M. Tech. (Master of Technology) in Biomedical Instrumentation & Signal Processing

Faculty of Engineering

M.TECH – Biomedical Instrumentation and Signal Processing

Biomedical Instrumentation and Signal Processing (BISP) program uses the principles of Engineering, Biology, and Medicine to solve existing problems in the healthcare field for the benefit of mankind. It applies quantitative, analytical, software and hardware methods which help in better understanding of basic biological processes and to develop innovative techniques for the diagnosis, treatment and prevention of diseases. Future of enhanced healthcare services through biomedical instrumentation lies in the design and development of low-cost systems and solutions which are wearable, portable, energy efficient, and user friendly to measure and monitor in real-time, the parameters in both invasive and non-invasive manner. To achieve this, a highly multidisciplinary curriculum has been prepared which can cater all the above. Students when they graduate will be well trained in advanced signal processing, advanced digital image processing, lab on chips, effective analysis and learning of interrelated parameters using data science concepts, machine learning, MEMS sensor systems, IoT systems, big data analytics, flexible electronics and to develop wearable wireless systems.

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PROGRAM OUTCOMES

PO1	An ability to independently carry out research/investigation and develop to solve practical problems
PO2	An ability to write and present a substantial technical report / document
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than requirements in appropriate bachelor program
PO4	Understanding of how the basic theories can be applied to solve practical problems.
PO5	Ability to bridge the gap from research to community needs

PROGRAM EDUCATIONAL OUTCOMES

PEO1	Understanding of the biomedical instrumentation and signal processing ecosystem, devices, and current practices in the academia and industry
PEO2	Develop skills on developing, applying and evaluating signal processing and data analysis technique in healthcare applications
PEO3	Develop critical understanding of state-of-art research in the field of biomedical instrumentation, signal processing, data analysis, and machine learning, and develop capability to design embedded systems and associated instruments for medical applications

EVALUATION SCHEME AND GRADING SYSTEM

The assessment pattern for each course is based on its credit. The grading options are decided by the instructor and it should be approved by the class committee at the starting of the semester. The assessment patterns of different credit courses are as follows.

1 – credit course:

*** The instructor can choose one of the following options for course assessment**

****Continuous assessment has to be properly decided at the starting of the semester and should be approved by the Chairperson.***

Grading Options	Internal assessment	External assessment
A(Theory course)	50 % (Mid-sem exam, assignments, quizzes, Lab experiments, mini-project) Mid Sem – 15% Continuous Evaluation – 35%	50% (2 hr exam)
B (Lab Based Course)	70% - Lab based assessment (minimum of 4 experiments with an end semester lab exam(mini-project) evaluated by an external examiner) Lab experiments – 40% Mini Project/End Sem (20%) + Viva (10%) – 30%	30% (1 hr exam)
C (Project Based Course)	70% - Project based (one final review with a review panel comprised of atleast one external examiner, student should submit a project report duly signed by the chairperson and external examiner) Project Implementation – 40% Final Review (20%)+ Report (10%) – 30%	30% (1 hr exam)

D(Analytical Courses)	70% - Assignment and quiz based (Mathematical courses) Assignments (min 2) – 30% Quizzes (min 2) - 40%	30% (1 hr exam)

2 – credit course:

*** The instructor can choose one of the following options for course assessment**
****Continuous assessment has to be properly decided at the starting of the semester and should be approved by the Chairperson.***

Grading Options	Internal assessment	External assessment
A(Theory course)	50 % (Mid-sem exam, , assignments, quizzes, Lab experiments, mini-project) Periodical 1 – 15% Periodical 2 – 15% Continuous Evaluation – 20%	50% (2 hr exam)
B (Lab Based Course)	70% - Lab based assessment (minimum of 6 experiments with an end semester lab exam(mini-project) evaluated by an external examiner) Lab experiments – 40% Mini Project/End Sem (20%) + Viva (10%) – 30%	30% (1 hr exam)
C(Project Based Course)	70% - Project based (one final review with a review panel comprised of at least one external examiner, student should submit a project report duly signed by the chairperson and external examiner) Project Implementation – 40% Final Review (20%)+ Report (10%) – 30%	30% (1 hr exam)
D(Analytical Courses)	70% - Assignment and quiz based Assignments (min 4) – 30% Quizzes (min 2) – 40%	30% (1 hr exam)

3 – credit course:

*** The instructor can choose one of the following options for course assessment**

****Continuous assessment has to be properly decided at the starting of the semester and should be approved by the Chairperson.***

Grading Options	Internal assessment	External assessment
A (Theory Course)	50 % Periodical 1 – 15% Periodical 2 – 15% Continuous Evaluation – 20%	50% (3 hr exam)
B	70 % Periodical 1 – 15% Periodical 2 – 15% Continuous Evaluation – 40%	30% (2 hr exam)
C (For Courses Completed in 6 weeks)	50% Periodical 1 – 15% Assignments + Quizzes / lab-based experiments / mini-project – 35%	50% (3 hr exam)
D (Lab Based Course)	70% One Periodical Exam – 15% 50 % - Lab based assessment (minimum of 5 experiments With one end semester exam(mini-project) which should be evaluated by an external examiner) Lab experiments - 25% Mini Project/End Sem Lab (20%) + Viva (10%) – 30%	30% (2 hr exam)
E (Project Based Course)	70% - Project based (one mid-sem review and one final review with a review panel comprised of atleast one external examiner, student should submit a project report duly signed by the chairperson and external examiner) Project Implementation – 40% (this can have a mid-sem review) Final Review (20%)+ Report (10%) – 30%	30% (2 hr exam)
F (Analytical Courses)	70% - One Periodical - 15% Assignments (min 6) – 20% Quizzes (min 4) - 35%	30% (2 hr exam)

4 – credit course:

*** The instructor can choose one of the following options for course assessment**

****Continuous assessment has to be properly decided at the starting of the semester and should be approved by the Chairperson.***

Grading Options	Internal assessment	External assessment
A (Theory Course)	50 % Periodical 1 – 15% Periodical 2 – 15% Continuous Evaluation – 20%	50% (3 hr exam)
B	70 % Periodical 1 – 15% Periodical 2 – 15% Continuous Evaluation – 40%	30% (2 hr exam)

C (For Courses Completed in 6 weeks)	50% Periodical 1 – 15% Assignments + Quizzes / lab-based experiments / mini-project – 35%	50% (3 hr exam)
D (Lab Based Course)	70% One Periodical Exam – 15% 50 % - Lab based assessment (minimum of 7 experiments With one end semester exam(mini-project) which should be evaluated by an external examiner) Lab experiments - 25% Mini Project/End Sem Lab (20%) + Viva (10%) – 30%	30% (2 hr exam)
E (Project Based Course)	70% - Project based (one mid-sem review and one final review with a review panel comprised of atleast one external examiner, student should submit a project report duly signed by the chairperson and external examiner) Project Implementation – 40% (this can have a mid-sem review) Final Review (20%)+ Report (10%) – 30%	30% (2 hr exam)
F (Analytical Courses)	70% - One Periodical - 15% Assignments (min 8) – 20% Quizzes (min 6) - 35%	30% (2 hr exam)

Based on the performance in each course, a student is awarded, at the end of the semester, a letter grade in each of the courses registered, in a ten point scale. The letter grades, the corresponding grade points and the ratings are as follows:

Letter Grade	***Grade Points***	***Ratings***
O	10.00	Outstanding
A+	9.50	Excellent
A	9.00	Very Good
B+	8.00	Good
B	7.00	Above Average
C	6.00	Average
P	5.00	Pass
F	0.00	Fail
FA	0.00	Failed due to insufficient attendance
I	0.00	Incomplete (awarded only for Lab Courses /Project/ Seminar)
W	-	Withheld

Note:
The 'I' grade may be given for Laboratory courses, Seminars, and Dissertation Research. It will be subsequently changed to an appropriate grade when the student passes the supplementary examination.

Semester Grade Point Average (SGPA)
On completion of a semester, each student is assigned Semester Grade Point Average (SGPA) which is computed as below for all courses registered by the student during that semester.

$$SGPA = \Sigma (C_i \times GP_i)/\Sigma C_i$$

where C_i is the number of credits for i_{th} course in that semester and GP_i is the grade points earned by the student for that course.

Cumulative Grade Point Average (CGPA)
The overall performance of a student at any stage of the M.Tech. program is evaluated by the Cumulative Grade Point Average (CGPA) upto that point of time.

$$CGPA = \Sigma (C_i \times GP_i)/\Sigma C_i$$

where C_i is the number of credits for i_{th} course in any semester and GP_i is the grade points earned by the student for that course. The summation is over all the courses registered by the student and evaluated during all the semesters up to that point of time, including the failed courses. The CGPA is rounded off to two decimals. The ranking of the students in a batch at any intermediate or final stage is based on CGPA.

CURRICULUM

First Semester

Course Code	Type	Course	L	T	P	Cr.
21MA615	FC	Foundations of Mathematics	2	0	1	3
21BI601	FC	Basics of Digital Signal Processing	2	0	1	3
21BI611	SC	Basics of Human Anatomy and Physiology	2	0	0	2
21BI612	SC	Internet of Things & Embedded Systems Design	3	0	1	4
21BI602	FC	Advanced Computer Programming	0	0	1	1
21BI613	SC	Sensor Design and System Development	2	0	1	3
21BI614	SC	Biomedical Instruments and Data Interpretation	2	0	0	2
21BI681	P	Live-in-Labs-I - Participatory Design and Modelling	0	0	0	0
21HU601	HU	Amrita Values Program*	0	0	0	P/F
21HU602	HU	Career Competency I*	0	0	0	P/F
		Total Credits				18

*Non-credit Course

Second Semester

Course Code	Type	Course	L	T	P	Cr.
21BI615	SC	Biomedical Image Processing	2	0	1	3
21BI616	SC	Machine Learning	2	0	1	3
21BI603	FC	Design and Analysis of Algorithm	2	0	1	3
	E	Elective I	2	0	0	2
	E	Elective II	2	0	1	3
21BI617	SC	Biomedical Equipment and Safety, Intellectual Properties and Medical Ethics	1	0	0	1
21RM619	SC	Research Methodology	2	0	0	2
	FE	Fractal Elective	1	0	0	1
21BI618	SC	Biomedical Instruments and Applications	0	0	1	1
21HU603	HU	Career Competency II	0	0	2	1
		Total Credits				20

Third Semester

Course Code	Type	Course	L	T	P	Cr
	E	Elective III	2	0	1	3
21BI798	P	Dissertation- Phase I				10
21BI781	P	Live-in-Labs II- Lab-to-Field: People Centered Innovation	0	0	0	0
		Total				13

Fourth Semester

Course Code	Type	Course	L	T	P	Cr.
21BI799	P	Dissertation- Phase II				16
21BI782	P	Live-in-Labs III- Social Business: People Centered Innovation	0	0	1	1
						17

Total Credits: 68

List of Courses

Foundation Core

Course Code	Type	Course	L	T	P	Cr
21MA615	FC	Foundations of Mathematics	2	0	1	3
21BI601	FC	Basics of Digital Signal Processing	2	0	1	3
21BI602	FC	Advanced Computer Programming	0	0	1	1
21BI603	FC	Design and Analysis of Algorithms	2	0	1	3

Subject Core

Course Code	Type	Course	L	T	P	Cr
21BI611	SC	Basics of Human Anatomy and Physiology	2	0	0	2
21BI612	SC	Internet of Things & Embedded Systems Design	3	0	1	4
21BI613	SC	Sensor Design and System Development	2	0	1	3
21BI614	SC	Biomedical Instruments and Data Interpretation	2	0	0	2
21BI615	SC	Biomedical Image Processing	2	0	1	3
21BI616		Machine Learning	2	0	1	3
21BI617	SC	Biomedical Equipment and Safety, Intellectual Properties and Medical Ethics	1	0	0	1
21BI618	SC	Biomedical Instruments and Applications	0	0	1	1
21RM619	SC	Research Methodology	2	0	0	2

