# 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

**Session 2023-2024**

# Biomedical Engineering
# BM 75203: Neural Network and Fuzzy Logic
## Syllabus

**Course Outcomes:-**

CO1: Interpret and apply supervised and unsupervised learning in neural networks.

CO2: Apply supervised learning in feedback networks.

CO3: design complex networks using basic networks.

CO4: Summarize the role of neural networks and fuzzy logic in engineering, artificial intelligence, and cognitive modelling.

CO5: Apply fuzzy sets and logic in uncertain events

| 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.

**Course Articulation Matrix**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 |
|---|---|---|---|---|---|
| **CO1** | 2 | 1 | 1 | - | 1 |
| **CO2** | 2 | 1 | 1 | 1 | **1** |
| **CO3** | 2 | 2 | 3 | - | 2 |
| **CO4** | 3 | 2 | 2 | - | 1 |
| **CO5** | 3 | 2 | 3 | 1 | 1 |
| **Average** | 2.4 | 1.6 | 2 | 0.4 | 1.2 |

# Biomedical Engineering
# BM-75003: Medical Imaging Systems
## Syllabus

**Course Outcomes:-**

CO1: To explain basics of radiographic imaging and components of radiographic machines.

CO2: summarize basics of computed tomography imaging technique and its image reconstruction.

CO3: To summarize basic physics of magnetic resonance imaging and its instrumentation.

CO4: To explain basic physics of ultrasound, the instrumentation involved and modes of operation.

CO5: To compare various imaging modalities with its instrumentation.

| 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


**Course Articulation Matrix**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 |
|---|---|---|---|---|---|
| **CO1** | 2 | 3 | 2 | 1 | 2 |
| **CO2** | 3 | 3 | 2 | 1 | 2 |
| **CO3** | 3 | 3 | 3 | 1 | 2 |
| **CO4** | 3 | 3 | 2 | 1 | 2 |
| **CO5** | 2 | 3 | 3 | 1 | 2 |
| **Average** | 2.6 | 3 | 2 | 1 | 2 |

# Biomedical Engineering
# BM 75202: Rehabilitation and Prosthetics
## Syllabus

**Course Outcomes:-**

CO1:To explain the continuum of care for clinical rehabilitation.

CO2: To exemplify key aspects of sensorimotor systems as related to human performance.

CO3: To exemplify the importance of accessibility including information technology, healthcare, and telecommunication.

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

CO5: To design and analyse the innovative approaches in neurorehab.

| 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.

**Course Articulation Matrix**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 |
|---|---|---|---|---|---|
| **CO1** | 2 | 2 | 1 | 1 | - |
| **CO2** | 2 | 1 | 1 | 2 | **1** |
| **CO3** | 1 | 1 | 3 | - | 1 |
| **CO4** | 3 | - | 3 | - | 1 |
| **CO5** | 3 | 2 | 2 | 1 | 2 |
| **Average** | 2.2 | 1.2 | 2 | 0.8 | 1 |

# Biomedical Engineering
# BM 75001: Physiology For Engineers
## Syllabus

**Course Outcomes:-**

CO1: Classify different types of cell based on their structure and functionality.

CO2: Explain physiology of cardiovascular and respiratory systems and their implications..

CO3: Describe the physiology and anatomy of digestive and excretory systems.

CO4: Describe the interdependence and interactions of nervous and musculoskeletal systems.

CO5: To summarize 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.

**Course Articulation Matrix**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 |
|---|---|---|---|---|---|
| **CO1** | - | 1 | 2 | 2 | 3 |
| **CO2** | - | 1 | 2 | 2 | 3 |
| **CO3** | - | 1 | 2 | 2 | 3 |
| **CO4** | - | 1 | 2 | 2 | 3 |
| **CO5** | 3 | 3 | 3 | 2 | 3 |
| **Average** | 3 | 1.4 | 2.2 | 2 | 3 |

# Biomedical Engineering
# BM-75451: Electronic System Design
## Syllabus

**Course Outcomes:-**

CO1: To explain circuit analysis and synthesis.

CO2: To operate various hardware and software for data acquisition.

CO3: To design and build op amp based circuits for measuring op-amp characteristics.

CO4: Classify different OP-Amp configurations based on their design and working.

CO5: 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.


