensional and two-dimensional Numpy arrays.
5. Write a pandas program to create and display a DataFrame from a specified dictionary data which has the index labels.
6. Write a pandas program to join and merge data frames.
7. Write a python program to define constants, variables and placeholders using Tensorflow.
8. Write a python program to define functions in Tensorflow.
9. Write a python program to do mathematical operations on Tensor/Matrix.
10. (a) Write a python program to convert image array to a new color space using skimage.
11. (b) Write a python program for conversions between one color space to another color space using skimage.

30 Hrs.

Total: 45 Hrs.

Learning Resources

Text Books

1. Kenneth A. Lambert, “Fundamentals of Python: First Programs”, CENGAGE Learning, 2012.
2. Charles Dierbach, “Introduction to Computer Science using Python: A Computational Problem-Solving Focus, Wiley India Edition, 2013.

Reference Books

1. John V Guttag, “Introduction to Computation and Programming Using Python’’, Revised and expanded Edition, MIT Press, 2013.
2. Kenneth A. Lambert, “Fundamentals of Python: First Programs”, CENGAGE Learning, 2012.
3. Robert Sedgewick, Kevin Wayne, Robert Dondero, “Introduction to Programming in Python: An Inter-disciplinary Approach, Pearson India Education Services Pvt. Ltd., 2016.
4. Timothy A. Budd, “Exploring Python”, Mc-Graw Hill Education (India) Private Ltd., 2015.

Web sources/videos:

1. https://www.geeksforgeeks.org/python-programming-language

Course Code	Course Title	L	T	P	C
10212BM208	Introduction to Computer Vision	3	0	2	4

a) Course Category:
Specialization

b) Preamble
Computer Vision is a field of AI which deals with understanding and extracting information from digital images and videos. This course provides an outline of important notions in the field of computer vision

c) Prerequisite:
10211BM204 - Image Processing

d) Related Courses:
10211BM204 - Image processing, Image analysis and machine vision

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

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Compare the various ways by which image stitching and image aligning algorithm is working	K2
CO2	Explain the need for segmentation in computer vision and compare the different segmentation algorithms applied to computer vision Solve problems on clustering algorithms	K3
CO3	Compare the various ways in which image stitching and image aligning algorithm is working	K2
CO4	Explain how deep learning is applied in computer vision	K3
CO5	Summarize the steps in creating a computer-aided diagnostic tool	K2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	-		1	-	-	-	-	-	-	-	-	2
CO2	3	2	-	2	1	-	-	3	-	-	-	-	-	2
CO3	3	-	-	-	-	-	-	-	-	-	-	-	-	2
CO4	3	2	-	-	-	-	-	-	-	-	-	-	-	2
CO5	3	2	-	-	2	-	-	-	-	-	-	-	-	2

f) Course Content

UNIT-1 TEXTURE REPRESENTATION 8 Hrs

Computer vision an Introduction, Local texture representation using filters- Spots and bars, Filter output to texture representation, Shape from texture-Shape from texture for planes, shape from texture for curved surfaces, Analysis and synthesis of texture

UNIT-II SEGMENTATION BY CLUSTERING 10 Hrs

Image segmentation by clustering pixels-Basic clustering methods, the watershed algorithm, Segmentation using K means, Clustering and segmentation with mean shift, Segmentation, clustering and graphs-Terminology and facts for graphs, Agglomerative Clustering with a graph, Divisive clustering with the graph

UNIT-III IMAGE ALIGNMENT AND STITCHING 9 Hrs

Pairwise alignment- 2D alignment using least squares, Iterative algorithms, Robust least squares and RANSAC. Image stitching- parametric motion models, Rotational panoramas, Gap closing, cylindrical and spherical coordinates. Global Alignment- bundle adjustment and parallax removal.

UNIT-IV INTRODUCTION TO DEEP LEARNING 10 Hrs

Introduction to Deep Neural Networks- Weights and layers, Activation functions, Regularization and normalization, Loss function, Back propagation. Convolutional Neural Networks- Pooling and Unpooling, Network Architectures, Application of CNN (Digit Classification). Introduction to 3D CNNs.

UNIT-V STEPS IN CREATING A CAD DIAGNOSTIC TOOL 8 Hrs

What is computer vision in healthcare, Key applications in healthcare, issues with medical image database, Data de-identification, Data annotation. Finding a AI Dataset, Computer vision algorithms-DeepNets

Total: 45 Hrs.

g) Learning Resources

Text Books

1. Szeliski, R. (2022). *Computer vision: algorithms and applications*. Springer Nature.

Reference Books

1. Steger, C., Ulrich, M., & Wiedemann, C. (2018). *Machine vision algorithms and applications*. John Wiley & Sons.
2. Raja, R., Kumar, S., Rani, S., & Laxmi, K. R. (Eds.). (2020). *Artificial intelligence and machine learning in 2D/3D medical image processing*. CRC Press.
3. Gonzalez, R. C. (2009). *Digital image processing*. Pearson education India.

LIST OF EXPERIMENTS

1. Bar and spot filters
2. Texture analysis with gray level co-occurrence matrix
3. Segmentation using K means
4. Agglomerative Clustering
5. Image stitching
6. Image alignement
7. U-Net for medical image segmentation
8. Cancer image annotation by software

Course Code	Course Title	L	T	P	C
10212BM209	GPU Architecture and Programming	3	0	2	4

a) Course Category

Specialization

b) Preamble

This course explores the basics of programming for heterogeneous architectures. Also, the course introduces different GPU programming models and the issues in mapping algorithms for GPUs.

c) Prerequisite

10210CS301 – Problem solving using C lab

d) Related Courses

10211BM107 - Microcontroller and Digital Signal Processor

e) Course Outcomes

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Describe GPU hardware and software architecture Solve problems on thread, block, gird associated with software abstraction/model/architecture Analyze how parallel processing is achieved through warps and threads	K3
CO2	Write simple CUDA programs for mathematical operations like addition and multiplication	K3
CO3	Comprehend different types of programming issues with respect to multiprocessor programming with GPU	K2
CO4	Compare the software model with OpenCL and GPU	K2
CO5	Explain how different algorithms written for CPU processing can be parallelized for GPU	K2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	-	-	-	-	-	-	-	-	-	-	-	1
CO2	3	3	-	3	3	-	-	2	2	-	-	-	-	1
CO3	3	-	-	-	1	-	-	1	1	-	-	-	-	1
CO4	3	2	-	-	-	-	-	2	2	-	-	-	-	1
CO5	3	3	2	-	3	-	-	2	2	-	-	-	-	1

f) Course content

UNIT I GPU ARCHITECTURE **10 Hrs**

Evolution of GPU architectures – Understanding Parallelism with GPU –Typical GPU Architecture – CUDA Hardware Overview – Threads, Blocks, Grids, Warps, Scheduling – Memory Handling with CUDA: Shared Memory, Global Memory, Constant Memory and Texture Memory.

UNIT II CUDA PROGRAMMING **9 Hrs**

Cuda programing template for Hello world, CUDA code for printing global thread ID, CUDA code for vector addition, CUDA code for matrix addition and Multiplication

UNIT III PROGRAMMING ISSUES **8 Hrs**

Common Problems: CUDA Error Handling-527, Parallel Programming Issues-536, Synchronization-537, Algorithmic Issues-544, Finding and Avoiding Errors-547.

UNIT IV OPENCL BASICS **9 Hrs**

Origin of OpenCL, CUDA and OpenCL correspondence, OpenCL-Platform model, execution model, memory model and programing model. OpenCL Host code and kernel code. Simple examples

UNIT V ALGORITHMS ON GPU **9 Hrs**

Parallel Patterns: Convolution, Prefix Sum, Sparse Matrix – Matrix Multiplication – Programming Heterogeneous Cluster (theoretical treatment).

Total 45 Hrs.

LIST OF THE EXPERIMENTS **15 hrs**

The following experiments to be done with both CUDA and OpenCL

1. CUDA Hello world program
2. Global thread ID computation for multi thread and block application
3. Vector addition

4. Vector multiplication
5. Matrix addition
6. Matrix multiplication

g) Learning Resources

Text Books

1. Shane Cook, CUDA Programming: ―A Developer's Guide to Parallel Computing with GPUs (Applications of GPU Computing), First Edition, Morgan Kaufmann, 2012.
2. David R. Kaeli, Perhaad Mistry, Dana Schaa, Dong Ping Zhang, ―Heterogeneous computing with OpenCL, 3rd Edition, Morgan Kauffman, 2015.

Reference Books

1. Nicholas Wilt, ―CUDA Handbook: A Comprehensive Guide to GPU Programming, Addison – Wesley, 2013.
2. Jason Sanders, Edward Kandrot, ―CUDA by Example: An Introduction to General Purpose GPU Programming, Addison – Wesley, 2010.
3. David B. Kirk, Wen-mei W. Hwu, Programming Massively Parallel Processors – A Hands-on Approach, Third Edition, Morgan Kaufmann, 2016.
4. http://www.nvidia.com/object/cuda_home_new.html
5. http://www.openCL.org

Course Code	Course Title	L	T	P	C
10212BM125	**Computing Architecture of Deep Learning**	**3**	**0**	**0**	**3**

a) Course Category
Specialization

b) Preamble
This course explores the basics of programming for heterogeneous architectures. Also, the course introduces different GPU programming models and the issues in mapping algorithms for GPUs.

c) Prerequisite
10210CS301 – Problem solving using C lab

d) Related Courses
10211BM107 - Microcontroller and Digital Signal Processor

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Describe GPU hardware and software architecture Solve problems on thread, block, gird associated with software abstraction/model/architecture Analyze how parallel processing is achieved through warps and threads	K3
CO2	Write simple CUDA programs for mathematical operations like addition and multiplication	K3
CO3	Comprehend different types of programming issues with respect to multiprocessor programming with GPU	K2
CO4	Compare the software model with OpenCL and GPU	K2
CO5	Explain how different algorithms written for CPU processing can be parallelized for GPU	K2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	-	-	-	-	-	-	-	-	-	-	-	1
CO2	3	3	-	3	3	-	-	2	2	-	-	-	-	1
CO3	3	-	-	-	1	-	-	1	1	-	-	-	-	1
CO4	3	2	-	-	3	-	-	2	2	-	-	-	-	1
CO5	3	3	2	-	3	-	-	2	2	-	-	-	-	1

f) Course content

UNIT I GPU ARCHITECTURE **10 Hrs**

Evolution of GPU architectures – Understanding Parallelism with GPU –Typical GPU Architecture – CUDA Hardware Overview – Threads, Blocks, Grids, Warps, Scheduling – Memory Handling with CUDA: Shared Memory, Global Memory, Constant Memory and Texture Memory.

UNIT II CUDA PROGRAMMING **9 Hrs**

Cuda programing template for Hello world, CUDA code for printing global thread ID, CUDA code for vector addition, CUDA code for matrix addition and Multiplication

UNIT III PROGRAMMING ISSUES **8 Hrs**

Common Problems: CUDA Error Handling-527, Parallel Programming Issues-536, Synchronization-537, Algorithmic Issues-544, Finding and Avoiding Errors-547.

UNIT IV OPENCL BASICS **9 Hrs**

Origin of OpenCL, CUDA and OpenCL correspondence, OpenCL-Platform model, execution model, memory model and programing model. OpenCL Host code and kernel code. Simple examples

UNIT V ALGORITHMS ON GPU **9 Hrs**

Parallel Patterns: Convolution, Prefix Sum, Sparse Matrix – Matrix Multiplication – Programming Heterogeneous Cluster (theoretical treatment).

Total: 45 Hrs.

g) Learning Resources

Text Books

1. Shane Cook, CUDA Programming: ―A Developer's Guide to Parallel Computing with GPUs (Applications of GPU Computing), First Edition, Morgan Kaufmann, 2012.
2. David R. Kaeli, Perhaad Mistry, Dana Schaa, Dong Ping Zhang, ―Heterogeneous computing with OpenCL, 3rd Edition, Morgan Kauffman, 2015.

