SHRI G.S. INSTITUTE OF TECHNOLOGY AND SCIENCE, INDORE

(An Autonomous Institute Established in 1952)

23, Sir M. Visvesvaraya Marg, Indore-452003

SYLLABUS

Of

MASTER OF TECHNOLOGY

BIOMEDICAL INSTRUMENTATION AND SIGNAL PROCESSING

2022-2023

Biomedical Engineering
BM 75001: Physiology For Engineers
Syllabus

Course Outcomes:-

CO1: Knowledge about cellular structure, tissues organs, blood.
CO2: Understand the cardiovascular & respiratory systems.
CO3: Get familiar with gastrointestinal and renal system.
CO4: Understand basics of nervous system
CO5: Clinical and technological implications.

Subject-Code	Subject Name	L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
								Theory		Practical		Total
								Th.	CW	SW	Pr.	
BM 75001	Physiology for Engineers	4	-	-	4	-	4	70	30		-	100

Unit. 1 Basic Cell Physiology

Anatomy nomenclature, introduction to cellular-sub-cellular structure and function, extra cellular matrix, physiology of membrane transport: basic structure and function, osmosis and its implication. Neuromuscular transmission and muscle contraction mechanism (including skeletal, cardiac and smooth muscle characteristics).

Unit. 2 Blood, Lymphatic and other Body-Fluids

Basic structure function, circulation and interrelation with other systems. Red blood cells and oxygen transport, white blood cells their types and role in immunity, platelets and coagulation, blood groups and blood typing, blood pressure measurement.

Unit. 3 Cardiovascular and Respiratory System

Cardiovascular: Basic structure function, circulation, heart valves, prosthetic valves, cardiac cycle, heart sounds and electrical activity of heart with basic ECG interpretation. Respiratory: - basic structure function, mechanism of breathing, principle of gas exchange: - lung volumes and capacities. Various implications: - nitrogen narcosis, asthma and aerosol, lung surfactant.

Unit. 4 Gastrointestinal and Renal System

Salivary secretion, GI tract, stomach, lever, large & small intestine pancreas interaction with other systems. Renal system: - basic structure and function, nephron hemodynamics, clearance and regional transport, acid-base disturbance.

Unit. 5. Nervous system and Special Senses

Nervous system: Structure of neuron and nerve fibre, synapse, autonomic nervous system. Central nervous system: - parts of brain& their functions, spinal cord-reflex mechanism sympathetic and parasympathetic nervous system.

Special senses: Organs of vision, hearing, taste & smell. Mechanism of vision, color vision, mechanism of hearing, sense of taste, sense of smell, tests of hearing, audiometry.

TEXT BOOKS

1. Guyton and Hall, *Textbook of Medical Physiology Book*, Elsevier Health Science, 1994.
2. W.F Ganong, *Review of Medical Physiology*, McGraw Hill, 2012.

REFERENCES

1. Chappel Michael, *Physiology for Engineers*, Springer, 2015.

Biomedical Engineering
BM 75004: Bio-MEMS

For Students from B.E. Biomedical Engineering

Course Outcomes:-

CO1: To understand fundamental of microsystems engineering.
CO2: Knowledge of micro fabrication and micromachining
CO3: Have experience in design consideration for Bio-MEMS device.
CO4: Understand its applications in field of biomedical devices.

Subject-Code	Subject Name	L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
								Theory		Practical		Total
								Th.	CW	SW	Pr.	
BM-75004	Bio-MEMS	4	-	-	4	-	4	70	30		-	100

Unit. 1 Introduction to Microsystems

Overview of biomedical microsystems technology. Definition - MEMS materials. Laws of scaling, the multi-disciplinary nature of MEMS, and applications of MEMS in biomedical.

Unit. 2 Micro Fabrication and Micromachining

Introduction to micro fabrication, photolithography, crystallography, deposition processes, mask design, wet and dry etching; substrate bonding, silicon based MEMS processes- surface and bulk micromachining, non-silicon micro fabrication- LIGA and SU-8, molding.

Unit. 3 Biomedical Micro Sensors and Micro Actuators

Working principle of micro sensors, micro sensors for biomechanics, chemical bio systems, and electrical bio systems. Micro actuation techniques, micromanipulators, surgical microsystems, micro needles, micro filters, micro valves.

Unit. 4 Biomedical Microsystems

Micro fluidic systems, micro total analysis systems (u-TAS), fluid control components, sample handling, lab-on-a-chip, various therapeutic and diagnostic bio-MEMs device, drug delivery systems, optical biosensors. Overview of micro assembly, micro assembly processes, and technical challenges in micro assembly, overview and general consideration in micro packaging micro packaging processes.

Unit. 5 Introduction to microfluidics

Transportation in micro channels, Microfluidic components: Filters, mixers, valves , pumps etc.

TEXT BOOKS

1. Marc J. Madou, *Fundamentals of Micro-fabrication: The Science of Miniaturization Detection*, CRC Press, 2002.
2. Manz and H. Becker, Eds., *Microsystem Technology in Chemistry and Life Science*, Springer, 1998.

REFERENCE BOOKS

1. Tai- ran- Hsu, *MEMS and Microsystems: Design, Manufacture, and Nano scale Engineering*, Wiley, 2008.
2. A Sadana, *Engineering Biosensors: Kinetics and Design Applications*, Academic Press, 2001.