Electives

Course Code	Type	Course	L	T	P	Cr
		Elective I				
21BI701	E	Fundamental Biomechanics	2	0	0	2
21BI702	E	Biofluid Mechanics	2	0	0	2
21BI703	E	MEMS and NEMS Sensors and Applications	2	0	0	2
21BI704	FE	Recent Trends in Targeted Drug Delivery Systems	2	0	0	2
		Elective II				
21BI711	E	Wireless Body Area Networks	2	0	1	3
21BI712	E	Mobile Computing	2	0	1	3
21BI713	FE	Biocompatible Materials and Flexible-Stretchable Electronics	2	0	1	3
21BI714	E	Wearable Computing	2	0	1	3
		Elective III				
21BI721	E	Artificial Intelligence in Biomedicine and Healthcare	2	0	1	3
21BI722	E	Bioinformatics	2	0	1	3
21BI723	E	Advanced Biomedical Instrumentation	2	0	1	3
21BI724	E	Biostatistics	2	0	1	3
21BI725	E	Security and Risks in Wearable Technologies	2	0	1	3

Fractal Electives

		Fractal Elective I				
21BI731	FE	Overview of Telemedicine for Healthcare Applications	1	0	0	1
21BI732	FE	Haptics and Robotics in Healthcare	1	0	0	1
21BI733	FE	Clinical Engineering	1	0	0	1
21BI734	FE	Rehabilitation Engineering	1	0	0	1
21BI735	FE	Optical Fiber Technology for e-Healthcare	1	0	0	1

Project Work

Course Code	Type	Course	L	T	P	Cr
21BI681	P	Live-in-Labs-I - Participatory Design and Modelling				0
21BI781	P	Live-in-Labs II- Lab-to-Field: People Centered Innovation				0
21BI782	P	Live-in-Labs III- Social Business: People Centered Innovation				1
21BI798	P	Dissertation- Phase I				10
21BI799	P	Dissertation- Phase II				16

21MA615- FOUNDATIONS OF MATHEMATICS (2-0-1-3)

a. Course Objective

The course will give an in depth knowledge in the areas of linear algebra and probability theory. These topics will thus help in attaining an application level knowledge in mathematics which will help in the mathematical modelling when designing biomedical devices.

b. Course Outcome

CO1	Understand the foundations of mathematics.
CO2	Be able to perform basic computations in higher mathematics.
CO3	Be able to read and understand middle-level proofs
CO4	Be able to write and understand basic proofs
CO5	Develop and maintain problem-solving skills
CO6	Have experience using technology to address mathematical ideas

c. Syllabus

Part I: Linear Algebra

Determinants- Row Reduction and Cofactor Expansions, Cramer's rule. Row picture, Column picture, Vector Spaces- Euclidean space, General (real) Vector Spaces, Subspaces, Linear Independence, Dimension, Row, Column and Null spaces.

Inner products: Norms, Orthogonal Bases and Gram-Schmidt Orthogonalization; Matrix Multiplication Problems, Matrix Analysis, Gauss Elimination Technique, LU and LDU Decomposition methods, Diagonalization of a Matrix, Singular value decomposition, Dimensionality Reduction, Principal Component Analysis.

Linear Transformations: Kernel and Range, Inverse Transformations, Matrices of Linear Transformations, Change of Basis, Similarity; Orthogonalizations and Least Squares, Parallel Matrix Computations, Unsymmetric Eigenvalue problem, Symmetric Eigenvalue problem, Iterative methods for linear systems, Lanczos methods.

Part II: Probability Theory

Introduction to Probability, Conditional Probability, Bayes' theorem; Random Variables, Analysis of discrete and continuous random variables, Probability Distributions, Distribution Functions, Mean and Variance of random variables, Standard Discrete and Continuous Distributions and their properties; Analysis of Joint Probability Distributions of discrete and continuous random variables, Two or more random variables, Joint, Marginal and Conditional Probability Distributions, independence of random variables, Covariance and correlation, Linear functions of random variables, several functions of random variables, Convergence of random variables, Law of Large Numbers, Central Limit Theorem.

TEXT BOOKS/REFERENCES:

1. Golub and Loan, "Matrix Computations", 3rd, John Hopkins University Press, 1996.
2. Carl. D. Meyer, "Matrix Analysis and Applied Linear Algebra", SIAM, 2001.
3. Gilbert Strang, "Introduction to Linear Algebra", 4th, Wellesley Cambridge Press, 2009.
4. Howard Anton, Chris Rorres, “Elementary Linear Algebra - Applications Version”, 11th, 2014
5. Vijay K Rohatgi and A K Saleh, "An Introduction to Probability and Statistics", 2nd, John Wiley & Sons, 2011.
6. Douglas C. Montgomery and George C. Runger, "Applied Statistics and Probability for Engineers", 4th, John Wiley & Sons, 2007.
7. Sheldon M. Ross, "A First Course in Probability", 8th, Pearson Prentice Hall, 2010.

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	2	1
CO2	2	2	3	2	
CO3	2	2	3	2	
CO4	2	2	3	2	
CO5	3	2	3	2	
CO6	3	2	3	2	3

3-strong, 2-moderate, 1-weak

21BI601 - BASICS OF DIGITAL SIGNAL PROCESSING (2-0-1-3)

a. Course Objective

The course gives the overview of the Digital Signal Processing and its applications in Wireless Sensor Networks. Digital Signal Processing begins with a discussion in introduction to Digital signals and systems, signal classification and basic signal operations. The discussion is followed by the analysis and representation of discrete-time signal systems, including discrete-time convolution, difference equations, the z-transform, and the discrete-time Fourier transform. The topics of Discrete-Time Fourier transform, Linearity and time invariance, FIR and IIR filters, Z-Transforms: Region of Convergence are covered. The main highlight of this course involves discussion of sampling theorem, anti-aliasing and components involved in a DSP system, and its applications to real life signals. The course proceeds to cover digital network and non-recursive (finite impulse response) digital filters. Digital Signal Processing concludes with digital filter design and a discussion of the fast Fourier transform algorithm for computation of the discrete Fourier transform, causality and Stability, Frequency spectrum, Inverse z-Transforms.

Lab: Practice sessions are provided for familiarizing MATLAB. Implementation of the concepts covered in the theory sessions are given as practice questions. MATLAB Implementations to the signals applicable to Biomedical instrumentation and signal processing (case

studies on processing of physiological signals ECG,EEG,EMG etc)are also given as practice questions.

b. Course Outcomes

CO1	Use concepts of trigonometry, complex algebra, Fourier transform, z-transform to analyze the operations on signals and acquire knowledge about Systems
CO2	Select proper tools for analog-to-digital and digital-to-analog conversion. Also select proper tools for time domain and frequency domain implementation.
CO3	Design, implementation, analysis and comparison of digital filters for processing of discrete time signals
CO4	Develop a thorough understanding on basics of signal pre-processing and digital filtering
CO5	Develop a thorough understanding on basics of ECG and EEG feature extraction.
CO6	Develop a thorough understanding on basics of ECG pattern recognition and classification algorithms

c. Syllabus

Sampling and Reconstruction: Sampling theorem, Anti-aliasing prefilters, Sampling of sinusoids, Analog reconstruction and aliasing, Spectra of sampled signals, Discrete-Time Fourier transform, Spectrum Replication, Practical Antialiasing prefilters.
Basic components of DSP systems: Quantization, Quantization Process, Oversampling and Noise shaping, D/A converters, A/D converters, Analog and Digital Dither. Discrete-Time systems: input/output.
Rules, Linearity and Time invariance, Impulse response, FIR and IIR filters, Causality and Stability. FIR Filtering and Convolution: Block processing methods Sample processing methods, FIR filtering in direct form. Z-Transforms: Region of Convergence, Causality and Stability, Frequency spectrum, Inverse z-Transforms.
Transfer functions: Sinusoidal response, Steady-State response, Transient response, Pole/Zero designs, First-Order filters, Parametric resonators and Equalizers, Notch and Comb filters, Deconvolution, Inverse filters, and Stability. Signal processing applications, DFT/FFT algorithms, Design of FIR filters, Using windows, Frequency sampling, Linear phase FIR filters. IIR Filters: Structure for IIR, State Space Analysis, Impulse invariance, Bilinear transformation, Weiner filters.
Lab: Implementation using MATLAB (case studies on processing of physiological signals like ECG, EMG and EEG)

TEXT BOOKS/REFERENCES:

1. Sophocles J. Orfanidis, “Introduction to Signal Processing”, US Edition, Prentice Hall, 1995.
2. John G.Proakis and DimitusG.Manolakis, “Digital Signal Processing, Principles, Algorithms and Applications", Third Edition, Prentice Hall of India, 2002.
3. SanjitK.Mitra, "Digital Signal Processing", Third Edition, Tata McGraw Hill, 2001.
4. Richard G. Lyons, "Understanding Digital Signal Processing", Second Edition, Prentice Hall, 2004.
5. Simon Haykin, “Signal and Systems”, John Wiley and Sons, 1999.

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	-	-
CO2	3	3	2	-	-
CO3	3	3	3	-	-
CO4	3	3	2	-	-
CO5	3	3	2	-	-
CO6	3	3	2	-	-

3-strong, 2-moderate, 1-weak

21BI602 – ADVANCED COMPUTER PROGRAMMING (0-0-1-1)

a. Course Objectives

Advanced Computer Programming is a lab course offered to 1st semester of M. Tech in Biomedical Instrumentation and Signal Processing. Students gain a deep understanding and practice of fundamental programming constructs using C language. The topics covered are indispensable as technical expertise needed in different fields of research and in industry such as in the design of embedded systems, IoT (Internet of Things) systems, network programming, software application development etc.

b. Course Outcomes

CO1	Develop problem-solving skills. Modularize a complex task and formulate a program structure with defined subtasks
CO2	Mastering fundamental programming constructs that are an indispensable skill in both well established and emerging technologies
CO3	Use low-level language features to directly manipulate memory
CO4	Use high-level language to abstract the algorithms and data structures from hardware-dependent details
CO5	Learning to work with libraries

c. Syllabus

Programming in C, Basic Computer Organization and Architecture, Build and Compilation process, Debugging concepts, Data Types and Variables, Input/ Output implementation and usage, Control flow, Modular Programming with functions, Stack Frames and Activation Records, Arrays, Pointers, Strings, Structures, Implementation of Structures, Memory, Stacks, Recursion, Dynamic Memory Allocation, Heap, Program Runtime Analysis, Big-Oh Notation.
Significant labs, e.g., Spell Checker with a real dictionary, complicated data structure such as a Vector/Set, Customer Relationship Management system, custom string Abstract Data Type, Maze, etc.

TEXT BOOKS/REFERENCES:

1. Brian W Kernighan and Dennis M Ritchie, "The C Programming Language", Second Edition, Prentice Hall, 1988.
2. K. N. King, "C Programming: A Modern Approach", Second Edition, W. W. Norton & Company, 2008.
3. Yashavant Kanetkar, "Let Us C" 15th Edition.

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	2
CO2	3	3	3	3	3
CO3	3	2	2	2	1
CO4	3	3	3	2	1
CO5	3	2	2	2	2

3-strong, 2-moderate, 1-weak

21BI603 - DESIGN AND ANALYSIS OF ALGORITHMS (2-0-1-3)

a. Course Objectives

Design and Analysis of Algorithms is a course offered to 2nd semester M. Tech in Wireless Networks & Applications. The objective of the course is to teach techniques for effective problem solving for a given challenge. The use of different paradigms of problem solving will be used to illustrate clever and efficient ways to analyse, interpret and solve a given problem. Theoretical basis of algorithms and data structure is also discussed.

b. Course Outcomes

CO1	Ability to Understand, Analyze the performance of recursive and non-recursive algorithms and to measure the performance of algorithms.
CO2	Able to apply the knowledge gained to determine the efficiency of algorithms, considering time and space tradeoffs by using asymptotic notations.

