SCHEME OF INSTRUCTION AND EVALUATION
B.E. (BIOMEDICAL ENGINEERING)

BE HONORS In BME with extra 18 credits in BME

Note:

Sl. No	Code	Course Name	Contact hours per week		Scheme of Examination		Credits	SEM
			L	P	CIE	SEE		
1.	HR 501 BM	Fiber Optics & Laser in Medicine	3	-	40	60	3	During V-VIII
2.	HR 502 BM	Cell and Tissue Engineering	3	-	40	60	3	
3.	HR 601 BM	Biotribology	3	-	40	60	3	
4.	HR 602 BM	Biostatistics	3	-	40	60	3	
5.	HR 603 BM	Nanotechnology for Medical Applications	3	-	40	60	3	
6.	HR 604 BM	Bioinformatics	3	-	40	60	3	
7.	HR 701 BM	Drug Delivery Systems	3	-	40	60	3	
8.	HR 702 BM	Micro Electro-Mechanical Systems	3	-	40	60	3	
9.	HR 801 BM	Bio-microfluidics	3	-	40	60	3	
10.	HR 802 BM	Product Design and Development	3	-	40	60	3	
11.	HR 803 BM	Rehabilitation Engineering	3	-	40	60	3	
12.	HR 804 BM	Calibration of Medical Equipment	3	-	40	60	3	
13.	HR 805 BM	Artificial Intelligence in Healthcare	3	-	40	60	3	
		PRACTICALS						
1.	HR 861 BM	Project work	-	6	50	50	3	
		TOTAL	**15**	**6**	**250**	**350**	**18**	

Note:

1. Out of the above listed courses, the students can opt for any 5 courses, which he/she has not pursued in the regular curriculum.
2. The student may opt for any relevant NPTEL courses of 12 weeks duration instead of the above courses, which he/she has not pursued in the regular curriculum after approval by the Chairperson, BoS (A).

L-Lectures
T-Tutorials
P-Practicals
CIE-Continuous Internal Evaluation
SIE-Semester End Evaluation

HR 501 BM

FIBER OPTICS & LASER IN MEDICINE

Instruction	3 Periods per week
Duration of University Examination	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Course Objectives:

1. To offer clear understanding of tissue characteristics when it is exposed to optical energy.
2. To know about various optical sources and applications of lasers.
3. To expose the students to the Laser fundamentals and fiber optics.

Course Outcomes: Successfully the student will be able to:

1. Use optical sources for Medical LASER instrumentation and measurement.
2. Analyze the optical properties of tissues and light interactions with tissues
3. Understand basic concepts of optical fibers and their properties
4. Applications of Fiber Optics used in medical imaging systems
5. To provide adequate knowledge about Medical applications of Lasers

UNIT-I

INTRODUCTION: Historical background .Medical Lasers: Introduction, Laser physics-fundamentals, principles, advances. Medical Laser system-fundamentals, principles. Laser safety-fundamentals.

APPLICATION OF LASERS IN DIAGNOSIS &THERAPY: Introduction, Laser assisted diagnosis and therapy fundamentals.

UNIT-II

LASER-TISSUE INTERACTION: Laser interaction with tissue-principles; laser assisted diagnostic –principles, application of lasers in diagnosis and imaging-advances, laser surgery and therapy –principles-photo thermal & photomechanical mechanism, thermal interaction between laser and tissue-advances.

UNIT-III

SINGLE OPTICAL FIBER: Introduction, historical background, optical fiber fundamentals. Light transmission in optical fibers-principles, optical properties of optical fibers-advances, fabrication of optical fibers- principles, optical fibers for UV, visible, IR light-principles, power transmission through optical fibers-principles.

UNIT-IV

OPTICAL FIBER BUNDLES: Introduction, non-ordered fiber optic bundles for light guides-fundamental & principles, ordered fiber optic bundles for imaging devices-fundamentals & principles, fiberscope and endoscopes-fundamentals fiber optic imaging systems-advances. ENDOSCOPY: Introduction endoscopic imaging systems-fundamental, principles, advances, endoscopic diagnostic –advances endoscopic therapy –fundamentals.

UNIT-V

CLINICAL APPLICATIONS OF FIBER OPTIC LASER SYSTEMS: Introduction, fiber optic laser system in cardiovascular disease, gastroenterology. Gynecology, neurosurgery, oncology, ophthalmology, orthopedics, otolaryngology (ENT), urology, and flow diagram for laser angioplasty& photodynamic therapy.

Suggested Reading:

1. Laser and optical fibers in Medicine by Abraham Katzir, Academics Press,1998.
2. Therapeutic Lasers-Theory and Practice by G. David Baxter, Churchill Livingstone Publications.

3. Medical Lasers and their safe use DAVID H Shiney .Stephen and L Trokel, Springer, Springer. verlag publications.
4. Elements of fiber optics S.L.Wymer, Regents PHI
5. Biomedical Electronics and Instrumentation S. K. Venkata Ram Galgotia publications.

HR 502 BM

CELL AND TISSUE ENGINEERING

Instruction	3 Periods per week
Duration of University Examination	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

COURSE OBJECTIVES:

- This course helps to gain deeper knowledge of cell and tissues for variety of approaches used to regenerate the damaged tissue.
- The students will learn about the key concepts of cell biology and tissue organization and the technologies used in tissue engineering.