Biomedical Engineering
BM-75451: Electronic System Design
Syllabus

Course Outcomes:-

CO1: Learn about circuit analysis and synthesis.
CO2: Hardware and software for data acquisition.
CO3: Basics of op amp based circuits.
CO4: Design and development of biomedical based project.

Subject-Code	Subject Name	L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
								Theory		Practical		Total
								Th.	CW	SW	Pr.	
BM-75451	Electronic System Design Laboratory	4	-	-	4	-	4	70	30		-	100

Unit. 1 Detailed study of CRO.
Unit. 2 Detailed study of DSO.
Unit. 3 Op-amp based experiments list:

a. Characterization of op-amp: To measure the input bias current, input offset current, input offset voltage, input and output voltage ranges, the slew rate and bandwidth of op - amp.
b. To measure and adjust the offset of an amplifier, measure its bandwidth and see how its performance is limited by its slew rate.
c. To design and realize inverting, non-inverting and buffer amplifier using 741 op-amp
d. To design and realize op-amp based filters, integrators and differentiator.

Unit. 4 PCB layout design using CAD.
Unit. 5 Biomedical based project.

TEXT BOOKS

1. Gary Johnson, *Lab-VIEW Graphical Programming*, Second edition, McGraw Hill, 1997.
2. Lisa K. wells & Jeffrey Travis, *Lab-VIEW for everyone*, Prentice Hall, 1997.
3. Kevin James, *PC Interfacing and Data Acquisition: Techniques for Measurement, Instrumentation and Control*, Newness, 2000.

REFERENCE BOOKS

1. Peter W. Gofton, *Understanding Serial Communications*, Sybex International
2. Robert H. Bishop, *Learning with Lab-view*, Prentice Hall, 2003.

Biomedical Engineering
BM 75452: Virtual Instrumentation

Course Outcomes:-

CO1: To review background information required for studying virtual instrumentation.
CO2: To study the basic building blocks of virtual instrumentation
CO3: To study the various techniques of interfacing of external instruments of PC.
CO4: To study the various graphical programming environment in virtual instrumentation.

Subject-Code	Subject Name	L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
								Theory		Practical		Total
								Th.	CW	SW	Pr.	
BM-75452	Virtual Instrumentation	-	-	4	-	4	4	-	-	40	60	100

Unit. 1 Introduction to Virtual Instrumentation

Virtual instrumentation, history of VI, architecture of virtual instrumentation, conventional and graphical programming, distrubuted systems, and advantage of PC based medical instruments. Introduction to bioelectric signals.

Unit. 2 Application Development Software

Basics of LabVIEW, for and while loops, structures, arrays and clusters, graphs and charts, file i/o- sample VI's to demonstrate file i/o- string handling, configuring external instrument with PC.

Unit. 3 Basics of Data Acquisition

Hardware/Analog interfacing, practical vs ideal interfacing. Building GUI for use in data acquisition.

Unit. 4 Signal Sampling Fundamentals for Data acquisition

Acquisition of general waveforms and bio-signals, Fourier and Fast Fourier transform, wavelet transform, correlation (windowing and filtering tools).

Unit. 5 Medical Applications of VI

Data acquisition with Lab View, VI based temperature monitoring system, cardiac monitor (ECG), Biobench - A virtual instrument application for data acquisition and analysis of physiological signal (ECG).

TEXT BOOKS

1. Gary Johnson, *Lab-VIEW Graphical Programming*, Second edition, McGraw Hill.
2. Lisa K. wells & Jeffrey Travis, *LabVIEW for everyone*, Prentice Hall, 1997.
3. Kevin James, *PC Interfacing and Data Acquisition: Techniques for Measurement, Instrumentation and Control*, Newnes, 2000.

REFERENCE BOOKS

1. Robert H. Bishop, *Learning with Lab-view*, Prentice Hall, 2003.
2. Peter W. Gofton, *Understanding Serial Communications*, Sybex International, 1994.

Biomedical Engineering
BM-75002: Bio Sensors & Instrumentation
Syllabus

Course Outcomes:-

CO1: To make the student acquire an adequate knowledge of the physiological systems of the human body and relate them to the parameters that have clinical importance.
CO2: Identify to describe how bio specific interaction is used for various applications.
CO3: To describe the most common sensor principles used today, such as electric, optical, and mechanic.
CO4: To compare different techniques with emphasis on sensitivity and selectivity.
CO5: To provide awareness of electrical safety of medical equipment's.

Subject-Code	Subject Name	L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
								Theory		Practical		Total
								Th.	CW	SW	Pr.	
BM-75002	Bio Sensors & Instrumentation	4	-	-	4	-	4	70	30		-	100

Unit. 1 Electrophysiological Measurements

Resting and action potential, Nernst and GHK potentials. Basic block diagram of biomedical instruments, instrumentation amplifier, electrodes tissue interface, skin contact impedance, sensor design and characteristics for measurement of bio-signals - ECG, EMG, EEG.

Unit. 2 Measurement of Blood Pressure

Cardiac output, heart rate, heart sound, pulmonary function measurements, spirometer, photo plethysmography, body plethysmography, blood gas analyzers, pH of blood, measurement of blood pCO2, pO2 - pulse oximeter.

