Group No.	Course Code	Course Title	UNIQUE CODE
1	20LBI21	Advanced Medical Image Processing	201EI001
1	20LBI244	Statistical Signal Processing	201EI002
1	20LBI323	Biomechanics and Rehabilitation Engineering	201EI003
1	**20LBI333**	**IoT for Healthcare**	201EI004
2	20LBI14	Advanced Biomedical Signal Processing	202EI001
2	20LBI242	Bioinformatics and Applications	202EI002
2	20LBI243	Health Care Data Analytics	202EI003
2	20LBI321	Biometrics and Applications	202EI004
3	20LBI22	Speech Signal Processing	203EI001
3	20LBI23	Neural Network and Fuzzy Logic in Medicine	203EI002
3	20LBI241	Photonics for Medical Imaging	203EI003
3	20LBI334	Modelling and Simulation in Biomedical Engineering	203EI004
4	20LBI252	Wireless Technologies for Medical Applications	204EI001
4	20LBI254	Artificial Intelligence	204EI002
4	20LBI331	Biostatistics	204EI003
4	20LBI322	Wavelet Transforms and Applications	204EI004
5	20LBI13	Modern Medical Instrumentation	205EI001
5	20LBI31	Bio-MEMS and Nanotechnology	205EI002
5	20LBI324	Machine Learning	205EI003
5	**20SCS322**	**Virtual Reality**	205EI004
6	20LBI12	Physiology for Biomedical Engineering	206EI001
6	20LBI15	Medical Imaging Techniques and Systems	206EI002
6	20LBI251	Biomaterials and Artificial Organs	206EI003
6	20LBI253	ARM Embedded System Design	206EI004

Visvesvaraya Technological University, Belagavi.
Ph.D. Coursework Courses – 2020 in
Electronics and Instrumentation Engineering (EI/BM/ML) Board

(Group-1):20LBI21Advanced Medical Image Processing	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**
Module-1	
Fundamentals of Digital Image Processing: Introduction, Fundamental steps in DIP, A simple image formation model, representing digital images, Spatial & Gray level resolution, Basic relationship between pixels. **Image Enhancement:** Point operations, Spatial averaging, Median filtering, Spatial low pass, high pass and band pass filtering, Histogram equalization, Transform operations.	
Module-2	
Image Compression: Huffman coding, DFT, DCT, Wavelet coding & JPEG standard.	
Module-3	
Image Segmentation: Detection of discontinuities, Edge linking and Boundary detection by local processing & global processing using Hough transform, Region based segmentation.	
Module-4	
Image Representation and Description: Representation – Chain codes, polygonal approximations, signatures, boundary segments, skeletons, Boundary descriptors – Some simple descriptors, Shape numbers, Fourier descriptors, statistical moments, Regional descriptors – Some simple descriptors, topological descriptors, texture.	
Module-5	
Morphological Image Processing : Basic concepts of set theory, Logical operations involving binary images, Dilation and erosion, Opening and closing, The hit-or-miss transformation, Basic morphological algorithms.	
Question paper pattern: • The question paper will have ten questions. • Each full question is for 20 marks. • There will be 2 full questions (with a maximum of four sub questions in one full question) from each module. • Each full question with sub questions will cover the contents under a module. • Students will have to answer 5 full questions, selecting one full question from each module.	
Textbooks: 1. Digital Image Processing, Rafael C. Gonzalez & Richard E. Woods, Second Edition. Pearson Education Inc. 2. Fundamentals of Digital Image Processing, Anil K. Jain. Prentice Hall of India.	
Reference Books: 1. Image Processing, Analysis and Machine Vision, Milan Sonka, Vaclav Hlavac & Roger Boyle, 2nd Edition. 2. Digital Image Processing, Rafael C. Gonzalez & Richard E. Woods, First Edition. Pearson Education Inc. 3. Practical Algorithms for Image Analysis: Description, Examples & Codes by Michael Seul, Lawrence O'Gorman, Michel J.Sammon, Cambridge University Press. 4. Biomedical Imaging visualization and analysis, Richard A Robb, John Wiley & Sons, Inc.	

(Group-1): 20LBI244Statistical Signal Processing	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**
Module-1	
Digital Filter design using least-square method: Least Square error criterion in the design of Pole-zero filters, FIR least squares inverse filters.	
Module-2	
Spectral Estimation and Analysis -Non parametric methods: Periodogram, Bartlett and Welch modified periodogram, Blackman-Tukey Methods.	
Module-3	
Spectral estimation and analysis -Parametric methods: wide sense stationary random process, rational power spectra: Auto Regressive (AR) Process, Moving Average (MA) Process, ARMA Process, Relationship between the Filter Parameters and the auto correlation sequence.	
Module-4	
Forward and backward Linear Prediction: Forward Linear Prediction, Backward Linear Prediction, Relationship of an AR process to Linear Prediction: Yule–Walker Method, Levinson–Durbin Algorithm. 12 Hrs	
Module-5	
Adaptive Algorithms to adjust coefficients of digital filters: Least Mean Square (LMS), Recursive Least Square (RLS) and Kalman Filter Algorithms. 10 Hrs	
Question paper pattern: • The question paper will have ten questions. • Each full question is for 20 marks. • There will be 2 full questions (with a maximum of four sub questions in one full question) from each module. • Each full question with sub questions will cover the contents under a module. • Students will have to answer 5 full questions, selecting one full question from each module.	
Textbooks: 1. Statistical signal processing and Modelling, Monson H.Hayes, Wiley, 1996 2. Fundamentals of statistical signal processing, Estimation Theory, S.M.Kay, Prentice Hall, 1993	
Reference Books: 1. Digital Signal Processing, Principles, Algorithms, and Applications, Proakis, John G., Dimitris G. Manolakis, and D. Sharma:, Pearson Education, 2006. 2. Digital Signal Processing a computer Based approach, Mitra Sanjit.K, Tata McGraw Hill, 2001. 3. Adaptive Signal Processing, B. Widrow & S Stearns, PHI, 1985. 4. Statistical and Adaptive Signal Processing, Dimitris, Manolakis, McGraw Hill, 2000.	

(Group-1): 20LBI323Biomechanics and Rehabilitation Engineering	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Biomechanics Applications to Joint Structure and Function: Introduction to Kinematics; Displacement in space; Force vectors and gravity; Linear forces and concurrent forces; Kinetics of rotary and translatory forces; Classes of levers; Close chain force analysis.

Module-2

Joint Structure and Function: Properties of connective tissues; Human Joint design; Joint Function and changes in disease.

Integrated Functions: Kinetics and Kinematics of Postures; Static and Dynamic Postures; Analysis of Standing, Sitting and Lying Postures.

Module-3

Gait: Gait cycle and joint motion; Ground reaction forces; Trunk and upper extremity motion; internal and external forces, moments and conventions; Gait measurements and analysis.

Force Platform and Kinematic Analysis: Design of force platforms, Integrating force and Kinematic data; linked segment, free-body analysis.

Module-4

Orthotic Devices in Rehabilitation Engineering:

General orthotics, Classification of orthotics-functional & regional, General principles of Orthosis, Biomechanics of orthoses, merits & demerits of orthotics, Material design consideration in orthotics, Callipers-FO, AFO, KAFO, HKAFO. Spinal Orthosis, Cervical, Head cervical thoracic orthosis, Thoraco lumbar sacral orthosis, Lumbosacro-orthosis, Splints-its functions & types.

