August 2019

M.TECH – BIOMEDICAL INSTRUMENTATION AND SIGNAL PROCESSING (2019)

Biomedical Instrumentation and Signal Processing (BISP) program uses the principles of Engineering, Biology, Medicine and Management 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, MEMS sensor systems, IoT systems, big data analytics, flexible electronics and to develop wearable wireless systems.

CURRICULUM

First Semester

Course Code	Type	Course	L	T	P	Cr.
19MA601	FC	Foundations of Mathematics	2	0	1	3
19BI601	FC	Basics of Digital Signal Processing	2	0	1	3
19BI611	SC	Basics of Human Anatomy and Physiology	2	0	0	2
19BI612	SC	Embedded Systems Design	3	0	1	4
19BI602	FC	Advanced Computer Programming	0	0	1	1
19BI613	SC	Sensor Design and System Development	2	0	1	3
19BI614	SC	Biomedical Instruments and Data Interpretation	2	0	0	2
19BI795	P	Live-in-Labs-I - Participatory Design and Modelling	0	0	0	0
19HU601	HU	Amrita Values Program*	0	0	0	P/F
19HU602	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.
19BI615	SC	Biomedical Image Processing	2	0	1	3
19BI616	SC	Machine Learning	2	0	1	3
19BI603	FC	Design and Analysis of Algorithm	2	0	1	3
	E	Elective I	2	0	0	2
19BI617	SC	Biomedical Equipment and Safety, Intellectual Properties and Medical Ethics	1	0	0	1

19RM600	SC	Research Methodology	2	0	0	2
	FE	Fractal Elective I	0	1	0	1
	FE	Fractal Elective II	0	1	0	1
19BI618	SC	Biomedical Instrumentation Lab *IoC	0	0	1	1
19HU603	HU	Career Competency II	0	0	2	1
		Total Credits				18

*Industry Oriented Course

Third Semester

Course Code	Type	Course	L	T	P	Cr
19BI619	SC	Internet of Things: Architecture and System Design	2	0	1	3
	E	Elective II	2	0	0	2
	E	Elective III	2	0	0	2
	E	Fractal Elective III	0	0	1	1
19BI798	P	Dissertation				6
19BI796	P	Live-in-Labs II- Lab-to-Field: People Centered Innovation	0	0	0	0
		Total				14

Fourth Semester

Course Code	Type	Course	L	T	P	Cr.
19BI799	P	Dissertation				14
19BI797	P	Live-in-Labs III- Social Business: People Centered Innovation	0	0	1	1
						15

Total Credits: 65

List of Courses

Foundation Core

Course Code	Type	Course	L	T	P	Cr
19MA601	FC	Foundations of Mathematics	2	0	1	3
19BI601	FC	Basics of Digital Signal Processing	2	0	1	3
19BI602	FC	Advanced Computer Programming	0	0	1	1
19BI603	FC	Design and Analysis of Algorithms	2	0	1	3

Subject Core

Course Code	Type	Course	L	T	P	Cr
19BI611	SC	Basics of Human Anatomy and Physiology	2	0	0	2
19BI612	SC	Embedded Systems Design	3	0	1	4
19BI613	SC	Sensor Design and System Development	2	0	1	3
19BI614	SC	Biomedical Instruments and Data Interpretation	2	0	0	2
19BI615	SC	Biomedical Image Processing	2	0	1	3
19BI616	SC	Machine Learning	2	0	1	3
19BI617	SC	Biomedical Equipment and Safety, Intellectual Properties and Medical Ethics	1	0	0	1

19BI618	SC	Biomedical Instrumentation Lab	0	0	1	1
19RM600	SC	Research Methodology	2	0	0	2
19BI619	SC	Internet of Things: Architecture and System Design	2	0	1	3

Electives

Course Code	Type	Course	L	T	P	Cr
		Elective I				
19BI701	E	Fundamental Biomechanics	2	0	0	2
19BI702	E	Biofluid Mechanics	2	0	0	2
19BI703	E	Mobile Computing	1	0	1	2
		Elective II				
19BI711	E	Wireless Body Area Networks	2	0	0	2
19BI712	E	Artificial Intelligence in Biomedicine and Healthcare	1	0	1	2
19BI713	E	Wearable Computing	1	0	1	2
19BI714	E	Security and Risks in Wearable Technologies	2	0	0	2
		Elective III				
19BI721	E	Bioinformatics	2	0	0	2

19BI722	E	Clinical Engineering	2	0	0	2
19BI723	E	MEMS and NEMS Sensors and Applications	2	0	0	2
19BI724	E	Rehabilitation Engineering	2	0	0	2
19BI725	E	Advanced Biomedical Instrumentation	2	0	0	2
19BI726	E	Biostatistics	2	0	0	2