Unit. 3 Introduction of Biosensors

Introduction of biosensors, classification of biosensors, sensor characteristics. Different transduction mechanism in biosensor, electrochemical, optical, enzymatic, immune, DNA biosensors. Applications of biosensors. Analytical modeling of biosensors.

Unit. 4 Medical Imaging Systems

X-Ray, computed tomography and MRI. Biomedical telemetry**.**

Unit. 5 Electrical Hazards & their Prevention

Physiological effects of electrical currents, preventive measures to reduce shock hazards, leakage current, isolation of patient circuit, open ground problems and earthing methods.

TEXT BOOKS

1. John G Webster, *Medical Instrumentation - Application and Design*, Wiley, 2009.
2. Marks, Robert S, *Handbook of Biosensors and Biochips*, John Wiley, 2007.
3. R.S.C. Cobbold, *Transducers for Biomedical Measurements: Principles and Applications*. Wiley, 1974.

REFERENCE BOOKS

1. Donald G. Buerk, Lancaster, *Biosensors: Theory and Applications*, CRC Press, 1995.

Biomedical Engineering
BM-75003: Medical Imaging Systems
Syllabus

Course Outcomes:-

CO1: This course aims to provide an introduction to the physics and engineering of tomographic imaging devices.

CO2: Compare and contrast the benefits and limitations of different tomographic modalities.

CO3: Introduction to the mathematical, physical and computational principles underlying modern imaging techniques.

CO4: To understand electronics and other hardware used in imaging modalities.

Subject-Code	Subject Name	L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
								Theory		Practical		Total
								Th.	CW	SW	Pr.	
BM-75003	Medical Imaging Systems	4	-	-	4	-	4	70	30		-	100

Unit. 1 Radiographic Imaging

Physics of radiography, introduction, instrumentation, X-ray tubes, filtration and restriction, compensation filters & contrast agents, grids, airgaps & scanning slits, film-screen detector, X-ray image intensifiers, image formation, noise and scattering, filters, fundaments of active filters.

Unit. 2 Computed Tomography

Introduction, CT instrumentation, image formation, parallel ray reconstruction, fan-beam reconstruction, helical CT reconstruction, cone beam reconstruction, image quality in CT, OCT-introduction, instrumentation, OCT imaging technique, OCT image formation and reconstruction

Unit. 3 Magnetic Resonance Imaging

Nuclear magnetic resonance (NMR), magnetic resonance imaging (MRI). Spatial localization, K-space, basic MRI techniques, signal and noise in MRI, fast MRI techniques, magnetic resonance spectroscopy, RF receive coil array, conductor less signal transmission, possible implementations.

Unit. 4 Ultrasound Imaging

Physics of ultrasound, ultrasound imaging principles, instrumentation for diagnostic ultrasound, ultrasound scanning, understanding ultrasound images, ultrasound beam formation, and ultrasound transmit/receive cycle, imaging techniques, transducers characteristics, and ultrasound imaging modes, steering and focusing.

Unit. 5 Nuclear Medicine

Introduction, nuclear medicine imaging, radioactive decay, modes of decay, radiotracers, detection systems, clinical SPECT & PET principles of operation, SPECT & PET-instrumentation, image formation, image quality in SPECT and PET.

TEXT BOOKS

1. Jerry L. Prince, Jonathan M. Links, *Medical Imaging Signals and Systems*, PHI, 2010.
2. Krzystof Iniewski, *Medical Imaging Principles Detectors and Electronics*, Wiley, 2009.
3. Gengsheng Lawrence Zeng, *Medical Image: Reconstruction A Conceptual Tutorial*, Springer, 2010.

REFERENCE BOOKS

1. Kavita Garg et al., *Practical Differential Diagnosis for CT and MRI*, Thelme, 2008.
2. Pablo R et al.., *Learning Diagnostic Imaging: 100 Essential Cases*, Paperback.
3. Govind Chavhan, Bhavin Jankharia, *Cross Sectional Anatomy CT & MRI*, 1st Edition.

Biomedical Engineering
BM 75201: Adaptive Signal Processing
Syllabus

For Students from B.E. Biomedical Engineering

Course Outcomes:-

CO1: To understand fundamental of signal processing.
CO2: To learn techniques of linear prediction filtering.
CO3: Have experience in designing frequency domain filters.
CO4: Apply filtering technique in biomedical applications.

Subject-Code	Subject Name	L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
								Theory		Practical		Total
								Th.	CW	SW	Pr.	
BM-75201	Adaptive Signal Processing	4	-	-	4	-	4	70	30		-	100

Unit. 1 Introduction

Random variables, random processes, filtered random processes. Ensemble averages, correlation, covariance, power spectrum, cross power spectrum-ergodicity, time averages, biased & unbiased estimators, consistent estimators.

Unit. 2 Linear Prediction Filtering

Direct form linear prediction filtering. Normal equations for linear prediction filtering. Levinson algorithm, linear prediction lattice filtering.

Unit. 3 Digital Wiener Filtering

Wiener smoothing and prediction filters. Application of Wiener smoothing to noise cancelling. Application of Wiener prediction filters. Constrained, linear MMSE filtering. Minimum variance beam forming.