CO3	Able to understand the concept of graph traversal and search algorithms.
CO4	Solve problems by applying appropriate algorithm design techniques and analyze the efficiency of various algorithms
CO5	Able to apply divide and conquer strategy for the design of various algorithms

c. Syllabus

Algorithm Analysis: Methodologies for Analyzing Algorithms, Asymptotic Notation, Recurrence Relations. Data Structures: Linear Data Structures (Stacks, Queues, Linked-Lists, Vectors), Trees (Binary Search Trees, AVL trees, Red-Black trees, B-trees), Hash-Tables (Dictionaries, Associative Arrays, Database Indexing, Caches, Sets) and Union-Find Structures. Searching and Sorting(Insertion and Selction Sort, Quick Sort, Merge Sort, Heap Sort, Bucket Sort and Radix Sort), Comparison of sorting algorithms and lower bounds on sorting. Fundamental techniques: The Greedy Method, Divide and Conquer, Dynamic Programming. Graph Algorithms: Elementary Algorithms, ie Breadth-first search, Depth-first search, Topological sort, Strongly connected components. Minimum Spanning Trees, Single-Source Shortest Paths, All-Pairs Shortest Paths, Maximum Flow, Network Flow and Matching, Flows and Cuts. Nondeterministic Polynomial Time Problems: P and NP, NP-Complete, NP-Hard, Important NP-Complete/Hard Problems.

Significant labs: Implementation of algorithms using a structured or object-oriented programming language.

TEXT BOOKS/REFERENCES:

1. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein, "Introduction to Algorithms", Third Edition, MIT Press, 2009.
2. SanjoyDasgupta, Christos Papadimitriou and UmeshVazirani, "Algorithms", McGraw-Hill, 2006.
3. Jon Kleinberg and EvaTardos, "Algorithm Design", Addison Wesley, 2005.
4. RobertSedgewick and Kevin Wayne, "Algorithms", Fourth Edition, Addison Wesley, 2011.
5. Kurt Mehlhorn and Peter Sanders, "Data Structures and Algorithms: The Basic Toolbox", Springer, 200

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	2	1	2
CO2	3	3	2	1	2
CO3	3	3	3	1	1

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

3-strong, 2-moderate, 1-weak

21BI611-BASICS OF HUMAN ANATOMY AND PHYSIOLOGY (2-0-0-2)

a. Course Objectives

Anatomy, Physiology and Biochemistry is the tripod on which the study of life sciences rests.

Anatomy is the study of structure of the body and Physiology refers to function. The merger of life sciences with engineering has opened a new realm of biomedical engineering and this in turn has brought to the table, innovation to the practice of medicine.

The course will align structural composition of the body to its function from cellular to organs and organ systems. Learning objectives will be achieved through didactic lectures and small group discussion.

b. Course Outcome

CO1	To be able to describe the structural organization of the body
CO2	To be able to describe basic functioning of the body
CO3	To be familiar with possible deviations from normal in terms of structure and function
CO4	To understand man – machine interface

c. Syllabus

Introduction to general human anatomy, gross location of various systems, Embryology - development of various tissues and formation of organs, anatomy that can go wrong during development - congenital anomalies, Basic physiology at cellular level - functions of each cellular organ; Cell biology, homeostasis, biopotentials, transport mechanisms. Musculosketal system: classification and identification of major bones, joints and muscles, Cardiovascular system: location, position, parts of heart - internal and external anatomy, conducting system of heart, cardioelectrical activity, regulation of arterial pressure.

Respiratory system: location, structure/parts and their functions, mechanism of respiration, Digestive system (gastrointestinal system): Location, structure/parts and their functions of stomach, Other related structures/function: liver, spleen and pancreas, connecting tubes and vessels, Urinary system: Kidney - location, anatomy, function - filtration, body fluid balance, control of minerals.

Central nervous system & spine: parts of brain and their functionalities, Head/neck/face system : major parts of face and related bones, and structures, salivary glands, thyroid, lymph nodes, muscles of mastication; Measurement of testing of various parameters that define the function of each organ system – eg. lab tests of blood, urine and other samples; Anatomical/structure

evaluation methods correlation including: Radiology and Imaging techniques, Histology, Cytology.

TEXT BOOKS/REFERENCES:

1. Anatomy and Physiology Ashalatha and Deepa , Ed, Elsevier Publications
2. Marieb E and Hoehn K, Human Anatomy & Physiology, Tenth Edition, Benjamin Cummings, 2014.
3. Saladin K S, Human Anatomy, Fifth Edition, McGraw-Hill, 2011.
4. Guyton A C and Hall J E, Textbook of Medical Physiology, Thirteenth Edition, Elsevier Saunders, 2015.
5. Johnson L, Essential Medical Physiology, Third Edition, Elsevier Academic Press, 2006.
6. Anatomy and Physiology- https://opentextbc.ca/anatomyandphysiology/front-matter/preface-2/

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	-	-	-	-
CO2	1	1	-	-	-
CO3	2	1	2	-	-
CO4	2	2	1	1	2

3-strong, 2-moderate, 1-weak

21BI612 - Internet of Things and EMBEDDED SYSTEM DESIGN (3-0-1-4)

a. Course objectives

Embedded System Design **is** a course offered to 1st semester M. Tech in the Biomedical instrumentation and signal processing. It is a very hands-on course that introduces students to the intricate details of a typical microcontroller and single board computers used in designing embedded and IoT based applications. Students will refresh some of their basics of Computer architecture, Number systems, Electrical circuits, and Digital logic design before they go deeper into microcontroller internals like GPIO Interfaces, PLL, Interrupts, DAC, ADC, etc. The course covers complete systems design where they will interface external hardware like LEDs, Switches, various sensors, communication modules, LCD controller etc. to the microcontroller / single board computers and build working prototypes of different real world applications. They also learn to write and debug embedded software. By the end of the course, one will design, build and test a complete IoT end to end system.

Course Outcome

CO1	Understand the basics of Embedded Systems, Number Systems, and Assembly Language

CO2	Design interface circuits to control external devices via GPIO
CO3	Details of LM3S1968 Internals like PLL, Systick, Interrupts, and software configuration
CO4	Digitization of Analog inputs using ADC, Audible Analog Signal Generation using DAC
CO5	Mastering fundamental programming constructs required for IoT Programming and familiarising with programming IoT devices such as Raspberry Pi, Arduino etc
CO6	Gaining ability to analyze an IoT scenario and break it down into programmable modules using the procedural and OOP concepts learnt.
CO7	Design, build and test a complete IoT end to end system.

b. Syllabus

Microcontroller fundamentals: ARM ASM programming and basic of C; IO Interfacing: LED and Switch; Design and Development Process: Architecture, Microarchitecture, Design, Implementation, Verification and Validation; Development Tools: Block Diagrams, Flow Charts, Call Graphs, Dataflow Graphs, Finite State Machines; The Parallel Interface: GPIO; The Serial Interface: UART, I2C, SPI; PLL programming; Timer: SysTick; Fixed Point; Software: Structs, Stacks and Recursion; Device Driver: Interfacing with an Hitachi HD44780 display; IO Synchronization; Interrupts; DAC: Music Synthesis and Music Playback; ADC: Real world interfacing and Data Acquisition.

Significant labs include prototypes of actual embedded systems and IoT based systems, e.g., Traffic Light Controller (FSM), LCD Device Driver (Hitachi HD44780), Digital Piano (DAC, Interrupts), Digital Vernier Caliper (ADC, Interrupts, LCD), Distributed Data Acquisition (Interrupts, ADC, LCD, UART). Programming of single board computers. Interfacing Analog and Digital sensors. Interfacing RF modules. UART Communication. Data communication to the cloud. Prototype design of IoT Systems for a specific application. Capstone Design Project, A popular video game, e.g., Space Invaders, Connect-4, Pipe Dream, etc.

TEXT BOOKS/REFERENCES:

1. Jonathan WValvano, “Embedded Systems: Introduction to ARM® Cortex™-M Microcontrollers”, Fourth Edition,CreateSpace Independent Publishing Platform, 2013.
2. David Etter, “IoT (Internet of Things) Programming: A Simple and Fast Way of Learning IOT”.

References

1. Joseph Yiu, "The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors", Third Edition, Newnes, 2013.
2. Martin, "The Designer's Guide to the Cortex-M Processor Family: A Tutorial Approach", First Edition,Newnes, 2009.
3. Arnold S. Berger, “Embedded System Design”, First Edition, CRC Press, 2001.
4. Adrian McEwen, Hakim Cassimally, “Designing the Internet of Things”, Wiley, 2014.
5. Dr. OvidiuVermesan , Dr. Peter Friess , “Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems”, River Publishers.
6. Donald Norris, “The Internet of Things: Do-It-Yourself at Home Projects for Arduino, Raspberry Pi and Beagle Bone Black”, Copyright Material, Edition 1, 2015.

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	2	3
CO2	3	3	3	2	3
CO3	3	3	3	2	3
CO4	3	3	3	2	3
CO5	3	3	3	2	3
CO6	3	3	3	2	3
CO7	3	3	3	2	3

3-strong, 2-moderate, 1-weak

21BI613 -SENSOR DESIGN AND SYSTEM DEVELOPMENT (2-0-1-3)

a. Course Objectives

It provides an insight into the various types of sensors and sensing principles. Through this course, the students will get an idea about different characteristics of sensors that helps to design and develop sensors of custom specification meeting all quality requirement. Along with this, students will also be learning the system design and sensor integration. This course also gives an overall information on calibration methods considering the environmental factors, reliability and application characteristics.

b. Course Outcome

CO1	To understand various sensing principles and different types of sensors
CO2	To learn the sensor characteristics, both at static and dynamic conditions.
CO3	To learn electromechanical analogies and modelling of sensors

CO4	To understand sensor interfacing circuit design and integration
CO5	To acquire basic knowledge on Low power system design, integration and testing
CO6	To learn Calibration of sensor systems , environmental factors and reliability

c. Syllabus

Unit 1:
Overview of sensors, types of sensors and sensing principles.
Unit 2:
Sensor characteristics - receiving sensitivity, transmitting response, linearity, power handling capacity, Span, Full-Scale Output, Accuracy, Hysteresis, Nonlinearity Saturation, Repeatability, Dead Band, Resolution, Output Impedance, Output Format, Excitation, Dynamic Characteristics, Electromechanical analogies, Analogies, Dynamic Models of Sensor Elements.
Unit 3:
Interfacing circuit and signal conditioning: Interface electronic circuits design, Analog-to-Digital Converters, Noise in Sensors and Circuits
Unit 4:
Low-Power System: Design and modeling, System integration and testing.
Calibration methods, Environmental Factors, Reliability, Application Characteristics.

TEXT BOOKS:

1. Clarence W. de Silva, "Sensor Systems-FUNDAMENTALS AND APPLICATIONS", CRC Press.
2. Patrick F Dunn, "Fundamentals of Sensors for Engineering and Science", CRC Press.

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3				
CO2	1				
CO3	1		1		
CO4	2	1	2		2
CO5	1		1		1
CO6	2	1	1	2	1

3-strong, 2-moderate, 1-weak

21BI614 - BIOMEDICAL INSTRUMENTS AND DATA INTERPRETATION (2-0-0-2)

a. Course Objectives

The course gives a general overview of the various biomedical instrument technologies available, and methods of data acquisition and analysis from the same. Biomedical data can be signals, images, sounds and so on. Each kind of data has specific equipment designed for its extraction and interpretation. Based on this categorization, we will get familiarized with (a) biomedical signal acquisition modalities like ECG, EEG, EMG, (2) biomedical imaging modalities like x-ray, MRI, CT and (3) surgical and other analytic equipment.

b. Course Outcome

CO1	Understanding the significance and get a basic idea about the different biomedical instruments used.
CO2	Understand the different modalities and the data acquisition procedure
CO3	Familiarization with different signal acquisition modalities in ECG, EEG etc.
CO4	Familiarization with medical imaging modalities like X-ray, MRI, CT, PET, SPECT and Ultrasound.
CO5	A brief overview of other related medical instruments - ENT, Optical and Surgical.

c. Syllabus

Basic Concepts and Principles of Medical Instrumentation: Survey of major modalities, techniques, and data interpretation - X-ray, Computed Tomography (CT), Magnetic Resonance Imaging (MRI), PET, and SPECT. Electrocardiogram (ECG), Electroencephalogram (EEG), Electromyography (EMG), Surgical Instruments, ENT and Ophthalmic Instruments, Ultrasound Medical Diagnostic Instrumentation. Understand capabilities and limitations. Recent trends and developments in Medical Instruments and techniques.