COURSE OUTCOMES: Upon completion of the course, the student will be able to

1. Understand the basic concepts of tissue engineering in cells, scaffold and growth factors.
2. Understand the concepts of cell interactions and properties of various biomaterials used in biomedical applications.
3. Acquire knowledge on process of tissue culturing and significance of stem cells in tissue regeneration.
4. Learn about various tools and techniques to analyze the surface characterization and cell structure.
5. Understand the clinical challenges of tissue engineering applications.

UNIT-I

Cell structure and organization: Cell structure and basic functions of various cell organelles. Check points of cell cycle and its applications, cell growth, cell death and differentiation.

UNIT-II

Cell-extracellular matrix interactions: Cell-cell and cell-matrix interactions, cell adhesion molecules, components of the extracellular matrix, cellular junctions, Stem cells.

UNIT-III

Cell and tissue culture for tissue engineering: Cell fractionation. Types of tissue culture, media, culture environment and maintenance of cells in vitro, cryopreservation, cell revival, passage, cell counting.

UNIT-IV

Tools and Techniques of Cell Biology: Histology, staining, fluorescence, confocal microscopy, TEM and SEM, Fluorescent dyes and GFP tagged proteins in visualization.

UNIT-V

Tissue engineering applications and challenges: Types of biomaterials used in hard and soft tissue engineering, Bioreactors, challenges in Bone, Skin, Cornea, Liver tissue engineering applications.

Suggested reading:

1. Cell and Molecular Biology, Gerald Karp, John Wiley & Sons, Inc.6th Edition ISBN-13 978-0-470-48337-4.
2. The Principles of Tissue engineering (4th edition), by Robert Lanza, Robert Langer, and Joseph P. Vacanti. ISBN: 978-0-12-398358-9.
3. Tissue Engineering. Clemens van Blitterswijk. ISBN: 978-0-12-370869-4.
4. The molecular and cellular biology of wound repair. Clark, Plenum Press. ISBN: 978-1-4615-1795-5.
5. Biomaterials for tissue engineering applications, Burdick, Jason A., Mauck, Robert L. ISBN 978-3-7091-0385-2.

HR 601 BM

BIOTRIBOLOGY

Instruction	3 Periods per week
Duration of University Examination	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

COURSE OBJECTIVES:

- To provide students with a comprehensive understanding of the fundamental principles of tribology, including friction, wear, and lubrication.
- To familiarize students with various tribological materials and surface engineering techniques used to enhance material performance.
- To introduce students to the field of biotribology and its applications in biomedical engineering.
- To equip students with practical skills in tribological and biotribological testing and characterization methods.
- To explore the industrial and biomedical applications of tribology and biotribology

COURSE OUTCOMES: Upon completion of the course, the student will be able to

1. Explain the fundamental principles of tribology and apply them to solve practical engineering problems.
2. Identify and evaluate the properties of various tribological materials and surface treatments.
3. Describe the mechanisms of friction and wear in biological systems and understand the role of biomaterials.
4. Understand standard tribological tests, Understand test results, and characterization techniques and various microscopy and spectroscopy techniques.
5. Students will be able to assess the applications of tribology and biotribology in industry and biomedical fields.

Unit I

Fundamentals of Tribology: Definition and scope of tribology, Historical development and significance in engineering. Theories of contact: Hertzian contact theory, Surface roughness and texture, Contact pressure and stress distribution. Types of friction: static, kinetic, and rolling, Laws of friction and mechanisms of friction, Factors affecting friction: material properties, surface conditions, environment. Types of wear: abrasive, adhesive, erosive, and fatigue wear, Mechanisms of wear: micro and macro mechanisms, Factors influencing wear: material properties, load, speed, environment. Lubrication- Principles of lubrication: boundary, mixed, and hydrodynamic lubrication. Types of lubricants: solid, liquid, and gas lubricants, Properties and selection of lubricants: viscosity, additives, thermal stability.

Unit II

Tribological Materials- Metallic materials and their tribological properties, Polymers and composites in tribology, Ceramics and coatings for tribological applications. Surface treatment techniques: heat treatment, shot peening, and case hardening. Coating technologies: PVD (Physical Vapor Deposition), CVD (Chemical Vapor Deposition), thermal spraying, and electroplating. Surface texturing and microstructuring: laser texturing, chemical etching. Advanced Materials and Coatings, Diamond-like carbon (DLC) coatings, Nanocomposites and their tribological applications, Self-lubricating materials.

Unit III

Biotribology: Definition and scope of biotribology, Importance in biomedical applications, Biological Interfaces, Structure and properties of biological tissues: skin, cartilage, bone,

Biomechanics of joints and soft tissues. Friction in Biological Systems. Natural lubrication mechanisms: synovial fluid, mucus. Friction in joints and prosthetic interfaces. Factors affecting friction in biological systems. Wear in Biological Systems. Wear mechanisms in natural and artificial joints. Wear debris and its biological effects. Longevity and performance of joint replacements. Biomaterials for Tribological Applications. Materials used in joint replacements: metals, polymers, ceramics, Biocompatibility and bioactivity of tribological materials

Unit IV

Tribological Testing: Pin-on-disk test: principles, setup, and interpretation of results. Block-on-ring test, Ball-on-flat test. Scratch test, Wear Testing, Wear coefficient measurement, Abrasion testing, Erosion testing. Friction coefficient measurement techniques, Types of tribometers. Simulation of biological environments for testing, Joint simulator testing for prosthetic devices. Surface Characterization Techniques: Microscopy techniques: optical microscopy, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Surface profilometry and roughness measurement: contact and non-contact methods, Spectroscopy techniques: X-ray Photoelectron Spectroscopy (XPS), Auger Electron Spectroscopy (AES), Atomic Force Microscopy (AFM) and its applications in tribology.