Unit. 4 Adaptive Filters

Least mean squares adaptive filter, LMS adaptive algorithm. Properties of LMS adaptive filter. Normalized forms, finite precision effects, adaptive beam forming.

Unit. 5 Frequency Domain Filters

Frequency domain adaptive filters, adaptive lattice filters, adaptive IIR filtering, blind adaptive filtering, and Haykin cost functions. Higher-order statistics.

TEXT BOOKS

1. Simon Haykin and Adali, *Adaptive Signal Processing*, Wiley-IEEE, 2010.
2. Ali H. Sayed, *Fundamentals of Adaptive Filtering*, John Wiley, 2003.

REFERENCE BOOKS

1. J. Triechler, C. Johnson, M. Larimore, *Theory and Design of Adaptive Filters*, Prentice-Hall, 1995.

Biomedical Engineering
BM 75202: Rehabilitation and Prosthetics
Syllabus

Course Outcomes:-

CO1: To develop a strong "systems" understanding of the continuum of care for clinical rehabilitation, including from the context of optimizing outcomes.

CO2: To understand key aspects of sensorimotor systems as related to human performance and design/evaluation of human-technology interfaces.

CO3: To gain significant conceptual understanding of approaches for breaking down access barriers, and hands-on experience in using modern telecommunications technologies, especially in the context of access technologies, tele-rehabilitation and the roles of consensus standards.

CO4: To understand some basic principles and applications of biomechanics to rehab devices and interfaces.

Subject-Code	Subject Name	L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
								Theory		Practical		Total
								Th.	CW	SW	Pr.	
BM-75202	Rehabilitation and Prosthetics	4	-	-	4	-	4	70	30		-	100

Unit. 1 Clinical Rehabilitation Science & Engineering: Principles, Terminology & Models

Rehabilitative science foundations: healing biodynamic at the cell-tissue-organ-person levels, and understanding effects of interventions, existing infrastructure for the field of clinical rehabilitation and physical medicine, consensus terminology and models for the rehabilitation/disability field, clinical rehab engineering and the human activity / assistive technology (HAAT) model, rehabilitative continuum of care as a optimization problem, concepts in tele-access within the context of continuum of care**.**

Unit. 2 Sensorimotor Systems and Human Performance Assessment

Conceptual models of human performance and interface design, terminology and approaches in rehabilitation and ergonomics, basics of sensorimotor control (feed-back, feed-forward), components of sensory performance and relation to technology, vision, gaze and video codes, resolution and sampling, hearing, speaking and audio codecs, frequency content, volume, reflexes, spasticity, positioning and measurement sampling, arms, reaching, tracking and robotic manipulators, hands, grasping, manipulation and computer interface devices, example: virtual reality/environments. Tools for integrative task analysis: approaches to task analysis in rehabilitation, relation to fields of ergonomics and usability engineering.

Unit. 3 Access Engineering: Accessible Interfaces and Tele-rehabilitation

Foundations: access to information and services through accessible interfaces and telecommunications, accessible design regulations related to section 508 of rehab act, accessible design and universal design, universal access concepts, accessibility guidance for medical devices, models for tele-rehabilitation, optimization modeling framework.

Unit. 4 Rehab Biomechanics of Devices and Interfaces

Brief overview of biomechanics behind mobility and manipulation technologies, statics, solids, materials, kinematics, dynamics, principles of bi-causal mechanical interfaces, seated mobility devices, wheelchair considerations, seating considerations, device assisting manipulation tasks, concept of extended physiological proprioception (EPP), upper extremity prosthetics: body-powered, upper extremity prosthetics: externally-powered.

Unit. 5 Neuro-rehabilitation: Innovation in Therapeutic Strategies

Model of rehabilitation plan of care (e.g. neurorehab from traumatic event), conceptual framework: diagnosis, prognosis, intervention, assessment, outcomes. conventional approaches to diagnosis, intervention and outcomes assessment, patient records (paper, electronic), scales ("instruments" "forms" "measures") - by trained observer and/or self-report, objective (sensor-

based) measures (not common, but examples from PT, speech, gait), innovative approaches in neurorehab, classification: assessment, intervention/therapy, activity monitoring (e.g., wearable)**.**

TEXT BOOKS

1. Rory A Cooper, Hisaichi Ohnabe, Douglas A. Hobson, *An Introduction to Rehabilitation Engineering***,** CRC, 2006.

REFERENCE BOOKS

1. Raymond V. Smith, John H. Leslie Jr, *Rehabilitation Engineering*, CRC press, 1990.

Biomedical Engineering
BM 75203: Neural Network and Fuzzy Logic
Syllabus

Course Outcomes:-

CO1: Provide knowledge of supervised and unsupervised learning in neural networks.
CO2: Provide knowledge of computation and dynamical systems using neural networks.
CO3: Provide hands-on experience in selected applications.
CO4: Understand the role of neural networks and fuzzy logic in engineering, artificial intelligence, and cognitive modelling.