Module-5

Prosthetic Devices: Introduction, Partial Foot Prostheses- Foot-ankle assembly, Trans femoral Prostheses – Knee unit, Axis system, Friction Mechanisms, Extension aid, Stabilizers, Socket. Disarticulation Prostheses, Knee Disarticulation Prostheses, Hip Disarticulation Prostheses

Mobility Aids: Walking frames, Parallel bars, Rollators, Quadripods, Tripods & walking sticks, Crutches, Wheel chairs

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

Textbooks:

1. "Joint Structure and Function, A Comprehensive Analysis", Pamela K. Levangie and Cynthia C. Norkin, JAYPEE Publications, Fourth Edition, 2006.
2. "Biomechanics; Mechanical Properties of Living Tissues", Y. C. Fung Springer Verlag, 1985.
3. "Rehabilitation Medicine" - By Dr. S. Sunder, 2nd Edition, Jaypee Medical Publications, Reprint 2004.
4. "Physical Rehabilitation" - by Susan B O'Sullivan, Thomas J Schmitz. 5th Edition, Jaypee Pub.,2007.

Reference Books:

1. "Biomechanics, Structures and Systems", A. A. Biewener, Sports Publication.
2. "Biomechanics of Human Motion", T. McClurg, Anderson.

(Group-1):	**20LBI333**	**IoT for Healthcare**
Exam Hours: 3 hours		**Exam Marks(Maximum):100**

Module-1

IoT Landscape: Introduction to IoT ,Applications , Architectures , Wireless Networks ,Security and Privacy , Event-Driven Systems IoT System Architectures Basic building blocks of IoT architecture, Introduction Protocols Concepts , IoT-Oriented Protocols Databases Time Bases Security

IoT Smart X Applications- Smart health platform, Smart energy, Smart home, Smart food, water, tracking and sensitivity

Module-2

IoT and Assistive Technologies for people with disabilities: IoT - integrated state-of-the-art assistive technology, IoT applications for people who are deaf/hearing impaired, blind/visually impaired, and mobility disability. Smart Sensors, Self-Powered sensors, Nano-technology sensors, Issues of the IoT-based assistive technology for people with disabilities

Module-3

IoT for ambient assisted living: Introduction, system design, general architecture, wearable devices, experimental evaluation, functional list, operation list, and results. Hybrid integration system for wearable sensor system- Introduction, State-of-the-art of current health care wearable system(WHCS), a desirable WHCS, customized IC for wearable sensors, State-of-the-Art SoC technology, Bio sensing SoC architecture and applications

Module-4

Hybrid integration system for wearable sensor system: Printed electrodes and their characteristics, electrode technology, active electrode, passive electrode, dry electrode. Hybrid integration of flexible wearable sensors: flexible circuits and interconnection, silicon on flex bio-patch implementation and miniaturization

Module-5

Role of time in IoT: Introduction, Blood flow analysis, circulation diagnosis, flow quantification, synchronization in space, blood pressure, health things-single device, distinct times, multiple device-single time, redundant device, tolerance, data reliability. Case studies: Fall detection, Physical monitoring of aged people, hygienic hand control, Chronic disease management, sports men care, remote control appliances, sleep control, animal/ human tracking, indoor climate control, waste management, etc (any one per student)

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

Textbooks:

1. Internet of Things from research and Innovations to market development, Ovidiu Vermsan, Peter Friess, River publishers, ISBN: 978-87-93102-94-1, 2014.
2. IoT and advanced applications in health care, Catarina Reiss, Marisa da silva maximiano, IGI Global medical information science reference, ISBN: 2237-9354.,2017.
3. Internet-of-Things (IoT)Systems Architectures, Algorithms, Methodologies, Dimitrios Serpanos, Marilyn Wolf ,ISBN 978-3-319-69714-7 © Springer International Publishing AG 2018.
4. The Industry 4.0- The Industrial Internet of Thing, Alasdair Gilchrit, ISBN 978-1-4842-2046-7

(Group-2): 20LBI14 Advanced Biomedical Signal Processing	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Introduction: General measurement and diagnostic system, classification of signals, introduction to biomedical signals, Biomedical signal acquisition and processing, Difficulties in signal acquisition.

ECG: ECG signal origin, ECG parameters-QRS detection different techniques, ST segment analysis, Arrhythmia, Arrhythmia analysis, Arrhythmia monitoring system.

Module-2

ECG Data Reduction: Direct data compression Techniques: Turning Point, AZTEC, Cortes, FAN, Transformation Compression Techniques: Karhunen - Loeve Transform, Other data compression Techniques: DPCM, Huffman coding, Data compression Techniques comparison.

Signal Averaging: Basics of signal averaging, Signal averaging as a digital filter, A typical averager, Software and limitations of signal averaging.

Module-3

Frequency Domain Analysis: Introduction, Spectral analysis, linear filtering, cepstral analysis and homomorphic filtering. Removal of high frequency noise (power line interference), motion artifacts (low frequency) and power line interference in ECG,

Time Series Analysis: Introduction, AR models, Estimation of AR parameters by method of least squares and Durbin's algorithm, ARMA models. Spectral modelling and analysis of PCG signals.

Module-4

Spectral Estimation: Introduction, Blackman- tukey method, The periodogram, Pisarenko's Harmonic decomposition, Prony' method, Evaluation of prosthetic heart valves using PSD techniques. Comparison of the PSD estimation methods.

Event Detection and waveform analysis: Need for event detection, Detection of events & waves, Correlation analysis of EEG signals, The matched filter, Detection of the P wave , Identification of heart sounds, Morphological analysis of ECG waves, analysis of activity.

Module-5

Adaptive Filtering: Introduction, General structure of adaptive filters, LMS adaptive filter, adaptive noise cancellation, Cancellation of 60 Hz interference in ECG, cancellation of ECG from EMG signal, Cancellation of maternal ECG in fetal ECG.

EEG: EEG signal characteristics, Sleep EEG classification and epilepsy.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

Textbooks:

1. Biomedical Signal Processing Time and Frequency Domains Analysis (Volume I)- Arnon Cohen, CRC press, 1986.
2. Biomedical Signal Analysis-A case study approach - Rangaraj M. Rangayyan, Wiley-IEEE Press, 2002.
3. Biomedical Signal Processing Principles and Techniques - D.C.Reddy, Tata McGraw-

Hill, 2012.
4. Biomedical Digital Signal Processing - Willis J. Tompkins, PHI, 2000.

(Group-2): 20LBI242 Bioinformatics and Applications

Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

The Central Dogma: Watson's definition, information flow, from data to knowledge, Convergence, the organization of DNA, the organization of Proteins. XML (Bio XML) for Bioinformatics: Introduction, Differences between HTML and XML, fundamentals of XML, fundamentals of XML namespaces. Introduction to DTDs, Document type Declarations, Declaring elements, declaring attributes, working with entities XML Schemas, Essential Concepts, working with simple types, working with complex types, Basic namespaces issues.

Module-2

Perl (BIOPERL) for Bioinformatics: Representing sequence data, program to store a DNA sequence, concatenating DNA fragments, Transcription, Calculating the reverse complement in Perl, Proteins, files, reading proteins in files, Arrays, Flow control, finding motifs, counting Nucleotides, exploding strings into arrays, operating on strings, writing to files, subroutines and bugs.

Module-3

Databases: Flat file, Relational, object-oriented databases, object Relational and Hypertext, Introduction to database design, DBMS Architecture, Schema Architecture, SQL and Introduction to database application development.

Module-4

Sequence Alignment Algorithms: Biological motivations of sequence analysis, the models for sequence analysis and their biological motivation, global alignment, local alignment, End free-space alignment and gap penalty, Sequence Analysis tools and techniques.

Module-5

Phylogenetic Analysis: Introduction, methods of Phylogenetic analysis, distance methods, the neighbour- Joining (NJ) method, The Fitch/ Margoliash method, character-based methods, Other methods, Tree evaluation and problems in phylogenetic analysis.
Clustering**:** Protein structure visualization and Protein structure prediction.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

Textbooks:

1. Bioinformatics Methods and Applications, S.C.Rastogi, N. Mendiratta.
2. XML for Bioinformatics, CERAMI.
3. Beginning Perl for Bioinformatics, James D. Tisdall.
4. Bioinformatics Computing, Bryan Bergeron, M.D

(Group-2): 20LBI243 Health Care Data Analytics	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Introduction: Introduction to big data, risks of big data, structure of big data, exploring big data, filtering big data effectively, mixing big data with traditional data, need for standards-today's big data is not tomorrow's big data, web data: the original big data, web data overview web data in action, cross-section of big data sources and the value they hold.