Unit V

Applications and Future Trends in Tribology and Biotribology

Industrial Applications of Tribology. Tribology in manufacturing processes. Tribological considerations in automotive industries. Tribology in aerospace industries. Biomedical Applications of Biotribology. Joint replacements and prosthetics. Dental tribology. Contact lenses and ocular tribology. Current Research and Innovations. Advances in lubricants and lubrication techniques. Smart materials and surfaces in tribology. Nanotribology: atomic and molecular scale tribology, applications in nanotechnology.

Suggested Reading and Resources:

[1] "Engineering Tribology" by Gwidon W. Stachowiak and Andrew W. Batchelor

[2] "Introduction to Tribology" by Bharat Bhushan

[3] "Biotribology" by J. Paulo Davim

HR 602 BM

BIOSTATISTICS

Instruction:	3 Periods per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE:	40 Marks
Credits:	3

Course Objectives:

1. To introduce basic statistical methods like curve fitting, correlation and regression.
2. To provide the knowledge of probability distributions like normal, Poisson and tests of significance.

Course Outcomes: Upon completion of the course, the students will be able to:

1. Apply various probability distributions to solve practical problems, to estimate unknown parameters of populations and apply the tests of hypotheses.
2. Perform regression analysis and to compute and interpret the coefficient of correlation

UNIT- I

Concepts of Biostatistics. Basic statistical measures, measures of central tendency, measures of dispersion, variance, standard deviation, properties of probability, probability distribution, sampling distribution.

UNIT- II

Estimation and hypothesis testing. Confidence intervals for data, t distribution, determination of sample size for estimating means and proportions. Hypothesis testing for a single population mean/proportion difference between two population means/proportions, sample size to control type I and type II errors, Case studies.

UNIT- III

Analysis of variance. The completely randomized design, random sized complete block design, repeated measures design. Case studies.

UNIT- IV

Regression and correlation. Simple linear regression model, regression equation, the correlation model, multiple linear regression model, multiple regression equation, multiple correlation model, additional techniques of regression analysis. Case studies.

UNIT- V

Chi-square distribution, tests of good fit, independence, homogeneity, non-parametric statistical procedures, regression analysis.Case studies.

Suggested Reading:

1. Stanton A. Glantz, *Primer of biostatistics,* Mc GrawHill , 2nd Ed.
2. Wayne S. Daniel, *Biostatistics: A foundation for analysis in the health sciences*, John Wiley & Sons, 6th Ed. 2012.

HR 603 BM

NANOTECHNOLOGY FOR MEDICAL APPLICATIONS

Instruction:	3 Periods per week
Duration of SEE:	3 Hours
SEE:	60 Marks
CIE:	40 Marks
Credits:	3

COURSE OBJECTIVES:

- To introduce the students to the application of Nanotechnology to medicine
- To familiarize different Nanomaterials and their fabrication
- To introduce the diagnostic and therapeutic applications of Nanomaterials

COURSE OUTCOMES: Upon completion of the course, the students will be able to

1. Understand characteristics, properties and classification of Nanomaterials.
2. Compare the different types of Nanomaterials.
3. Explain the fabrication techniques of Nanomaterials
4. Recognize the applications of Nanomaterials to diagnostics
5. Apply Nanomaterials to therapeutics.

UNIT-I

Introduction to Nanotechnology: Nano materials- Definition, Structure and bonding, Characteristics and Properties of Nano materials, Classification of Nanodevices based on the characteristics, Nanotechnology in science.

UNIT-II

Nanomaterials: Types of Nanomaterials, Nanoparticles, Quantum dots and their properties, Fullerenes and carbon forms, Carbon Nanoparticles, Carbon Nanotubes, types of carbon Nanotubes, single-walled, multi- walled, torus, Nano bud, properties of carbon Nanotubes.

UNIT-III

Fabrication of Nanomaterials: Fabrication of Nanomaterials by Bottom-up and Top- down approaches, Synthesis of Nanoparticles, Synthesis of carbon Nanotubes by Arc discharge, laser ablation, chemical vapor deposition techniques, Characterization methods of Nanomaterials.

UNIT-IV

Nanomaterials in diagnostics: Molecular imaging, Medical use of Nanomaterials, Quantum Dots and Nanoparticles for cancer imaging, Applications of Nanomaterials in Medical imaging, Neuro-electronic interfaces.

UNIT-V

Nanomaterials in therapeutics: Drug delivery systems, Targeted drug delivery systems, Drug tracking systems, Nanomaterials for drug delivery, Quantum Dots and Nanoparticles for cancer treatment, Nanoparticle mediated gene therapy, Growth of neurons on Nanomaterials, Nanomaterials for brain protection and repair, Nanorobotics for surgery.