Fractal Electives

		Fractal Elective I				
19BI731	FE	Overview of Telemedicine for Healthcare Applications	1	0	0	1
19BI732	FE	Wearable Devices: Ethical Challenges and Solutions **	1	0	0	1
19BI733	FE	Radiation Detectors for Biomedical Application**	1	0	0	1
		Fractal Elective II				
19BI741	FE	Introduction to Biocompatible Materials	0	1	0	1
19BI742	FE	Recent Trends in Non-invasive Techniques **	0	1	0	1
19BI743	FE	Flexible and Stretchable Electronics for Wearable Technologies.	0	1	0	1
19BI744	FE	Recent Trends in Targeted Drug Delivery Systems	0	1	0	1
		Fractal Elective III				

19BI751	FE	Optical Fiber Technology for e-Healthcare **				
19BI752	FE	Haptics and Robotics in Healthcare **	0	1	0	1
19BI753	FE	Wearable Technologies - Energy Expenditure and Energy Harvesting **	0	1	0	1

** Based on the recent trends and the relevant IEEE/ACM Journals and selected case studies

Project Work

Course Code	Type	Course	L	T	P	Cr
19BI795	P	Live-in-Labs-I - Participatory Design and Modelling				0
19BI796	P	Live-in-Labs II- Lab-to-Field: People Centered Innovation				0
19BI797	P	Live-in-Labs III- Social Business: People Centered Innovation				1
19BI798	P	Dissertation				6
19BI799	P	Dissertation				14

19MA601 FOUNDATIONS OF MATHEMATICS2-0-1-3

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.

19BI601 BASICS OF DIGITAL SIGNAL PROCESSING 2-0-1-3

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.

19BI602 ADVANCED COMPUTER PROGRAMMING 0-0-1-1

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. YashavantKanetkar, “Let Us C” 15th Edition.

19BI603 DESIGN AND ANALYSIS OF ALGORITHMS 2-0-1-3

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 Eva Tardos, "Algorithm Design", Addison Wesley, 2005.
4. Robert Sedgewick and Kevin Wayne, "Algorithms", Fourth Edition, Addison Wesley, 2011.
5. Kurt Mehlhorn and Peter Sanders, "Data Structures and Algorithms: The Basic Toolbox", Springer, 2008.

19BI611 BASICS OF HUMAN ANATOMY AND PHYSIOLOGY 2-0-0-2

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

19BI612 EMBEDDED SYSTEMS DESIGN 3-0-1-4

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, 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). Capstone Design Project, A popular video game, e.g., Space Invaders, Connect-4, Pipe Dream,
etc.

TEXT BOOKS/REFERENCES:

1. Jonathan W Valvano, “Embedded Systems: Introduction to ARM® Cortex™-M Microcontrollers”, Fourth Edition, CreateSpace Independent Publishing Platform, 2013.
2. Joseph Yiu, “The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors”, Third Edition, Newnes, 2013.
3. Martin, “The Designer’s Guide to the Cortex-M Processor Family: A Tutorial Approach”, First Edition, Newnes, 2009.
4. Arnold S. Berger, “Embedded System Design”, First Edition, CRC Press, 2001.

19BI613 SENSOR DESIGN AND SYSTEM DEVELOPMENT 2-0-1-3

Overview of sensors , types of sensors and sensing principles, 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.
Interfacing circuit and signal conditioning : Interface electronic circuits design, Analog-to-Digital Converters, Noise in Sensors and Circuits, Low-Power System: Design and modeling, System integration and testing.
Calibration methods, Environmental Factors, Reliability, Application Characteristics.

TEXT BOOKS/REFERENCES:

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.

19BI614 BIOMEDICAL INSTRUMENTS AND DATA INTERPRETATION 2-0-0-2

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.

19BI615 BIOMEDICAL IMAGE PROCESSING 2-0-1-3

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

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. Reddy D C. "Modern Biomedical Signal Processing – Principles and Techniques", TMH, New Delhi, 2005.
2. Akay M. "Biomedical Signal Processing", Academic press, California,1994.
3. Tompkins W J "Biomedical Signal Processing", Prentice hall of India, New Delhi, 1999.
4. Bronzino J D "The Biomedical Engineering handbook", CRC and Free press, Florida, 1995.
5. Arnon Cohen "Biomedical Signal Processing" CrcPr I Llc; 2nd edition, May, 2002.
6. Gonzalez R C and Woods R E, Digital Image Processing, Third Edition, Prentice Hall, 2010.
7. Rangayyan R M, Biomedical Image Analysis, Fifth Edition, CRC Press, 2005.
8. Meyer-Baese A, Pattern Recognition and Signal Analysis in Medical Imaging, Academic Press, Second Edition,2014.
9. A. ArdheshirGoshtasby, 2-D and 3-D Image Registration for Medical, Remote Sensing, and Industrial Applications, John Wiley and Sons, 2005.