Data Analysis: Evolution of analytic scalability, convergence, parallel processing systems, cloud computing, grid computing, map reduce, enterprise analytic sand box, analytic data sets analytic methods, analytic tools, cognos, micro strategy, pentaho, analysis approaches, statistical significance, business approaches, analytic innovation, traditional approaches.

Module-2

Mining Data Streams: Introduction to streams concepts, stream data model and architecture, stream computing, sampling data in a stream, filtering streams, counting distinct elements in a stream, estimating moments, counting oneness in a window, decaying window, real time analytics platform (RTAP) applications, case studies, real time sentiment analysis, stock market predictions.

Module-3

Frequent itemsets and Clustering: Mining frequent itemsets ,market based model ,apriori algorithm, handling large data sets in main memory, limited pass algorithm, counting frequent itemsets in a stream ,clustering techniques ,hierarchical ,k-means ,clustering high dimensional data ,clique and proclus , frequent pattern based clustering methods , clustering in non-Euclidean space ,clustering for streams and parallelism.

Module-4

Frameworks and Visualization: Mapreduce , Hadoop, Hive, Mapr, Sharding , Nosql databases Hadoop distributed file systems, Visualizations -visual data analysis techniques, interaction techniques; systems and applications.

Module-5

Applications: Applications and Practical Systems for Healthcare– Data Analytics for Pervasive Health-Fraud Detection in Healthcare-Data Analytics for Pharmaceutical Discoveries-Clinical Decision Support Systems-Computer-Assisted Medical Image Analysis Systems-Mobile Imaging and Analytics for Biomedical Data.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

Textbooks:

1. Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Stream with advanced analytics, Bill Franks, John Wiley & sons, 2012.
2. Mining of Massive Datasets, Anand Rajaraman and Jefrey David Ulman, Cambridge University Press, 2012.
3. Healthcare data analytics, Chandan K. Reddy and Charu C Aggarwal, Taylor & Francis, 2015

4. Healthcare Analytics: From Data to Knowledge to Healthcare Improvement, Hui Yang and Eva K. Lee, Wiley, 2016.

Reference Books:

1. Core Java, Horstmann, Cay S, 10th Edition, Prentice Hall, 2016, ISBN: 9780134177304.
2. Java The Complete Reference, Herbert Schildt,8th Edition, Tata McGraw Hill, 2011.
3. Java 9 Recipes - A Problem-Solution Approach, Josh Juneau, 3rd Edition, Apress, 2017.
4. Introduction to JAVA Programming, Y. Daniel Liang, 6th Edition, Pearson Education, 2007.

(Group-2): 20LBI321Biometrics and Applications	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**
Module-1	
Introduction to Biometrics : Biometrics as authentication scheme, operation of a biometric system, verification versus identification, performance of a biometric system, error and accuracy in biometric systems, applications of biometrics, biometric characteristics and types,	

forensic biometric traits, dental, voice, signature identification.
Module-2
Fingerprint Recognition: fingerprint sensing, acquisition devices, feature extraction, ridge orientation and frequency, segmentation, singularity detection, enhancement and binarization, minute extraction, matching approaches, palmprint features, finger print and palmprint recognition in forensics.
Module-3
Face Recognition: face recognition techniques, principal component analysis (PCA), eigenfaces, linear discriminant analysis(LDA) and fisherfaces, local face recognition and hybrid face recognition techniques, Ear as a biometric, approaches, PCA, force field transformation, acoustic ear recognition.
Module-4
Iris Recognition and Vascular Pattern Recognition: typical iris recognition system, image acquisition, capturing devices, iris segmentation, segmentation using the integro-differential operator, segmentation using geodesic active contours, iris normalization, coordinate transformation, image enhancement, feature extraction, recognition, encoding and matching, performance evaluation, hand vascular pattern technology, operation, acquisition, feature extraction, pattern matching.
Module-5
Gait and Hand Geometry Recognition: Gait recognition, segmentation of walking humans, detection and extraction algorithms, shadow removal, gait cycle detection, gait analysis for feature extraction, radon transform, gait recognition, hand geometry, image capture, processing steps, performance.
Question paper pattern: • The question paper will have ten questions. • Each full question is for 20 marks. • There will be 2 full questions (with a maximum of four sub questions in one full question) from each module. • Each full question with sub questions will cover the contents under a module. • Students will have to answer 5 full questions, selecting one full question from each module.
Textbooks: 1. Hand Book of Biometrics: Anil K. Jain, Patrick Flynn, Arun A. Ross, Springer, 2008 (ISBN: 978-0-387-71040-2) . 2. Signal and Image Processing for Biometrics: ed. Amine Nait-Ali and Regis Fournier, Wiley 2012, (ISBN: 978-1-84821-385-2). 3. Guide to Biometrics, Ruud M. Bolle, Jonathan H. Connel, Sharath Pankanti, Nalini K Ratha, Andrew W Senior, Springer, 2009 (ISBN: 0387400893).

2	20LBI23	Neural Network and Fuzzy Logic in Medicine	14
3	20LBI241	Photonics for Medical Imaging	15
4	20LBI334	Modelling and Simulation in Biomedical Engineering	17

(Group-3): 20LBI22 Speech Signal Processing	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**
Module-1	
Digital Models for Speech Signals: Process of Speech Production, The Acoustic Theory of speech production, Digital models for Speech signals. **Time Domain Models for Speech Processing:** Time dependent processing of speech, Short	

time Energy and average magnitude, Short time average zero crossing rate, Speech vs. silence discrimination using energy and zero crossing

Module-2

Time Domain Models for Speech Processing: Pitch period estimation using parallel processing approach, Short time autocorrelation function, Short time average magnitude difference function, Pitch period estimation using autocorrelation function.
Short Time Fourier Analysis : Introduction, Definitions and properties, Fourier transform interpretation, Linear filtering interpretation

Module-3

Digital Representations of the Speech Waveform: Sampling speech signals, Review of the statistical model for speech, Instantaneous quantization, Adaptive quantization, General theory of differential quantization, Delta modulation, Differential PCM, Comparison of systems.

Module-4

Linear Predictive Coding of Speech: Basic principles of linear predictive analysis, Solution of LPC equations, Prediction error signal, Frequency domain interpretation, Relation between the various speech parameters, Applications of LPC parameters.

Module-5

Speech Synthesis: Principles of Speech synthesis, Synthesis based on waveform coding, Synthesis based on analysis synthesis method, Synthesis based on speech production mechanism, Synthesis by rule, Text to speech conversion.
Speech Recognition: Principles of Speech recognition, Speech period detection, Spectral distance measures, Structure of word recognition systems, Dynamic time warping (DTW), Word recognition using phoneme units.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

Textbooks:

1. Digital Processing of Speech Signals, L R Rabiner and R W Schafer, Pearson Education 2004.
2. Digital Speech Processing, Synthesis and Recognition, Sadoaki Furui, Second Edition, Mercel Dekker 2002.