Reference Books

1. Nicholas Wilt, ―CUDA Handbook: A Comprehensive Guide to GPU Programming, Addison – Wesley, 2013.
2. Jason Sanders, Edward Kandrot, ―CUDA by Example: An Introduction to General Purpose GPU Programming, Addison – Wesley, 2010.
3. David B. Kirk, Wen-mei W. Hwu, Programming Massively Parallel Processors – A Hands-on Approach, Third Edition, Morgan Kaufmann, 2016.
4. http://www.nvidia.com/object/cuda_home_new.html
5. http://www.openCL.org

Course Code	Course Title	L	T	P	C
10212BM205	Foundations of Data Science and R	3	0	2	4

a) Course Category
Honors Specialization

b) Preamble
To give insights about data science, tools for data science and R language

c) Prerequisite
None

d) Related Courses
None

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Get insights about data, data science basics and data science process	K2
CO2	Apply statistical techniques to interpret the given dataset	K3
CO3	Compute the statistical measures using Z scores, normalization, regression and correlation.	K3
CO4	Get insights about foundations of R, dataset creation; and work with graphs	K3
CO5	Do data management in R	K3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	-	-	-	-	-	-	1	-	3
CO2	3	2	-	-	3	-	-	-	-	-	-	1	-	3
CO3	3	2	-	-	3	-	-	-	-	-	-	1	-	3

CO4	3	-	-	-	3	-	-	-	-	-	-	1	-	3
CO5	3	1	-	-	3	-	-	-	-	-	-	1	-	3

f) Course content

UNIT I Introduction to Data and Data Science **9 Hrs**

Need for data science – benefits and uses – facets of data – data science process – setting the research goal – retrieving data – cleansing, integrating, and transforming data – exploratory data analysis – build the models – presenting and building applications

UNIT II Describing Data I – Descriptive Statistics **9 Hrs**

Frequency distributions – outliers – relative frequency distributions – cumulative frequency distributions – frequency distributions for nominal data – interpreting distributions – graphs – averages – mode – median – mean – averages for qualitative and ranked data – describing variability – range – variance – standard deviation – degrees of freedom – interquartile range – variability for qualitative and ranked data. Exercise problems.

UNIT III Describing Data II – Descriptive Statistics **9 Hrs**

Normal distributions – z scores – normal curve problems – finding proportions – finding scores – more about z scores – correlation – scatter plots – correlation coefficient for quantitative data – computational formula for correlation coefficient – regression – regression line – least squares regression line – standard error of estimate – interpretation of r2 – multiple regression equations – regression toward the mean. Exercise problems.

UNIT IV Introducing R, Dataset Creation and Graphs **9 Hrs**

Why use R - obtaining and installing R - working with R - R packages – batch processing - using output as input—reusing results - working with large datasets - Creating a dataset - understanding datasets - data structures – data input - entering and importing data - annotating datasets - useful functions for working with data objects - working with graphs - a simple example - graphical parameters - Adding text, customized axes, and legends - combining graphs

UNIT V Data Management in R **9 Hrs**

Creating new variables – recording and renaming variables – missing values – date values – type conversions – sorting data – merging datasets – subsetting datasets - Numerical and character functions - mathematical, statistical, probability, character, and other useful functions - applying functions to matrices and data frames - Control flow - Repetition and looping, conditional execution - user-written functions - aggregation and restructuring

Total: 45 Hrs.

LISTS OF THE EXPERIMENTS

1.Installation of R (Rstudio) and packages (tidyverse - ggplot2, tibble, tidyr, readr, purrr, and dplyr) – Basic Coding Syntax – Running R code

2. Creating matrices, arrays, data frame, and lists

3. Entering and importing data
4. Measures of central tendency and variability
5. Skewness, kurtosis and Correlation
6. Creating – Bar, box and dot plots – Pie charts – Histograms
7. Creating – Kernel density plots, scatter plots and line chart
8. Working with Messy data
9. Writing conditional statements and creating loops
10. SQL and R

Total: 30 hrs

g) Learning Resources

Text Books

1. Introducing Data Science, Davy Cielen, Arno D. B. Meysman, and Mohamed Ali, Manning Publications, 2016 – (Unit I)
2. Statistics, Robert S. Witte and John S. Witte, Wiley, Eleventh Edition, 2017 – (Unit – II and III)
3. R in Action - Data analysis and graphics with R, Robert I. Kabacoff, Manning Publications, 2011 – (Unit IV and Unit V)

Reference Books

1. Data Science and Predictive Analytics - Biomedical and Health Applications using R, Ivo D. Dinov, Springer, 2018
2. Practical Statistics for Data Scientists, Peter Bruce and Andrew Bruce, O'Reilly, 2017
3. R for Data Science - Import, Tidy, Transform, Visualize, and Model Data, Hadley Wickham and Garrett Grolemund, O'Reilly, 2017
4. Practical Data Science with R, Nina Zumel and John Mount, Manning Publications, Second Edition, 2020

Web Links

- R Fundamentals - http://becomingvisual.com/rfundamentals/conditionals-controls-functions.html
- R for Data Science - https://r4ds.had.co.nz/program-intro.html
- Data Science Tutorials - https://www.simplilearn.com/tutorials/data-science-tutorial/linear-regression-in-r?source=sl_frs_nav_playlist_video_clicked

Course Code	Course Title	L	T	P	C
10212BM111	**Inferential Analysis and Machine Learning**	**3**	**0**	**0**	**3**

a) Course Category
Honors Specialization

b) Preamble
To give insights about inferential data analysis using machine learning

c) Prerequisite
10212BM201 - Foundations of Data Science and R

d) Related Courses
None

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Summarize the fundamentals of probability and inference statistics	K2
CO2	Apply appropriate statistical inference methods for numerical data using t-tests, paired tests, and ANOVA.	K3
CO3	Prepare data for regression analysis, and estimate and interpret a regression model	K3
CO4	Get insights about machine learning fundamentals and apply supervised learning process for biomedical use	K3
CO5	Apply unsupervised learning process, in machine learning, for biomedical use	K3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	-	-	-	-	-	-	-	-	-	2	-	3
CO2	3	2	-	-	-	-	-	-	-	-	-	2	-	3

CO3	3	2	-	-	-	-	-	-	-	-	-	2	-	3
CO4	3	2	-	-	2	-	-	-	-	-	-	2	-	3
CO5	3	2	-	-	2	-	-	-	-	-	-	2	-	3

f) Course content

UNIT I Probability and Inference Basics **9 Hrs**

Probability - defining probability - conditional probability - sampling from a small population - random variables - continuous distributions - distributions of random variables - normal distribution - evaluating the normal approximation - geometric distribution - binomial distribution - more discrete distributions. Foundations for inference - variability in estimates - confidence intervals - hypothesis testing - examining the central limit theorem - inference for other estimators

UNIT II Inferential Statistics **9 Hrs**

Inference for numerical data - one-sample means with the t-distribution - paired data - difference of two means - power calculations for a difference of means - comparing many means with ANOVA - exercises. Inference for categorical data - inference for a single proportion - difference of two proportions - testing for goodness of fit using chi-square - testing for independence in two-way tables - small sample hypothesis testing for a proportion - randomization test – exercises

UNIT III Regression **9 Hrs**

Introduction to linear regression - line fitting, residuals, and correlation - fitting a line by least squares regression - types of outliers in linear regression - inference for linear regression – exercises, case study – predicting medical expenses using linear regression. Multiple and logistic regression - introduction to multiple regression - model selection - checking model assumptions using graphs - introduction to logistic regression – exercises.

UNIT IV Machine Learning – I **9 Hrs**

Origins of machine learning - how machines learn - data storage, abstraction, generalization, evaluation - machine learning in practice - types of input data, types of machine learning algorithms, matching input data to algorithms - lazy Learning – classification using nearest neighbors -understanding nearest neighbor classification - the k-NN algorithm - measuring similarity with distance - choosing an appropriate k - preparing data for use with k-NN - why is the k-NN algorithm lazy? – case study – diagnosing breast cancer with the k-NN algorithm.

UNIT V Machine Learning – II **9 Hrs**

Clustering with k-means - understanding clustering - clustering as a machine learning task - the k-means clustering algorithm - using distance to assign and update clusters - choosing the appropriate number of clusters. probabilistic learning - understanding naive Bayes - basic concepts of Bayesian methods -understanding probability - understanding joint probability - computing conditional probability with Bayes' theorem - the naive Bayes algorithm - classification with naive Bayes - the Laplace estimator - using numeric features with naive Bayes – case study – simple medical data mining with the naïve Bayes algorithm.

Total: 45 Hrs.

g) Learning Resources

1. OpenIntro Statistics, David M Diez, Christopher D Barr, Mine Cetinkaya-Rundel, Third Edition, 2015 – (Unit I-III)
2. Machine Learning With R, Brett Lantz, Packt Publishing, Third Edition, 2019 – (Unit IV-V)

Reference Resources

1. Statistics, Robert S. Witte and John S. Witte, Wiley, Eleventh Edition, 2017
2. Data Science and Predictive Analytics - Biomedical and Health Applications using R, Ivo D. Dinov, Springer, 2018
3. Machine Learning for Predictive Data Analytics, John D. Kelleher, Brian Mac Namee and Aoife D'Arcy, MIT Press, 2015

Web Link

1. OpenIntro Statistics - https://www.openintro.org/book/os/
2. Data Analysis and Machine Learning Using R: Biomedial Data- https://rpubs.com/thanrajks/med-ana

Course Code	Course Title	L	T	P	C
10212BM112	**Precision Medicine in Chronic Diseases**	**3**	**0**	**0**	**3**

a) Course Category
Honors Specialization

b) Preamble
To give insights about precision medicine in chronic disease

c) Prerequisite
10212BM201 - Foundations of Data Science and R

d) Related Courses
None

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Summarize the concept of Precision medicines and precision healthcare technology	K2
CO2	Explain the role of epigenetics in precision medicine	K2
CO3	Apply R language for EHR and Big Data	K3
CO4	Explain the role of Precision medicine in Oncology	K2
CO5	Comprehend the role of Precision medicine in Cardiovascular Prevention	K2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	-	-	-	-	-	-	-	-	1	1	-	3
CO2	3	1	-	-	-	-	-	-	-	-	1		-	3
CO3	3	1	-	-	-	-	-	-	-	-	1	1	-	3
CO4	3	1	-	-	-	-	-	-	-	-	1	-	-	3

CO5	3	1	-	-	-	-	-	-	-	-	1	-	-	3

f) Course content

Unit I Progress and challenges in Precision medicine **9 Hrs**

Introduction to Precision Medicine - Personalized medicine Vs Precision medicine, Precision medicine in complex chronic disease, Precision medicine initiatives and Programs, The Role of electronic health record data - Small data, Big data and data analytics in precision healthcare technology, Mobile technology and EHRs in personalized healthcare technology, Role of mobile technology in diabetes control and other diseases, Remote patient monitoring.

UNIT II Epigenetics in Precision Medicine **9 Hrs**

Introduction-Genetics-Epigenetics-Biomarkers-Genomics-Proteomics, Epigenetic Biomarkers and in Vitro Diagnostics, Epigenetic Biomarkers-an overview of recent advances, Epigenetics in precision medicine of breast cancer-DNA methylation, -DNA methylation as a biomarker for breast cancer.

UNIT III Big Data in Precision Medicine **9 Hrs**

The Concept of Big Data and the Specificities of Healthcare-Volume, Variety, Velocity, Variability, Veracity , Value, Sources of Data, Big Data Analytical Techniques, Representation of Big data and EHR using R language, Challenges in Big Data Analytics.

UNIT IV Precision Medicine in Oncology **9 Hrs**

Introduction- Definition of Precision Medicine in Oncology,-DNA and RNA Sequencing Techniques, Precision Medicine in Specific Tumors- Lung Cancer, Head and Neck cancers, Blood-Based Biomarkers for the Diagnosis and Prognosis of Cancer ;Importance of Blood-Based Biomarkers – Circulating Proteins as Biomarkers, Circulating Tumor DNA as Biomarkers; Challenges of Precision Oncology

UNIT V Precision Medicine in Cardiovascular Prevention **9 Hrs**

Social Determinants of Health and Cardiovascular Care: A Historical Perspective, Biomarkers-Lipid Biomarkers and Cardiovascular Risk, Cardiac Biomarkers in Hypertension, Cardiac Biomarkers in Aortic Stenosis, Cardiac Biomarkers in Heart Failure, Atherosclerosis Imaging-Proposed Tools for Personalizing Risk Estimation.