Subject-Code	Subject Name	L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
								Theory		Practical		Total
								Th.	CW	SW	Pr.	
BM-75203	Neural Network and Fuzzy Logic	4	-	-	4	-	4	70	30		-	100

Unit. 1 Feed Forward Networks

Structure and function of a single neuron: Biological neuron, artificial neuron, definition of ANN, single layer network, learning and adaptation, Mc Cullloh Pitt's neuron model, neural network learning rules- perceptron training algorithm, linear separability, Widro & Hebb's learning rule/Delta rule, ADALINE, MADALINE, AI vs. ANN.

Unit. 2 Feedback Networks

Generalized delta learning rule; delta learning rule for multi-layer perceptron. Learning factors, the back propagation algorithm single layer feedback networks: basic concept of dynamic networks, the Hopfield network both discrete and gradient forms.

Unit. 3 Other Networks

Associative memory: linear associator, recurrent associative memory, bidirectional associative memory matching and self-associating networks: Hamming net and Max net, unsupervised learning of clusters, counter propagation network, feature mapping, self-organizing feature maps, ART 1.

Unit. 4 Basics of Fuzzy Sets

Basic concepts of fuzzy sets, fuzzy logic, operations on fuzzy sets, fuzzy relations, equivalence and similarity relations, ordering, morphisms, fuzzy relation equations, fuzzy measures.

Unit. 5 Uncertainty Based Information

Probability measures, possibility and necessity measures, measures of uncertainty, dissonance, confusion and non-specificity. Principles of uncertainty and information, applications of fuzzy sets in management, decision making, computer science and systems science.

TEXT BOOKS

1. Dr. R.P. Das and L. Sreedhar, *Neural Networks and Fuzzy Logic*, S.K. Kataria & Sons, 2012.
2. Sushil Kumar Singh, *Soft Computing: Neural Networks, Fuzzy Logic and Genetic Algorithms*, Galgotia, 2012.

REFERENCE BOOKS

1. Vinoth Kumar and R. Saravana Kumar, *Neural Networks and Fuzzy Logic*, S.K. Kateria & Sons, 2012.
2. Chennakesava R. Alavala, *Fuzzy Logic and Neural Networks: Basic Concepts & Applications*, New Age, 2008.
3. Bhaska, *Neural Networks and Fuzzy Logic*, BS Publication, 2011.

Biomedical Engineering
BM 75204: Biomaterials: Design and Application
Syllabus

Course Outcomes:-

CO1: To understand the classes of biomaterials used.
CO2: To get an introduction to host reactions to biomaterials.
CO3: To have knowledge of biomaterial design applications.
CO4: To get aware to the various implantation techniques.

Subject-Code	Subject Name	L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
								Theory		Practical		Total
								Th.	CW	SW	Pr.	
BM-75204	Biomaterial: Design and Application	4	-	-	4	-	4	70	30		-	100

Unit. 1 Introduction

Classes of materials used in medicine: metals, polymers, FRPs, fabrics, nano-composites, bio resorbable and bio-erodible materials, ceramics, glasses.

Unit. 2 Host Reactions to Biomaterials

Host reactions to biomaterials: biocompatibility, implant associated infection.

Unit. 3 Testing of Biomaterials

In vitro assessment, in vivo assessment, blood materials interactions.

Unit. 4 Design of Materials for Biomedical Application

Cardiovascular, dental implants, orthopedic application, skin, ophthalmologic, applications, wound healing, sutures.

Unit. 5 Practical Consideration

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

1. S Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons, *Biomaterials Science: An Introduction to Materials in Medicine*, Academic Press, 2004.
2. J.B. Park and J.D. Bronzino, *Biomaterials: Principles and Applications*. CRC Press, 2002.

REFERENCE BOOKS

1. 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.
2. L Ambrosio, *Biomedical composites*, Woodhead Publishing Limited, UK, 2009.

Biomedical Engineering
BM 75501: Bio-Statistics
Syllabus

Course Outcomes:-

CO1: Introduction to measurement & descriptive statistics in medical practices.
CO2: Get familiar with statistics software.
CO3: Knowledge of regression & correlation.
CO4: Understand basics of sampling.
CO5: Study of Hypothesis testing.

Subject-Code	Subject Name	L	T	P	Theory Credits	Practical Credits	Total credits	Maximum Marks				
								Theory		Practical		Total
								Th.	CW	SW	Pr.	
BM-75501	Biostatistics	4	-	-	4	-	4	70	30			100

Unit. 1 Measurements and Descriptive Statistics in Medical Research and Practice

Data types and scales of measurement: continuous vs. enumeration data, sampling distributions - normal distribution (continuous data), binomial distribution (proportions, based on enumeration data), measures of central tendency-mean, median, mode, measures of variability-standard deviation and standard error.

Unit. 2 Introduction to R - Software for Statistical Computing

Basics of R programming, data entry and exporting data, grouping, loops and conditional execution, functions. Summary statistics, graphics in R, probability and distribution

Unit. 3 Sampling

Concept of a source population, random sampling, estimation of population statistics, standard error of a sample mean and of a proportion, and their differences, confidence intervals

Unit.4 Inference and Hypothesis Testing

Hypothesis generation, null hypothesis, Type I and II errors, statistical power, interpretation of P-values and confidence intervals, statistical and clinical significance. Comparing 2 or more groups: Comparing means of two populations with the t-test (continuous data), comparing proportions of responders in two populations (enumeration data), Chi square with corrections (goodness of fit, test of independence). One - Way ANOVA: F distribution test.