Reference Books:

1. Digital Processing of Speech Signals, L R Rabiner and R W Schafer, Pearson Education 2004.
2. Digital Speech Processing, and Recognition, Sadoaki Furui, Second Edition, Mercel Dekker 2002.
3. Designing with speech processing chips, Ricardo Jimenez, Academic press, INC 1991.
4. Introduction to Data Compression, Khalid Sayood, Third Edition, Elsevier Publications.
5. Digital Speech, A M Kondoz, Second Edition, Wiley Publications

(Group-3): 20LBI23 Neural Network and Fuzzy Logic in Medicine	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Learning and Soft Computing: Examples, basic tools of soft computing, basic mathematics of soft computing, Differences between neural network and Biological neural network, Network Architecture, Artificial Intelligent

Learning process : Error correction Algorithm, Memory based Learning, Hebian Learning, Learning with Teacher, Learning without Teacher
Module-2
Single Layer Networks: Perception, Perceptron Convergence theorem, Realization of Basic logic gates using single layer Perceptron, Adaptive linear neuron (Adaline) and the LMS algorithm.
Module-3
Multilayer Perception: Error back propagation algorithm, generalized delta rule, XOR Problem, Practical Aspects of Error Back Propagation Algorithm. Problems **Radial Basis Function Networks:** Ill Posed Problems and Regularization Technique, Stabilizers and Basis Functions, Generalized Radial Basis Function Networks.
Module-4
Support Vector Machines : Risk minimization principles and the Concept of Uniform Convergence, VC dimension, Structural Risk Minimization, support vector machine algorithms **Fuzzy Logic:** Introduction to Fuzzy Logic, Classical and Fuzzy Sets: Overview of Classical Sets, Membership Function, Operations on Fuzzy Sets, Fuzzy Arithmetic, Compliment, Intersections, Unions, Fuzzy Relation.
Module-5
Fuzzy Rule based system Linguistic Hedges. Rule based system, Graphical techniques for Inference, Fuzzification and Defuzzification, fuzzy additive models Applications. **Case studies:** Fuzzy logic control of Blood pressure during Anaesthesia, Fuzzy logic application to Image processing equipment, Adaptive fuzzy system. Introduction to Neuro-fuzzy logic tool using LabView
Question paper pattern: • The question paper will have ten questions. • Each full question is for 20 marks. • There will be 2 full questions (with a maximum of four sub questions in one full question) from each module. • Each full question with sub questions will cover the contents under a module. • Students will have to answer 5 full questions, selecting one full question from each module.
Textbooks: 1. S. Haykin, "Neural networks: A Comprehensive Foundation"' Pearson Education (Asia) Pvt. Ltd/Prentice Hall of India, 2003. 2. Timothy J Ross, "Fuzzy logic with Engineering Applications", McGraw Hill Publication, 2000. 3. Bart Kosko, "Neural Networks and Fuzzy Systems", Prentice Hall of India, 2005
Reference Books: 1. Vojislav Kecman, "Learning and soft computing", Pearson Education (Asia) Pvt. Ltd.2004. 2. M.T.Hagan, H.B.Demuth and M. Beale, "Neural Network Design", Thomson Learning, 2002. 3. George J. Klir and Bo Yaun, "Fuzzy sets and Fuzzy Logic: Theory and Application", Prentice Hall of India, 2001.

(Group-3): 20LBI241 Photonics for Medical Imaging	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**
Module-1	
Basic of Lasers: Principles of Lasers, Current Laser Technology, and Nonlinear Optics: Principles of Lasers, Principles of Laser Action, Classification of Lasers, Some Important	

Lasers for Bio-photonics Current Laser Technologies, Quantitative Description of Light: Radiometry, Nonlinear Optical Processes with Intense Laser Beam, Mechanism of Nonlinear Optical Processes, Frequency Conversion by a Second-Order Nonlinear Optical Process, Symmetry Requirement for a Second-Order Process, Frequency Conversion by a Third-Order, Nonlinear Optical Process, Multiphoton Absorption, Time-Resolved Studies, Laser Safety.

Module-2

Bio-imaging: Principles and Techniques: An Overview of Optical Imaging, Transmission Microscopy, Simple Microscope, Compound Microscope, Kohler Illumination, Numerical Aperture and Resolution.

Module-3

Optical Bio-microscopic Imaging: Optical Aberrations and Different Types of Objectives, Phase Contrast Microscopy, Dark-Field Microscopy, Differential Interference Contrast Microscopy, Fluorescence Microscopy, Scanning Microscopy, Confocal Microscopy, Multi-photon Microscopy. Optical Coherence Tomography, Total Internal Reflection Fluorescence Microscopy, Near-Field Optical Microscopy, Spectral and Time Resolved Imaging, Spectral Imaging , Band pass Filters, Excitation Wavelength Selection, Acousto-Optic Tuneable Filters, Localized Spectroscopy, Fluorescence Resonance Energy Transfer (FRET) Imaging, Fluorescence Lifetime Imaging Microscopy (FLIM), Nonlinear Optical Imaging, Second-Harmonic Microscopy, Third-Harmonic Microscopy, Coherent , Anti-Stokes Raman Scattering (CARS) Microscopy, Multifunctional Imaging, Pi Imaging, Combination Microscopes, Miniaturized Microscopes, Some Commercial Sources of Imaging Instruments.

Module-4

Applications of Bio-photonics: Fluorophores as Bio-imaging Probes, Organometallic Complex Fluorophores, Near-IR and IR Fluorophore, Two-Photon Fluorophores, Inorganic Nanoparticles, Green Fluorescent Protein, Imaging of Organelles, Imaging of Microbes, Confocal Microscopy, Near-Field Imaging, Cellular Imaging, Probing Cellular Ionic Environment, Intracellular pH Measurements, Optical Tracking of Drug-Cell Interactions, Imaging of Nucleic Acids, Cellular Interactions Probed by FRET/FLIM Imaging, Tissue Imaging, In Vivo Imaging, Commercially Available Optical Imaging Accessories

Module-5

Optical Biosensors: Principles of Optical Bio-sensing, Bio-recognition, Optical Transduction, Fluorescence Sensing, Fluorescence Energy Transfer Sensors, Molecular Beacons, Optical Geometries of Bio-sensing, Support for and Immobilization of Bio-recognition Elements. Immobilization, Planar Waveguide Biosensors, Evanescent Wave Biosensors, Interferometry Biosensors, Surface Plasmon Resonance Biosensors, Some Recent Novel Sensing Methods, Commercially available sensors.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

Textbook:

1. Introduction to Bio-photonics, Paras N Prasad, A John Wiley & Sons, Inc., Publication. 2003.

Reference Book:

1. Fundamentals of Light Microscopy & Electronic Imaging, Douglas B Murphy, John

Wiley & Sons, 2001.
2. Biomedical Optics: Principles and Imaging, Lihong V Wang, Hsin-I Wu, May 2007.

(Group-3): 20LBI334 Modelling and Simulation in Biomedical Engineering	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**
Module-1	
Modeling continuous – time signals as sums of sine waves Introduction, analysis of circadian rhythm, orthogonal functions, sinusoidal basis functions,	

the Fourier series, the frequency response and non-sinusoidal periodic inputs, Parseval's relation for periodic signals, CTFT, relationship of Fourier transform to frequency response, properties of the Fourier transform, the generalized Fourier transform, examples Fourier transform calculations, Parseval's relation for nonperiodic signals, filtering, output response via the Fourier transform.
Module-2
Modeling signals as sums of discrete-time sine waves Introduction, introductory example, the discrete-time Fourier series, Fourier transform of discrete-time signals, Parseval's relation for DT nonperiodic signals, output of an LSI system, relation of DFS and DTFT, windowing, sampling, DFT, biomedical applications.
Module-3
Modeling stochastic signals as filtered white noise Introduction, EEG analysis, random processes, mean and auto correlation function of random process, stationarity and ergodicity, general linear processes, Yule-Walker equations, Autoregressive(AR) processes, Moving Average (MA) processes, Autoregressive - Moving Average (ARMA) processes, harmonic processes, biomedical examples.
Module-4
Nonlinear models of signals Introduction, nonlinear signals and systems, Poincare sections and return maps, chaos, measures of nonlinear signals and systems, characteristic multipliers and Lyapunov exponents, estimating the dimension of real data, tests of null hypotheses based on surrogate data, biomedical applications.
Module-5
Modeling biomedical systems Problem statement, illustration of the problem, point processes, parametric system modelling, autoregressive or all-pole modelling, pole-zero modelling, electromechanical models of signal generation, applications.
Question paper pattern: • The question paper will have ten questions. • Each full question is for 20 marks. • There will be 2 full questions (with a maximum of four sub questions in one full question) from each module. • Each full question with sub questions will cover the contents under a module. • Students will have to answer 5 full questions, selecting one full question from each module.
Textbooks: 1. Eugene N Bruce, "Biomedical Signal Processing and Signal Modelling" John Wiley & Sons, Inc, reprint 2009 (Chapters I-IV). 2. Rangaraj M. Rangayyan, "Biomedical Signal Analysis", John Wiley & Sons, Inc, reprint 2000, (Chapter- V)