**Course Articulation Matrix**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 |
|---|---|---|---|---|---|
| CO1 | - | 1 | 2 | 2 | 2 |
| CO2 | 2 | 1 | 2 | - | 2 |
| CO3 | 1 | 2 | 3 | 1 | 3 |
| CO4 | 1 | 2 | 2 | 2 | 3 |
| CO5 | 3 | 3 | 3 | 2 | 3 |
| Average | 1.75 | 1.8 | 2.4 | 1.75 | 2.6 |

# 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.

**Course Articulation Matrix**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 |
|---|---|---|---|---|---|
| **CO1** | 1 | 1 | - | 1 | 2 |
| **CO2** | 1 | 1 | 2 | 1 | **2** |
| **CO3** | 1 | 1 | 3 | 1 | 3 |
| **CO4** | 1 | 1 | 3 | - | 3 |
| **CO5** | 2 | 1 | 2 | 2 | 3 |
| **Average** | 1.2 | 1 | 2.5 | 1.25 | 2.6 |

# Biomedical Engineering
# BM 75852: Modeling & Simulation
# Syllabus

**Course Outcomes:-**

CO1: To summarize background information required for studying virtual instrumentation.

CO2: To apply the basic building blocks of simulation in a model

CO3: To develop a few applications of physiological modelling.

CO4: To compare the various graphical programming environments in virtual instrumentation

CO5: To design and conduct experiments, as well as to analyses and interpret results.

| Subject-Code | Subject Name | L | T | P | Theory Credits | Practical Credits | Total credits | Maximum Marks | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Theory | | Practical | | Total |
| | | | | | | | | Th. | CW | SW | Pr. | |
| BM-75852 | Modeling and Simulation | - | - | 4 | - | 4 | 4 | - | - | 40 | 60 | 100 |

**Unit. 1 Introduction to Simulation**

Basics of modelling and simulation. Need of simulation.

**Unit. 2 Basic Blocks of Simulink**

Closed loop control system, integrators and derivatives, time response of second order system

**Unit. 3 Physiological Modeling 1**

Linear model of respiratory mechanics, linear model of muscle mechanics, steady –state analysis of the muscle reflex model. Regulation of glucose and insulin model, neuromuscular reflex model.

**Unit. 4 Physiological Modeling 2**

To determine the study-state operating point of ventilator control system, pupillary light reflex model.

**Unit. 5 Designing and analysis of any physiological model.**

**TEXT BOOK**

1. M.C. KHOO, *Physiological Control Systems: Analysis, Simulation and Estimation*, Wiley, 1999.

**REFERENCES**

1. Mark L, David A., *Learning Python*, Shroff, 2009.

**Course Articulation Matrix**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 |
|---|---|---|---|---|---|
| **CO1** | 2 | 1 | 1 | - | 1 |
| **CO2** | 2 | 1 | 1 | - | **1** |
| **CO3** | 2 | 2 | 3 | 1 | 3 |
| **CO4** | 3 | 2 | 2 | - | 1 |
| **CO5** | 3 | 3 | 3 | 2 | 3 |
| **Average** | 2.4 | 1.8 | 2 | 1.5 | 1.8 |

# Biomedical Engineering
# BM 75704: Mechatronics

**Course Outcomes:-**

CO1: To explain basics of mechatronics.
CO2: To classify various of hydraulic systems for automation
CO3: Discuss design and application of bearings and belts
CO4: Report various simulation techniques to get prototyping models
CO5: to study the application of Robots and therapies**.**

| 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, zero$^{th}$, first and second order system, solution of 2$^{nd}$ 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.

## Course Articulation Matrix

| CO | PO1 | PO2 | PO3 | PO4 | PO5 |
|---|---|---|---|---|---|
| **CO1** | 2 | 1 | 1 | - | 1 |
| **CO2** | 2 | 1 | 1 | 1 | **1** |
| **CO3** | 2 | 2 | 3 | - | 2 |
| **CO4** | 3 | 2 | 2 | - | 1 |
| **CO5** | 3 | 2 | 3 | 1 | 1 |
| **Average** | 2.4 | 1.6 | 2 | 0.4 | 1.2 |

# Biomedical Engineering
# BM 75501: Bio-Statistics
## Syllabus

**Course Outcomes:-**

CO1: Discuss measurement & descriptive statistics in medical practices.
CO2: Outline the basic functions of statistics software.
CO3: Apply regression & correlation to real world health data.
CO4: Discuss the basics concept of sampling.
CO5: Categries various Hypothesis testing based on case study.

| 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


**Course Outcomes:-**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 |
|---|---|---|---|---|---|
| **CO1** | 2 | 1 | 1 | - | 2 |
| **CO2** | 2 | 1 | 1 | 1 | **2** |
| **CO3** | 2 | 2 | 2 | - | 2 |
| **CO4** | 2 | 2 | 2 | - | 2 |
| **CO5** | 2 | 2 | 2 | 1 | 2 |
| **Average** | 2 | 1.6 | 1.6 | 0.4 | 2 |

# Biomedical Engineering
# BM 75701: Advanced signal Processing
## Syllabus

**Course Outcomes:-**

CO1: To acquire the fundamental concepts of Signal processing.
CO2: To differentiate various design techniques for linear phase analysis.
CO3: To apply multi rate signal processing to real world problem.
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.