Suggested Readings:

1. Alain Nouailhat, *An introduction to Nanoscience and Nanotechnology,* ISBN: 978-0-470-39353-6, Wiley-VCH
2. Gunter Schmid, *Nanotechnology: Volume 1: Principles and Fundamentals* ,ISBN: 978-3-527-31732-5 Wiley-VCH
3. Dieter Vollath, *Nanoparticles - Nanocomposites – Nanomaterials, An Introduction for Beginners,* ISBN: 978-3-527-33460-5, Wiley-VCH
4. CSSR Kumar, J.Hormes, C. Leuschner, *Nanofabrication towards Biomedical, Techniques, Tools, Applications, and Impact* by WILEY-VCH
5. Gabor L. Hornyak, John J. Moore, H.F. Tibbals, Joydeep Dutta, *Fundamentals of Nanotechnology,* ISBN 9781138627413, CRC Press

HR 604 BM

BIOINFORMATICS

Instruction:	3 Periods per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE:	40 Marks
Credits:	3

Course Objectives:

1. To give students an introduction to the basic techniques of bioinformatics.
2. Emphasis will be given to the application of bioinformatics and biological databases to problem solving in real research problems.

Course Outcomes: Upon completion of the course, the students will be able to:

1. Describe the contents and properties of the most important bioinformatics databases, perform text- and sequence-based searches, and analyze and discuss the results in light of molecular biological knowledge
2. Explain the major steps in pair-wise and multiple sequence alignment, explain the principle for, and execute pair-wise sequence alignment by dynamic programming.
3. Predict the secondary and tertiary structures of protein sequences.

UNIT I

Prediction of protein molecular function and structure: Primary sequence of a protein and its analysis, Secondary, Tertiary and quaternary structures and their prediction methods, Fold recognition methods, Homology/comparative modeling of proteins, Energy calculations, local and global minimization, Energy Minimizations: Conjugate, steepest and Powell , Molecular dynamics and simulation studies.

UNIT II

Algorithms: Algorithms and complexity, Biological algorithms, computer algorithms, The change problem, Correct, incorrect algorithms, Recursive algorithms, Iterative, recursive algorithms, Fast and slow algorithms, Big-O notation, Algorithm designing techniques- Exhaustive search, Branch-and-bound algorithms, Dynamic programming, Divide-and-conquer algorithms, Randomized algorithms, Gibbs sampling.

UNIT III

Computer algorithms for prediction of protein structures. DNA Sequence Comparison, Algorithms for alignment of sequences and structures of proteins and protein families, PAM, BLOSUM, Bayesian modeling and networks, Probabilistic models or Hidden Markov models, Needleman Wunch and Smith Waterman algorithms, Global sequence alignment, Scoring alignments, Local sequence alignment, Alignment with gap penalties. Multiple alignment, Gene prediction-Statistical and Similarity-based approaches. Spliced alignment.

UNIT IV

Genetic algorithms: Genetic algorithms for the prediction of multiple sequence alignment, Gene expression analysis, Hierarchical clustering, K-Means clustering, clustering and corrupted cliques. Evolutionary trees- Distance-based tree reconstruction, Reconstructing trees from additive matrices, Evolutionary trees and hierarchical clustering. Character-based tree reconstruction- Small parsimony problem, large parsimony problem.

UNIT V

Neural Networks: Biological neurons and neural networks. Networks of artificial neurons. Learning in single layer and multi-layer perceptrons. Back-propagation. Radial basis function networks: Algorithms and applications. Committee machines. Self-organizing maps:

algorithms and applications. Learning vector Quantization. Machine Learning, Statistical learning, Decision trees. Inductive logic programming, Computation learning, Unsupervised learning, temporal difference learning, Delayed reinforcement learning, Explanation based learning.

Suggested Reading:

1. Bioinformatics – Sequence and Genome Analysis. David W. Mount.
2. Beale and T.J. Jackson, Introduction to Neural Networks, IOP Publishing Company, 1990.
3. Baeck, D.B. Fogel and Z. Michalewicz ,Genetic Algorithms, IOS Press, 1997.

HR 701 BM

DRUG DELIVERY SYSTEMS

Instruction:	3 Periods per week
Duration of SEE:	3 Hours
SEE:	60 Marks
CIE :	40 Marks
Credits:	3

COURSE OBJECTIVES:

1. Understand various approaches for development of novel drug delivery systems
2. Formulate and evaluate novel drug delivery systems
3. Understand criteria for selection of drugs and polymers for the development of delivering system.
4. Develop skills in formulation and evaluation of novel drug delivery systems

COURSE OUTCOMES: Upon completion of the course, the students will be able to

1. Explain the fundamental principles of drug delivery systems.
2. Students understand the various approaches for development of drug delivery system.
3. Students understand the criteria for selection of drugs and polymers for the development of delivering system.
4. Students shall be able to develop skills in formulation and evaluation of novel drug delivery system.
5. Students shall be able to formulate and evaluate novel drug delivery systems.

UNIT-I

Controlled and Sustained Drug Delivery Systems: fundamental concepts of controlled drug delivery, mechanism of drug release – diffusion, dissolution, osmotic, floating, ion-exchange and bioadhesive. Physicochemical & biological approaches for SR/CR formulation. Formulation approaches to design controlled release. Polymers: Classifications, properties, drug in polymer matrices polymers in the formulation of controlled release drug delivery systems.