2	20LBI254	Artificial Intelligence	20
3	20LBI331	Biostatistics	21
4	20LBI322	Wavelet Transforms and Applications	23

(Group-4): 20LBI252 Wireless Technologies for Medical Applications	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**
Module-1	
Fundamentals of Wireless Communication: Digital Communications, Wireless Communication System, Wireless Media, Frequency Spectrum, Technologies in Digital	

wireless Communication, Coding, Types of Wireless Communication Systems.
Module-2
Wireless Body Area Network (WBAN): Network Architecture, Network Components, Design Issues, Network Protocols, WBAN Technologies, WBAN Applications.
Module-3
Wireless Personal Area Networks: Wireless Personal Area Network (WPAN) , Network Architecture, WPAN Components, WPAN Technologies and Protocols, WPAN Applications.
Module-4
Wireless Local Area Networks: Network Components, Design Requirements of WLAN, Network Architecture, WLAN Standards, Case studies in biomedical domain.
Module-5
Applications of Wireless Sensor Networks: Introduction, Background Examples of Category of WSN Applications Home Control, Building Automation, Industrial Automation, Medical Applications, Case studies in biomedical domain.
Question paper pattern: • The question paper will have ten questions. • Each full question is for 20 marks. • There will be 2 full questions (with a maximum of four sub questions in one full question) from each module. • Each full question with sub questions will cover the contents under a module. • Students will have to answer 5 full questions, selecting one full question from each module.
Textbooks / Reference Books: 1. Wireless and Mobile Networks, Concepts and Protocols, Sunilkumar S. Manvi , Mahabaleshwar S. Kakkasageri ,2nd Edition, 2016, ISBN-13: 978-8126520695. 2. Fundamentals of Wireless Sensor Networks: Theory and Practice, Waltenegus Dargie, Christian Poellabauer, Willey Publications, ISBN-13: 978-8126551255 3. Wireless Communications & Networks, William Stalling Pearson 2nd Edition, ISBN 978-8132231561. 4. Wireless Communication – Principles & Practice , T.S. Rappaport ,Pearson 2nd Edition, 2010. ISBN-13: 978-8131731864.

(Group-4): 20LBI254 Artificial Intelligence	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**
Module-1	
Introduction: Introduction to Agents and environment; Rationality; the nature of environment; the structure of agents. Problem solving: Problem-solving agents; Example	

problems; Searching for solution; uninformed search strategies. Informed Search and Exploration: Informed search strategies; Heuristic functions; Constraint Satisfaction: Backtracking search for CSPs

Module-2

Knowledge and Reasoning: Logical Agents: Knowledge-based agents; The Wumpus world as an example world; Logic; propositional logic: A very Simple Logic: Reasoning patterns in propositional logic; Effective propositional inference; Agents based on propositional logic. First-Order Logic, Inference in First-Order Logic – 1: Representation revisited; Syntax and semantics of first-order logic; Using first-order logic; Knowledge engineering in first-order logic

Module-3

Inference in First-Order Logic – 2: Propositional versus first-order inference; Unification and lifting forward chaining; backward chaining; Resolution.

Knowledge Representation: Ontological engineering; Categories and objects; Actions, situations, and events; Mental events and mental objects; The Internet shopping world; Reasoning systems for categories; Reasoning with default information; Truth maintenance systems

Module-4

Planning: The problem; Planning with state-space approach; planning graphs; Planning with propositional logic. Uncertainty: Acting under certainty; Inference using full joint distributions; Independence; Bayes' rule and its use.

Probabilistic Reasoning: Representing knowledge in an uncertain domain; the semantics of Bayesian networks; efficient representation of conditional distributions; exact inference in Bayesian networks

Module-5

Learning: Learning from Observations: Forms of Learning; Inductive learning; Learning decision trees; Ensemble learning; Computational learning theory.AI: Present and Future: Agent components; Agent architectures; Are we going in the right direction? What if AI does succeed?

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

Textbook:

1. Artificial Intelligence A Modern Approach: Stuart Russel and Peter Norvig, 2nd Edition, Pearson Education, 2003.

Reference Books:

1. Artificial Intelligence: Elaine Rich, Kevin Knight, 3rd Edition, Tata McGraw Hill, 2009.
2. Principles of Artificial Intelligence: Nils J. Nilsson, Elsevier, 1980.

NPTEL Learning Material: http://nptel.ac.in/courses/106105077/

(Group-4): 20LBI331 Biostatistics	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Introduction to Biostatistics: Introduction, Some basic concepts, Measurement and Measurement Scales, Simple random sample, Computers and biostatistical analysis.
Descriptive Statistics: Introduction, ordered array, grouped data-frequency distribution, descriptive statistics – measure of central tendency, measure of dispersion, measure of central tendency computed from grouped data, variance and standard deviation-grouped data.

Module-2

Basic Probability Concepts: Introduction, two views of probability – objective and subjective, elementary properties of probability, calculating the probability of an event.
Probability Distributions : Introduction, probability distribution of discrete variables, binomial distribution, Poisson distribution, continuous probability distributions, normal distribution and applications.

Module-3

Sampling Distribution: Introduction, sampling distribution, distribution of the sample mean, distribution of the difference between two samples means, distribution of the sample proportion, distribution of the difference between two sample proportions.
Estimation: Introduction, confidence interval for population mean, t-distribution, confidence interval for difference between two population means, population proportion & difference between two population proportions, determination of sample size for estimating means, estimating proportions, confidence interval for the variance of normally distributed population & ratio of the variances of two normally distributed populations.

Module-4

Hypothesis Testing: Introduction, hypothesis testing – single population mean, difference between two population means, paired comparisons, hypothesis testing-single population proportion, difference between two population proportions, single population variance, ratio of two population variances.
Analysis of Variance (ANOVA): Introduction, completely randomized design, randomized complete block design, repeated measures design, factorial experiment.

Module-5

Linear Regression and Correlation: Introduction, regression model, sample regression equation, evaluating the regression equation, using the regression equation, correlation model, correlation coefficient.
Multiple Regression and Chi-Square Distribution: Multiple linear regression model, obtaining multiple regression equation, evaluating multiple regression equation, using the multiple regression equation, multiple correlation model, mathematical properties of Chi-square distribution, tests of goodness of fit, tests of independence, tests of homogeneity, nonparametric regression analysis.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

Textbooks:

1. "Biostatistics-A Foundation for Analysis in the Health Sciences" Wayne W. Daniel, John Wiley & Sons Publication, 6th Edition.
2. "Basic Biostatistics and its Applications" Animesh K. Dutta (2006)

Reference Books:

1. "Principles of Biostatistics", Marcello Pagano and Kimberlee Gauvreu, Thomson Learning Pub., 2006.
2. "Introduction to Biostatistics" by Ronald N Forthofer and Eun Sul Lee, Academic Press.