19BI616 MACHINE LEARNING 2-0-1-3

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, Bayesian decision theory, Parametric methods, multivariate methods, dimensionality reduction, Support Vector Machine, clustering, nonparametric methods, decision trees, linear discrimination, Sparse Linear models, multilayer Perceptrons, local models, hidden Markov models, assessing and comparing classification algorithms, combining multiple learners, and reinforcement learning.

TEXT BOOKS/ REFERENCES:

1. Tom. Mitchell, "Machine Learning", McGraw Hill, 1997.
2. E. Alpaydin, "Introduction to Machine Learning", Prentice Hall of India, 2005. Nils J. Nilsson, "Introduction to Machine Learning", http://ai.stanford.edu/~nilsson, 1996.
3. Kevin P. Murphey, "Machine Learning, a Probabilistic Perspective", MIT press, Cambridge, Massachusetts, 2012.
4. Chris Baton et al., "Understanding Big Data", McGraw Hill, 2012.
5. Christopher Bishop, "Pattern Recognition and Machine Learning", Springer.

6. Hastie, T., Tibshirani, R, Friedman, J, “Elements of Statistical Learning: Data Mining, Inference, and Prediction.” 2nd Edition, 2009.

19BI617 BIOMEDICAL EQUIPMENT AND SAFETY, INTELLECTUAL PROPERTIES AND MEDICAL ETHICS 1-0-0-1

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. Shamoo A and Resnik D B, Responsible Conduct of Research, Third Edition, Oxford University Press, 2015.
2. 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

19BI618 BIOMEDICAL INSTRUMENTATION LAB 0-0-1-1

Laboratory visits and practical experiments based on **Medical 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.

19RM600 RESEARCH METHODOLOGY 2-0-0-2

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. ConfirmatoryResearch, 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 SystemsAnalysis, Error Propagation, Validity of experiments, Statistical Design of Experiments, FieldExperiments, Data/Variable Types & Classification, Data collection, Numerical and Graphical DataAnalysis: Sampling, Observation, Surveys, Inferential Statistics, and Interpretation of Results

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

19BI619 INTERNET OF THINGS: ARCHITECTURE AND SYSTEM DESIGN 2-0-1-3

Internet of things: Internet of Things definitions and frameworks, Internet of Things application examples, Fundamental IoT mechanisms and key technologies, Evolving IoT standards, Layer 1/2 connectivity: wireless technologies for the IoT; Applications of IoT Scenarios such as Environmental monitoring, Disaster management , Smart city, Smart Building, Healthcare, Structural monitoring. Internet of Aerial (flying) Things.

Architectures of IoT: Three Layer and Five Layer Architecture, Cloud and Fog Based architectures, Social IoT.

Overview of IoT Networking: Communication & Networking Requirements in IoT. IoT Protocol Stack. Physical Layer and Data Link Layer: IEEE 802.15.4, Bluetooth/Bluetooth LE, RFID/NFC, IEEE 802.11, GSM/LTE. Standardized LPWA (EC-GSM-IoT, NB-IoT), Non-standard LPWA (LoRaWAN, Sigfox). Network Layer: IPv6, 6LoWPAN, RPL, IPSec,

Transport Layer: TLS1.3, DTLS, TCP, TCP/UDP, Application Layer: HTTP, XXMPP, DPWS, SOAP, CoAP, MQTT.
Introduction to Security Mechanisms and Technologies for Constrained IoT Devices extending to block chain based security. Cloudification of IoT concepts covering architecture, deployment models, and foundational technology enablers including XML, SoA/ web services, networking protocols, GPS and GIS.
Laboratory Exercises: Prototype design of IoT Systems for a specific application: Network protocols, Transport protocols, Application protocols, security protocols.

TEXT BOOKS/REFERENCES:

1. Adrian McEwen, Hakim Cassimally, "Designing the Internet of Things", Wiley, 2014.
2. Dr. OvidiuVermesan , Dr. Peter Friess , "Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems", River Publishers.
3. David Etter, "IoT (Internet of Things) Programming: A Simple and Fast Way of Learning IOT".
4. 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.