Unit.5 Regression and Correlation

Simple, partial and multiple correlation, simple linear /nonlinear regression, introduction to data mining for patterns, analytics.

TEXT BOOKS

1. Rao S, *Introduction to Biostatistics and Research Methods*, PHI, 2012.
2. Chad L., C. Wayne, W. Daniel, *Biostatistics: Basic Concepts and Methodology for the Health Sciences*, Wiley, 2014.

REFERENCES

1. B.K Mahajan, *Methods in Biostatistics*, Jaypee Brothers, 2010.

Biomedical Engineering
BM 75502: Embedded Systems
Syllabus

Course Outcomes:-

CO1: Describe the differences between the general computing system and the embedded system, also recognize the classification of embedded systems.

CO2: Become aware of the architecture of the ATOM processor and its programming aspects (assembly Level).

CO3: Design real time embedded systems using the concepts of RTOS.

CO4: Analyse various examples of embedded systems based on ATOM processor.

Subject-Code	Subject Name	L	T	P	Theory Credits	Practical Credits	Total credits	Maximum Marks				
								Theory		Practical		Total
								Th.	CW	SW	Pr.	
BM-75502	Embedded Systems	4	-	-	4	-	-	70	30	-	-	100

Introduction to Embedded Systems

Difference between general purpose systems and embedded systems, review of fundamentals of CPU, memory and I/O – performance evaluation – instruction set principles – design issues, example architectures, instruction level parallelism, pipelining and handling hazards

Unit. 1 Programming Embedded Systems

Embedded program, role of infinite loop, compiling, linking and locating, downloading and debugging, emulators and simulators processor, external peripherals, memory testing, flash memory, role of device drivers, device driver designing.

Unit.3 Operating Systems

Operating system basics, process creation. inter process communication, virtual memory, embedded operating system, real time characteristics, selection process, RTOS, tasks and task states, semaphores, shared data – message queues, mail boxes and pipes, memory management, hard real-time scheduling

Unit.4 Hardware Fundamentals

Various electrical components- relay, motors (stepper, dc, servomotor), basic electronic components-counters, timers, driver ICs, switches, A/D conversion, communication basics-importance of baud rate, protocols and their meaning.

Unit 5 Embedded Software Development Tools

Host and target machines, linkers / locators for embedded software, debugging techniques – instruction set, simulators laboratory tools, practical example – source code.

TEXT BOOKS

1. Daniel W.Lewis, *Fundamentals of embedded software where C and assembly meet*, Pearson Education., 2001.
2. F Vahid, T Giogarvis, *Embedded systems: A unified hardware/software approach*, Wiley, 1999.
3. Raj Kamal, *Embedded Systems Introduction*, 2nd Ed., TMH publication, 2015.

REFERENCES

1. David E Simons, *An Embedded Software Primer*, Pearson, 1999

1. .

Session: 2022-23

Biomedical Engineering
MA 75503: Applied Computational Linear Algebra
Syllabus

Course Outcomes:-

CO1: To provide students with a good understanding of the concepts and methods of linear algebra, described in detail in the syllabus.

CO2: To help the students develop the ability to solve problems using linear algebra.

CO3: To connect linear algebra to other fields both within and without mathematics.

CO4: To develop abstract and critical reasoning by studying logical proofs and the axiomatic method as applied to linear algebra.

Subject-Code	Subject Name	L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
								Theory		Practical		Total
								Th	CW	SW	Pr.	
MA-75503	Applied Computational Linear Algebra	4	-	-	4	-	4	70	30	-	-	100

Unit 1. Vector Spaces

Vector spaces, subspaces, linear equations, linear independence and linear dependence, basis and dimension, four fundamental spaces, linear transformation, matrix and representation of linear transformation, null space, range dimension theorem. Solving systems of linear equations, imposing constraints**,** rank of a matrix, representing a linear transformation, the geometry of Euclidean space, dot products.

Unit 2. Orthogonality

Cauchy's inequality, vectorization of a matrix, systems of linear equations, row-reduction, row operations as matrix multiplications, determinants, homogeneous systems of linear equations, real and complex systems of linear equations, determined systems of linear equations, over-determined systems of linear equations, perpendicular vectors and orthogonal subspaces, inner product spaces, projection onto lines, projection, least square approximations, orthogonal bases, orthogonal matrices and gram Schmidt orthonormalization process – Fast Fourier Transforms.

Unit 3 Eigenvalues, Eigenvectors and Positive Definite Matrices

Diagonal form of a matrix, difference equations and the powers, differential equations and the exponential, similarity transformations, minima, maxima and saddle points, test for positive, negative and semi definite and indefinite matrices.

Unit 4 Numerical Solution of Linear System of Equations

Solution of linear system of equations, direct method: Gauss elimination method, pivoting – Gauss-Jordan method, LU decomposition method, Cholesky decomposition method - Iterative methods: Gauss-Jacobi and Gauss-Seidel, SOR Method. 51.

Unit 5 Numerical Solution of Eigenvalue Problems and Generalized Inverses

Eigenvalue problems: power method, inverse power method- Jacobi's rotation method, conjugate gradient method – QR algorithm. Singular value decomposition method, principal-component analysis and the SVD, using the SVD in PCA, the PCA and factor analysis, the MUSIC method, singular values of sparse matrices.