(Group-4):	**20LBI322**	**Wavelet Transforms and Applications**
Exam Hours: 3 hours		**Exam Marks(Maximum):100**

Module-1

Continuous Wavelet Transform: Continuous time frequency representation of signals, The Windowed Fourier Transform, Uncertainty Principle and time frequency tiling, Wavelets,

specifications, admissibility conditions, Continuous wavelet transform, CWT as a correlation, CWT as an operator, Inverse CWT.
Module-2
Discrete wavelet Transform: Approximations of vectors in nested linear vector spaces, Example of an MRA, Formal definition of MRA, Construction of genera orthonormal MRA, a Wavelet basis for MRA, Digital filtering interpretations- Decomposition and Reconstruction filters, examples of orthogonal basis generating wavelets, interpreting orthonormal MRA for Discrete time signals, Mallat algorithm Filter bank implementation of DWT.
Module-3
Alternative wavelet representations- Biorthogonal Wavelets: biorthogonality in vector space, biorthogonal wavelet bases, signal representation using biorthogonal wavelet system, advantages of biorthogonal wavelets, biorthogonal analysis and synthesis, Filter bank implementation, Two dimensional Wavelets, filter bank implementation of two-dimensional wavelet transform.
Module-4
Lifting scheme: Wavelet Transform using polyphase matrix factorization, Geometrical foundations of the lifting scheme, lifting scheme in the z- domain, mathematical preliminaries for polyphase factorization, Dealing with Signal Boundary.
Module-5
Applications: Image Compression: EZW Coding, SPIHT, Wavelet Difference Reduction Compression Algorithm, Denoising, speckle removal, edge detection and object isolation, audio compression, communication applications – scaling functions as signalling pulses, Discrete Wavelet Multitone Modulation. **Beyond Wavelet:** Ridge lets and curve lets: Ridge let transform and Digital Curve let transform, Curve let construction, Properties and applications.
Question paper pattern: • The question paper will have ten questions. • Each full question is for 20 marks. • There will be 2 full questions (with a maximum of four sub questions in one full question) from each module. • Each full question with sub questions will cover the contents under a module. • Students will have to answer 5 full questions, selecting one full question from each module.
Textbooks: 1. Wavelet Transforms –Introduction and applications - Raguveer M. Rao and Ajit S. Bopardikar- -Pearson Education, 2008 2. Insight into Wavelets from Theory to practice - K.P Soman, K. I. Ramachandran, PHI, 2006 3. Fundamentals of Wavelets: Thory, Algorithms and Applications- J C Goswamy and A K Chan, Wiley- Inderscience Publications, John Wiley and Sons, 1999.

2	20LBI31	Bio-MEMS and Nanotechnology	27
3	20LBI324	Machine Learning	29
4	**20SCS322**	**Virtual Reality**	30

(Group-5): 20LBI13Modern Medical Instrumentation	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**
Module-1	
Bioelectric Signals and Electrodes : Sources of biomedical signals, basic medical instrumentation system, PC based medical instruments, General constraints in design of	

medical instrumentation systems, origin of bioelectric signals, Electrocardiogram (ECG), Electroencephalogram (EEG), Electromyogram (EMG), Electrooculogram (EOG), Electroretinogram (ERG), Recording Electrodes – Electrode-tissue interface, polarization, skin contact impedance, motion artifacts, Silver-Silver Chloride electrodes, Electrodes for ECG, Electrodes for EEG, Electrodes of EMG, Electrical conductivity of electrode jellies and creams, microelectrodes.

Module-2

Biomedical Recording Systems & Recorders : Electrocardiograph-block diagram, ECG leads, effects of artifacts, multi-channel, ECG machine, Phonocardiograph-origin of heart sounds, microphones and amplifiers for PCG, Electroencephalograph- block diagram, computerized analysis of EEG, Electromyograph, biofeedback instrumentation.

Module-3

Patient Monitoring Systems & Oximeters: Bedside monitors, Central Monitors, Measurement of Heart Rate, Average Heart Rate meter, Instantaneous heart rate meter, Measurement of pulse rate, Blood Pressure measurement ,Direct and indirect method, Automatic blood pressure measuring apparatus using Korotkoff's method. Oximetry, ear oximeter, pulse oximeter, skin reflectance oximeter and intravascular oximeter.

Module-4

Blood Flow Meters, Cardiac Pacemakers and Defibrillators:
Electromagnetic blood flow meter, Types of electromagnetic blood flow meters, Ultrasonic blood flow meters, NMR blood flow meters, Laser Doppler blood flow meters. Need for Cardiac pacemaker, External Pacemaker, Implantable Pacemaker, Types of Implantable Pacemaker, Ventricular Synchronous Demand Pacemaker and Programmable Pacemaker. Need for a defibrillator, DC defibrillator. Defibrillator electrodes, DC defibrillator with synchronizer.

Module-5

Respiratory & Advanced Diagnostic & Therapeutic Instruments: Pulmonary function measurement, basic spirometer, ultrasonic spirometer, Pneumotachometer, Measurement of volume by Nitrogen washout technique. Artificial kidney-Principle and haemodialysis machine. Lithotripters- principle, modern lithotripter-block diagram and working. Anaesthesia-Need for anaesthesia, delivery of anaesthesia, anaesthesia machine. Infusion pumps-principle and programmable volumetric infusion pump.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

Textbooks:

1. R. S. Khandpur , Handbook of Biomedical Instrumentation, Tata McGraw-Hill ,2nd Edition, 2008.
2. J. G. Webster, Medical instrumentation: Application & Design, Wiley Publications, 3rd Edition, 2008.

Reference Books:

1. Leslie Cromwell & others, Biomedical Instrumentation and Measurements, Wiley Publications, 2nd Edition, 2010.
2. Richard Aston, Principles of Biomedical Instrumentation and Measurement, Prentice

Hall of India, 4th Edition, 2005.

(Group-5): 20LBI31 Bio-MEMS and Nanotechnology	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**
Module-1	
Over view of MEMS& Microsystems and Working Principles of Microsystems: MEMS and Microsystems, Typical MEMS and Microsystem Products, Evolution of Microfabrication, Microsystems and Microelectronics, Multidisciplinary Nature of Microsystem Design and Manufacture, Applications of Microsystems in Automotive, Health Care, Aerospace and other Industries. **Working Principle of Microsystems: Microsensors:** Acoustic, Chemical, Optical, Pressure, Thermal and Biomedical& Biosensors. **Microactuation:** Using Thermal forces, Shape Memory alloys, Piezoelectric Crystals and Electrostatic forces. **MEMS with Microactuators:** Microgrippers, Micromotors, Microvalves and Micropumps.	
Module-2	
Thermo-fluid Engineering and Microsystem Design, Scaling Laws in Miniaturization: Introduction to Thermofluidic Engineering, Overview of the Basics of Fluid Mechanics in Macro and Mesoscales: Viscosity of fluids, Streamlines and Stream Tubes, Control Volumes and Control Surfaces, Flow Patterns and Reynolds Number. Basic Equations in Continuum Fluid Dynamics: The Continuity Equation, The Momentum Equation and the Equation of motion. Laminar Fluid Flow in Circular Conduits, Computational Fluid Dynamics, Incompressible Fluid Flow in Microconduits, Fluid Flow in Submicrometer and Nanoscale, Heat conduction in Multi-layered Thin Films. Introduction to Scaling, Scaling in Geometry, Scaling in Rigid-Body Dynamics, Scaling in Electrostatic Forces, Scaling in Electromagnetic Forces and Scaling in Fluid Mechanics.	
Module-3	
Materials for MEMS and Microsystems, Microsystems Fabrication Processes: Substrates and Wafers, Active Substrate Materials, Silicon as a Substrate Material, Silicon Compounds, Silicon Piezoresistors, Gallium Arsenide, Quartz, Piezoelectric Crystals, Polymers and Packaging Materials. Introduction to Microsystem Fabrication Process, Photolithography, Ion Implantation, Diffusion, Oxidation, Chemical Vapor Deposition (CVD), Physical Vapor Deposition-Sputtering, Deposition by Epitaxy, Etching, The LIGA Process: General Description of LIGA Process, Materials for Substrates and Photoresists, Electroplating and SLIGA Process.	
Module-4	
Introduction to BioMEMS Microactuators and Drug Delivery: What is BioMEMS, the Driving force behind Biomedical Applications, Biocompatibility, Reliability Considerations Regulatory Considerations, Activation Methods, Microactuators for Microfluidics, Equivalent Representation, Drug Delivery, Introduction to Clinical Laboratory Medicine, Chemistry, Haematology, Immunology, Microbiology, Urinalysis, Coagulation Assays, Arterial Blood gases.	
Module-5	
Micro-Total-Analysis Systems (μTAS): Lab-on-Chip, Capillary Electrophoresis Arrays (CEA), Cell, Molecule and Particle Handling, Surface Modification Microspheres, Cell Based Bioassay Systems. Introduction to Emerging Bio-MEMS Technology, Minimally Invasive	