**Course Articulation Matrix**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 |
|---|---|---|---|---|---|
| **CO1** | 2 | 1 | 1 | - | 1 |
| **CO2** | 2 | 1 | 1 | 1 | **1** |
| **CO3** | 2 | 2 | 3 | - | 2 |
| **CO4** | 3 | 2 | 2 | - | 1 |
| **CO5** | 3 | 2 | 3 | 1 | 1 |
| **Average** | 2.4 | 1.6 | 2 | 0.4 | 1.2 |

# Biomedical Engineering
# BM 75702: Advanced Biomechanics
## Syllabus

**Course Outcomes:-**

CO1: To explain the need of studying biomechanics with respect to rigid body mechanics
CO2: To describe the key concept of tissue characterization.
CO3: To Demonstrate the mechanics of muscle fibre.
CO4: To analyze how adding time in study brings deformation in state of objects
CO5: To be able to apply concept of mechanics in cardiovascular system.

| 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

**Course Articulation Matrix**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 1 | 1 | - | 1 |
| **CO2** | 3 | 1 | 1 | 1 | 1 |
| **CO3** | 3 | 1 | 3 | - | 1 |
| **CO4** | 3 | 1 | 2 | - | 1 |
| **CO5** | 3 | 1 | 3 | 1 | 1 |
| **Average** | 3 | 1 | 2 | 0.4 | 1 |

# Biomedical Engineering
# BM 75201: Adaptive Signal Processing
# Syllabus

**For Students from B.E. Biomedical Engineering**

**Course Outcomes:-**

CO1: To understand random variables and apply its knowledge in calculating various parameters related to it

CO2: To understand and be able to compare various prediction filters

CO3: to compare Wiener filter with other predictive filters

CO4: to evaluate the choice of adaptive filters and apply on various signals..

CO5: compare frequency domain filters with time domain filters. decide which one to opt for a particular situation

| 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.


**Course Articulation Matrix**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 1 | 1 | - | 1 |
| **CO2** | 3 | 2 | 1 | 1 | 2 |
| **CO3** | 3 | 2 | 3 | - | 1 |
| **CO4** | 3 | 2 | 2 | - | 1 |
| **CO5** | 3 | 2 | 3 | 1 | 2 |
| **Average** | 3 | 1.8 | 2 | 0.4 | 1.4 |

# Biomedical Engineering
# BM 75004: Bio-MEMS

**For Students from B.E. Biomedical Engineering**

**Course Outcomes:-**

CO1: To understand fundamental of microsystems engineering.

CO2: Attain knowledge about micro fabrication and micromachining.

CO3: Have experience in design consideration for Bio-MEMS device.

CO4: Understand its applications in field of biomedical devices

CO5: Awareness of different packaging and microsystem designing

| 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.

**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.


**Course Articulation Matrix**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|
| **CO1** | - | 1 | 1 | - | 2 | - | - |
| **CO2** | - | 1 | 2 | - | 2 | 1 | 2 |
| **CO3** | 1 | 1 | 3 | 1 | 2 | 3 | - |
| **CO4** | 1 | 1 | 3 | 1 | - | 3 | - |
| **CO5** | 1 | 1 | 2 | - | 1 | 1 | 2 |
| **Average** | 0.6 | 1 | 2.2 | 0.4 | 1.4 | 1.6 | 0.8 |

# Biomedical Engineering
# BM 75703: Computer Vision and Machine Learning
## Syllabus

**Course Outcomes:-**

CO1: To introduce student to concept of image formation and fundamentals of image processing.
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


**Course Articulation Matrix**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 1 | 1 | - | 2 |
| **CO2** | 3 | 2 | 1 | 1 | 3 |
| **CO3** | 3 | 2 | 3 | - | 2 |
| **CO4** | 3 | 2 | 2 | - | 1 |
| **CO5** | 3 | 2 | 3 | 1 | 3 |
| **Average** | 3 | 1.8 | 2 | 0.4 | 2.2 |