Total: 45 Hrs.

g) Learning Resources

Reference Books

1. Paul Cerrato:John D Halamka.”Realizing the Promise of precision medicine:the role of patient data,mobile technology and consumer engagement.London ,United Kingdom:Academic Press is an imprint of Elsevier,[2018].(Unit I)
2. Bullet Aydogan,JamesA.Radosevich”Precision Medicine in Oncology” Wiley Blackwell,2021(Unit III and Unit IV)

3. Luis García-Giménez , J. (2022).” Epigenetics in Precision Medicine”,2022(Unit II)
4. Seth S.Matin”Precision Medicine in Cardiovascular Disease Prevention”,Springer,2021.(Unit V)

Web Links

1. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0171784
2. rEHR: An R package for manipulating and analysing Electronic Health Record data (nih.gov)

Course Code	Course Title	L	T	P	C
10212BM301	**Inferential Medical Data Analytics Using R**	**0**	**0**	**4**	**2**

a) Course Category
Honors Specialization/Lab

b) Preamble
To give hands-on-experience on the analysis of medical data using R language

c) Prerequisite
10212BM201 - Foundations of Data Science and R

d) Related Courses
None

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

CO Nos.	Course outcomes	Skill Level (Dave'sTaxonomy)
1	Create a function and Arrays for EHR data in R	S2
2	Perform matrix operations in R	S3
3	Perform Regression and distribution using R	S3
4	Implement ANOVA test and Machine learning	S3
5	Implement Machine Learning classification using R	S3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	-	-	3	-	-	-	-	-	-	1	-	3
CO2	3	1	-	-	3	-	-	-	-	-	-	1	-	3
CO3	3	1	-	-	3	-	-	-	-	-	-	1	-	3
CO4	3	1	-	-	3	-	-	-	-	-	-	1	-	3
CO5	3	1	-	-	3	-	-	-	-	-	-	1	-	3

LIST OF EXPERIMENTS

1. a) Creating and Calling R-Function
   b) Implementing Matrix operations in R
2. a) Creating Arrays in R
   b) Mean, Median and Mode in R language
3. Operation on Linear Regression
4. Operation on Multiple and Logistic Regression
5. Analyzing Normal and Binomial Distribution using R
6. Performing ANOVA test for EHR data in R
7. Supervised Learning for Cancer epidemiological data in R
8. K-NN classifier for an EHR data in R
9. Naïve Bayes Classification for epidemiological data on COVID-19 using R
10. Implementing K-means clustering for an EHR data using R

Total: 60 Hrs

Web Links:

1. https://www.tutorialspoint.com/r/index.htm
2. https://www.geeksforgeeks.org/introduction-to-machine-learning-in-r/?ref=lbp

Course Code	Course Title	L	T	P	C
10212BM113	Predictive Analysis of Medical Data	3	0	0	3

a) Course Category
Honors Specialization

b) Preamble
To give insights of analysis of medical data

c) Prerequisite
10212BM111-Inferential Analysis and Machine Learning

d) Related Courses
None

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Summarize the concept of supervised learning and kernel classifiers.	K3
CO2	Apply the decision tree algorithm for various applications.	K3
CO3	Compare the various dimensionality reduction techniques and do case study in biomedical applications.	K3
CO4	Comprehend the usage of data in personalized medicine	K2
CO5	Use clinical decision support system frameworks to address real-world healthcare problems.	K2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	-	-	-	-	-	-	-	-	-	2	-	2
CO2	3	2	-	-	-	-	-	-	-	-	-	2	-	2
CO3	3	2	-	-	-	-	-	-	-	-	-	2	-	2

CO4	3	2	-	-	-	-	-	-	-	-	-	2	-	2
CO5	3	2	-	-	-	-	-	-	-	-	-	2	-	2

f) Course content

UNIT I Introduction to Supervised Learning and Classifiers 9 Hrs

Supervised learning - types - Vapnik-Chervonenkis Dimension – Learning multiple classes – Model selection and Generalization – Dimensions of a Supervised machine learning algorithm. SVM - Binary Classification-Classification with Hyperplanes-Multi-class classification-Algorithm implementation to SVM. Case study-prediction of metastasis of colorectal cancer.

UNIT II Decision Trees 9 Hrs

Decision tree-Divide and conquer-Entropy-Misclassification error and Gini index-C5.0 Decision tree algorithm-Pruning the decision tree-Comparing different impurity indices-Classification rules, case study- Predicting disease and outcome using decision trees-Random Forest classifier, case study- Personalized risk prediction in clinical oncology.

UNIT III Dimensionality Reduction Technique 9 Hrs

Dimensionality reduction- definition and application- Reducing dimension- Matrix rotation-Notation; Principal Component Analysis (PCA)- Principal Components- using PCA; case study-estimating outcome of biomechanical factors in cutting, automatic recognition of arrhythmia.

UNIT IV Analysis of Healthcare Data 9 Hrs

Biomedical Image Analysis - Mining of sensor data in healthcare - Biomedical Signal Analysis-Data analytics for Pervasive Health-Fraud detection in healthcare-Data analytics for pharmaceutical discoveries.

UNIT V Applications 9 Hrs

Genomic Data Analysis for Personalized Medicine, Clinical Prediction model, Predicting models for Integrating clinical and genomic data. Clinical decision support systems-Computer-assisted medical image analysis system-Mobile imaging and analytics of Biomedical Data.

Total: 45 Hrs

g) Learning Resources

Text Books

1. Data Science and Predictive Analytics - Biomedical and Health Applications using R, Ivo D. Dinov, Springer, 2018
2. Machine Learning for Predictive Data Analytics, John D. Kelleher, Brian Mac Namee and Aoife D'Arcy, MIT Press, 2015
3. Introduction to Machine Learning, Ethem Alpaydin, Third Edition, 2014

Reference Books

1. Learning with Support Vector Machines, Colin Campbell, Yiming Ying, 2011
2. Pattern Recognition and Machine Learning, Christopher M Bishop, Springer, 2006
3. Healthcare Data Analytics, Chandan K. Reddy and Charu C Aggarwal, Taylor & F

Course Code	Course Title	L	T	P	C
10212BM114	Healthcare Operations Research	3	0	0	3

a) Course Category
Honors Specialization

b) Preamble
The students will gain insight into the health care operational research

c) Prerequisite
10212BM111-Inferential Analysis and Machine Learning

d) Related Courses
None

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Illustrate the significance of Operations Research in healthcare systems.	K2
CO2	Identify analytical, quality and lean tools for performance improvement.	K2
CO3	Summarize linear programming, decision analysis, and queueing theory techniques for decision-making problems.	K2
CO4	Classify various Operations Research techniques along with their applications.	K2
CO5	Summarize the applications of Operations Research in the medical field.	K2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	-	-	-	-	-	-	-	-	-	2	-	2
CO2	3	2	-	-	-	-	-	-	-	-	-	2	-	2

CO3	3	2	-	-	-	-	-	-	-	-	-	2	-	2
CO4	3	2	-	-	-	-	-	-	-	-	-	2	-	2
CO5	3	1	-	-	-	-	-	-	-	-	-	-	-	2

f) Course content

UNIT I Introduction to Operations Research **9 Hrs**

OR- Definition, history, scope and limitation- Problem-solving and decision-making using OR. Methods-Multi-criteria decision analysis, linear and non-linear programming, discrete-event simulation, queuing and stochastic process modeling, conjoint analysis, neural networking. Process of Operational Research in Healthcare.

UNIT II Performance improvement tools, techniques and programs **9 Hrs**

Problem identification tools- Root-cause analysis, Failure mode and effect analysis, theory of constraints. Analytical tools- Optimization, linear programming, sensitivity analysis, decision analysis. Quality management- Defining quality, cost of quality, Six Sigma. Lean- type of waste.

UNIT III OR Techniques I **9 Hrs**

Techniques: Linear programming-Construction of models, Finding solution, Types, Application in Healthcare; Decision analysis – Decision marketing problems, decision making process, decision making environment, decision under uncertainty, decision under risk, decision tree analysis; Queueing theory – Elements, Characteristics, probability distribution.

UNIT IV OR Techniques II **9 Hrs**

Markov Decision process– Modeling, types of results, modification and extension, application in personalized medicine. Game theory- key concepts, information economics, applications- Incentive design for healthcare providers. Queuing theory- components of Queuing system, queuing models, applications. Network models: PERT/CPM-Advantages, limitations, differences, resource allocation; Demand Forecasting- Qualitative and quantitative approaches.

UNIT V Application in Hospital and healthcare **9 Hrs**

Deceased donor organ allocation system, healthcare supply chain management, POMDP model for personalized breast cancer screening, Subtype based treatment for DLBCL, managing patient flow, improving ambulance operation using simulation.

Total: 45 Hrs

g) Learning Resources

Text Books

1. Handbook of Healthcare analytics, Tinglong Dai, Sridhar Tayur, Wiley, 2008
2. Healthcare Operations Management, Daniel B McLaughlin, Julie M Hays, 2008
3. Operations Management in Healthcare, Corinne M Karuppan, Nancy E Dunlap, Michael R Waldrum, Springer, 2016

Reference Books

1. Handbook of healthcare operations management: Methods and applications, Brian T Denton, Springer, 2013.
2. Operations Research: An introduction, Hamdy A Taha, 10th edition, 2017
3. Operations Research, P. Rama murthy, 2nd Edition, 2008

Course Code	Course Title	L	T	P	C
10212BM115	**Medical Data Analytics**	**3**	**0**	**0**	**3**

a) Course Category

Honors Specialization

b) **Preamble**

This course deals with the fundamentals of predictive analysis and its application in healthcare.

c) **Prerequisite**

10212BM111 - Inferential Analysis and Machine Learning

d) **Related Courses**

None

e) Course Outcomes

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

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Interpret the principles of Supervised learning and kernel-based classification.	K3
CO2	Apply decision tree algorithms for solving classification and prediction problems.	K3
CO3	Comprehend dimensionality reduction methods for effective data analysis.	K2
CO4	Identify datasets using data mining techniques for fraud prevention and infectious disease identification.	K2
CO5	Summarize recent technologies adopted for data analysis in healthcare applications.	K2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	-	-	-	-	-	-	-	-	-	2	-	2
CO2	3	2	-	-	-	-	-	-	-	-	-	2	-	2
CO3	3	2	-	-	-	-	-	-	-	-	-	2	-	2

CO4	3	2	-	-	-	-	-	-	-	-	-	2	-	2
CO5	3	2	-	-	-	-	-	-	-	-	-	2	-	2

f) Course content

UNIT I Introduction to Supervised Learning and Classifiers **9 Hrs**

Supervised learning - types - Vapnik-Chervonenkis Dimension – Learning multiple classes – Model selection and Generalization – Dimensions of a Supervised machine learning algorithm. SVM - Binary Classification-Classification with Hyperplanes - Multi-class classification-Algorithm implementation to SVM. Case study-prediction of metastasis of colorectal cancer.

UNIT II Decision Trees **9 Hrs**

Decision tree- Divide and conquer-Entropy-Misclassification error and Gini index-C5.0 Decision tree algorithm-Pruning the decision tree-Comparing different impurity indices-Classification rules, case study- Predicting disease and outcome using decision trees-Random Forest classifier, case study- Personalized risk prediction in clinical oncology.

UNIT III Dimensionality Reduction Technique **9 Hrs**

Dimensionality reduction- definition and application- Reducing dimension- Matrix rotation-Notation; Principal Component Analysis (PCA)- Principal Components - using PCA; case study - estimating outcome of biomechanical factors in cutting, automatic recognition of arrhythmia.

UNIT IV Biomedical Data Analysis **9 Hrs**

Biomedical Image Analysis - Biomedical Imaging Modalities, Object Detection, Image Segmentation and Registration, and Feature extraction. Biomedical Signal Analysis - Types of Biomedical Signals, ECG signal Analysis, Denoising of Signals, Multivariate Biomedical Signal Analysis and Recent Trends.