Surgery, Point-of-care Clinical Diagnosis, Cardiovascular, Diabetes, Endoscopy, Neurosciences, Oncology Ophthalmology, Dermabrasion, Tissue Engineering, Cell based Biosensors.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

Textbooks:

1. Tai Ran Hsu, "MEMS and Microsystems, Design & Manufacture" , TMH2002
2. Steven S. Saliterman, "Fundamentals of BioMEMS and Medical Microdevices", Cengage Learning, India Edition

Reference Books:

1. Mohammed had-el-hak, "MEMS Introduction & Fundamentals" ,CRC Press.
2. Harisingh Nalwa, "Nanoscience and Nanotechnology", American Scientific Publishers.
3. Sergey Edward Lyshevski, "Nano &MEMS", CRC press
4. Nadim Maluf, "An Introduction to MEMS Engineering" , Artech House Publishing.
5. Taun-Vo-Dish, "Nanotechnology in Biology & Medicine methods" , devices & Applications, CRC.

(Group-5):	**20LBI324**	**Machine Learning**
Exam Hours: 3 hours		**Exam Marks(Maximum):100**

Module-1

Introduction: Learning Problems, Designing Learning systems, Perspectives and Issues. Concept learning: Concept Learning, Version Spaces and Candidate Elimination Algorithm, Inductive bias. Decision Trees: Decision Tree learning, Representation, Algorithm, Heuristic

Space Search.
Module-2
Regression: Logistic Regression, Support Vector Machine, Kernel function and Kernel SVM Clustering: k-means, Adaptive hierarchical clustering, Gaussian mixture model.
Module-3
Neural Networks: Neural Network Representation, Problems, Perceptron, Multilayer Networks and Back Propagation Algorithms. Genetic Algorithms: Hypothesis Space Search, Genetic Programming, Models of Evolution and Learning.
Module-4
Bayesian Learning: Bayes Theorem, Concept Learning, Maximum Likelihood, Minimum Description Length Principle, Bayes Optimal Classifier, Gibbs Algorithm, Naïve Bayes Classifier, EM Algorithm
Module-5
Instant Based Learning: K-Nearest Neighbour Learning, Locally Weighted Regression, Radial Basis Functions, Case-Based Reasoning, Sequential Covering Algorithm. Learning set of rules: Learning Rule Sets, Learning First Order Rules, Learning Sets of First Order Rules, Induction as Inverted Deduction, Inverting Resolution.
Question paper pattern: • The question paper will have ten questions. • Each full question is for 20 marks. • There will be 2 full questions (with a maximum of four sub questions in one full question) from each module. • Each full question with sub questions will cover the contents under a module. • Students will have to answer 5 full questions, selecting one full question from each module.
Textbooks: 1. Tom M. Mitchell, "Machine Learning", McGraw-Hill Education (INDIAN EDITION), 2013. 2. Ethem Alpaydin, "Introduction to Machine Learning", 2nd Ed., PHI Learning Pvt. Ltd., 2013.
Reference Books: 1. T. Hastie, R. Tibshirani, J. H. Friedman, The Elements of Statistical Learning, Springer; 1st edition, 2001.

(Group-5):20LBI332 Virtual Reality	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**
Module-1	
Definition of VR, modern experiences, historical perspective. Hardware, sensors, displays, software, virtual world generator, game engines, human senses, perceptual psychology, psychophysics. Geometric modelling, transforming rigid bodies, yaw, pitch, roll, axis-angle	

representation, quaternions, 3D rotation inverses and conversions, homogeneous transforms, transforms to displays, look-at and eye transforms, canonical view and perspective transforms, viewport transforms
Module-2
Light propagation, lenses and images, diopters, spherical aberrations, optical distortion; more lens aberrations; spectral properties; the eye as an optical system; cameras; visual displays. Parts of the human eye, photoreceptors and densities, scotopic and photopic vision, display resolution requirement, eye movements, neural vision structures, sufficient display resolution, other implications of physiology on VR. Depth perception, motion perception, vection, stroboscopic apparent motion, colour perception, combining information from multiple cues and senses, implications of perception on VR
Module-3
Graphical rendering, ray tracing, shading, BRDFs, rasterization, barycentric coordinates, VR rendering problems, anti-aliasing, distortion shading, image warping (time warp), panoramic rendering. Velocities, acceleration, vestibular system, virtual world physics, simulation, collision detection, avatar motion, vection.
Module-4
Tracking systems, estimating rotation, IMU integration, drift errors, tilt and yaw correction, estimating position, camera-feature detection model, perspective n-point problem, sensor fusion, lighthouse approach, attached bodies, eye tracking, inverse kinematics, map building, SLAM. Remapping, locomotion, manipulation, social interaction, specialized interaction mechanisms.
Module-5
Sound propagation, ear physiology, auditory perception, auditory localization; Fourier analysis; acoustic modelling, HRTFs, rendering, auralization. Perceptual training, recommendations for developers, best practices, VR sickness, experimental methods that involve human subjects Touch, haptics, taste, smell, robotic interfaces, telepresence, brain-machine interfaces
Question paper pattern: • The question paper will have ten questions. • Each full question is for 20 marks. • There will be 2 full questions (with a maximum of four sub questions in one full question) from each module. • Each full question with sub questions will cover the contents under a module. • Students will have to answer 5 full questions, selecting one full question from each module.
Textbook: Virtual Reality, Steven M. LaValle. Cambridge University Press 2016, http://vr.cs.uiuc.edu/book.html.
Reference Book Handbook of Virtual Environments: Design, Implementation, and Applications, Kelly S. Hale and Kay M. Stanney, CRC Press, 2nd Edition, 2015

(Group-6): 20LBI12 Physiology for Biomedical Engineering	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

General Physiology: Cell, Cell junctions, Transport through cell membrane, Homeostasis, Acid base balance.

Respiratory System & Environmental Physiology: Physiological anatomy of respiratory tract, Pulmonary circulation, Mechanics of respiration, Pulmonary function tests, Ventilation, Exchange of respiratory gases, Transport of respiratory gases, Regulation of respiration, Artificial respiration.

Module-2

Renal Physiology : Kidney, Nephron, Juxtaglomerular apparatus, Renal circulation, Urine formation, Concentration of urine, Acidification of urine, Renal function tests, Renal disorders, Micturition, Uro flow studies, Dialysis.

Cardiovascular System : Introduction to cardiovascular system, Properties of cardiac muscle, Cardiac cycle, Heart sounds, Cardiac murmurs, Electrocardiogram, Vector, Arrhythmia, Cardiac output, Regulation of heart rate, Hemodynamics, Arterial blood pressure, Haemorrhage.

Module-3

GIS: GIS, Functions of stomach, pancreas, liver, intestine, function tests: endoscopies.

Nervous System: Introduction to nervous system, Neuron, Classification of nerve fibres, Properties of nerve fibres, Degeneration & regeneration of nerve fibres, Neuroglia, Receptors, Synapse, Neurotransmitters, Reflex activity, Physiology of pain, Hypothalamus, Electroencephalogram.

Module-4

Physiology of sleep, Epilepsy, cerebrospinal fluid, Autonomic nervous system and ANS tests. Evoked potentials. Cerebral circulation and tests.

Muscle Physiology: Classification of muscles, Structure of skeletal muscles, Properties of skeletal muscles, Changes during muscular contraction, Neuromuscular junction, Electromyogram & disorders of skeletal muscles.