TEXT BOOKS/REFERENCES:

1. Ananthi, S. A, “Textbook of medical instruments”, New Age International, 2005.
2. Webster, J. G. (ed.), “Medical instrumentation: application and design”, Fourth edition, John Wiley & Sons, Hoboken
3. J.J.Carr&J.M.Brown, “Introduction to Biomedical Equipment Technology” Pearson Education, Asia.

PO / CO	PO1	PO2	PO3	PO4	PO5

CO1	3	3	2	1	2
CO2	3	3	2	1	2
CO3	2	2	2	1	2
CO4	1	2	2	1	2
CO 5	1	2	2	1	2

3-strong, 2-moderate, 1-weak

21BI615 - BIOMEDICAL IMAGE PROCESSING (2-0-1-3)

a. Course Objectives

The course covers overview of biomedical signal gathering, image forming, picture processing, and image display to medical diagnosis based on features extracted from images. Biomedical image processing is similar in concept to biomedical signal processing in multiple dimensions. It includes the analysis, enhancement and display of images captured via x-ray, ultrasound, MRI, nuclear medicine and optical imaging technologies. Also introducing concepts of augmented / virtual / mixed reality and its applications in the medical field.

b. Course Outcomes

CO1	Ability to understand the methods of medical image acquisition and the challenges in the processing pipeline;
CO2	Understanding of image processing techniques in enhancement, correction, noise removal and clustering;
CO3	Numerical ability to apply these techniques on digital images.

c. Syllabus

Imaging Modalities: Survey of Major Modalities for Medical Imaging: Ultrasound, X-ray, CT, MRI, PET, and SPECT. Introduction to Image Processing Requirements and their Techniques, Properties, Advantages and Disadvantages; Image Enhancement - Enhancement in Spatial and Frequency Domains, Applications: Noise Reduction in Nuclear Medicine Imaging, Contrast Enhancement of Mammograms.

Medical Image Segmentation, Threshold Based, Region Growing, Active Contours, Level Set, Graph Partitioning, Deep Learning Based Segmentation on 2D or 3D Volume of Data Feature Extraction, Morphological Features, Textural Features, SIFT, SURF, MSER, HoG, Image Registration and Fusion, Keypoints Selection, Keypoint Descriptors, Keypoint Matching, Geometric transformations.

Morphological Image Processing: Binary and Gray-scale Morphological Operations, Morphological Algorithms, Applications: Enhancement of Masses in Mammograms; Image Segmentation, Global Thresholding, Adaptive Thresholding, Region Growing, Region Splitting and Merging, Edge Detection Reconstruction Techniques, Image Registration, Linear Transformation, Non-Linear Transformation, Non-Rigid Transformation, Feature-Based and Voxel-Based Registration, Case Studies in Medical Images. Classification and Clustering, Examples of Image Classification for Diagnostic/Assistive Technologies, Traditional and Deep Learning Based Classifiers 3D Volume Reconstruction, CT and MRI Volume Reconstruction – Wavelet Based Volume Rendering

Augmented, virtual, mixed reality - concepts, techniques and its applications in the medical field.

Lab: The Course also has a laboratory component where the student will apply the algorithms and techniques learnt, on various biomedical images of interest.

TEXT BOOKS/REFERENCES:

1. Suetens, P. Fundamentals of Medical Imaging, Cambridge University Press
2. Dougherty, G, Digital Image Processing for Medical Applications, Cambridge University Press
3. Prince, J. & Links, J. Medical Imaging Signals and Systems, Prentice Hall, Bankman, Isaac.Handbook of Medical Imaging: Processing and Analysis, Academic Press,
4. Yoo, Terry S. Insight into Images: Principles and Practice for Segmentation, Registration and Image Analysis, CRC Press,
5. Sethian, J.A., Level-set Methods, Cambridge University Press, 2000,

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	1	-	3	2
CO2	2	2	-	2	1
CO3	2	3	3	2	1

3-strong, 2-moderate, 1-weak

21BI616 - MACHINE LEARNING (2-0-1-3)

a. Course Objectives

Machine Learning has become ubiquitous with the advent of the huge volume of data generated, stored, and processed across all domains. Machine learning involves various algorithms that enable computers to learn from data without being explicitly programmed. The crux of machine learning algorithms revolve around core mathematical concepts such as linear algebra, probability, and statistics. Data mining uses machine learning algorithms to discover interesting facts and patterns from data in various applications so as to develop models for classification or prediction. In this course, the students will learn overlapping concepts of data mining and machine learning and get an insight into various types of machine learning, motivation and challenges of machine learning, fundamental machine learning algorithms for supervised and unsupervised learning required for data mining process. Hands-on lab sessions in Python to build and evaluate predictive models using real-world data will help to bridge the gap between theory and practice in an effective manner.

b. Course Outcomes

CO1	Analyze the data and find standard quantities of central tendencies, dispersion and the possible distribution of the data.
CO2	Conduct data analysis and data visualization using both spreadsheet and python anaconda frameworks
CO3	Describe different machine learning paradigms - supervised and unsupervised learning and their application domains
CO4	Analyze and identify the machine learning algorithms to be used on a given dataset for regression/classification problems.
CO5	Use python scikit framework to use various machine learning algorithms.
CO6	Explain different dimensionality reduction techniques such as PCA, and to also apply it on data for preprocessing
CO7	Use different performance metrics and infer the meaning of the ML results based on that.
CO8	Describe the fundamentals of neural networks and apply it on problems.
CO9	Apply oversampling techniques for solving the missing data problem.
CO10	Describe and apply the complete ML pipeline in real-world dataset - Analyze datasets, decide pre-processing steps, visualize data,

	apply ML models, and infer the meaning based on different performance metrics.

c. Syllabus

Role of learning in intelligent behavior, general structure of a learning system; learning from example; concept learning, Introduction to machine learning and machine learning applications, Supervised learning, linear regression, polynomial regression, logistic regression, multivariate methods, dimensionality reduction, Support Vector Machine, clustering. Neural networks, multilayer perceptrons, local models, assessing and comparing ML models. MLOps - introduction to converting ML models from test bench to production (saving, loading, using trained models).

TEXT BOOKS/ REFERENCES:

1. Tom. Mitchell, "Machine Learning", McGraw Hill, 1997.
2. Géron, Aurélien. Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow: Concepts, tools, and techniques to build intelligent systems. O'Reilly Media, 2019.

REFERENCES

1. Kevin P. Murphey, "Machine Learning, a Probabilistic Perspective", MIT press, Cambridge, Massachusetts, 2012.
2. Chris Baton et al., "Understanding Big Data", McGraw Hill, 2012.
3. Christopher Bishop, "Pattern Recognition and Machine Learning", Springer.

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	3
CO2	1	1	2	2	1
CO3	2	2	2	2	2
CO4	3	3	3	3	3
CO5	1	2	1	3	3
CO6	3	3	3	3	3
CO7	3	3	3	3	3
CO8	3	3	3	3	3
CO9	3	3	3	3	3
CO10	3	3	3	3	3

3-strong, 2-moderate, 1-weak

21BI617 - BIOMEDICAL EQUIPMENT AND SAFETY, INTELLECTUAL PROPERTIES AND MEDICAL ETHICS (1-0-0-1)

a. Course Objectives

This course mainly focuses on the study safety consideration in design and development of electrical equipment, patient and device safety. And also give an idea about IPR, registration and its enforcement. This course will examine some of the ethical issues faced by medical professionals, various ethical decisions we make as a society that affect medical practice, and the fundamental moral principles and ethical values that underlie our view of the place of medical practices in our lives. Learning objectives will be achieved through didactic lectures and small group discussions.

b. Course Outcomes

CO1	Understanding how to develop medical equipment that conforms to safety standards
CO2	Ability to manage Intellectual Property portfolio to enhance the value of the firm
CO3	General awareness on medical ethics to be considered in patient data handling, clinical trials, case studies etc
CO4	Medical Ethics with reference to Moral, Legal, Social, Religious and Cultural Contexts.

c. Syllabus

Biomedical equipment safety: Safety standards to be considered in design and development of electrical equipment, patient and device safety.

Intellectual property: To give an idea about IPR, registration and its enforcement.

Medical Ethics: Moral, Legal, Social, Religious and Cultural Contexts, Information and Consent, Truthfulness, Voluntariness, Patient Data Confidentiality, End-of-Life Ethics, Genetics and Biotechnology, Children and Pregnant Women, Clinical Trials, Case Studies, Regulatory Compliance.

TEXT BOOKS/REFERENCES:

1. Bertil Jacobson and Alan Murray, “Medical Devices Use and Safety”, Elsvier Limited,2007.
2. Richard Fries,“Reliable Design of Medical Devices – Second Edition”, CRC Press,Taylor& Francis Group, 2006.
3. V. Scople Vinod, Managing Intellectual Property, Prentice Hall of India pvt Ltd, 2012
4. S. V. Satakar, ―Intellectual Property Rights and Copy Rights, Ess Ess Publications, New Delhi, 2002.
5. Shamoo A and Resnik D B, Responsible Conduct of Research, Third Edition, Oxford University Press, 2015.

6. Gopalakrishnan B, Khaute M, Bhat B S, Bhat S, Sastry S R, Kaur K, Menon M, Kamath A, Saha M, Sadhya M, Reflections on Medical Law and Ethics in India, First Edition, Eastern Law House, 2016

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	-	-	-	
CO2	2	1	1	-	-
CO3	-	1	-	-	-
CO4	1	-	-	-	-

3-strong, 2-moderate, 1-weak

21BI618 - BIOMEDICAL INSTRUMENTS AND APPLICATIONS (0-0-1-1)

a. Course Objectives

The course gives a general overview of the various biomedical instrument technologies available, and methods of data acquisition and analysis from the same. A detailed study of the different biomedical equipment's they had studied in the first semester course in '19BI614: Biomedical Instruments and Data Interpretation' is to be carried out by engaging in actual experimentation with laboratory equipment's, virtual laboratories, referring practical demo videos and IEEE publications. To understand the real-world scenario, the students will visit
Amrita School of Medicine, Kochi for actual experimentation and demonstration of selected medical instruments in specific application scenarios and engage in data interpretation for each of the instruments for different types of diseases.

b. Course Outcomes

CO1	Understanding the significance of the course and to get a basic idea about the different biomedical instruments used.
CO2	To get an idea about the sphygmomanometer and glucometer
CO3	Familiarization with different signal acquisition modalities in ECG, EEG etc. Also familiarize medical imaging modalities like X-ray, MRI, CT, PET, SPECT and Ultrasound.
CO4	A brief overview of other related medical instruments - ENT, Optical and Surgical. Practical hands on experience by using different biomedical instruments in real time

c. Course Syllabus

Laboratory visits and practical experiments based on Biomedical **Instruments and Data interpretation** course in *Semester I.*

TEXT BOOKS/REFERENCES:

1. Ananthi, S. A, "Textbook of medical instruments", New Age International, 2005.
2. Webster John G and Clark John W, "Medical Instrumentation: Application and Design", 3rd Edition, John Wiley, 1998.

