

**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 2018-2019**

# 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. Trierchler, C. Johnson, M. Larimore, *Theory and Design of Adaptive Filters*, Prentice-Hall, 1995.

# 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 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

## 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 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 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-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 pCO<sub>2</sub>, pO<sub>2</sub> - 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 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 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

# 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. .

# 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 75851: Finite Element Method

### Syllabus

**Course Outcomes:-**

CO1: To learn basic principles of finite element analysis procedure

CO2: To learn the characteristics of finite elements that represent engineering structures.

CO3: To learn and apply finite element solutions to structural, thermal, dynamic problem to develop the knowledge and skills needed to effectively evaluate finite element.

| Subject-Code | Subject Name          | L | T | P | Theory Credits | Practical Credits | Total Credits | Maximum Marks |    |           |     |       |
|--------------|-----------------------|---|---|---|----------------|-------------------|---------------|---------------|----|-----------|-----|-------|
|              |                       |   |   |   |                |                   |               | Theory        |    | Practical |     | Total |
|              |                       |   |   |   |                |                   |               | Th.           | CW | SW        | Pr. |       |
| BM-75851     | Finite Element Method | - | - | 4 | -              | 4                 | 4             | -             | -  | 40        | 60  | 100   |

**Unit. 1** Introduction to Hyper-mesh

**Unit. 2** Construction and analysis of 3-D Model of teeth.

**Unit. 3** Construction and analysis of 3-D Model of hip Joint.

**Unit. 4** Construction and analysis of 3-D Model of bone.

**Unit. 5** Construction and analysis of 3-D Model of spinal section.

**REFERENCES**

1. G.R. Liu, *The Finite Element Method: A Practical Courses*, Elsevier, 2013.

# 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, zero<sup>th</sup>, first and second order system, solution of 2<sup>nd</sup> 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*, Chapman 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.

# 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, fundamentals 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. Krzysztof 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*, 1<sup>st</sup> Edition.



# Biomedical Engineering

## BM 75852: Modeling & Simulation

### Syllabus

**Course Outcomes:-**

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

CO2: To study the basic building blocks of simulation.

CO3: To study a few applications of physiological modeling.

CO4: An ability to design and conduct experiments, as well as to analyse 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.

# 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 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, liver, 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 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.