Unit 2

Rate Controlled Drug Delivery Systems: Principles and fundamentals, Types of release kinetics, formulation, modulated drug delivery systems, mechanically activated, pH activated, enzyme- triggered, and osmotic controlled release, feedback regulated drug delivery systems. Advantages, disadvantages and applications.

Microencapsulation: Introduction, types of microencapsulated particles- microspheres, microcapsules, microparticles. Methods and applications of microencapsulation in drug delivery systems.

Unit 3:

Occular Drug Delivery Systems: Barriers to drug permeation in ocular tissues, strategies to overcome the barriers. **Gastroretentive Drug Delivery Systems**: Principles, concepts advantages and disadvantages, approaches for GRDDS- floating, high density systems, inflatable and gastro adhesive systems. **Buccal drug delivery systems:** Principle of muco adhesion, advantages and disadvantages, mechanism of drug permeation, Methods of formulation and its evaluations.

Unit 4

Transdermal Drug Delivery Systems (TDDS): Structure of skin and barriers, Penetration through skin, factors affecting penetration, penetration enhancers, transdermal drug delivery systems, formulation and evaluation.

Mucosal Drug Delivery Systems: Introduction, principles of bioadhesion /mucoadhesion, penetration of transmucosal and advantages and disadvantages.
Protein and Peptide Delivery: Barriers for protein delivery. Formulation and evaluation of delivery systems of proteins and other macromolecules.

Unit 5
Vaccine Drug Delivery Systems: Vaccines, uptake of antigens, single shot vaccines, mucosal and transdermal delivery of vaccines. **Implantable Drug Delivery System:** Concept of implants and osmotic pump. **Targeted Drug Delivery:** Concepts of liposomes, niosomes, nanoparticles, monocolonal antibodies and their applications. Approaches of TDD with advantages and disadvantages.

Suggested Reading and Resources:
[1] "Controlled Drug Delivery: Fundamentals and Applications" by Joseph R. Robinson and Vincent H.L. Lee
[2] "Biomedical Engineering Principles in Drug Delivery" by K. Park
[3] "Drug Delivery Systems" by Vladimir P. Torchilin
[4] "Polymeric Drug Delivery Systems" by Glen S. Kwon
[5] "Drug Delivery Systems: Methods and Protocols" by Kewal K. Jain

HR 702 BM

MICRO ELECTRO-MECHANICAL SYSTEMS

Instruction	3 Periods per week
Duration of University Examination	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

COURSE OBJECTIVES:

- To introduce to basics of Micro-electro-mechanical systems
- To understand properties of materials involved in MEMS
- To pertain fabrication methods involved in MEMS manufacturing
- To apply the concepts for various applications

COURSE OUTCOMES: Upon completion of the course, the student will be able to

1. Elucidate basic concepts involved in MEMS technologies
2. Realize the properties of various materials involved in MEMS technologies
3. Apply the concepts and technologies involved in designing of MEMS
4. Relate different manufacturing processes involved in fabrication of MEMS
5. Recognize micro sensors, micro actuators and their applications in various fields.

UNIT I

Introduction to MEMS: What is MEMS, Historical Background, classification, Micro-engineering, importance of micro-engineering. Technological advancements in MEMS, advantages and disadvantages of MEMS.

UNIT II

MEMS materials: Materials used in MEMS. Material properties: electrical, mechanical, thermal, chemical, biological, optical and processing. Reliability issues of materials

UNIT III

Designing of MEMS: Design and analysis process for MEMS. Initial design process, structured design process. Commonly used design flow, structured design flow. Design flow for MEMS cad design. Designand verification flow for integrated MEMS.

UNIT IV

MEMS fabrication Techniques: Photolithography, materials for micromachining, bulk micromachining Surface micromachining, High aspect-ration-micromachining, assembly and system integration.

UNIT V

MEMS structures and devices: Mechanical sensors, mechanical actuators, micro-fluidic devices, optical/photonic micro-systems, biological transducers.

Suggested Readings:

1. Adams TM, Layton RA. Introductory MEMS: Fabrication and applications, 2010.
2. Tobergte DR, Curtis S. “An Introduction to Micro-electro-mechanical Systems Engineering” Second Edition. vol. 53. 2013.
3. Kreith F, Kreider JF. :The MEMS Handbook” CRC Press 2002.
4. Reza Ghodssi · Pinyen Lin. “MEMS Materials and Processes Handbook” Springer 2013
5. Gad-el-Hak M. “MEMS applications” 2nd edition, CRC press 2006.

HR 801 BM

BIOMICROFLUIDICS

Instruction	3 Periods per week
Duration of University Examination	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Course Objectives

1. Understand various approaches for development of novel drug delivery systems
2. Formulate and evaluate novel drug delivery systems
3. Understand criteria for selection of drugs and polymers for the development of delivering system.
4. Develop skills in formulation and evaluation of novel drug delivery systems

Course Outcomes: Upon the completion of the course, the student will be able to:

1. Understand the fundamental principles of microfluidics.
2. Explore various microfabrication methods and optimal functional materials.
3. Design and develop microfluidic systems.
4. Implement flow characterization techniques for optimizing microfluidic device performance.
5. Apply microfluidic technologies in various biomedical systems.