UNIT V Healthcare Data Analysis **9 Hrs**

Mining of sensor data in healthcare - Scope, Challenges in Healthcare Data Analysis, Sensor Data Mining Applications and Nonclinical Healthcare Applications. Fraud Detection in Healthcare - Definition, Types, Identifying Healthcare Fraud from Data, Knowledge Discovery-Based Solutions for Identifying Fraud. Social Media Analytics for Healthcare - Social Media Analysis for Detection and Tracking of Infectious Disease, Social Media Analysis for Public Health Research and Analysis of Social Media Use in Healthcare

Total: 45 Hrs

g) Learning Resources

Text Books

1. Data Science and Predictive Analytics - Biomedical and Health Applications using R, Ivo D. Dinov, Springer, 2018
2. Machine Learning for Predictive Data Analytics, John D. Kelleher, Brian Mac Namee and Aoife D'Arcy, MIT Press, 2015
3. Introduction to Machine Learning, Ethem Alpaydin, Third Edition, 2014

Reference Books

1. Learning with Support Vector Machines, Colin Campbell, Yiming Ying, 2011
2. Pattern Recognition and Machine Learning, Christopher M Bishop, Springer, 2006
3. Healthcare Data Analytics, Chandan K. Reddy and Charu C Aggarwal, Taylor & Francis,

Course Code	Course Title	L	T	P	C
10213BM110	Neurophysiology	2	0	0	2

a) Course Category
Minor Specialization

b) Preamble
This course will provide the basic functioning of cerebral cortex and its peripherals.

c) Prerequisite
None

d) Related Courses
None

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

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Comprehend the physiology of neural conduction	K2
CO2	Summarize the structure and function of cerebral cortex	K2
CO3	Discuss the neural pathway for visual, auditory and proprioceptive stimulus.	K2
CO4	Compare the types of motor controls and feedback	K2
CO5	Summarize the motor control functions	K2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	-	-	-	-	-	-	-	-	-	1	-	2
CO2	3	1	-	-	-	-	-	-	-	-	-	2	-	2
CO3	3	1	-	-	-	-	-	-	-	-	-	2	-	2
CO4	3	1	-	-	-	-	-	-	-	-	-	2	-	2
CO5	3	1	-	-	-	-	-	-	-	-	-	2	-	2

f) Course content

UNIT-1: Neurons and Neuronal Potentials **6 Hrs**

Structure of the neuron - myelinated and non-myelinated, flow of electrical impulse through the nerves, nerve fibres as cables. Nerve impulse - Membrane potential and Action potential, propagation of action potentials, monophasic and biphasic action potentials, threshold - all or none law, refractory period. Neural codes - frequency, spatial, conduction velocity and capacitance. Definitions - Neuromuscular junction, synapses and neurotransmitters.

UNIT 2: Anatomy and Physiology of the cerebral cortex **6 Hrs**

Histology, lobes, Cerebral dominance, Brodmann areas. Physiology: Frontal lobe - precentral and prefrontal area, Parietal lobe - somesthetic areas, Temporal lobe- Primary and secondary auditory areas and equilibrium, Occipital lobe - visual area.

UNIT-III: Proprioceptive functions **6 Hrs**

Muscle proprioception - spindle, golgi tendon; Joint receptors; Conscious proprioception; Vestibular apparatus.

Temporal coding for low frequency sound, central pathways and responses.

Vision - neural processing

UNIT-IV: Motor control and feedback **6 Hrs**

Ballistic, Parametric adjustment, direct feedback, internal feedback, Hierarchy of control, functional characteristics of different levels.

UNIT-V: Motor functions **6 Hrs**

Local motor control - sensory feedback from muscles - golgi tendon and muscle spindles - spinal reflex, muscle tone, servo hypothesis, load, servo-assistance. posture control.

Higher motor control - components of voluntary action, Primary motor cortex - cortical influence in spinal cord, somatosensory input and manipulation

Total:30 Hrs

g) Learning resources

Reference Book

1. Neurophysiology a conceptual approach by Carpenter, Roger H. S. Reddi, Benjamin

Course Code	Course Title	L	T	P	C
10213BM111	Introduction to BCI and Signal Acquisition Methods	3	0	0	3

a) Course Category
Minor Specialization

b) Preamble
This course will provide the basic knowledge of types of BCI, brain acquisition modalities and types of brain signal used for BCI applications

c) Prerequisite
None

d) Related Courses
None

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

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Summarize the importance of BCI and the different types of BCI	K2
CO2	Differentiate the principles of non-invasive BCI signal acquisition methods	K2
CO3	Compare the Non-invasive type of BCI signal acquisition and their instrumentation based on metabolic activity of brain and electric potential from brain	K3
CO4	Identify the appropriate stimulation methods for various BCI applications	K2
CO5	Compare the various brain signals used for BCI application	K3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	-	-	1	1	-	1	2	1	-

CO2	3	2	-	-	-	-	-	1	1	-	1	2	2	-
CO3	3	-	-	-	-	-	-	1	1	-	1	2	2	-
CO4	3	-	-	-	-	-	-	1	1	-	1	2	1	-
CO5	3	2	-	-	-	-	-	1	1	-	1	2	2	-

f) Course content

UNIT-I Introduction to BCI **9 Hrs**

BCI-definition, objectives, advantage of BCI, BCI Vs neuroprosthetics, BCI components, BCI types: based on recordings-Invasive, non-invasive and semi invasive, BCI that stimulate, bidirectional and recurrent BCI.

UNIT-II Recording of signal Invasive method **6 Hrs**

Introduction - Electrode theory and types of electrode, Unipolar and Bipolar Electrodes. Invasive: Microelectrodes, Intracellular Recording, Extracellular Recording, Multielectrode Arrays, Electrocorticography (ECoG)-electrode placement, Working principle, Recording setup, Micro ECoG.

UNIT-III Recording of signal Non Invasive method **12 Hrs**

Non-Invasive: Electroencephalography (EEG)-EEG-EEG electrodes-10-20 standard system, EEG acquisition-Hardware, EEG rhythms & artifacts, EEG Recording setup; Magnetoencephalography (MEG)-working principle-Recording setup-importance of MEG; Functional Magnetic Resonance Imaging (fMRI)-Principles of FMRI, Recording setup, Imaging techniques, Advantages and disadvantages;, Functional Near Infrared (fNIR) Imaging-working principle & recording setup; PET-working principle & recording setup.

UNIT-IV Stimulating the signal **7 Hrs**

Invasive: Microelectrodes, Direct Cortical Electrical Stimulation (DCES), Optical Stimulation
Non-Invasive: Transcranial Magnetic Stimulation (TMS), Transcranial Ultrasound Simultaneous Recording and Stimulation: Multielectrode Arrays, Neurochip. Stimulus design - checkerboard and RSVP

UNIT-V Brain signals for BCI **11 Hrs**

BCI using Evoked potential-P300, ODDBALL Paradigm, P300 Origin & function, Amplitude and SSVEP
BCI using sensory motor rhythm-sensory motor behavior,MI movements & slow cortical potential
BCI signals from inside-ECoG & brain metabolic activity-fMRI & fNRI signal

Total:45 Hrs

g) Learning Resources

1. Introduction to Non-Invasive EEG-Based Brain-Computer Interfaces for Assistive Technologies by Teodiano Freire Bastos-Filho (editor)
2. Brain-Computer Interfacing an Introduction by Rajesh P. N. Rao

3. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7283463/pdf/fnbot-14-00025.pdf
4. Medical Instrumentation by John G Webster.

Course Code	Course Title	L	T	P	C
10213BM112	Digital Signal Processing	3	1	0	4

a) **Course Category**
Minor Specialization

b) **Preamble**
This course provides the basic knowledge on the required mathematics for the process of analog and digital signals

c) **Prerequisite**
None

d) **Related Courses**
Microprocessor and Microcontroller, Image Processing

e) **Course Outcomes**
Upon the successful completion of the course, students will be able to:

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Classify the continuous/discrete time signals/systems from the given equation according to their properties	K3
CO2	Compute the spectrum of periodic and aperiodic signals using Continuous and Discrete Fourier Transform	K3
CO3	Solve problems on analog to digital signal conversion, Aliasing and identify the signal using Fourier transform	K3
CO4	Design FIR filter for the given specification	K3
CO5	Design IIR filter for the given specification	K3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	-	-	-	-	-	1	1	-	-	2	-	1
CO2	2	1	-	-	-	-	-	1	1	-	-	2	-	1
CO3	2	2	-	-	-	-	-	1	1	-	-	2	-	1
CO4	2	2	1	1	2	-	-	1	1	-	-	2	-	1
CO5	2	2	1	1	2	-	-	1	1	-	-	2	-	1

f) **Course content**

UNIT-I Classification of signals and systems **12 Hrs**

Continuous Time signals (CT signals) – Discrete Time signals (DT signals) – Elementary CT signals and DT signals – Basic properties of signals , Classification of CT and DT signals – Basic properties of systems – Classification CT systems and DT systems – Linear time invariant systems and properties

UNIT-II Signal and system analysis (CT and DT) **12 Hrs**

Fourier Transform in signal analysis and system analysis, convolution integral and impulse response, Fourier transform of discrete sequence, Z-transform and its properties, inverse z-transforms; Stability analysis, frequency response – Convolution..

UNIT-III Representation of discrete time signals and FFT **12 Hrs**

Sampling of Continuous Time signals and aliasing –z transform in Discrete Time signal analysis, Discrete Fourier Transform, (DFT), DFT for periodic sequence, Fast Fourier Transform (FFT), Butterfly Diagram, Convolution through FFT

UNIT-IV Design of FIR Filters **12 Hrs**

FIR design: Windowing Techniques - Rectangular, Hamming, Hanning – Need and choice of windows – Linear phase characteristics.

UNIT-V Design of IIR Filters **12 Hrs**

IIR design: Analog filter design - Butterworth filter design using impulse invariant and bilinear transformation - Warping, prewarping - Frequency transformation..

Total: 60 Hrs

g) **Learning Resources**

Text Books

1. Haykin " Signals and Systems", Khanna Publishers, 2000
2. Proakis, J. G. and Manolakis, D. G "Digital Signal Processing Principles, Algorithms and Applications", Pearson Publishers, 2003

Reference Books

1. Ashok Ambardar, "Analog and Digital Signal Processing", Thomson Learning Inc., 1999
2. Douglas K.Lindner, "Signals and Systems", McGraw-Hill International, 1999.
3. Mithrs S.K, "Digital Signal Processing –A Computer Based Approach, Tata McGraw Hill Publications, New Delhi 2001
4. Allan V. Oppenheim et al, "Signals and Systems", 2nd edition, Prentice Hall of India Pvt. Ltd, 2004

Course Code	Course Title	L	T	P	C
10213BM203	BCI Feature Extraction & Translation	3	0	2	4

a) Course Category
Minor Specialization

b) **Preamble**
This course provides basic knowledge on the commonly used feature extraction and translation techniques

c) Prerequisite
10211BM108 - Digital Signal Processing

d) Related Courses
None

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Choose a proper signal conditioning method for BCI input signal	K3
CO2	Determine a proper feature extraction technique for BCI application	K3
CO3	Select a proper Classification method	K4
CO4	Examine the performance of the translational algorithm	K3
CO5	Demonstrate the EEGLAB toolbox for EEG signal analysis	K3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	-	-	2	-	-	1	1	-	-	3	-	2
CO2	2	2	-	-	2	-	-	1	1	-	-	3	-	2
CO3	2	2	1	-	2	-	-	1	1	-	-	3	-	2
CO4	2	2	-	-	2	-	-	1	1	-	-	3	-	2
CO5	1	2	-	-	2	-	-	1	1	-	-	2	-	2

f) **Course content**

UNIT-I Principles of Signal Processing & Signal Conditioning 12 Hrs

Analog-To-Digital Conversion-*Sampling, Quantization,* Fourier Analysis, Digital filtering-FIR, IIR. Frequency-Range Prefiltering, Data Decimation and Normalization, Spatial Filtering-Data-Independent Spatial Filters, Data-Dependent Spatial Filters-Bipolar, Laplacian and common average referencing (CAR), ICA, PCA, CSP, Detection and removal of environmental interference and biological artifacts-50/60-Hz power-line interference, EMG and EOG activities and eye blinks- thresholding, band stop and notch filter

UNIT-II Feature extraction techniques in BCI 10 Hrs

Time (Temporal) Features- Hjorth Parameters, peak-picking and integration, Correlation and Template-Matching, Frequency (Spectral) Features-Band Power, Fast Fourier Transform, Autoregressive Modelling, Time-Frequency Features (Wavelets), Similarity Features- Phase Locking Value, Coherence, Mahalanobis Distance

UNIT-III Feature conditioning and translation methods in BCI 9 Hrs

Normalization, Log-Normal Transforms, Feature Smoothing, PCA, ICA, General principles-discriminative model and regression model, variations in the data, supervised and unsupervised learning, Linear models-linear discriminant analysis (LDA), Naïve Bayesian classifiers, support vector machines, Non-linear model-KNN, ANN

UNIT-IV Evaluating Translational Algorithm 8 Hrs

Measuring performance- Accuracy, confusion matrix, kappa co-efficient, minimizing error versus minimizing complexity, BIT rate, Offline evaluation-cross validation, evaluating specific aspects of translational algorithm

UNIT-V EEGLAB toolbox 6 Hrs

Dataset management, import data, preprocess data, reject artifacts, extract data epochs, plot data.