19BI701 FUNDAMENTAL BIOMECHANICS 2-0-0-2

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

TEXTBOOKS / 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. NihatOzkaya, 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, 2012

19BI702 BIOFLUID MECHANICS 2-0-0-2

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.

19BI703 MOBILE COMPUTING 1-0-1-2

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].

19BI711 WIRELESS BODY AREA NETWORKS 2-0-0-2

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.

19BI712 ARTIFICIAL INTELLIGENCE IN BIOMEDICINE AND HEALTHCARE 1-0-1-2

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

TEXT BOOKS/REFERENCES:

1. Begg, Rezaul, Daniel TH Lai, and MarimuthuPalaniswami. 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.

19BI713 WEARABLE COMPUTING 1-0-1-2

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.

19BI714 SECURITY AND RISKS IN WEARABLE TECHNOLOGIES 2-0-0-2

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**.**

19BI721 BIOINFORMATICS 2-0-0-2

Introduction to Bioinformatics: Understanding links between modern biology, genomics and bioinformatics, Analyse protein, DNA and RNA sequences, Pairwise sequence alignments: Sequence similarity, identity, and homology. Molecular biology primer, Multiple sequence alignment, Computational approaches: Mapping, Sequencing, Comparing Sequences and Predicting Genes.

Introduction to Advanced Bioinformatics techniques.Hands-on in algorithms for solving various biological problems.

TEXTBOOKS / REFERENCES:

1. Claverie, J.M. and Notredame C. 2003 Bioinformatics for Dummies. Wiley Editor.
2. Neil C. Jones and Pavel A. Pevzner, "An Introduction to Bioinformatics Algorithms", MIT Press, 2005.
3. Baldi, P. and Brunak, S. 2001 Bioinformatics: The machine learning approach, The MIT Press.
4. Setubal, J. and Meidanis, J. 1996 Introduction to Computational Molecular Biology. PWS Publishing Co., Boston.
5. Steffen Schulze-Kremer, "Molecular Bioinformatics: Algorithms and Applications", Walter de Gruyter, 1996.
6. Gary Benson, Roderic Page (Eds.), "Algorithms in Bioinformatics", Springer International Edition, 2004.
7. Edward H Shotliffe, Biomedical informatics, Springer, Fourth edition, 2013

19BI722 CLINICAL ENGINEERING 2-0-0-2

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.

19BI723 MEMS AND NEMS SENSORS AND APPLICATIONS 2-0-0-2

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.

19BI724 REHABILITATION ENGINEERING 2-0-0-2

Introduction 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., ImmaculadaPlacencia-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.

19BI725 ADVANCED BIOMEDICAL INSTRUMENTATION 2-0-0-2

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.

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

19BI726 BIOSTATISTICS 2-0-0-2

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. Primer of Biostatistics, 7th edition (2011), Stanton Glantz, McGraw-Hill Medical. ISBN13: 978-0071781503.
2. Biostatistics: A Foundation for Analysis in the Health Sciences, 10th edition (2013), Wayne W Daniel and Chad L. Cross, Wiley. ISBN-13: 978-1118302798.
3. Principles of Biostatistics, 2nd edition (2000), Marcello Pagano and KimberleeGauvrean, Thompson learning. ISBN-13: 978-0534229023. 4. Biostatistical Analysis, 5th edition (2009), Jerrold H. Zar, Pearson. ISBN-13: 978- 0131008465.

19BI731 OVERVIEW OF TELEMEDICINE FOR HEALTHCARE APPLICATIONS 1-0-0-1

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.

19BI741 INTRODUCTION TO BIOCOMPATIBLE MATERIALS 0-1-0-1

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.

TEXT BOOKS/REFERENCES:

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. J.B. Park and J.D. Bronzino. Biomaterials: Principles and Applications. CRC Press. 2002. ISBN: 0849314917 Reference Books
3. 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.

4. L Ambrosio. Biomedical composites, Woodhead Publishing Limited, UK, 2009
5. K.C. Dee, D.A. Puleo and R. Bizios. An Introduction to Tissue-Biomaterial Interactions. Wiley 2002. ISBN: 0-471-25394-4.

19BI743 FLEXIBLE AND STRETCHABLE ELECTRONICS FOR WEARABLE TECHNOLOGIES 0-1-0-1

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/REFERENCES:

1. Recent review and journal + conference papers.
2. Edward Sazonov and Michael R. Neuman, "Wearable Sensors: Fundamentals, Implementation and Applications", 1st Edition, Elsevier.

19BI744 RECENT TRENDS IN TARGETED DRUG DELIVERY SYSTEMS 0-1-0-1

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.