UNIT-I

Introduction to Microfluidics: Definition and Historical Development, Significance; Fluid Mechanics at Microscale: Fluid properties, Types of Fluid Flow, Reynolds Number and its Implications, Surface tension and Capillarity, Slip Boundary Condition, Entrance Effects; Pressure-Driven and Electrokinetic Flow.

UNIT-II

Microfabrication Techniques: Materials and Methods: Additive, Subtractive, and Pattern transfer techniques; Material Selection for Microfluidic Devices. Polymer microfabrication, PMMA/COC/PDMS substrates, micromolding, hot embossing, fluidic interconnections. Oxidation, photolithography- mask, spin coating, exposure and development, Etching, Bulk and Surface micromachining, Waferbonding.

UNIT-III

Microfluidic Components and Systems: Microvalves, Micropumps, Microsensors, Micromixers, and, Microreactors: Design Considerations, Functions.

UNIT-IV

Experimental Flow Characterization: Measurement Techniques: Point wise and Full-field Methods; Particle Image Velocimetry: Fundamentals, Microfluidic Nanoscope, Microparticle Image Thermometry, Infrared Particle Image Velocimetry, Particle Tracking Velocimetry.

UNIT-V

Applications in Biomedical Engineering: Diagnostic Devices: Lab-on-a-chip Systems, Point-of-care Testing Technologies; Drug Delivery Systems; Tissue Engineering and Regenerative Medicine: Microfluidic Scaffolds and Cell Culture Systems, Organ-on-a-chip models, Biocompatibility Tests.

Suggested Reading:

1. Nguyen, N.-T., Wereley, S. T., &Shaegh, S. A. M. (2019). Fundamentals and applications of microfluidics (Third edition). Artech House.
2. Santra, T. S. (Ed.). (2021). Microfluidics and Bio-MEMS: Devices and applications. Jenny Stanford Publishing.

3. Song, Y., Cheng, D., & Zhao, L. (2018). Microfluidics: Fundamentals, devices and applications. Wiley-VCH.
4. Zahn, J. D. (2010). Methods in bioengineering: Biomicrofabrication and biomicrofluidics. Artech House.

HR 802 BM

PRODUCT DESIGN AND DEVELOPMENT

Instruction:	3 Periods per week
Duration of SEE:	3 Hours
SEE:	60 Marks
CIE :	40 Marks
Credits:	3

COURSE OBJECTIVES:

- This course is designed to focus on theory, technologies and practical applications in the product design, development and management over whole product life cycle.

COURSE OUTCOMES: Upon completion of the course, the students will be able to

1. Identify and analyze the product design and development processes in manufacturing industry
2. Define the components and their functions of product design and development processes
3. Analyze, evaluate and apply the methodologies for product design, development and Management
4. Develop the concept of human factor engineering
5. Familiar with different test methods for biocompatibility

UNIT-I

Biomedical engineering design: Design, essential of design, biomedical engineering design in an industrial context, generic steps in the design and development of products and processes. Fundamental design tools - brainstorming and idea generation techniques, conventional solution searches, function analysis, elementary decision making techniques, objective trees, introduction quality function deployment diagrams, introduction to TRIZ.

UNIT-II

Product Definition -– Definition of Medical Device, Product definition process, Overview of QFD, QFD Process, Product Development – Product Requirements, Design & Development planning, system Requirements specification, design input & output, design Verification & Validation, Design Transfer.

UNIT-III

Hardware Development Methods And Tools – Six Sigma, Redundancy, Component Selection, Component Derating, Safety Margin, Load Protection, Product Misuse, Extended TRIZ Design techniques.

UNIT-IV

Software Development Methods and Tools - Software Development Planning,- Choice of the Software Development Process Model, Software Design Levels, Design Alternatives and Trade-Offs, Software Architecture, Choice of Methodology and Language, Software Risk Analysis, Requirements Traceability Matrix, Software Review, Design Technique, Performance Predictability and Design Simulation, Module Specifications, Coding Design Support Tools, Design as the Basis for Verification and Validation Activity.

UNIT-V

Human Factors- Definition, Hardware and Software Element in Human Factors, Human Factors Process, Planning, Analysis, Conduct User Studies Set Usability Goals, Design User Interface Concepts, Model the User Interface, Test the User Interface, Specify the User Interface, Additional Human Factors Design Considerations, Fitt's Law. Industrial Design –

Design user interface concepts, specify the user interface, additional industrial design considerations.

Suggested reading:

1. Paul H. King & Richard C. Fries, *Design of Biomedical Devices and system*, 2013.
2. Richard C. Fries, *Handbook of Medical Device Design*, Marcel Dekker Inc., 2001.

HR 803 BM

ARTIFICIAL INTELLIGENCE & NEURAL NETWORKS IN MEDICINE

Instruction	3 Periods per week
Duration of University Examination	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

COURSE OBJECTIVES:

- Understand the role of artificial intelligence and neural networks in engineering
- Provide knowledge of control strategies and search techniques
- Develop a basic understanding of the building blocks of AI as presented in terms of intelligent agents: Search, Knowledge representation, inference, logic, and learning.
- Provide knowledge of supervised and unsupervised learning using neural networks.
- Apply AI and ML algorithms in medical applications

COURSE OUTCOMES: The student will be able to:

1. Apply the concepts and search techniques of artificial intelligence.
2. Represent the knowledge base using predicate calculus.
3. Perform knowledge representation using non-monotonic logic.
4. Familiarize with the concepts of Artificial Neural networks.
5. Apply the Artificial Intelligence algorithms in the field of medicine.