TEXT BOOKS

1. Strang, G., *Linear Algebra and Its Applications*, Thomson (Brooks/Cole), 2005.

2. Faires, J.D. and Burden, R., *Numerical Methods*, Thomson Publications, 2002.

REFERENCES

1. Kumaresan, S., *Linear Algebra – A geometric approach*, Prentice – Hall of India, 2010.

2. Friedberg, A.H., Insel, A.J. and Spence, L., *Linear Algebra*, Prentice - Hall of India, 2004.

Biomedical Engineering
BM 75701: Advanced signal Processing
Syllabus

Course Outcomes:-

CO1: To acquire the fundamental concepts of Signal processing.
CO2: To understand various design techniques for linear phase analysis.
CO3: To introduce multi rate signal processing.
CO4: To study various signal model.
CO5: To apply concept of power spectrum analysis to various engineering problems.

Subject-Code	Subject Name	L	T	P	Theory Credits	Practical Credits	Total credits	Maximum Marks				
								Theory		Practical		Total
								Th.	CW	SW	Pr.	
BM-75701	Advanced Signal Processing	4	-	-	4	-	4	70	30	-	-	100

Unit. 1 IIR Filter Design

Review of classical analog filter design (Butterworth, Chebyshev, Elliptic)–design of digital filters based on continuous-time filters–mapping of differentials–impulse invariant transformation–modified impulse invariant transformation–bilinear transformation–matched.

Unit. 2 Linear Phase Analysis

Review of conditions needed for precise linear phase–design techniques for linear phase. FIR filters: (a) windowing method, (b) frequency sampling, (c) weighted Chebyshev approximation. All pass Filters: All pass transfer function and its properties–digital two-pair–design of all pass filters using digital two-pair–parallel all pass realization of certain IIR transfer functions. Hilbert transformers.

Unit. 3 Multi-rate Signal Processing

Introduction, decimation by a factor D, interpolation by a factor I, sampling rate conversion by a rational factor I/D, filter design and implementation for sampling rate conversion, multistage implementation of sampling rate conversion, sampling rate, conversion of band-pass signals, sampling rate conversion by an arbitrary factor, applications of multi-rate signal processing. Haar wavelet transform. Daubechies wavelet transform.

Unit. 4 Signal Models

Autoregressive model, moving average model, autoregressive moving average model, state variable model, lattice structures.

Unit. 5 Power Spectrum Estimation

Estimation of spectra from finite-duration observations of signals, nonparametric methods for power spectrum estimation, parametric methods for power spectrum estimation, minimum variance spectral estimation, eigen analysis algorithm for spectral estimation.

TEXT BOOKS

1. Monson H. Hayes, *Statistical Digital Signal Processing and Modeling*, John Wiley & Sons, 2001.
2. Andreas Antoniou, *Digital Filters: Analysis, Design, and Applications*, 2nd ed., Tata McGraw-Hill Publishing Co. Ltd., 1993.

REFERENCES

1. Leland B. Jackson, *Digital Filters and Signal Processing***,** 3rd ed., Kluwer Academic, 1996.

Biomedical Engineering
BM 75702: Advanced Biomechanics
Syllabus

Course Outcomes:-

CO1: To understand the need of Biomechanics study

CO2: To understand key concept of tissue characterization.

CO3: To understand key concepts of mechanics of skeletal muscle.

CO4: To understand the role of motion in biomechanics and basic principles cardiovascular mechanics

Subject-Code	Subject Name	L	T	P	Theory Credits	Practical Credits	Total credits	Maximum Marks				
								Theory		Practical		Total
								Th.	CW	SW	Pr.	
BM-75702	Advance Biomechanics	4	-	-	4	-	4	70	30	-	-	100

Unit. 1 Introduction

Introduction to Biomechanics, History, Perspectives in Biomechanics. Rigid Body Biomechanics. Anatomical Concepts in Biomechanics.

Unit. 2 Material Characterization of Tissues

Classification of Tissues, Properties of: Tissues from Mechanics Point of View, Modeling of Tissues.

Unit. 3 Mechanics of Skeletal Muscles

Skeletal Muscles as Elastic fibers in one dimension, Viscous behavior, Non-linear viscoelasticity; Continuum Mechanics, Concepts in Modeling of large deformation; Stress in three-dimensional continuous media.

Unit. 4 Motion

The time as an extra dimension; Deformation and rotation, deformation, rate and spin; Constitutive modeling of solids and fluids.

Unit. 5 Cardiovascular Mechanics

Cardiovascular Physiology, Blood Flow Models, Blood Vessel Mechanics, Heart Valve Dynamics, Prosthetic Valve Dynamics

TEXT BOOKS

1. Biomechanics, by Fung C., Springer, 1993

REFERENCE BOOKS

1. Basic Biomechanics by Hall et., McGraw Hill, 2011

Biomedical Engineering
BM 75703: Computer Vision and Machine Learning
Syllabus

Course Outcomes:-

CO1: **To** introduce student to computer vision algorithms.
CO2: To introduce mechanisms used in biological visual systems that inspire design of artificial unit.
CO3: Introduction to techniques of image segmentation.
CO4: Various techniques for image representation.
CO5: To introduce principles of motion analysis and object recognition.