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	1	3
CO2	3	2	2	1	3
CO3	3	2	2	1	3
CO4	3	2	2	1	

3. 3-strong, 2-moderate, 1-weak

21RM619 RESEARCH METHODOLOGY (2-0-0-2)

a. Course Objectives

Research Methodology is a subject core course offered to 2nd semester M.Tech in Biomedical Instrumentation and Signal Processing. This course focuses to give students an understanding of some fundamental research techniques. The course works towards building reading and writing skills in the context of research articles with ample practice. Focus will be given on conducting literature survey, identifying research questions, reading, reviewing and writing research articles.

b. Course Outcomes

CO1	Learning how to effectively read a research article.
CO2	Practice in technical writing styles and using academic writing tools
CO3	Need for literature review, Identify various sources of information for literature review and data collection, Steps to carry out a literature review
CO4	Critical analysis of top rated research papers including at least one survey paper and one or two good journal paper in the broad areas
CO5	Understand the research components of the selected paper such as problem definition, assumptions, solution, and solution

	methodology, analyze the findings of the paper, identify the research gaps
CO6	Formulate a research problem based on the critical analysis
CO7	Presentation of research proposals on selected topic

c. Syllabus

Unit I:
Meaning of Research, Types of Research, Research Process, Problem definition, Objectives of Research, Research Questions, Research design, Approaches to Research, Quantitative vs. Qualitative Approach, Understanding Theory, Building and Validating Theoretical Models, Exploratory vs. Confirmatory Research, Experimental vs Theoretical Research, Importance of reasoning in research.
Unit II:
Problem Formulation, Understanding Modeling & Simulation, Conducting Literature Review, Referencing, Information Sources, Information Retrieval, Role of libraries in Information Retrieval, Tools for identifying literatures, Indexing and abstracting services, Citation indexes
Unit III:
Experimental Research: Cause effect relationship, Development of Hypothesis, Measurement Systems Analysis, Error Propagation, Validity of experiments, Statistical Design of Experiments, Field Experiments, Data/Variable Types & Classification, Data collection, Numerical and Graphical Data Analysis: Sampling, Observation, Surveys, Inferential Statistics, and Interpretation of Results.
Data in Biology: Development in Biostatistics, Samples and Populations, Techniques of 2 Sampling (random and stratified), Sampling and Non-sampling Errors, Variables in Biology, Accuracy, Precision, Univariate and Bivariate Frequency Distributions and their Graphical Representations;

Unit IV:
Preparation of Dissertation and Research Papers, Tables and illustrations, Guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript. References, Citation and listing system of documents
Unit V:
Intellectual property rights (IPR) - patents-copyrights-Trademarks-Industrial design geographical indication. Ethics of Research- Scientific Misconduct- Forms of Scientific Misconduct. Plagiarism, Unscientific practices in thesis work, Ethics in science

TEXT BOOKS/ REFERENCES:

1. Bordens, K. S. and Abbott, B. B., “Research Design and Methods – A Process Approach”, 8thEdition, McGraw-Hill, 2011

2. C. R. Kothari, “Research Methodology – Methods and Techniques”, 2nd Edition, New Age International Publishers
3. Davis, M., Davis K., and Dunagan M., “Scientific Papers and Presentations”, 3rd Edition, Elsevier Inc.
4. Michael P. Marder,“ Research Methods for Science”, Cambridge University Press, 2011
5. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008
6. Robert P. Merges, Peter S. Menell, Mark A. Lemley, “Intellectual Property in New Technological Age”.Aspen Law & Business; 6th Edition July 2012.

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	1
CO2	3	3	3	3	2
CO3	3	3	3	3	2
CO4	3	3	3	3	2
CO5					
CO6					
CO7					

3-strong, 2-moderate, 1-weak

21BI701 - FUNDAMENTAL BIOMECHANICS (2-0-0-2)

a. Course Objectives

Fundamental Biomechanics provides an introduction to human biomechanics for students.. The mechanical aspects of human movement and applied anatomy are explained with examples of relevant sport, clinical, and daily living applications.

b. Course Outcomes

CO1	Study the principles of Biomechanics.
CO2	Understanding biomechanical analysis of human motion.
CO3	Understanding of biomechanical analysis of joints, muscles, spine.
CO4	Developing skill in biomechanical modelling

c. Syllabus

Unit 1

Elements of Rheology and Principles of Continuum Mechanics, Visco Elastic Properties, Basics of Elasticity, Structure, Properties and Mechanics of Soft and Hard Tissues (Bones, Cartilage, Muscles, Tendon and Ligaments), Anatomical Positions, Planes and Axes. Segments of Human Body, Segmental Parameters, Centre of Mass and Centre of Gravity.

Unit 2

Biomechanical Analysis of Human Motion, Linear and Angular Kinematics, Linear and Angular Kinetics.

Unit 3

Classification of Joints, Mechanics of Joints in Lower and Upper Extremities, Mechanics of Spine, Estimation of Muscle Forces, Joint Reaction Forces and Moments. Biomechanical Modeling: Simulation and Analysis using Open Source Tools like Opensim, Febio Software Suite and GIBBON.

TEXT BOOKS/REFERENCES:

1. Margareta Nordin and Victor H. Frankel, Basic Biomechanics of Musculoskeletal System, Fourth Edition, Lippincott, Williams and Wilkins, 2012.
2. Fung Y C, Biomechanics: Mechanical Properties of Living Tissues, Second Edition, Springer Verlag, 1993.
3. Susan J. Hall, Basic Biomechanics, Seventh Edition, McGraw-Hill, 2014.
4. Nihat Ozkaya, Margareta Nordin, David Goldsheyder, Dawn Leger, Fundamentals of Biomechanics - Equilibrium, Motion, and Deformation, Fourth Edition, Springer, 2016.
5. Masao Tanaka, Shigeo Wada, and Masanori Nakamura, Computational Biomechanics - Theoretical Background and Biological/Biomedical Problems, Springer.

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	1	2	-	2
CO2	3	1	2	-	2
CO3	3	1	2	-	2
CO4	3	3	3	3	2

3-strong, 2-moderate, 1-weak

21BI702 - BIOFLUID MECHANICS (2-0-0-2)

a. Course Objectives

The focus of the course is on the integration of various fluid mechanics concepts to address relevant problems of the human body's systems. An important objective of the course is to develop a broad knowledge and a critical thinking regarding the current research challenges in biological fluid dynamics.

b. Course Outcome

CO1	Study of fundamentals of fluid and solid mechanics and cardiovascular physiology
CO2	Study about the biomechanics of human circulation
CO3	Introduction to different therapeutic techniques
CO4	Awareness about the different fluid dynamic measurement techniques
CO5	Human body simulations and modelling

c. Syllabus

Fluid and Solid Mechanics and Cardiovascular Physiology: Fundamentals of Fluid Mechanics and Solid Mechanics; Cardiovascular Physiology: Heart, Cardiac Valves, Systemic Circulation, Coronary Circulation, Pulmonary Circulation and Gas Exchange in the Lungs, Cerebral and Renal Circulations, Microcirculation, Regulation of the Circulation, Atherosclerosis.

Biomechanics of the Human Circulation: Rheology of Blood and Vascular Mechanics, Static and Steady Flow Models, Flow in Collapsible Vessels, Unsteady Flow and Nonuniform Geometric Models; Cardiovascular Implants and Biomechanical Measurement; Vascular Therapeutic Techniques: Vascular Graft Implants, Arteriovenous Fistulas, Types of Vascular Graft Materials Used, Clinical Experience with Vascular Grafts.

Fluid Dynamic Measurement Techniques: Blood Pressure Measurement, Blood Flow Measurement, Impedance Measurement; Computational Fluid Dynamic Analysis of the Human Circulation: Computational Fluid Dynamic (CFD) Analysis Techniques, Modeling, Mechanical Simulations, Fluid Dynamic Simulations in the Human Circulation, Future Directions: Multiscale Modeling.

TEXT BOOKS/REFERENCES:

1. Krishnan B. Chandran, Ajit P. Yoganathan, Stanley E. Rittgers. Boca Raton, “Biofluid mechanics : the human circulation” : CRC, Taylor & Francis, 2007.
2. Rubenstein, David, Wei Yin, and Mary D. Frame. Biofluid mechanics: an introduction to fluid mechanics, macrocirculation, and microcirculation. Academic Press, 2015.
3. Ozkaya, Nihat, et al. Fundamentals of biomechanics. USA: Springer, 2012.

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	1	-	2	
CO2	3	1	-	2	

CO3	1	1	1	2	
CO4	3	2	1	1	

3-strong, 2-moderate, 1-weak

21BI712 - MOBILE COMPUTING (2-0-1-3)

a. Course Objectives

This course is aimed to provide understanding of fundamentals of wireless communications. Analyze security, energy efficiency, mobility, scalability, and their unique characteristics in wireless networks. Demonstrate basic skills for cellular networks design. Apply knowledge of TCP/IP extensions for mobile and wireless networking.

b. Course Outcomes

CO1	Introduction to mobile devices, operating systems and applications
CO2	Awareness about different mobile application development languages
CO3	Introduction to Android platform
CO4	Study of design of user interface for mobile applications
CO5	Introduction to integration and working with database systems
CO6	Overview is Security systems and permissions in mobile computing

c. Syllabus

History of mobile devices, mobile operating systems and mobile application frameworks, Modern mobile operating systems and their architecture. Overview of mobile application development languages: C and Java. Introduction to Android platform: virtual machine, development tools, Java packages, emulators, services, Structure and lifecycle of an application for Android system. User-interface design for mobile applications: Graphical User Interface - preparing containers and components, management of component layout, event handling; Introduction to integration and working with database. Overview of security and permissions, bluetooth communication, deployment of application.

TEXT BOOKS/REFERENCES:

1. Bill Phillips, Chris Stewart, Brian Hardy, and Kristin Marsicano, “Android Programming: The Big Nerd Ranch Guide”, Big Nerd Ranch LLC, 3rd edition, 2017;
2. Rajiv Ramnath, Roger Craws, and Paolo Sivilotti, “Android SDK 3 for Dummies”, Wiley.

3. Asoke K. Talukder, Roopa R. Yavagal, “Mobile Computing: Technology, Applications, and Service Creation”, McGraw-Hill Communications Engineering 2007
4. Burnette E., “Hello, Android: Introducing Google's Mobile Development Platform”, Pragmatic Bookshelf, 2010
5. Steele J, “The Android Developer's Cookbook: Building Applications with the Android SDK”, Addison-Wesley Professional, 2010
6. Chris Griffith, “Mobile App Development with Ionic: Cross-Platform Apps with Ionic, Angular & Cordova”, O’Reilly, 2017.
7. Joshua Morony, “Building Mobile Apps with Ionic & Angular” [ebook].

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	2	2	2
CO2	3	3	2	2	2
CO3	3	3	3	3	3
CO4	3	3	2	2	3
CO5	3	3	2	2	3
CO6	3	3	2	2	3

3-strong, 2-moderate, 1-weak

21BI711 WIRELESS BODY AREA NETWORKS (2-0-1-3)

a. Course Objectives

The aim of this course is to provide suitable and appropriate wireless technologies for such networks. An appropriate radio technology for WBANs can be decided upon based on the specific requirements of a WBAN application and at which level of the architecture it will be deployed.

b. Course Outcomes

CO1	General overview of body centric wireless communications
CO2	Antennas and radio propagation for body centric wireless communication
CO3	Introduction to mm wave antennas
CO4	Numeric modelling and signal processing in wireless body area networks

CO5	Introduction to flexible electronics
CO6	Study of Wireless Patient Monitoring in a Clinical Setting
CO7	Awareness about the protocols in designing wireless body area networks
CO8	Study of Wireless Power and Data Telemetry for Wearable and Implantable Electronics and Ultra-Wideband for Wireless Body Area Networks

c. Syllabus

Overview of Body: Centric Wireless Communications, Introduction to Wireless Body Area Network, Antennas & radio propagation for body-centric wireless communications. Measurements and practical considerations. Mm-wave antennas and radios for body-centric networks. Physical and digital phantoms methods and techniques. Numerical modelling issues. Signal Processing In-Node Frameworks for Wireless Body Area Networks: From Low-Level to High-Level Approaches, Hardware Development and Systems for Wireless Body Area Networks, Body-Worn RF Flexible Electronics for Medical Sensing and Communications. Industrial standards and real applications for healthcare, security and sports. Wireless Patient Monitoring in a Clinical Setting,

Network and Medium Access Control Protocol Design for Wireless Body Area Networks, Channel Modeling of Narrowband Body-Centric Wireless Communication Systems, Wireless Body Area Network Implementations for Ambulatory Health Monitoring, Power Management in Body Area Networks for Health Care Applications, Antenna Design and Propagation for WBAN Applications, Coexistence Issues with Wireless Body Area Networks, Wireless Power and Data Telemetry for Wearable and Implantable Electronics, Ultra-Wideband for Wireless Body Area Networks.