UNIT-I:

Introduction to Artificial Intelligence: Definition. AI Applications, AI representation. Properties of internal Representation, General problem solving, production system, control strategies: forward and backward chaining. Uninformed and informed search techniques. A* and AO* Algorithm

UNIT-II:

Knowledge representation using predicate logic: predicate calculus, Predicate and arguments, resolution and unification Semantic, Frame System, Scripts, conceptual Dependency

UNIT-III:

Knowledge representation using non-monotonic logic: TMS (Truth maintenance system), statistical and probabilistic reasoning, fuzzy logic, structure knowledge representation

UNIT-IV:

Introduction to Artificial Neural Network, network parameters, hebb rule, delta rule, supervised and unsupervised learning, pattern recognition problems, perception learning algorithm, Back propagation network-structure and algorithm

UNIT-V:

Application of Artificial Intelligence & Neural Networks in Medicine – AI in Diagnosis-ELISA Model, automated drug delivery systems, Tumor Boundary Detection, cardiovascular applications

Suggested reading:

1. Eugene, Charniak, Drew Mcdermott: Introduction to artificial intelligence.
2. Elaine Rich and Kerin Knight, Nair B., "Artificial Intelligence (SIE)", Mc Graw Hill-2008.

3. Donna L. Hudson, Maunee E. Cohan, Neural Networks & Artificial Intelligence for Biomedical Engineering, Prentice Hall of India, New Delhi - 2001.
4. Kishen Mehrotra, Sanjay Rawika, K Mohan; Artificial Neural Network
5. Laurene Fausett, "Fundamentals of Neural Networks: Architectures, Algorithms and Applications", PEI 3rd Edition, 2008.

HR 804 BM

REHABILITATION ENGINEERING

Instruction	3 Periods per week
Duration of University Examination	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

COURSE OBJECTIVES:

- To extend knowledge of the amputee, of lost and remaining functions affecting locomotion, and to collect information on the best possible medical treatment.
- To improve fitting techniques and practices, including training, so that existing devices might be used with greater comfort and function.
- To develop improved lower-extremity devices.

COURSE OUTCOMES: Successfully the student will be able to:

1. Apply fundamental knowledge of engineering in rehabilitation
2. Apply analytical skills to assess and evaluate the need of the end-user
3. Develop self-learning initiatives and integrate learned knowledge for problem solving
4. Understand the basics of robotics and apply their principles in developing prosthetics
5. Apply the knowledge of computers in solving rehabilitation problems

UNIT- I

Introduction to Rehabilitation Engineering, Definition of Rehabilitation Engineering, Scope and importance of the field, Historical perspective. Interdisciplinary nature and collaboration with healthcare professionals. Physical disabilities: mobility impairments, spinal cord injuries. Cognitive disabilities: learning disabilities, traumatic brain injuries. Psychosocial aspects of disability.

UNIT-II

Assistive Technology, Human Factors and Ergonomics in Assistive Technology Design. Mobility Aids, Types of Wheelchairs and design aspects: Manual wheelchairs, Powered wheelchairs, Customizable features and design considerations, Auxiliary devices and systems. Human-Centered Designing.

UNIT – III

Sensory disabilities: visual and hearing impairments. Sensory augmentation and substitution: Visual system: Visual augmentation. Tactual vision substitution, Auditory vision substitution; Auditory system: Auditory augmentation. Cochlear implantation, Visual auditory substitution, Tactual auditory substitution, Tactual system: Tactual augmentation. Tactual substitution. Assessment and Outcome Measurement

UNIT–IV

Rehabilitation Robotics, Exoskeletons, Major Limb Prosthetic Devices, Orthotic Devices, Types of orthotics and prosthetics, Intelligent prosthetic Knee, Prosthetic Hand, Controlled orthotics and prosthetics Materials and fabrication techniques, Functional and cosmetic considerations. FES system, Restoration of Hand function, Restoration of standing and walking, Myo-electric Hand.

UNIT-V

Case Studies and Real-World Applications. Augmentative and Alternative communications, Software tools for simulation and testing. Virtual reality applications in rehabilitation. Machine learning applications in assistive technology. Predictive analytics for personalized rehabilitation

Suggested Reading:

1. Robinson C.J., *Rehabilitation Engineering*, CRC Press, 1995.
2. Ballabio E., et al., *Rehabilitation Technology*, IOS Press, 1993.
3. Rory A Cooper, Hisaichi Ohnabe, Douglas A. Hobson, *Series in medical physis and biomedical engineering: An introduction to rehabilitation engineering*, Taylor and Francis Group, London, 2007.
4. Joseph D. Bronzino *The biomedical engineering handbook -biomedical engineering fundamentals*, 3rdEd., CRC Press, Taylor & Francis Group, London, 2006.