Module-5

Types of joint- Fibrous, Cartilaginous, Synovial, characteristics of synovial joints, shoulder joint, elbow joint, radioulnar joint, wrist joint, joints of hands and fingers, Hip joint, Knee joint, ankle joint, joints of foot and toes.

Physiology of Eye and Ear: Structure of the Eye, Visual process, Field of vision, Visual pathway, Pupillary reflexes, Colour vision, Errors of refraction. ERG and EOG. Structure of ear, Auditory defects.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

Textbooks:

1. Essentials of Medical Physiology - K Sembulingam & Prema Sembulingam (Jaypee Publications, 2004).
2. Concise Medical Physiology - Sujit K. Chaudhuri, 5th Edition, New Central Book Agency Pvt. Ltd.

(Group-6): 20LBI15 Medical Imaging Techniques and Systems	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**
Module-1	
Introduction to Medical Imaging: Basic imaging principle, Imaging Modalities-Projection radiography, Computed Tomography, Nuclear medicine, Ultrasound imaging, Magnetic Resonance Imaging. **X-Ray and Radiography:** Interaction between X-Rays and matter, Intensity of an X-Ray, Attenuation, X-Ray Generation and Generators, Beam Restrictors and Grids, Intensifying screens, fluorescent screens and Image intensifiers, X-Ray detectors, Conventional X-Ray radiography, Fluoroscopy, Angiography, Digital radiography, X-Ray image characteristics, Biological effects of ionizing radiation.	
Module-2	
Computed Tomography : Conventional tomography, Computed tomography principle, Generations of CT machines – First, Second, Third, Fourth, Fifth, Sixth & Seventh, Projection function, Reconstruction algorithms – Back Projection Method, 2D Fourier Transform Method, Filtered Back Projection Method, Iteration Method, Parallel Beam Reconstruction, Fan Beam Reconstruction, Helical CT Reconstruction.	
Module-3	
Ultrasound Imaging: Acoustic propagation, Attenuation, Absorption and Scattering, Ultrasonic transducers, Transducer Arrays, A mode, B mode, M mode scanners, Tissue characterization, Colour Doppler flow imaging, Echocardiography.	
Module-4	
Radio Nuclide Imaging: Interaction of nuclear particles and matter, Nuclear sources, Radionuclide generators, Nuclear radiation detectors, Rectilinear scanner, scintillation camera, SPECT, PET. **Infrared Imaging:** Physics of thermography – imaging systems – pyroelectric vidicon camera clinical thermography – liquid crystal thermography.	
Module-5	
Magnetic Resonance Imaging: Angular momentum, Magnetic dipole moment, Magnetization, Larmor frequency, Rotating frame of reference, Free induction decay, Relaxation times, Pulse sequences, Generation and Detection of NMR Imager. Slice selection, Frequency encoding, Phase encoding, Spin-Echo imaging, Gradient-Echo imaging, Imaging safety, Biological effects of magnetic field, Introduction to Functional MRI.	
Question paper pattern: • The question paper will have ten questions. • Each full question is for 20 marks. • There will be 2 full questions (with a maximum of four sub questions in one full question) from each module. • Each full question with sub questions will cover the contents under a module. • Students will have to answer 5 full questions, selecting one full question from each module.	
Textbooks: 1. Principles of Medical Imaging, K Kirk Shung, Michael B Smith & Benjamim M W Tsui, Academic Press Inc.	

2. Hand Book of Biomedical Instrumentation, R S Khandpur, Tata McGraw Hill Publication, Second Edition.

Reference Books:

1. Medical Imaging Signals and Systems, Jerry L Prince & Jonathan M Links, Pearson Prentice Hall.
2. The physics of medical imaging, Steve Webb, Adam Hilger, Bristol, England, Philadelphia, USA, 1988.
3. Basics of MRI, Ray H Hashemi & William G Bradley Jr, Lippincott Williams & Wilkins.
4. Diagnostic Ultrasound Principles & Instruments, 5th Edition, Frederick W Kremkau.
5. 2D Echocardiography, Jay N Schapira, Williams & Wilkins

(Group-6): 20LBI251 Biomaterials and Artificial Organs	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**
Module-1	
Structure of Bio-Materials and Bio-Compatibility Definition and classification of bio-materials, mechanical properties, visco-elasticity, wound-healing process, body response to implants, blood compatibility.	
Module-2	
Implant Materials Metallic implant materials, stainless steels, co-based alloys, Ti-based alloys, ceramic implant materials, aluminium oxides, hydroxyapatite glass ceramics carbons, medical applications.	
Module-3	
Polymeric Implant Materials Polymerization, polyamides, Acrylic polymers, rubbers, high strength thermoplastics, medical applications. Bio polymers: Collagen and Elastin.	
Module-4	
Tissue Replacement Implants Soft-tissue replacements, sutures, surgical tapes, adhesive, Percutaneous and skin implants, maxillofacial augmentation, blood interfacing implants, hard tissue replacement implants, internal fracture fixation devices, joint replacements.	
Module-5	
Artificial Organs Artificial Heart, Prosthetic Cardiac Valves, Artificial lung (oxygenator), Artificial Kidney (Dialysis and Dialyser membrane), Dental Implants, Artificial limb & hand.	
Question paper pattern: • The question paper will have ten questions. • Each full question is for 20 marks. • There will be 2 full questions (with a maximum of four sub questions in one full question) from each module. • Each full question with sub questions will cover the contents under a module. • Students will have to answer 5 full questions, selecting one full question from each module.	
Textbooks: 1. Sujata V. Bhat, Biomaterials Second Edition, Narosa Publishing House,2005. 2. Joon B. Park Joseph D. Bronzino, Biomaterials - Principles and Applications – CRC Press, 2003.	
Reference Books: 1. Park J.B., "Biomaterials Science and Engineering", Plenum Press, 1984. 2. Myer Kutz, "Standard Handbook of Biomedical Engineering & Design", McGraw-Hill, 2003. 3. John Enderle, Joseph D. Bronzino, Susan M. Blanchard, "Introduction to Biomedical Engineering", Elsevier, 2005.	

(Group-6): 20LBI253 ARM Embedded System Design	
Exam Hours: 3 hours	**Exam Marks(Maximum):100**

Module-1

Introduction To Embedded systems

Introduction, Processor embedded into a system, embedded hardware units and devices in a system, examples, SOC and use of VLSI, Complex systems design, formalization of system design, classification of embedded systems, skills required for an embedded system designer, processor and memory organization.

Module-2

ARM Embedded Systems and ARM processor fundamentals

The RISC Design philosophy, The ARM Design philosophy, Embedded system hardware , Registers, Current program status register, pipeline, exceptions, interrupts and Vector table, Core extensions, Architecture revisions, ARM processor families.

Module-3

Introduction to ARM instruction set and

Data processing instructions, branch instructions, load-store instructions, software interrupts instruction, Program status register instructions, loading constants, ARMv5E extensions, conditional execution.

Module-4

Introduction to the thumb instruction set and Exception and interrupt handling

Thumb register usage, ARM-Thumb interworking, data processing instructions, Single & multiple-register Load-store instruction, stack instructions, software interrupt instruction, Exception handling, interrupts, interrupt handling schemes.

Module-5

Embedded operating systems and Future of the Architecture

Fundamental components, **Example:** Simple little operating system. Advanced DSP and SIMD support in ARMv6, System and multiprocessor support additions to ARMv6, Armv6 implementations, Future technologies beyond ARMv6.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

Textbooks:

1. ARM system developers guide, Andrew N Sloss, Dominic Symes and Chris wright, Elsevier, Morgan Kaufman publishers, 2008, ISBN:1558608745
2. ARM Architecture reference manual, David seal: Addison-Wesley second edition, 2009, ISBN:978- 0201737196.
3. Embedded Systems, Rajkamal, Tata McGraw-Hill publishers, 2008, ISBN:0070494703.

Reference Book:

1. ARM System on chip Architecture Addison Wesley, Formatted: paperback, 2008, ISBN:978- 0201675191.