Subject-Code	Subject Name	L	T	P	Theory Credits	Practical Credits	Total credits	Maximum Marks				
								Theory		Practical		Total
								Th.	CW	SW	Pr.	
BM-75703	Computer Vision and Machine Learning	4	-	-	4	-	4	70	30	-	-	100

Unit. 1 Digital Image Formation, Depth Estimation and Multi-Camera Views

Fundamentals of image formation, transformation: orthogonal, Euclidean, affine, projective, etc; Fourier transform, convolution and filtering, image enhancement, restoration, histogram processing. Perspective, binocular stereopsis: camera and epipolar geometry; homography, rectification, direct linear transform, random sample consensus **(**RANSAC**)**, 3-D reconstruction framework; auto-calibration.

Unit. 2 Feature Extraction

Edges - Canny, Laplacian of Gaussian, difference of Gaussian; line detectors (Hough Transform), corners - Harris and Hessian Affine, orientation histogram, scale invariant feature transform, SURF, histogram of oriented gradients scale-space analysis- image pyramids and Gaussian derivative filters, Gabor Filters and DWT.

Unit. 3 Image Segmentation

Region growing, edge based approaches to segmentation, graph-cut, mean-shift, MRFs, texture segmentation; object detection.

Unit. 4 Shape Representation

Deformable curves and surfaces, snakes and active contours, level set representations, Fourier and wavelet descriptors, medial representations, multiresolution analysis.

Unit. 5 Object Recognition and Motion Analysis

Shape correspondence and shape matching, principal component analysis, shape priors for recognition background subtraction and modeling, optical flow, KLT, spatio-temporal analysis, dynamic stereo; motion parameter estimation.

TEXT BOOKS

1. Richard Szeliski, *Computer Vision: Algorithms and Applications*, Springer-Verlag, 2011.
2. D. A. Forsyth, J. Ponce, *Computer Vision: A Modern Approach*, Pearson Education, 2003.

REFERENCES

1. H Richard, Z Andrew, *Multiple View Geometry in Computer Vision*, Cambridge Press, 2003.
2. R.C. Gonzalez and R.E. Woods, *Digital Image Processing*, Addison- Wesley, 1992

Session: 2022-23

Biomedical Engineering
BM 75704: Mechatronics

Course Outcomes:-

CO1: To develop understanding of basics of mechatronics.
CO2: Familiarity with various types of drives used in automated systems.
CO3: To understand hydraulics and mechanical design.
CO4: To understand industrial and medical robotics.

Subject-Code	Subject Name	L	T	P	Theory Credits	Practical Credits	Total Credits	Maximum Marks				
								Theory		Practical		Total
								Th	CW	SW	Pr.	
BM 75704	Mechatronics	4	-	-	4	-	4	70	30	-	-	100

Unit. 1 Introduction

Definition of mechatronics, mechatronics in manufacturing, products, and design. Comparison between traditional and mechatronics approach, review of fundamentals of electronics. Data conversion devices, sensors, micro-sensors, transducers, signal processing devices, relays, contactors and timers, microprocessors controllers and PLCs.

Unit. 2 Design of Hydraulic Systems

Hydraulic systems: flow, pressure and direction control valves, actuators, and supporting elements, hydraulic power packs, and pumps. Design of hydraulic circuits. Pneumatics: production, distribution and conditioning of compressed air, system components and graphic representations, design of systems.

Unit. 3 Design of Mechanical Element

The phases of design, design considerations, codes and standards, optimum design process, design variables, cost functions, design constraints, optimum design. Springs, rolling contact bearing, journal bearing, spur and helical gear, bevel and worm gears, shafts, axes and spindles, flexible mechanical elements, belts, timing belts, chain and sprocket, flexible shafts, brakes, clutches, cams, four bar mechanism.

Unit. 4 Simulation Techniques

Solution of model equations and their interpretation, zeroth, first and second order system, solution of 2nd order electro-mechanical equation by finite element method, transfer function and frequency response, non-parametric methods, transient, correlation, frequency, Fourier and spectra analysis, design of identification experiments, choice of model structure, scaling, numeric methods, validation, methods of lumped element simulation, modelling of sensors and actuators, hardware in the loop simulation (HIL), rapid controller prototyping, coupling of simulation tools, simulation of systems in software (MATLAB, LabVIEW) environment.

Unit. 5 Industrial and Medical Robotics

Application in manufacturing processes, e.g. casting, welding, painting, machining, heat treatment and nuclear power stations, etc., medical robots: image guided surgical robots, radiotherapy, cancer treatment, etc.

TEXT BOOKS

1. HMT, Mechatronics, Tata McGraw-Hill, 1988.
2. T.O. Boucher, *Computer Automation in Manufacturing - An Introduction*, Chappman and Hall, 1996.

REFERENCES

1. Musa Jouaneh, *Fundamentals of Mechatronics*, 1st Edition, Cengage Learning, 2012.
2. V. Giurgiutiu and S. Lyshevski, *Micromechatronics, Modeling, Analysis, and Design with MATLAB*, CRC Press, 2009.
3. D. Patranabis, *Principles of Industrial Instrumentation*, Tata McGraw-Hill, 2008.