Total: 45 Hrs

List of Experiments

1. Design FIR and IIR bandpass filters for filtering in a particular frequency band.
2. Comparison of FIR and IIR filters.
3. Design a spatial filter for extracting the motor imagery features.
4. Removal of biological artifacts/environmental interference.
5. Extract the features using the time-frequency method from the EEG signal
6. Extract the features based on the band power of the signal
7. Topoplot
8. Design LDA classifier for classifying two classes
9. Design KNN classifier for the two-class separation

Total: 30 Hrs

g) Learning Resources

1. Brain-Computer Interfaces: Principles and Practice by Jonathan R. Wolpaw & Elizabeth Winter Wolpaw
2. Brain-Computer Interfacing- An Introduction by Rajesh P. N. Rao
3. Dataset management - EEGLAB Wiki

Course Code	Course Title	L	T	P	C
10213BM302	BCI Data Analysis with MNE	0	0	2	1

a) Course Category
Minor Specialization/Lab

b) **Preamble**
This course provides basic knowledge on the commonly used feature extraction and translation techniques

c) Prerequisite
Neurophysiology, Digital Signal Processing

d) Related Courses
BCI signal processing

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

CO Nos.	Course outcomes	Skill Level (Dave'sTaxonomy)
CO1	Identify EEG data from given file format	S2
CO2	Extract and analyze the information from EEG signal dataset	S2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	-	-	-	-	1	1	2	2	-	1	2	1	1
CO2	2	1	-	-	1	1	1	2	2	-	1	2	1	2

List of Experiments
Cycle-1

S. No	Experiment	Skill Level
1	Study of importing different data – EEG and fNIRS	S1
2	Raw data Structure a) loading continuous data b) Querying raw object	S2

3	Modifying Raw objects a) Selecting, dropping and re ordering channels b) changing name or type c) selection in time domain	S2
4	Extraction of data from raw objects and exporting a) Extracting data by index b) extracting channels by name c) extracting channels by type d) raw.get_data()method e) summary f) exporting and saving	S2

Cycle-2

	Experiment	Skill Level
5	Event Handling a) read or write event from or to the file b) subselect or combine event c) mapping event to description d) plotting events e) event arrays	S2
6	Annotating continuous data a) creating annotations b) operations on annotations objects (overlapping annotations) c) reading or writing annotations from or to a file	S2
7	plotting methods for raw objects a) plot as time series b)plot spectral density c) plot sensor locations and projections	S2

Total: 30 Hrs

Course Code	Course Title	L	T	P	C
10213BM113	BCI-Applications and Ethics	3	0	0	3

a) Course Category

Minor Specialization

b) **Preamble**

This course will provide knowledge on current applications of BCI and the ethics to be followed in designing BCI systems

c) Prerequisite

None

d) Related Courses

None

e) Course Outcomes

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Comprehend the importance of evaluating the BCI systems clinically	K2
CO2	Apply the BCI concepts for rehabilitation with case studies	K3
CO3	Summarize the applications of BCI in therapy	K2
CO4	Differentiate the medical and non-medical applications of BCI	K2
CO5	Apply necessary ethics to be followed for designing practical applications of BCI with case studies	K3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	1	-	1	1	-	-	1	-	-
CO2	3	2		1	-	1	-	1	1	-	1	2	-	1
CO3	3	2	-	1	-	1	-	1	1	-	1	3	-	1
CO4	3	-	-	-	-	1	-	1	1	-	1	3	-	1
CO5	3	2	-	1	-	1	2	1	1	-	1	1	-	-

f) **Course content**

UNIT-I CLINICAL EVALUATION OF BCI **12 Hrs**

Long term and independent use. BCI users and needs, BCI for home environment-caregivers, evaluating and configuring BCI for home, safety, training caregivers, providing technical support.

UNIT-II BCI FOR RESTORATION APPLICATIONS **10 Hrs**

Sensory Restoration, Motor Restoration, Communication Restoration, Improving Recovery of Motor Function - Brain Plasticity And Strategies For Using BCI In Motor Rehabilitation, BCI Controlled Wheelchairs, BCI For Rehabilitation Of Stroke Patients, Case Studies.

UNIT-III THERAPEUTIC APPLICATIONS OF BCI **9 Hrs**

BCI based Feedback As A Possible Therapeutic Tool, reducing seizures, Improving cognitive function, Improving Emotion Processing And Control, Pain Management. Case Studies - healing of phantom pains.

UNIT-IV NON MEDICAL APPLICATIONS OF BCI **8 Hrs**

Web Browsing And Navigating Virtual Worlds, Robotic Avatars, High Throughput Image Search, Lie Detection And Applications In Law, Monitoring Alertness, Estimating Cognitive Load, Education And Learning, Security, Identification, And Authentication, Physical Amplification With Exoskeletons, Mnemonic And Cognitive Amplification, Applications In Space, Gaming And Entertainment, Brain-controlled Art

UNIT-V ETHICAL ISSUES IN BCI **6 Hrs**

Ensuring Quality of Care, Ensuring Accessibility Of Results, Invasive BCI Research, Studying BCI Use by People With Disabilities - Physical And Psychological Risks- The Risk of Inappropriate Outputs, Invasion of Privacy, Deleterious CNS Plasticity, Uncensored Actions, Respect For Persons: Informed Consent. Case Studies

Total: 45 Hrs

g) Learning Resources

References

1: BRAIN COMPUTER INTERFACES-PRINCIPLES AND PRACTICE - Jonathan R Wolpaw and Elizabeth Winter Wolpaw

2. Brain-Computer Interfacing - An Introduction BY Rajesh P. N. Rao

3. Brain-Computer Interfaces Current Trends and Applications - Aboul Ella Hassanien, Ahmad Taher Azar

Course Code	Course Title	L	T	P	C
10213BM303	EEG Recording & Analysis Laboratory	0	0	2	1

a) Course Category
Minor Specialization

b) Preamble
Brain-Computer interface deals with the recording of brain signals and analysis it for interfacing with external devices. This course gives a hands-on for setting up the EEG recording system, acquiring and analysis.

c) Prerequisite
10213BM110 - Neurophysiology

d) Related Courses
None

e) Course Outcomes
Upon successful completion of the course students will be able to

CO. Nos	Course outcome	Skill Level (Dave'sTaxonomy)
1	Record the EEG signals using different hardware set up	S2
2	Design the different stimuli for BCI application	S2
3	Demonstrate the analysis of signal using EEGLAB	S3
4	Extract the feature component and visualize it using EEGLAB	S2
5	Choose the appropriate channel and output stimulus for a BCI-based application.	S3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	-	-	-	2	1	1	1	1	1	1	2	2	-
CO2	2	-	2	-	2	-	-	1	1	2	1	2	-	2
CO3	2	1	-	-	2	-	-	1	1	2	1	2	-	2
CO4	2	1	-	-	2	-	-	1	1	2	1	2	-	2

CO5	1	1	-	-	2	1	-	1	1	2	1	2	-	2

List of experiments

1. Hardware set up of EEG acquisition system
   a) Ganglion board
   b) Cyton board
2. Hardware set up of EEG acquisition system
   a) RMS system
3. Recording of signal
   a) Using Ganglion board
   b) Using Cyton Board
4. Recording of signal
   a) Using RMS system
5. Design of Recording setup with stimulus
   a) Motor imagery
   b) Motor movement
   c) Mental arithmetic
   d) Visual stimulus
6. Import the following using EEGLAB-continuous data, event information, channel locations and
7. Filter the line noise and bandpass filter the EEG data using EEGLAB
8. Remove the bad channels and bad data using EEGLAB
9. Plot the 2D ERP, 3D ERP, Channel spectra, and time-frequency analysis
10. Real-time acquisition of EEG signal by designing an experimental set up and analysis it.

Total: 30 Hrs.

g) Learning Resources

1. Neurophysiology a conceptual approach by Carpenter, Roger H. S. Reddi, Benjamin
2. Introduction to Non-Invasive EEG-Based Brain-Computer Interfaces for Assistive Technologies by Teodiano Freire Bastos-Filho (editor)
3. Brain-Computer Interfacing an Introduction by Rajesh P. N. Rao
4. OpenBCI | Home
5. Tutorials - EEGLAB Wiki

Course Code	Course Title	L	T	P	C
10213BM201	Bio Signal Processing Instrumentation	2	0	2	3

a) Course Category
Open Elective

b) Preamble
The course gives hands on experience to build their own simple signal processing medical devices to measure physiological parameters.

c) Prerequisite
It is added advantage if you have Microprocessor / C coding Knowledge

d) Related Courses
Microprocessor and Microcontrollers

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
1	Write C code for peripheral programing using MSP430	K3
2	Summarize the signal acquisition challenges in designing Medical Instruments	K2
3	Build ECG using MSP430 and interpret the waveform	K3
4	Describe the principles of ultrasonic and build simple application	K3
5	Compare the architecture of DSP with Microprocessor	K2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	-	-	-	-	-	-	-	-	-	1	-	3
CO2	3	1	-	1	-	-	-	-	-	-	-	1	-	3
CO3	3	1	-	1	-	-	-	-	-	-	-	1	1	3
CO4	3	1	-	-	-	-	-	-	-	-	-	1	1	3
CO5	3	1	-	1	-	-	-	-	-	-	-	1	-	3

f) Course Content

UNIT I MSP430G2553 **6 Hrs**

16-bit low power MCU MSP430: Introduction to microcontrollers and embedded systems, Von Neumann and Harvard architecture, RISC and CISC machine, Introduction to MSP430: Architecture, Programming Techniques, Addressing Modes, Programming System registers and configuration I/O ports pull up/down registers concepts, Configuring Peripherals in MSP430**,** interrupt programming, Timer/ counter interrupt, Programming MSP430 timer

UNIT II Components of signal processing Instruments **6 Hrs**

Medical Instruments, Signal Acquisition challenges, Instrumentation amplifier requirement, Analog front end (AFE) for bio potential measurements, Low noise and Low power AFE, Precision voltage references

UNIT III Electrocardiogram **6 Hrs**

Working of heart, ECG waveform, AFE H/W, software flowchart,

UNIT IV Ultrasound Imaging system **6 Hrs**

Basics of ultrasound physics, Basic principle of ultrasound imaging, Ultrasound system block diagram, Ultrasound DAQ, Digital ultrasound beam former, AFE5808A

UNIT V TMS320C5515 **6 Hrs**

Architecture difference between Digital signal processor and microprocessor, System Block diagram, CPU core and peripherals, Program and data memory, external and I/O memory map,

30 Hrs.

List of experiments: **30 Hrs.**

1. Creating Project using CCStudio for MSP430 board
2. Timer Mode 0 with MSP430
3. Timer Mode 1 with MSP430
4. Demonstration of GPIO interrupt (external button interrupt)
5. ADC programing using polling
6. Interfacing AD8232 with MSP430G2553
7. Ultrasonic distance meter using MSP430G2553
8. ECG simulation using MATLAB

Total: 60 Hrs.

g) Learning Resources

Text Books

1. TMS320C5515 User Guide http://www.ti.com/lit/ug/sprufx5e/sprufx5e.pdf
2. TI Health Tech Applications Guide.

Course Code	Course Title	L	T	P	C
10213BM202	Brain Computer Interface	2	0	2	3

a) Course Category
Open Elective

b) Preamble
This course helps to design the brain computer interface system using brain signals.

c) Prerequisite
None

d) Related Courses
Anatomy and Physiology of brain, Signals and systems and Digital signal processing

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
1	Comprehend the structure and function of nervous system	K2
2	Compare different types of EEG acquisition systems	K2
3	Compare different types of BCI input signal	K2
4	Identify the major components of BCI system	K2
5	Summarize the applications of BCI system	K2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	1	-	-	-	-	-	-	1	-	2	2	1	-
CO2	2	1	-	-	-	-	-	-	1	-	2	2	2	-
CO3	2	2	-	-	-	-	-	-	1	-	1	3	2	-
CO4	1	1	-	-	-	-	-	-	1	-	3	3	1	-
CO5	1	1	-	-	-	-	-	-	1	-	2	1	1	-

f) Course Content

UNIT-I Nervous System **5 Hrs**

Anatomy and Physiology of Brain, Basic cells of the nervous system, functions of the nervous system, Regions of the Brain, Disorders of nervous system.

UNIT-II Brain computer interface **5 Hrs**

Fundamentals of BCI – Structure of BCI system – Classification of BCI: Invasive, Non-invasive and Partially invasive BCI, Brain signal acquisition systems- EEG, MEG, fNIRS, fMRI.

UNIT-III EEG features and stimulus design used in BCI **5 Hrs**

EEG-Temporal characteristics, Spatial Characteristics, Oscillatory EEG activity, event-related potentials (ERP), slow cortical potentials (SCP), and neuronal potentials, Motor Imagery.

UNIT-IV Signal processing of BCI **5 Hrs**

Signal Processing-spatial and time domain, Feature extraction, Machine Learning.