TEXT BOOKS/REFERENCES:

1. Huan-Bang Li, KamyaYekehYazdandoost Bin-Zhen, “Wireless Body Area Networks”,River Publishers, 2010.
2. MuhannadQuwaiderSubirBiswas, “Wireless Body Area Networks”
3. Mark Andrew Hanson, Amy Nicole Miller, “Wireless Body Area Sensor Network Technology For Motion Based Health Assessment”
4. Mehmet RastiYuce, JamilY.Khan, “Wireless Body Area Network:Technology, Implementation And Application”
5. UweHansmann, LotharMerk, Martin S. Nicklons and Thomas Stober, “Principles of Mobile Computing”, Springer, 2003.
6. C.K. Toh, “AdHoc Mobile Wireless Networks”, First Edition, Pearson Education, 2002.
7. Terrance J. Dishongh and Michael Mcgrath, “Wireless Sensor Networks for Healthcare Applications”, Artech House; First edition, October 30, 2009, ISBN – 978- 1596933057

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	3	2	
CO2	3	2	3	2	
CO3	3	2	3	2	
CO4	3	2	3	3	
CO5	3	2	3	2	
CO6	3	2	3	2	
CO7	3	2	3	2	
CO8	3	2	3	2	

3-strong, 2-moderate, 1-weak

21BI721 - ARTIFICIAL INTELLIGENCE IN BIOMEDICINE AND HEALTHCARE (2-0-1-3)

a. Course Objectives

This course give a fundamental idea about the health-related AI applications and analyze relationships between prevention or treatment techniques and patient outcomes. AI programs are applied to practices such as diagnosis processes, treatment protocol development, drug development, personalized medicine, and patient monitoring and care.

b. Course Outcomes

CO1	General introduction to artificial intelligence and its role in biomedicine and healthcare
CO2	Introduction to the different concepts, methods and potential intelligent systems in medicine
CO3	Study about the decision support systems
CO4	Understanding and applying neural networks and deep neural networks for healthcare problems
CO5	Understanding and applying Time series forecasting for healthcare applications

c. Syllabus

Introduction of concepts, methods, and potential of intelligent systems in medicine: History and status quo, and decision support system.

Application on any specific area of interest, Risk stratification, Data acquisition and preprocessing, Feature identification and extraction, Model selection and implementation, Model validation and evaluation with performance metrics, visualization and interpretability.

Introduction to neural networks and applications in healthcare. Deep neural networks, Convolutional neural networks, ARIMA for time series forecasting, SHAP analysis for feature analysis and selection

TEXT BOOKS/REFERENCES:

1. Begg, Rezaul, Daniel TH Lai, and Marimuthu Palaniswami. computational intelligence in biomedical engineering. CRC Press, 2007.
2. Hudson, Donna L., and Maurice E. Cohen. "Neural networks and artificial intelligence for biomedical engineering." Institute of Electrical and Electronics Engineers, 2000.
3. Agah, Arvin. "Introduction to medical applications of artificial intelligence." Medical Applications of Artificial Intelligence. CRC Press, 2013. 18-25.

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	3	2	
CO2	3	2	3	2	
CO3	3	2	3	2	1
CO4	3	2	3	3	1
CO5	3	2	3	2	

3-strong, 2-moderate, 1-weak

21BI714 - WEARABLE COMPUTING (2-0-1-3)

a. Course Objectives

The course is intended to provide students with an understanding of: Wearable Technology Devices. Application of Wearable Device Technology, such as Medicine, Sports, Fitness, Entertainment, Communication, Connected Homes, Connected Cars. User Experience Design for Wearable Technology. This course offers the study or practice of inventing, designing, building, or using miniature body-borne computational and sensory devices.

b. Course Outcomes

CO1	Overview of wearable computing
CO2	Study of the advances in sensor technologies
CO3	Innovations in the areas of wearable technologies
CO4	Development of android application for wearable devices
CO5	Familiarization of cloud services
CO6	Application using pattern recognition and machine learning technologies

c. Syllabus

History of wearable computing, Commercialization: Advances in sensor technologies, multi-device computing paradigm, ubiquitous computing and context awareness, Possible innovations: Integrated with computer vision and artificial intelligence. Understand the technology ecosystem for latest wearable devices. Tradework with different network protocols: Advantages and tradeoffs (ex. Zigbee, Bluetooth).

Develop android application for wearable devices. Familiarize with implementation of cloud services via restful API. Apply development process to lifestyle innovation: including choosing the right project, prototyping effort for proof-of-concept, development of user cases, and software modeling. Apply pattern recognition and machine learning techniques to wearable device data.

TEXT BOOKS/REFERENCES:

1. Burnette E., “Hello, Android: Introducing Google's Mobile Development Platform”, Pragmatic Bookshelf, 2010.
2. Edward Sazonov and Michael R. Neuman, “Wearable Sensors: Fundamentals, Implementation and Applications”, 1st Edition, Elsevier.
3. Steele J, “The Android Developer's Cookbook: Building Applications with the Android SDK”, Addison-Wesley Professional, 2010.

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	3	2	
CO2	3	2	3	2	
CO3	3	2	3	2	2
CO4	3	2	3	3	3

CO5	3	2	3	2	
CO6	3	2	3	2	3

3-strong, 2-moderate, 1-weak

21BI725 - SECURITY AND RISKS IN WEARABLE TECHNOLOGIES (2-0-1-3)

a. Course Objectives

The will give an awareness about the risks and need for security in wearable technologies. The knowledge in this area will be helpful in designing wearable devices for biomedical application.

b. Course Outcomes

CO1	Overview about the scope, purpose and technical aspects of wearable technologies
CO2	Confidentiality and privacy of wearable technologies
CO3	Managing of security issues in wearable technology

c. Syllabus

Purpose, Scope, and Technical Considerations of Wearable Technologies, Wearable Computers, Health and Fitness Wearables, The Promise and Perils of Wearable Technologies, Confidential Data Storage Systems for Wearable Platform, Model Course Syllabus: Management of Security Issues in Wearable Technology.

TEXT BOOKS/REFERENCES:

1. Wearable Technologies: Concepts, Methodologies, Tools, and Applications, 2018**.**

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	1	2	1	
CO2	3	1	2	1	
CO3	3	1	2	1	

3-strong, 2-moderate, 1-weak

21BI733 - CLINICAL ENGINEERING (1-0-0-1)

a. Course Objectives

This course provides a basic understanding of the clinical engineering profession – qualifications, roles, activities, and expectations. To understand the current trends, challenges and issues in healthcare technology and how clinical engineers can tackle them. To engage the students to work as a team to address projects in clinical engineering. Help students better communicate with clinical and other healthcare staff involved with healthcare technology, administration, and vendors. Develop the student's interest, and prepare them for further study and more advanced application of the principles.

b. Course Outcomes

CO1	Study in designing medical devices
CO2	Overview of current technologies and applications in biomedical instruments
CO3	Designing healthcare environment and support
CO4	Medical Technology Lifecycle Management

c. Syllabus

Medical Device Design and Regulation: Product Development, Testing, Usability / Compatibility Assessment, Clinical Trials & Investigational Research (human use), Human Factors ,Ergonomics, Design Considerations for use in the Healthcare Environment vs. Home, etc. Overview of Current Technology and Applications: Acute Care, Operating Room & Anesthesiology, Hemodialysis, Imaging and Radiation Therapy, Lasers, Laboratory, Physiology & Cardiology, Infusion Devices and General Medical, Telehealth, RTLS. Healthcare Environment Design and Support: Utility Systems Design (power, HVAC medical gas, water), Building Design and Construction/Renovation & Special Environments, Safety, Radiation Safety, MRI Safety, EMI/RFI, Laser Safety, Laboratory Safety, Construction Safety, Electrical Safety, Hazardous Materials, Sanitation and Infection Prevention, Disaster Planning/Emergency Preparedness. Medical Technology Lifecycle Management: Healthcare Codes, Standards, Regulations, and Accreditation, Strategic Capital Planning, Equipment Assessment and Evaluation, Medical Device Procurement, Project Management, Technology Lifecycle & Costs.

TEXT BOOKS/REFERENCES:

1. Dyro, Joseph, ed. Clinical engineering handbook. Elsevier, 2004.
2. Atles, Leslie R., ed. A practicum for biomedical engineering and technology management issues. Kendall/Hunt Publishing Company, 2008

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	1	2	1	
CO2	3	1	2	1	
CO3	3	1	2	1	

3-strong, 2-moderate, 1-weak

21BI703 - MEMS AND NEMS SENSORS AND APPLICATION (2-0-0-2)

a. Course Objectives

Have a concept on the scope and recent development of the science and technology of micro- and nano-systems. Gain the physical knowledge underlying the operation principles and design of micro and nano- systems. Learn some typical or potentially applicable micro- and nano-systems at the frontier of the development of the field.

b. Course Outcomes

CO1	Ability to understand the operation of micro devices, micro systems and their applications
CO2	Ability to design the micro devices, micro systems using the MEMS fabrication process.
CO3	Gain a knowledge of basic approaches for various sensor design
CO4	Gain a knowledge of basic approaches for various actuator design
CO5	Develop experience on micro/nano systems for photonics .

c. Syllabus

MEMS history, overview of the different types of MEMS and microsystems.Smart systems and 3D architectures. Current state of the art and trends at the academic and industrial levels. Market

players and forecasts. Transducing principles review: Detection (capacitive, piezoresistive, thermal) and actuation (thermal, electromagnetic, electrostatic, piezoelectric) principles of common MEMS devices. MEMS Sensors: Introduction to motion sensors, 3D accelerometers, gyroscopes, pressure sensors, microphones, resonators, CMOS integration, multi-parametric sensor devices. MEMS Actuators and Optical MEMS: Electrostatic and magnetic actuators; MOEMS in Consumer Electronics and Mobile (Micromirrors and Arrays, Scanners, Projectors, Displays, MEMS Spectrometers and Optical Filters); MOEMS in Telecommunications (Optical Switches, Tunable Lasers, Filters and Variable Optical Attenuators). MEMS Thermal and Gas Sensors:Thermal flow sensors and accelerometers, capacitive, resistive, catalytic, FET, optical, silicon micromachined vapor and gas sensing devices, micro-analytical instruments for gas detection. RF-MEMS: RF resonators for filters, frequency sources, time reference, and sensors.

NEMS: Introduction to Nano electro mechanical systems with particular emphasis on physical,

chemical and biological sensors. Packaging: Die level vs. wafer level, packaging techniques, hermetic packaging, Through Silicon Vias (TSVs), 3D-integration. Power MEMS: Overview of micro power sources, batteries and solar cells vs. MEMS based devices, energy harvesting (thermal, mechanical and chemical).

TEXT BOOKS/REFERENCES:

1. Stephen Senturia (Editor in chief), MEMS Reference Shelf, Springer, 2010 and later.
2. Advanced Micro &NanoSystems, Wiley-VCH book series, 10 volumes, 2004 and later.
3. Thomas B. Jones, Nenad G. Nenadic, Electromechanics and MEMS, Cambridge University Press, 2013.
4. Gregory T.A. Kovacs, Micromachined Transducers Sourcebook, McGraw-Hill, 1998, 911 pp.
5. Marc Madou, Fundamentals of Microfabrication and Nanotechnology, 3rd Edition, CRC Press, 2011.
6. Manouchehr E. Motamedi, MOEMS : Micro-opto-electro-mechanical systems, 2005.