HR 805 BM

CALIBRATION OF MEDICAL EQUIPMENT

Instruction:	3 Periods per week
Duration of SEE	3 Hours
SEE	70 Marks
CIE:	30 Marks
Credits:	3

Course Objectives:

1. Perform calibration tests to assess the performance and safety of medical Equipment.
2. Learn the maintenance of biomedical equipment.
3. Learn about Quality concepts, Management system and NABL accreditation

Course Outcomes:

1. Learn the calibration of biomedical equipment.
2. Learn the standards of NABL and NABH Accreditations

UNIT I

General Metrology: Global metrology scenario, Measurement units, Measurement standards, Measurement traceability. Measurement Units: Base SI units, Derived SI units, SI multipliers and conversions, Fundamental constants, Common measurements.

UNIT II

Measurement Systems: Measurement methods, Measurement data & characteristics of measurements, T&ME specifications, Primary error sources, Measurement systems and capabilities, Measurement assurance programs.

UNIT III

Calibration Systems: Calibration procedures & methods Industry practices & regulations Control of calibration environment, Calibration processes Calibration processes contd., Manual & automated calibration. Calibration results &reporting, Records & records management.

UNIT IV

Technical & Applied mathematics: Scientific and engineering, notation, English/Metric conversions, Ratios. Linear interpolation and extrapolation, Rounding, truncation, and significant figure, Number bases, Volume and area, Angular conversions, Graphs and plots.

QC tools applied statistics: Basic statistical tools, Common distributions, Descriptive statistics

Sampling issues.

UNIT V

Uncertainty: Uncertainty management Uncertainty components Estimation of uncertainty Evaluation of uncertainty Reporting uncertainty

Quality Systems & Standards: Quality concepts Management system ISO/IEC 17025 NABL accreditation

Suggested Reading:

1. Jay L. Bucher, *The Metrology Handbook*, ASQ Quality press, 2004
2. Christian Elbert, *Calibration Technology* (Basics, reference instruments for pressure and temperature, professional calibration) 2nd ed., 2013.
3. Mike Cable, *Calibration : A Technician's Guide,* Instrumentation systems and automation Society, 2005

Course Code	Course Title						Course Type
HR 861 BM	Project Work						Core
Prerequisite	Contact hours per week				Scheme of Evaluation		Credits
	L	T	D	P	CIE	SEE	
	-	-	-	6	50	50	3

Course Objectives:

- To enhance practical and professional skills of the students
- To expose the students to hospital/ medical industry practices and team work

Course Outcomes: At the end of the course, the student will be able to:

1. Synthesize knowledge and skills previously gained and apply these to new technical problem.
2. Select from different methodologies, methods and analyses to produce a suitable research design, and justify their design.
3. Present the findings of their technical solution in a written report.
4. Develop oral and written communication skills to present and defend their work in front of technically qualified audience

Guidelines:

The project topic should be selected / chosen to ensure the satisfaction of the urgent need to establish a direct link between education, national development and productivity and thus reduce the gap between the world of work and the world of study.

After multiple interactions with guide and based on comprehensive literature survey, the student shall identify the domain and define dissertation objectives. The referred literature should preferably include IEEE/IET/IETE/Springer/Science Direct/ACM journals in the areas of Biomedical Instrumentation, Computing and Processing (Hardware and Software), Circuits-Devices and Systems, Robotics and Control Systems, Signal and Image Processing and Analysis and any other related domain. In case of industry sponsored projects, the relevant application notes, product catalogues should be referred and reported. The student is expected to detail out specifications, methodology, resources required, critical issues involved in design and implementation and phase wise work distribution, and submit the proposal within a month from the date of registration.

A document report comprising of summary of literature survey, detailed objectives, project specifications, paper and/or computer aided design, proof of concept/functionality, part results, record of continuous progress. In case of unsatisfactory performance, committee may recommend repeating the Project work.

. The evaluation and award of credits based on the performance of the students is done by a committee constituted by the Head of the department.

- Project topics may be chosen by the student with advice and approval from the faculty members
- Oral presentation is an important aspect of engineering education.
- Project topics may be chosen by the student with advice and approval from the faculty members.
- Students are to be assessed and evaluated as per the following criteria.

Each student is required to:

1. Submit a one-page synopsis at the beginning of the semester for display on the notice board (by 2nd week after commencement of the semester)
2. Give a 20-minutes demo and demonstrate the work through an LCD PowerPoint presentation followed by a 10 minutes discussion.
3. Submit a report on the project work with list of references and slides used.
4. Project reviews are to be scheduled from the 3rd week of the semester to the last week of the semester and any change in schedule should be discouraged.
5. Batch size should be ONE.
6. Finalization of the projects will be done by the supervisor at the concerned department.
7. Two reviews to be conducted – One during 5th week and another during 10th week and final evaluation shall be conducted during 15th to 16th week.
8. Students are required to give Presentations during the reviews.
9. Students are required to submit project report.

Distribution of marks for Continuous Internal Evaluation (CIE) - 50 Marks

Evaluation Criteria	**Maximum Marks**
Literature Review	05
Problem Formulation	05
Design/ Methodology	15
Implementation & Results	15
Presentation & Documentation	10

Distribution of marks for Semester End Examination (SEE) – 50 Marks

Evaluation Criteria	**Maximum Marks**
Design/ Methodology	10
Implementation & Results	15
Presentation & Documentation	15
Publication in a conference/ Journal (Published / accepted)(Compulsory)	10