UNIT-V BCI Application **5 Hrs**

Medical Application-Rehabilitation, Brain controlled wheelchair, and Non-medical application-Monitoring Alertness, Gaming and entertainment.

30 Hrs.

List of experiments **30 Hrs.**

1. Study and collection of online EEG datasets
2. Study of BCILAB toolbox
3. Designing of filter
4. Analysis of CSP parameters using BCILAB
5. CSP and FBCSP
6. Acquisition of EEG using ganglion board

Total: 60 Hrs.

g) Learning Resources

Reference Books:

1. Brain Computer Interfaces, a Review by Luis Fernando Nicolas-Alonso and Jaime Gomez-Gil
2. https://sccn.ucsd.edu/wiki/BCILAB
3. Spatially regularized common spatial patterns for EEG classification." Lotte, Fabien, and Cuntai Guan.
4. Introduction to Statistical Pattern Recognition 2nd Ed - Keinosuke Fukunaga.

Course Code	Course Title	L	T	P	C
10213BM101	Body Area Networks	3	0	0	3

a) Course Category
Open Elective

b) Preamble
This course will help the students to understand about body area networks along with the various hardwares used and their applications.

c) Prerequisite
Analog and Digital Communication

d) Related Courses
None

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

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Identify the technical challenges in BAN such as sensor design, biocompatibility and energy supply constraints	K2
CO2	Explain the specialized the processor requirements for sensor node and solve problems on interfacing is it ok?	K2
CO3	Differentiate RF communication properties in the human body and free space with respect to propagation, attenuation, frequency behavior, and safety constraints and explain the various standards used for wireless communication	K2
CO4	Identify transmission interferences, countermeasures, and security issues in BAN systems	K2
CO5	Apply BAN concepts to real-life use cases at an introductory application level.	K3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3

CO1	3	-	-	-	-	1	-	-	-	-	-	-	3	-
CO2	3	1	-	-	-	-	-	-	-	-	-	-	-	1
CO3	3	2	-	-	-	-	-	-	-	-	-	-	-	-
CO4	3	1	-	2	-	-	-	-	1	-	-	-	-	-
CO5	3	1	2	-	-	1		2	2	-	-	-	-	-

f) Course content

UNIT I INTRODUCTION **9 Hrs**

Definition, BAN and Healthcare, Technical Challenges- Sensor design, biocompatibility, Energy Supply, optimal node placement, number of nodes, System security and reliability, BSN Architecture –Introduction.

UNIT II HARDWARE FOR BAN **9 Hrs**

Processor-Low Power MCUs, Mobile Computing MCUs, Integrated processor with radio transceiver, Memory, Antenna-PCB antenna, Wire antenna, Ceramic antenna, External antenna, Sensor Interface, Power sources- Batteries and fuel cells for sensor nodes.

UNIT III WIRELESS COMMUNICATION AND NETWORK **9 Hrs**

RF communication in Body, Antenna design and testing, Propagation, Base Station-Network topology-Stand –Alone BAN, Wireless personal Area Network Technologies- IEEE 802.15.1, IEEE P802.15.3, IEEE 802.15.4, Zigbee

UNIT IV COEXISTENCE ISSUES WITH BAN **9 Hrs**

Interferences – Intrinsic - Extrinsic, Effect on transmission, Counter measures- on physical layer and data link layer, Regulatory issues-Medical Device regulation in USA and Asia, Security and Self protection-Bacterial attacks, Virus infection ,Secured protocols, Self protection.

UNIT V APPLICATIONS OF BAN **9 Hrs**

Monitoring patients with chronic disease, Hospital patients, Elderly patients, Cardiac arrythmia monitoring, Multi patient monitoring systems, Multichannel Neural recording, Gait analysis, Sports Medicine, Electronic pill.

Total: 45 Hrs.

g) Learning Resources

Text Books

1. Annalisa Bonfiglio, Danilo De Rossi ,"Wearable Monitoring Systems", Springer, 2011
2. Sandeep K.S. Gupta,Tridib Mukherjee,Krishna Kumar Venkatasubramanian, “Body Area Networks Safety, Security, and Sustainability”, Cambridge University Press, 2013.
3. Guang-Zhong Yang, “Body Sensor Newtorks”, Springer, 2006

Course Code	Course Title	L	T	P	C
10213BM102	Environmental Conservation	3	0	0	3

a) Course Category

Open Elective

b) Preamble

To provide a basic understanding of occupancy of the ecosystem in line with Biodiversity. Its conservative measures taken by the agencies as well as the federal Government.

c) Prerequisite

None

d) Related Courses

None

e) Course Outcomes

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

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Define and classify the types of biodiversity, including species, genetic, and ecosystem diversity	K2
CO2	Compare the threats to biodiversity and their associated ecological impacts	K2
CO3	Classify biodiversity conservation approaches and protection strategies.	K2
CO4	Identify biodiversity governance mechanisms, international agencies, legal frameworks, biopiracy issues and biodiversity informatics related to plant genetic resources.	K2
CO5	Summarize the legal aspects for environmental conservation.	K2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	-	-	-	-	-	2	-	-	-	-	-	-	-	-

CO2	-	-	-	-	-	2	2	-	-	-	-	-	-	-
CO3	-	-	-	-	-	2	2	-	-	-	-	-	-	-
CO4	-	-	-	-	-	2	2	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	2	-	-	-	-	-	-	-

f) Course content

UNIT -I Types, functions and benefits of biodiversity 9 Hrs

Types of Biodiversity: Species, Genetic and Ecosystem diversity – Alpha, beta, and gamma diversity – Biodiversity and ecosystem function – Megadiversity zones and Biodiversity Hot Spots in India – Ecologically Sensitive Areas (ESA) in India - Use of Biodiversity: Source of food, medicine, raw material, aesthetic and cultural uses – Biodiversity Prospecting: Significance of Indigenous Knowledge Systems

UNIT II Threats to Biodiversity 9 Hrs

Natural and anthropogenic threats to biodiversity – Human-Animal conflict with special reference to elephants and tigers - IUCN Threat Categories – Red Data Book – Wildlife exploitation - Species extinctions – Endangered and endemic species of flora and fauna in India - Over-harvesting and Climate change on biodiversity - Causes and Impacts of Invasive species to biodiversity

UNIT III Conservation Strategies 9 Hrs

Current practices in conservation: Habitat or Ecosystem Approaches - Species-based Approaches - Social Approaches: Chipko Movement – In-situ conservation: Afforestation, Social Forestry, Agroforestry, Botanical gardens, Zoos, Biosphere Reserves, National Parks, Sanctuaries, Protected Area Network, Sacred Groves and Sthalavrikshas – Ex-situ conservation: Cryopreservation, Gene Banks, Seed Banks, Pollen Banks, Sperm Banks, DNA Banks, Tissue Culture and Biotechnological Strategies

UNIT IV Sustainable Management of Bio Resources 9 Hrs

National Biodiversity Authority (NBA) – Functions of State Biodiversity Board (SBB) and Biodiversity Management Committee's (BMC) – The role of WWF, FAO, UNESCO, UNDP and UNEP for biodiversity conservation – An elementary account on WTO, GAAT and TRIPS – Biopiracy rights of farmers, breeders and indigenous people –Biodiversity informatics with special reference to plant genetic resources

UNIT V Policies, Programmes and Acts for Conservation 9 Hrs

Status and protection of species in National and International levels – Role of CITES and IUCN – Convention on Biological Diversity (CBD) – Nagoya Protocol – Man and Biosphere Programme (MAB) – Policies implemented by MoEF for biodiversity conservation – Salient features of Biological Diversity Act 2002.

Total: 45 Hrs

g) Learning Resources:

Text books:

1. Chaudhuri AB and Sarkar DD, "Mega diversity Conservation: Flora, Fauna and Medicinal Plants of India's Hot Spots" - Daya Publishing House, New Delhi, 2003.

2. Dadhich LK and Sharma AP, “Biodiversity: Strategies for Conservation” - APH Publishing Corporation, New Delhi, 2002.

Reference books:

1. Gary K Meffe and Ronald Carroll C, “Principles of Conservation Biology” - Sinauer Associates Inc. Massachusetts, 1994.
2. Groombridge B (Ed.) “Global Biodiversity Status of the Earths Living Resources” - Chapman & Hall, London, 1992.
3. Khan TI, Dhari N and Al Ajmi, “Global Biodiversity: Conservation Measure” - Pointer Publishers, Jaipur 1999.

Course Code	Course Title	L	T	P	C
10213BM103	Remote Health Technology	3	0	0	3

a) Course Category

Open Elective

b) Preamble

This course helps the students to learn about the E Healthcare with their standards. Also this course gives the detail information about the security, transmission, and storage

c) Prerequisite

None

d) Related Courses

None

e) Course Outcomes

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Summarize the basic principles of healthcare in telemedicine.	K2
CO2	Compare the different types of communication and networks	K2
CO3	Solve the ethical & legal issues involved in telemedicine.	K3
CO4	Apply the different types of data storage and communication standards used in telehealth system.	K3
CO5	Analyze the various applications of telemedicine.	K4

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	-	1	-	-	-	-	-	-	1	1	-	-
CO2	3	2	-	1	-	-	-	-	-	-	1	1	-	-

CO3	1	2	-	1	-	-	-	-	3	2	1	-	1	-
CO4	3	2	-	1	-	-	-	-	-	-	1	1	-	-
CO5	3	3	-	1	-	-	-	-	2	2	1	-	1	-

f) Course content

UNIT I History and Fundamentals of Telemedicine **9 Hrs**

What is Telemedicine? History, Major Areas of Telemedicine, Benefits of Telemedicine, Types of Telemedicine services, Challenges in Implementing Telemedicine, Telemedicine Standards and Guidelines.

UNIT II Communication & Network **9 Hrs**

Principles of Multimedia - Text, Audio, Video, data, Data communications and networks, PSTN, POTS, ANT, ISDN, Internet, Air/ wireless communications: GSM satellite, and Micro wave, Amplitude Modulation (Qualitative Analysis), Communication infrastructure for telemedicine – LAN and WAN technology.

UNIT III Ethical and legal aspects of Telemedicine **9 Hrs**

Ethical and legal aspects of Telemedicine (Case study) - Confidentiality, Social and legal issues (Case Study), Safety and regulatory issues (Case Study), Trends in Telemedicine, Delivery Modes in Telemedicine System, Setting up Telemedicine Facility.

UNIT IV Technology of Telemedicine System **9 Hrs**

Information Sources in Telemedicine, Data Transmission, Transmission of Still Images, Transmission of Video, Transmission of Audio.

UNIT V Applications of Telemedicine **9 Hrs**

Teleradiology, PACS, ChatGPT in telemedicine platforms, Telecardiology, Teleoncology, Telesurgery, Medical Emergencies and Disaster Relief, Tele-Education.

Total: 45 Hrs.

g) Learning Resources

Text Books

1. R.S. Khandpur, “Telemedicine Technology And Applications (Mhealth, Telehealth And Ehealth)”, PHI Learning, 2017.
2. Olga Ferrer-Roca, M.Sosa Ludicissa, “Handbook of Telemedicine”, IOS press 2002.
3. Norris A.C, “Essentials of Telemedicine and Telecare”, John Wiley & Sons, 2002.
4. Wootton R, Craig J, Patterson, “Introduction to Telemedicine” Royal Society of Medicine Press Ltd., (2nd ed.), 2006.

Reference Books:

1. Maheu M.M, Whitten P, Allen A, “E-Health, Telehealth, and Telemedicine” Jossy-Bass, 2001.

2. Keith J, Dreyer, David S, Hirschron, James Thrall H, Amit Mehta, PACS: “AGuide to the Digital Revolution”, 2nd Edition, Springer
3. Huang H K, “PACS and imaging informatics – Basic Principles & application”, Wiley-Blackwell
4. Latifi R, “Current Principles and Practices of Telemedicine and e-Health”. Washington DC: IOHS , 2008.
5. Bashshur R L, Shannon G W, “History of Telemedicine”. New Rochelle. NY, Mary Ann Liebert Publishers, 2009.