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	1	2	1	
CO2	3	2	3	3	2
CO3	3	2	3	3	2
CO4	3	2	3	2	
CO5	3	2	3	2	1

3-strong, 2-moderate, 1-weak

21BI734 - REHABILITATION ENGINEERING (1-0-0-1)

a. Course objectives

1. To study basics of Rehabilitation Engineering
2. To learn the design of Wheelchairs
3. To study various orthotic & prosthetic devices
4. To understand various assistive technology for vision & hearing
5. To gain knowledge of the recent developments in the field of rehabilitation engineering.

b. Course Syllabus

UNIT I –INTRODUCTION TO REHABILITATION ENGINEERING

Introduction to Rehabilitation Engineering - PHAATE model - Clinical practice of rehabilitation Engineering - Low technology tools - Service delivery - Universal design - Design based on human ability - Standards for assistive technology - Test for best design

UNIT II - WHEEL CHAIR

Seating Assessment - Interventions in seating system - Biological aspects of tissue health - Support surface classification - Manual wheelchairs - Electric power wheelchairs - Power assisted wheelchairs - Wheel chair standards & tests - Wheel chair transportation

UNIT III - ORTHOTIC & PROSTHETIC DEVICES

Anatomy of upper & lower extremities - Classification of amputation types, Prosthesis prescription - Components of upper limb prosthesis - Fabrication of prosthesis - Components of lower limb prosthesis – Orthoses Components of lower limb prosthesis – Orthoses: It"s need and types - Lower extremity- and upper extremity- orthoses - Slints – materials used

UNIT IV - ASSISTIVE TECHNOLOGY FOR VISION & HEARING

Anatomy of eye, Categories of visual impairment - Cortical & retinal implants - Auditory Information Display - Blind mobility aids – reading writing & graphics access, Orientation & navigation Aids - Anatomy of ear – hearing functional assessment - Surgical and non surgical hearing aids - Assistive technology solutions for hearing Tactile - Information Display

UNIT V - ADVANCED APPLICATIONS

Functional Electrical stimulation - Robots in rehabilitation - Rehabilitation in sports - Daily living aids - Assistive technology for dyslexia - Computer & internet access for challenged people - Neural engineering in rehabilitation engineering - Role of biomedical engineering in rehabilitation

TEXT BOOKS

1. Rory A Cooper, Hisaichi Ohnabe, Douglas A Hodson, "An Introduction to Rehabilitation Engineering", CRC Press, First edition, 2006

a. Course Objectives

Rehabilitation engineering is the use of engineering principles to provide technology solutions to problems confronted by people with disabilities. For most of us, technology makes things easier. For people with disabilities, technology makes things possible. Rehabilitation engineers use devices and other materials to increase the functional capabilities of someone with a disability. Rehabilitation engineers can use technology to improve mobility, written and verbal communication, hearing, vision, independent living, educational access, recreational access, and tasks associated with employment, among many others. Technology that is used to help increase functional capabilities is often called assistive technology.

b. Course Outcomes

CO1	Gain adequate knowledge about the needs of rehabilitations and its future development.
CO2	Have an in depth idea about Engineering Concepts in Sensory and Motor rehabilitation.
CO3	Apply the different types of Therapeutic Exercise Technique to benefit the society.
CO4	Design and apply different types Hearing aids, visual aids and their application in biomedical field and hence the benefit of the society
CO5	Gain in-depth knowledge about different types of models of Hand and arm replacement.

c. Syllabus

Introduction to Types of Physical Impairments, Principles of Rehabilitation, Motor, Sensor and Communication Disorders; Intelligent Prosthetic Knee & Arm, Advanced Automatic Prosthetics and Orthotics.

Prevention and Cure of Visual Impairment, Electronics Travel Appliances, Path Sounder, Laser Cane, Ultrasonic Torch and Guide, Light Probes, Obstacle Sensors, Electro Cortical Prosthesis, Classification; Subjective and Objective Measurement Methods, Characterizing Human Systems, Sub, Systems and Assertive Devices; Biomaterials Outlook for Organ Transplant, Design Considerations Evaluation Process; Engineering Design of Artificial Heart and Circulatory Assist Devices, Implementation and implantation Aspects; Computer Application in Rehabilitation

Engineering; Interfaces in Compensation for Visual Perception and Improvement of Orientation and Mobility, Rehabilitation Aids for Mentally Impaired.

TEXT BOOKS/REFERENCES:

1. Ballabio, E., Immaculada Placencia-Porrero, and R. Puig de la Bellacasa, eds. Rehabilitation Technology: Strategies for the European Union: Proceedings of the 1st TIDE Congress, 6-7 April 1993, Brussels. Vol. 9. IOS Press, 1993..
2. Bronzino, Joseph D. Biomedical engineering handbook. Vol. 2. CRC press, 1999.

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	1	2	1	
CO2	3	2	3	3	2
CO3	3	2	3	3	2
CO4	3	2	3	3	
CO5	3	2	3	2	1

3-strong, 2-moderate, 1-weak

21BI723 - ADVANCED BIOMEDICAL INSTRUMENTATION (2-0-1-3)

a. Course Objectives

The course has the following objectives: To introduce an fundamentals of transducers as applicable to physiology. To explore the human body parameter measurements setups. To make the students understand the basic concepts of forensic techniques. The course is designed to give the basic concepts of Instrumentation involved in medical field and human physiology. Biomedical Instrumentation is application of technology for Medical field. During the course, students will explore Electro- physiological measurements, medical imaging etc. The course will make the students understand the devices used in diagnosing the diseases.

b. Course Outcomes

CO1	To introduce an fundamentals of transducers as applicable to physiology
CO2	To explore the human body parameter measurements setups
CO3	To make the students understand the basic concepts of Biomedical Photonics.
CO4	To give basic ideas about how multimedia evidences are useful in crime investigation

c. Syllabus

Laser: Principle, Materials and Types, Future of medical lasers and fiber optics, Tissue response to lasers: Optical and Thermal, Monitoring methods. Ultraviolet radiation: uses and effects, Ultraviolet for photobiological studies, Tissue response. Laser for UV photobiological studies: Physics of Ultraviolet laser ablation. Therapeutic and Diagnostic applications of lasers - Ophthalmology, Dentistry, Urology, Neurosurgery, Dermatology, Orthopedics, Angioplasty, Cardiology, and Surgery diffused optical tomography.

Biomedical Photonics: Optical property of tissue, Light-tissue interaction, basic instrumentation in photonics, Biomedical diagnosis, Lasers for biophotonics: Intervention and Treatment techniques.

Lab component will be based on using these devices in clinical practise as well as understanding the internals.

TEXTBOOKS / REFERENCES:

1. Markolf H. Niemz, “Laser-Tissue Interactions: Fundamentals and Applications”, Third edition, Springer 2007.
2. Thyagarajan K, Ajoy K, Ghatak A, “Lasers Fundamentals and Applications, Second edition”, Springer 2010.
3. Tuan Vo-Dinh, “Biomedical Photonics Handbook”, CRC Press, 2003
4. R.S. Khandpur, “Handbook of Biomedical Instrumentation”, McGraw Hill Education, Third Edition, 2014

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	1	2	1	
CO2	3	2	3	3	2
CO3	3	2	3	3	2
CO4	3	2	3	3	

3-strong, 2-moderate, 1-weak

21BI724 - BIOSTATISTICS (2-0-1-3)

a. Course Objectives

This course represents an introduction to the field and provides a survey of data and data types. Specific topics include tools for describing central tendency and variability in data; methods for performing inference on population means and proportions via sample data; statistical hypothesis

testing and its application to group comparisons; issues of power and sample size in study designs; and random sample and other study types. While there are some formulae and computational elements to the course, the emphasis is on interpretation and concepts.

b. Course Outcomes

CO1	Recognize and give examples of different types of data arising in public health and clinical studies
CO2	Interpret differences in data distributions via visual displays
CO3	Calculate standard normal scores and resulting probabilities
CO4	Calculate and interpret confidence intervals for population means and proportions

c. Syllabus

Data in Biology: Development in Biostatistics, Samples and Populations, Techniques of 2 Sampling (random and stratified), Sampling and Non-sampling Errors, Variables in Biology, Accuracy, Precision, Univariate and Bivariate Frequency Distributions and their Graphical Representations; Measures of Central Tendency: Arithmetic, Geometric and Harmonic Means, Mode, Median and Partition values; Measures of Dispersion: Range, Standard Deviation, Coefficient of Variance and Covariance; Moments: Raw and Central Moments and theirnbf Relationships., Measures of Skewness: Pearson‟s, Bowley‟s and Kelly‟s.

Coefficients of skewness; Coefficient of skewness using moments, Measures of Kurtosis. Hypothesis Testing: Sampling Distributions and Standard Error, Null and Alternate Hypothesis, Basic Concept of Type I and Type II Errors, Concept of Confidence Interval Estimation, Large Sample Tests for Single Mean and Difference of Means, Single Proportion and Difference of Proportions; Student's t-distribution: Test for Single Mean, Difference of Means and Paired t-test, chi-square Distribution: Tests for Goodness of Fit, Independence of Attributes and Homogeneity, F-distribution, One-way and Two-way Analysis of Variance (ANOVA); Non-parametric Analysis: Sign and Run Tests.

TEXT BOOKS/REFERENCES:

1.Biostatistics: A Foundation for Analysis in the Health Sciences, 10th edition (2013), Wayne W Daniel and Chad L. Cross, Wiley. ISBN-13: 978-1118302798

2.Principles of Biostatistics, 2nd edition (2000), Marcello Pagano and Kimberlee Gauvrean, Thompson learning. ISBN-13: 978-0534229023. 4. Biostatistical Analysis, 5th edition (2009), Jerrold H. Zar, Pearson. ISBN-13: 978- 0131008465.

3. 1. Primer of Biostatistics, 7th edition (2011), Stanton Glantz, McGraw-Hill Medical. ISBN13: 978-0071781503.

5.

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	2	2	2	1	
CO2	2	3	3	3	2
CO3	2	3	3	3	2
CO4	2	3	3	3	

3-strong, 2-moderate, 1-weak

21BI731 - OVERVIEW OF TELEMEDICINE FOR HEALTHCARE APPLICATIONS (1-0-0-1)

a. Course Objectives

The telemedicine technologies provide improved health care to the underprivileged in inaccessible areas at reduced cost. Telemedicine also improves quality of health care and more importantly increases the accessibility of specialists, nurses and allied health professionals. Learning objectives will be achieved through didactic lectures and small group discussions.

b. Course Outcomes

CO1	Understanding of basic concepts of telehealth and its applications
CO2	Understanding of telehealth standards, and its ethical and legal issues
CO3	Understanding of techniques used for sensing and transfer of data in telehealth systems
C04	Ability to apply concepts of telehealth to design future remote patient care systems

c. Syllabus

Communication Networks and Services; Scope, Benefits and Limitations in Telemedicine, Basic telehealth technology and status quo: current technologies and service delivery systems; Sensing and transfer of data in telemedicine, Telemedicine standards, Mobile telemedicine, Internet applications in telemedicine, Ethical and Legal aspects of telemedicine. Future trends in Healthcare Technology. Evaluate opportunities to improve e-service initiatives.

TEXT BOOKS/REFERENCES:

1. Norris, Anthony Charles, and A. C. Norris. Essentials of telemedicine and telecare. Chichester: Wiley, 2002.
2. B.Fong, A.C.M Fong A.C.M and C.K. Li. Telemedicine technologies: Information technologies in medicine and telehealth. John Wiley & Sons, 2011.
3. Wootton R. Craig, J., Patterson, V., Introduction to Telemedicine. Royal Society of Medicine Press Ltd, 2006
4. H. Eren and J. G. Webster, eds. Telemedicine and electronic medicine. CRC Press, 2015.

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	-	-	-	-
CO2	1	-	2	3	1
CO3	-	-	-	-	
CO4	-	-	-	1	-

3-strong, 2-moderate, 1-weak

21BI713 - BIOCOMPATIBLE MATERIALS AND FLEXIBLE-STRETCHABLE ELECTRONICS (2-0-1-3)

a. Course Objectives

This study course provides in-depth knowledge on biomaterials and tissue biocompatibility and methodology of its assessment, to verify the safety of biomaterials and their interaction with biological environment. The study course is focused on obtaining theoretical knowledge as well as elaborating the laboratory and practical tasks on evaluation of biomaterial and biological environment interactions. It also provides fundamental knowledge on biomaterial pre-clinical tests through using biological systems and model substances, including studies in simulated body fluids, in vitro cell studies and in vivo models.