Course Code	Course Title	L	T	P	C
10213BM104	Medical Instrumentation	3	0	0	3

a) Course Category
Open Elective

b) Preamble
To make the student to acquire knowledge on how to record and measure bio signals and to design bio amplifiers.

c) Prerequisite
None

d) Related Courses
Bio Sensors and Transducers

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Compare the different types of electrodes and draw its equivalent circuit.	K2
CO2	Explain how to record the various bio signals.	K2
CO3	Design amplifiers used for measuring biosignals.	K3
CO4	Explain how Bio chemical parameters are measured using bioanalytical instruments	K2
CO5	Summarize the importance of Patient safety	K2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	-	-	-	-	-	-	1	-	-	2	2	-
CO2	3	1	-	-	-	-	-	-	2	-	-	2	2	-
CO3	3	2	-	-	-	-	-	-	1	-	-	2	2	-
CO4	3	1	-	-	-	-	-	-	2	-	-	2	2	-

CO5	3	1	-	-	-	-	-	-	2	-	-	2	2	-

f) Course content

UNIT I Bio Potential Electrodes **9 Hrs**

Origin of bio potential and its propagation. Electrode-electrolyte interface, electrode–skin interface, half cell potential, impedance, polarization effects of electrode – nonpolarizable electrodes. Types of electrodes - surface, needle and micro electrodes and their equivalent circuits. Recording problems - measurement with two electrodes.

UNIT II Electrode Configurations for Bio Signal Recording **9 Hrs**

ECG: origin, waveforms and their characteristics, Einthoven triangle – 12 lead configurations, EEG : origin, waveforms and their characteristics, 10-20 electrode placement system – unipolar and bipolar mode. EMG, ERG, EOG – unipolar and bipolar modes.

UNIT III Bio Amplifers **9 Hrs**

Need for bio-amplifier - single ended bio-amplifier, differential bio-amplifier – right leg driven ECG amplifier. Band pass filtering, isolation amplifiers – transformer and optical isolation - isolated DC amplifier and AC carrier amplifier. Chopper amplifier. Power line interference.

UNIT IV Bio Analitical Equipments **9 Hrs**

Blood cell counters –microscopic method, coulter counter, Selective ion electrodes, ion analyzer. pH, pCO2, pO2, - calorimeter, spectrophotometer, flame photometer. Autoanalyser

UNIT V Electrical Safety **9 Hrs**

Physiological effects of electricity, susceptibility parameters, Distribution of Electrical of Electric power. Macro shock hazards, micro shock hazards. Protection – power distribution, equipment design. Testing – electrical system and appliances. safety codes for electro medical equipment, electrical safety analyzer.

Total: 45 Hrs.

g) Learning Resources

Text Books

1.John G. Webster, “Medical Instrumentation Application and Design”, John Wiley and sons, New York, 2004.

2. Khandpur R.S, “Handbook of Biomedical Instrumentation”, Tata McGraw-Hill, New Delhi, 2003.(Units II & IV)

Reference Books

1. Leslie Cromwell, “Biomedical Instrumentation and measurement”, Prentice hall of India, New Delhi, 2007.

2. Myer Kutz, “Standard Handbook of Biomedical Engineering and Design”, McGraw Hill Publisher, 2003. 3. Joseph J. Carr and John M. Brown, “Introduction to Biomedical Equipment Technology”, Pearson Education, 2004

Course Code	Course Title	L	T	P	C
10213BM105	Drones in Healthcare	3	0	0	3

a) Course Category
Open Elective

b) Preamble
This course makes the learner to understand limitations, challenges and reasons for using drones in healthcare. Also, the course explores real-world deployments and cost benefit analysis of medical cargo drones.

c) Prerequisite
None

d) Related Courses
None

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Summarize the challenges and reasons for using drones in healthcare.	K2
CO2	Comprehend the technical challenges in the use of cargo drones in public health.	K2
CO3	Identify cargo drone deployments, system selection, payload handling, operational procedures, hybrid models, and weather considerations.	K2
CO4	Summarize the regulations and cost benefit analysis of medical cargo drones.	K2
CO5	Comprehend drone technologies, supply chain applications, pandemic-related deployments, and regulatory impacts.	K2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	-	-	-	-	-	-	-	-	-	-	-	-
CO2	3	1	-	-	-	-	-	-	-	-	-	-	-	-
CO3	3	1	-	-	-	-	-	-	-	-	-	-	-	-
CO4	3	2	-	-	-	-	-	-	-	-	-	-	-	-
CO5	3	1	-	-	-	-	-	-	-	-	-	-	-	-

f) Course content

UNIT – 1 Drones in Public Health **9 Hrs**

Introduction – Need for Drones in public health – Challenges – Empirical reasons for using drones in public health – push versus pull supply chain systems.

UNIT – 2 Cargo Drone Technologies and Challenges **9 Hrs**

Types of cargo drone technologies used in public health – Performance parameters and costs of cargo drone technologies – Technical challenges in the use of cargo drones in public health – public health use-cases for cargo drones – stability of samples during cargo drone transportation.

UNIT – 3 Real world deployments **9 Hrs**

Real world deployments of cargo drones across countries - selecting appropriate cargo drone solutions – vetting and selecting cargo drone companies - selecting appropriate cargo boxes – selecting takeoff and landing sites – standard operating procedures and checklists – hybrid cargo drone models – weather considerations

UNIT – 4 Regulations and Cost Benefit Analysis of Medical Cargo Drones **9 Hrs**

Aviation and medical regulations – Unmanned Traffic Management (UTM) systems - Estimating the cost of cargo drone deliveries - Cost savings and performance improvements - Selecting the right transportation solution - Cargo drone cost calculator.

UNIT – 5 Health Robotics **9 Hrs**

Supply chains, drone technologies and limitations – recent medical drone deployments in countries – delivery drones and Covid-19 – Impacts of pandemic in drone regulations

Total: 45 Hrs.

g) Learning Resources

Text Books:

1. Dauer, J. C. (Ed.). (2021). Automated Low-altitude Air Delivery: Towards Autonomous Cargo Transportation with Drones. Springer Nature.
2. Bradley, S. (2021), Medical Drones (World of Drones). ReferencePoint Press, Inc.

3. Anbaroğlu, B. (2021). Drones in healthcare: An extended discussion on humanitarian logistics. In Research Anthology on Reliability and Safety in Aviation Systems, Spacecraft, and Air Transport (pp. 973-994). IGI Global.

Reference Books:

1. Fancher, J. C. (2017). Drones for Medical Supplies.
2. John L. Hakala, How Drones Will Impact Society. San Diego: ReferencePoint, 2018.
3. Kathryn Hulick, How Robotics Is Changing the World. San Diego: ReferencePoint, 2019.

Course code	Course Title	L	T	P	C
10213BM301	Biomedical Laboratory	0	0	2	1

a) Course category
Open Elective

b) Preamble
Biomedical engineering deals with human physiological parameters. This course gives a hands on for understanding basic anatomy and measurement of a few vital signs

c) Prerequisite
None

d) Related Courses
Biology for Engineers

e) Course Outcomes
Upon successful completion of the course students will be able to

S.No	Course outcomes	Skill Level (Dave's Taxonomy)
1	Demonstrate the arrangement of organs in human body	S1
2	Measure a few vital parameters	S2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	-	-	-	-	1	-	2	2	-	-	-	1	-
CO2	1	-	-	-	-	1	-	2	2	-	-	-	1	-

List of Experiments

1. Study of body organization – cavities and organs
2. Visualization of cell using microscope
3. Blood group test

4. Bleeding and clotting time
5. Hearing loss test
6. Measurement of Blood pressure
7. Recording of ECG
8. Visual test and Eye anatomy.

Total: 30 Hrs

Course Code	Course Title	L	T	P	C
10213BM114	Biomimicry	3	0	0	3

a) Course Category
Open Elective

b) Preamble
The course introduces the inspirations for modern day technologies including the development of sensors, devices, robots and products from the existing nature.

c) Prerequisite
None

d) Related Courses
None

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

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain how nature acts as an inspiration for innovations in modern day	K2
CO2	Illustrate the implementation of nature's design in different products	K2
CO3	Contrast the evolution of flying in nature and man-made aircrafts	K2
CO4	Interpret designs from nature and their specific usage in developing different structures and technologies	K2
CO5	Relate nature with artistic creations. and explain the challenges in biomimicry	K2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	-	-	-	-	-	-	-	-	-	-	1	-
CO2	3	1	-	-	-	-	-	-	-	-	-	-	1	-

CO3	3	1	-	-	-	-	-	-	-	-	-	-	1	-
CO4	3	1	-	-	-	-	-	-	-	-	-	-	1	-
CO5	3	1	-	-	-	-	-	-	-	-	-	-	1	-

f) Course content

Unit – 1 Nature as a Source of Inspiring Innovation 8 Hrs

Introduction, Independent Human Innovation or Bioinspiration, Biologically Inspired Technologies and Mechanisms - Artificial Intelligence, Artificial and Biomimetic Materials, Biosensors, Vision and Colors, Artificial Muscles, Pumping Mechanisms, Robotics as a Beneficiary of Biomimetic Technologies, Nature as a Source of Innovation for Operation in Water, Birds and Insects as the Source of Inspiring Flight.

Unit – 2 Biomimicking and Self-X Products 10 Hrs

Develop Biomimicking Products—Potential, Self-X-Materials - Self-Repairing Membranes Self-Adapting Materials and Structure, Self-Cleaning: The Lotus Effect, Self-Sharpening Cutting Tools, Bio-Inspired Cable Entry Systems, Impact and Puncture-Resistant Materials, Shock-Absorbing Transportation Pallet and Light-Weight Structures

Unit – 3 Nature's Concepts in Flying Technology 9 Hrs

Nature of Evolution - The Process of Evolution, Coevolution Symbiotic Relations, Evolution of Biological Flight, Achieving Flight by Man - Understanding, Biological Inspiration – Flapping Wings, Aeroplane, Innovation from seeds, Chanute's Ten Critical Elements, Langley's Aerodrome, The Wright Brothers, Evolution of Modern Aircraft - Technical Advancements, Coevolution in Technical Flight. Biological Related Approaches for Technical Innovation,

Unit – 4 Nature's Concepts in Distinct Applications 9 Hrs

Bionics – Flying Cucumber and Wings, Gliders, Controlling Flight of Plane, Dragonfly and Helicopter, F-35, Tilt Wings, Gyrocopters. Velcro, Counter-current Heat Exchanger, Mercedes-Benz Bionic Car, Bionic Propeller, Jet Noise, Folded Wings, Echolocation, Sonar, Radar and Lidar, Shark's Skin and Riblets. Pseudo-Mimicry - Tandem and Parasol Wings, Structural Design Concepts and Turbine Engines

Unit – 5 Artistic Designs and Challenges in Biomimicry 9 Hrs

Biomimicry Principles combined with Art and Artistic Abstractions of Natural Phenomena. Biological Capabilities and Functions as Models for Mimicking – Materials, Sensors and Actuators, Pumping, Packaging, Defense, Robotics, Flying, Medicine, Toys and Architecture, Potential Revolution of Technology

Total: 45 Hrs

g) Learning Resources

Text Books:

1. Yoseph Bar-Cohen, "Biomimetics – Nature Based Innovation", CRC Press, 2012.

References:

1. Akhlesh Lakhtakia and Raúl J.Martín-Palma, "Engineered Biomimicry", Elsevier, 2013.
2. Janine M Benyus, "Biomimicry - Innovation Inspired by Nature", Mariner Books, 2002.

Course Code	Course Title	L	T	P	C
10213BM117	Drone Technology in Healthcare	3	0	0	3

a) Course Category
Open Elective

b) Preamble
This course makes the learner to understand limitations, challenges and reasons for using drones in healthcare. Also, the course explores real-world deployments and cost benefit analysis of medical cargo drones.

c) Prerequisite
None

d) Related Courses
None

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Demonstrate a comprehensive understanding of drone technology in healthcare, including the architecture, components, and systems involved.	K2
CO2	Summarize the role of drones in medical supply chain management	K2
CO3	Illustrate the drone used for emergency medical services	K2
CO4	Comprehend the use of drones for public health monitoring and surveillance	K2
CO5	Discuss the future directions and challenges of drone in healthcare	K2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	-	-	-	-	-	-	-	-	-	-	1	-

CO2	3	1	-	-	-	-	-	-	-	-	-	-	1	-
CO3	3	1	-	-	-	-	-	-	-	-	-	-	1	-
CO4	3	2	-	-	-	-	-	-	-	-	-	-	1	-
CO5	3	1	-	-	-	-	-	-	-	-	-	-	1	-

f) Course content

Unit - 1 Introduction to Drones in Healthcare **9 Hrs**

Overview of Drone Technology: Definitions, Types, Features. Drone Architecture: Components and Systems, Applications of Drones in Healthcare, Benefits and Challenges of Drone Use in Healthcare, Regulatory Considerations for Drone Operations in Healthcare, Ethical and Privacy Implications, Case Studies and Success Stories.

Unit - 2 Drones for Medical Supply Chain Management **9 Hrs**

Challenges in Traditional Medical Supply Chain Management, Role of Drones in Medical Supply Chain Management, Types of Medical Supplies Suitable for Drone Delivery, Drone Delivery Systems and Technologies, Regulatory Framework and Safety Considerations, Internet of Drones, Cost Management in Drone Operations.

Unit - 3 Drones for Emergency Medical Services **9 Hrs**

Importance of Drones in Emergency Medical Services, Drone Applications in Emergency Medical Services, Integration of Drones with Telemedicine and Remote Healthcare, Regulatory and Legal Considerations for Emergency Medical Drones, Safety and Risk Management in Emergency Medical Drone Operations, Standard Operating Procedures (SOPs) for Emergency Medical Drone Operations, Checklists for Emergency Medical Drone Missions, Selection of Take-off and Landing Sites for Medical Drones, UTM (Unmanned Traffic Management) for Drone Operations.

Unit - 4 Drones for Public Health Monitoring and Surveillance **9 Hrs**

Role of Drones in Public Health Monitoring and Surveillance, Applications of Drones in Public Health Monitoring and Surveillance, Regulatory and Legal Considerations for Public Health Drones, Data Collection and Analysis, Safety and Ethical Considerations in Public Health Drone Operations, Standard Operating Procedures (SOPs) for Public Health Drone Operations, Checklists for Public Health Drone Missions.

Unit - 5 Future Directions and Challenges **9 Hrs**

Emerging Trends in Drone Technology for Healthcare, Future Applications of Drones in Healthcare, Integration of Drones with Existing Healthcare Systems, Addressing Challenges in Drone Deployment, Safety, Reliability, and Risk Management, Ethical Considerations and Public Perception, Collaborative Research and Development, Regulation and UTM in the Future of Drone Operations, Best Practices: Standard Operating Procedures (SOPs) and Checklists in Drone Operations.

Total: 45 Hrs.

g) Learning Resources

References:

1. Bradley Steffens, Medical Drones (World of Drones) - Referencepoint Press, 2020

2. Saravanan Krishnan, M. Murugappan, Internet of Drones Applications, Opportunities, and Challenges, 1st Edition, CRC Press, 2023.
3. Medicine from the Sky, India: How Drones Can Make Primary Healthcare Accessible to All, INSIGHT REPORT, MAY 2022
4. Balasingam, M. (2017), Drones in medicine—The rise of the machines. Int J Clin Pract, 71: e12989. https://doi.org/10.1111/ijcp.12989
5. Michael S. Bau, Unmanned Aircraft Systems Traffic Management, 1st Edition, CRC Press, 2021.
6. https://www.asianhhm.com/healthcare-management/drones-in-healthcare
7. Wulfovich, S., Rivas, H., Matabuena, P. (2018). Drones in Healthcare. In: Rivas, H., Wac, K.(eds) Digital Health. https://doi.org/10.1007/978-3-319-61446-5_11

Web Links:

1. https://www.asianhhm.com/healthcare-management/drones-in-healthcare

Course Code	Course Title	L	T	P	C
10213BM118	Human-Computer Interface	3	0	0	3

a) Course Category
Open Elective

b) Preamble
This course helps to understand the components of the brain computer interface system.

c) Prerequisite
None

d) Related Courses
Analog Electronics and Integrated Circuits

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

CO Nos.	Course outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
1	Summarize the anatomy and physiology of the human brain and different types of BCI signals from instruments	K2
2	Discuss and compare different types of brain signals used for feature extraction	K2
3	Comprehend the major components of BCI system	K2
4	Summarize the applications based on BCI	K2
5	Use the toolbox BCILAB	K2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	-	-	1	1	-	1	2	1	3
CO2	2	1	-	-	-	-	-	1	1	-	1	2	3	2
CO3	3	1	-	-	-	-	-	1	1	-	1	2	3	3
CO4	1	1	-	-	-	-	-	1	1	-	1	2	2	1
CO5	1	2	-	-	-	-	-	1	1	-	1	2	3	1

f) Course Content

UNIT-I Brain computer interface **9 Hrs**

Anatomy and physiology of brain and function of nervous system, what is BCI? How BCI works-structure of BCI, BCI category-synchronous and asynchronous, Types of BCI-Invasive, Partially invasive, Non-invasive, Brain signal acquisition methods-EEG, MEG, fNIRS, fMRI, Non brain signals for BCI

UNIT-II EEG features used in BCI **9 Hrs**

EEG characteristic- Temporal characteristics, Spatial Characteristics, Types of control signal - Oscillatory EEG activity, event-related potentials (ERP), slow cortical potentials (SCP), and Sensory motor rhythms, BCI modality: Motor Imagery BCI, p300 speller, steady state visual evoked potential (SSVEP)

UNIT-III Brain signal processing approaches **9 Hrs**

Challenges in BCI, Filtering approaches-Spatial, temporal, spectral, spatio-temporal filters, Feature extraction, Classifier- linear discriminant analysis, Support vector machine, machine learning,

UNIT-IV BCI application **9 Hrs**

Medical BCI application- neuro prosthetic devices and wheel chair controlled, Communication device, gaming, monitoring workload

UNIT-V BCI LAB Tool Box **9 Hrs**

Toolbox Architecture, Plug-in concepts, analysis and comparison of feature extraction and classification methods, calibration and visualization of model, Implementing ERP Based BCI, ERP Analysis in BCI Lab

Total: 45 Hrs.

g) Learning Resources

Text Books

1. R. Wolpaw and Elizabeth Winter Wolpaw, "Review of "Brain-Computer Interfaces, principles and practice", Biomed Engineering online
2. Christian Kothe,"Introduction to Modern Brain Computer Interface design video lectures, https://sccn.ucsd.edu/wiki/Introduction_To_Modern_BrainComputer_Interface_Design

Reference Books

1. "Brain Computer Principles and Practices",Jonathan Wolpaw ,Elizabeth Winter Wolpaw, Oxford University Press

Research Paper

1. Nicolas-Alonso, L. F., & Gomez-Gil, J. (2012). Brain computer interfaces, a review. *sensors*, *12*(2), 1211-1279.

Course Code	Course Title	L	T	P	C
10214BM60X	Minor Project	0	0	4	2

a) Course Category

Independent learning

b) Preamble

This course enables the students to integrate and apply the theoretical knowledge they gained in their earlier semesters for solving some practical problems and this improves their technical skills

c) Prerequisite

None

d) Course outcomes

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

CO Nos.	Course Outcomes
CO1	Articulate the problem definition
CO2	Organize various resources and integrate information for completing the project in time
CO3	Collaborate with others as they work on intellectual projects
CO4	Write a report to communicate to others effectively their findings

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	-	-	1	-	2	2	3	3	3	3	3
CO2	3	3	2	-	2	1	-	2	3	3	3	2	2	2
CO3	3	3	-	-	-	-	-	3	2	3	3	-	-	-
CO4	2	2	-	-	-	-	3	3	3	2	3	-	-	-

Course Code	Course Title	L	T	P	C
10214BM701	Major Project	0	0	18	9

a) Course Category

Independent learning

b) Preamble

This course enables the students to explore edge-cutting technology through literature survey and provides an opportunity to explore real world problems by integrating their previous learnings from key areas

c) Prerequisite

All the courses per curriculum must have been completed

d) Course Outcomes

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

CO Nos.	Course Outcomes
CO1	Design and develop a system using comprehension of concepts of their earlier semester courses
CO2	Evaluate the designed system with respect to different performance criteria
CO3	Analyse the variety of issues in design concept through environmental issues and quality
CO4	Write a report to communicate to others effectively their findings

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3	-	2	2	-	-	-	-	1	3	3	3
CO2	3	2	-	3	-	2	-	-	-	-	-	3	3	3
CO3	3	3	-	-	3	3	-	-	-	-	-	3	3	3
CO4	3	2	-	-	-	-	3	3	3	3	3	-	-	-

Course Code	Course Title	L	T	P	C
10214BM501	Community Service Project	0	0	2	9

a) Course Category

Independent learning

b) Preamble

This course enables students to explore innovative solutions through a community service project, allowing them to address real-world challenges while integrating their previous learnings from key areas.

c) Prerequisite

None

d) Course Outcomes

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

CO Nos.	Course Outcomes
CO1	Identify technical and non-technical societal problems and design solutions
CO2	Design survey questions and conduct survey

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	1	1	1	1	-	-	-	-	-
CO2	-	-	-	-	-	-	1	1	1	-	-	-	-	-

Course Code	Course Title	L	T	P	C
10215BM8XX	In-Plant Training	0	0	30/60	1/2

a) Course Category

Industry/Higher Institute Learning Interaction (IHL)

b) Preamble

This provides students with hands-on exposure to medical equipment, clinical workflows, and healthcare technology management. It helps bridge the gap between theoretical concepts and real-world practice by allowing students to observe and engage in the installation, operation, calibration, maintenance, and safety management of biomedical instruments used in healthcare environments.

c) Prerequisite

None

d) Course Outcomes

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

CO Nos.	Course Outcomes
CO1	Gain practical knowledge of biomedical instruments and medical equipments
CO2	Understand hospital workflow, patient monitoring systems and safety protocols
CO3	Demonstrate teamwork, communication and ethical responsibility in healthcare settings

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	2	-	-	2	-	-	-	-	-
CO2	3	-	-	-	-	2	-	-	2	-	-	-	-	-
CO3	3	-	-	-	-	2	-	-	2	-	-	-	-	-

Course Code	Course Title	L	T	P	C
10215BM9XX	Industry/Higher Learning Institute Interaction (Int)	15/30	0	-	1/2

a) Course Category

Industry/Higher Institute Learning Interaction (IHL)

b) Preamble

This course is designed to equip students with advanced engineering knowledge and skills aligned with international academic. The course also fosters awareness of emerging technological trends worldwide while enhancing students' ability to comprehend and effectively engage with academic content delivered in diverse forms of English, preparing them for participation in international learning.

c) Prerequisite

None

d) Course Outcomes

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

CO Nos.	Course Outcomes
CO1	Demonstrate understanding and application of advanced engineering concepts, principles, and methodologies, as taught in line with international academic standards.
CO2	Apply advanced problem-solving skills to engineering systems, leveraging innovative techniques and tools aligned with current global industry practices.
CO3	Stay informed on emerging global technological trends and advancements in engineering
CO4	Demonstrate the ability to comprehend and engage with academic content delivered in various forms of English, including diverse accents, terminologies, and teaching styles, ensuring effective communication in an international learning environment.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	-	-	-	-	-	-	-	-	-

CO2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	3	-	-	-	3	-	-	-	-	-

Course Code	Course Title	L	T	P	C
10215BM9XX	Industry/Higher Learning Institute Interaction (Ind)	15/30	0	-	1/2

a) Course Category

Industry/Higher Institute Learning Interaction (IHL)

b) Preamble

This course is designed to equip students with advanced engineering knowledge and skills aligned with industry standards. The course also fosters awareness of emerging technological trends worldwide while enhancing students' ability to comprehend and effectively engage with academic content delivered in diverse forms of English, preparing them for participation in professional environments.

c) Prerequisite

None

d) Course Outcomes

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

CO Nos.	Course Outcomes
CO1	Demonstrate the ability to integrate academic knowledge with hands-on experience in practical settings
CO2	Collaborate effectively with industry professionals, gaining insights into the latest technologies, and learning how to work in a professional, industry-driven environment

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	-	-	1	-	-	-	-	-	-	-	-	-
CO2	1	-	-	-	1	-	-	-	-	1	-	-	-	-

Course Code	Course Title	L	T	P	C
10212BM4XX	MOOC	0	0	60/90	2/3

a) Course Category
Independent learning

b) Preamble
These courses are intended to supplement classroom learning, enhance subject knowledge, and promote self-paced, lifelong learning.

c) Prerequisite
None

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

CO Nos.	Course Outcomes
CO1	Critically analyse the given problem and give solution
CO2	Demonstrate the ability to independently engage with online courses, effectively manage learning schedules, and complete assessments within deadlines, ensuring command over the subject matter
CO3	Show proficiency in navigating and utilizing online learning platforms, demonstrating effective use of digital resources, self-assessment tools, and peer interaction mechanisms
CO4	Develop a mindset of continuous learning and stay updated with the latest advancements and best practices in the field.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	-	-	-	-	-	-	-	-	-	3	3	3
CO2	2	2	-	-	-	-	-	-	-	-	-	3	3	3
CO3	-	-	-	-	2	-	-	-	-	1	-	3	3	3
CO4	-	-	-	-	-	-	-	-	-	-	3	-	-	-