This course will also provide a general awareness in PCB designing for MEMS based biomedical applications. This knowledge will help in designing flexible materials and can be collaborated with flexible electronics for designing biomedical sensors.

b. Course Outcomes

CO1	Understand methodology of biocompatibility evaluation.
CO2	Ability to determine the biomaterial biocompatibility.
CO3	Design experimental studies of biocompatibility evaluation for biomaterials in simulated body fluids.
CO4	Overview of PCB designing
CO5	Overview of flexible and printed electronics
CO6	Design of flexible sensors for biomedical applications

c. Syllabus

Introduction; Classes of Materials Used in Medicine: Metals, Polymers, FRPs, Fabrics, Nanocomposites, Bioresorbable and Bioerodible Materials, Ceramics, Glasses; Host Reactions to Biomaterials: Biocompatibility, Implant Associated Infection; Testing of Biomaterials: in vitro Assessment, in vivo Assessment, Blood Materials Interactions; Design of Materials for Biomedical Application: Cardiovascular, Dental implants, Orthopedic Application, Skin, Ophthalmologic Applications, Wound Healing, Sutures, Biomedical and Biosensors; Implantation Techniques for Soft Tissue and Hard Tissue Replacements; Problems and Possible Solutions in Implant Fixation; Failure Analysis of Medical Devices and Implants.

Overview on PCB: Design Process, Manufacturing Process; Overview of Flexible and Printed Electronics: Its Emergence, Challenges, Materials Required, Manufacturing Process; Trends and its Application: Flexible Sensors, Conformal Electronics, MEMS, Lab-on-chip

TEXT BOOKS:

1. Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons. Biomaterials Science: An Introduction to Materials in Medicine, Academic Press, 2004, USA
2. Edward Sazonov and Michael R. Neuman, “Wearable Sensors: Fundamentals, Implementation and Applications”, 1st Edition, Elsevier.

REFERENCES

1.J.B. Park and J.D. Bronzino. Biomaterials: Principles and Applications. CRC Press. 2002.

2.T. M. Wright, and S. B. Goodman. Implant Wear in Total Joint Replacement: Clinical and Biologic Issues, Material and Design Considerations. American Academy of Orthopaedic Surgeons, 2001.
3.L Ambrosio. Biomedical composites, Woodhead Publishing Limited, UK, 2009
4.K.C. Dee, D.A. Puleo and R. Bizios. An Introduction to Tissue-Biomaterial Interactions. Wiley 2002. ISBN: 0-471-25394-4.

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	2	1	2	1	
CO2	2	2	1	1	
CO3	2	2	1	1	
CO4	2	1	2	1	
CO5	2	2	3	1	
CO6	2	2	3	1	

3-strong, 2-moderate, 1-weak

21BI704 - RECENT TRENDS IN TARGETED DRUG DELIVERY SYSTEMS (2-0-0-2)

a. Course Objectives

This Course basically focuses on smart drug delivery systems which concerns the administration of drug at the right time, right dose and targeted drug delivery with safety and efficacy. These new drug delivery systems led to better patient compliance, also adoption of better therapeutic regimen for patients.

b. Course Outcomes

CO1	Identify suitable polymers for specific controlled drug delivery systems
CO2	Select specific delivery systems for protein and peptide drugs
CO3	outline the approaches for parenteral controlled drug delivery systems
CO4	Develop various delivery systems for controlled release / a specific drug target
CO5	Discuss recent trends and advances in novel oral and parenteral controlled drug delivery systems

c. Syllabus

Controlled drug delivery systems: Introduction to Controlled Drug Delivery Systems,Materials for Inorganic Controlled Release Technology; Polymers: Introduction, types of polymers, application of polymers in drug delivery systems; Microencapsulation: Microspheres/Microcapsules, Microparticles, methods of microencapsulation and its applications; Mucosal Drug Delivery system, Implantable Drug Delivery Systems: Introduction to osmotic pump; Transdermal Drug Delivery Systems, Gastroretentive drug delivery systems, Nasopulmonary drug delivery system, Targeted drug Delivery:introduction to liposomes, niosomes, nanoparticles, monoclonal antibodies and their applications; Ocular Drug Delivery Systems, Intrauterine Drug Delivery Systems.

TEXT BOOKS/REFERENCES:

1. Y W. Chien, Novel Drug Delivery Systems, 2nd edition, revised and expanded, Marcel Dekker, Inc., New York, 1992.
2. Robinson, J. R., Lee V. H. L, Controlled Drug Delivery Systems, Marcel Dekker, Inc., New York, 1992.

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	-	2	1	
CO2	3	1	2	1	
CO3	2	1	2	1	
CO4	2	1	2	1	
CO5	2	-	1	-	1

3-strong, 2-moderate, 1-weak

21BI732 - Haptics and Robotics in Healthcare (1-0-0-1)

a. Course Objectives

Study of the design and control of robots for medical applications. Focus is on robotics in surgery and interventional radiology, with introduction to other healthcare robots.

b. Course Outcomes

CO1	Know basic concepts in kinematics, dynamics, and control relevant to medical robotics
CO2	Be familiar with the state of the art in applied medical robotics and medical robotics research
CO3	Understand the various roles that robotics can play in healthcare
CO4	Create a compelling proposal for a new medical robot technology

c.Syllabus

Introduction to medical robotics , Basic kinematics concepts (forward, inverse, remote center of motion), Human-machine interfaces, Medical imaging modalities (e.g., MRI, US, X-ray, CT) Robot compatibility with medical imagers, Current topics in medical robotics: Cardiac, abdominal, and urologic procedures with teleoperated robots , Orthopaedic surgery with cooperative robots.

TEXT BOOKS/REFERENCES:

1. Haptics for Teleoperated Surgical Robotic Systems (New Frontiers in Robotics) 1st Edition by Mahdi Tavakoli (Author), Rajni V Patel (Author), Mehrdad Moallen (Author), Arash Aziminejad (Author)

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	-	2	1	
CO2	3	-	2	1	
CO3	2	-	2	1	
CO4	2	-	2	1	1

3-strong, 2-moderate, 1-weak

21BI735 - Optical Fiber Technology for e-Healthcare ** REMOVED (1-0-0-1)

a. Course Objectives

This course mainly offers to understand the characteristics of tissue when it is exposed to light. Learn about the Instrumentation in photonics. Know about various optical sources and applications of lasers in medicine.

b. Course Outcomes

CO1	Understand the optical properties
CO2	Explain the different measurement techniques in medical optics
CO3	Illustrate the concept of biomedical optics in various real life applications
CO4	Analyze the instrumentation involved in biomedical optics
CO5	Apply laser instrumentation in medical diagnosis and therapy

c. Syllabus

Introduction to optical fiber technology in e-Healthcare, Optical Properties of the Tissues, Laser Applications, Imaging system fundamentals, Non Thermal Diagnostic Applications, Therapeutic applications.

TEXT BOOKS/REFERENCES:

1. Tuan Vo Dinh, Biomedical Photonics Handbook, CRC Press, Newyork, 2003

2. Lasers and Current Optical Techniques in Biology, Royal Society of Chemistry, 2004

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	-	2	1	
CO2	3	1	2	1	
CO3	2	1	2	1	
CO4	2	1	2	1	
CO5	2	-	1	-	1

3-strong, 2-moderate, 1-weak

21BI798 - Dissertation- Phase I (10)

a. Course Objectives

From this course, students gain knowledge in identifying relevant problems for Dissertation and finding their solutions for implementation, using recent technologies. Based on the novelty of the study, they get job/research opportunities in core industries/research establishments.

b. Course Outcomes

CO1	Demonstrate a sound technical knowledge of their selected project topic
CO2	Undertake problem identification, formulation and solution
CO3	Design engineering solutions to complex problems utilizing a systems approach
CO4	Learning procurement procedures and activity planning and time management
CO5	Implementation of an engineering project with project outcome
CO6	Communication and interaction with engineers and the community at large
CO7	Demonstrate the knowledge, skills and attitudes of a professional engineer
CO8	Developing skills for literature survey, technical presentation and paper writing for presentation /publication in international conferences/journals (Scopus)

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	-	3
CO2	3	3	3	3	2
CO3	3	3	3	2	-
CO4	3	2	2	2	-
CO5	3	1	2	-	-
CO6	3	-	-	-	-
CO7	3	-	-	-	3
CO8	3	-	-	-	-

3-strong, 2-moderate, 1-weak-

21BI681 - Live-in-Labs® I - Participatory Design and Modelling (0-0-0-0)

a. Course Objectives

Live-in-Labs® I is a course offered to 1st semester M.Tech in Biomedical Instrumentation and Signal Processing. It will provide an experiential learning opportunity where each student can come and spend for 2 weeks to a semester for identifying the problem in the specified villages.

b. Course Outcomes

CO1	Learn ethnographic research and utilise the methodologies to enhance participatory engagement
CO2	Prioritize challenges and derive constraints using Participatory Rural Appraisal
CO3	Identify and formulate the research challenges in rural communities
CO4	Design solutions using human centered approach

c. Syllabus

Unit 1

Human Centered Design I (HCD)

Fundamentals of Human Centered Design. Design Process. User Experience. User Research. Data Analysis.

Unit 2

Participatory Rural Appraisal (PRA)

Concept, Principles and Philosophy of PRA. Scope and Dimensions of PRA. Important Tools for PRA. Application of PRA.

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1		3		3	
CO2		3			
CO3		3			
CO4	3		3		

3-strong, 2-moderate, 1-weak

21BI799 – Dissertation-Phase II (16)

a. Course Objectives

From this course, students gain knowledge in identifying relevant problems for Dissertation and finding their solutions for implementation, using recent technologies. Based on the novelty of the study, they get job/research opportunities in core industries/research establishments.

b. Course Outcomes

CO1	Demonstrate a sound technical knowledge of their selected project topic
CO2	Undertake problem identification, formulation and solution
CO3	Design engineering solutions to complex problems utilizing a systems approach
CO4	Learning procurement procedures and activity planning and time management
CO5	Implementation of an engineering project with project outcome
CO6	Communication and interaction with engineers and the community at large
CO7	Demonstrate the knowledge, skills and attitudes of a professional engineer
CO8	Developing skills for literature survey, technical presentation and paper writing for presentation /publication in international conferences/journals (Scopus)

Identify the problem, Proposal Writing -Proposal Format, Budget Estimation, Proposal Drafts, Proposal re-evaluation, Final Proposal Draft. Advanced Human Centered Design

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	-	3
CO2	3	3	3	3	2
CO3	3	3	3	2	-
CO4	3	2	2	2	-
CO5	3	1	2	-	-
CO6	3	-	-	-	-
CO7	3	-	-	-	3
CO8	3	-	-	-	-

3-strong, 2-moderate, 1-weak-

21BI781 - Live-in-Labs® II - Co-design and Analysis (0-0-0-0)

a. Course Objectives

Live-in-Labs® II is a course offered to 2nd semester M.Tech in Biomedical Instrumentation and Signal Processing. Students earn skills to engage with community and deploy outdoor system. Also they were capable of design optimization and its development.

b. Course Outcomes

CO1	Understand the PRA and co-design concepts
CO2	Practical application PRA and co-design tools in live projects
CO3	Lab scale implementation and validation

c. Syllabus

Unit I

Participatory Rural Appraisal (PRA)

Important Tools for PRA. Application of PRA.

Unit II

Co-design

Introduction to co-design. Benefits of co-design. Co-design process. Co-design tools. Virtual co-design. Context specific co-design

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1		3	3	2	3
CO2		3	3	2	3
CO3	3		3		

3-strong, 2-moderate, 1-weak

21BI782 - Live-in-Labs® III- Social Business: People Centered Innovation (0-0-1-1)

a. Course Objectives

Live-in-Labs® III is a course offered to 4th semester M.Tech in Biomedical Instrumentation and Signal Processing.. Students earn skills to design and validate the optimized system for specified solutions to implement in real world application.

b. Course Outcomes

CO1	Understand sustainable social change models and identify change agents in a community
CO2	Project deployment

c. Syllabus

Unit I
Social Business Model
Introduction to social business models.application of social business models.

PO / CO	PO1	PO2	PO3	PO4	PO5
CO1	1	2	1	1	3
CO2	3	11	1	1	

3-strong, 2-moderate, 1-weak