SCHEME OF INSTRUCTION AND EVALUATION
B.E. (BIOMEDICAL ENGINEERING)
BE (HONORS) in BME DEGREE with extra 18 credits in BME

Sl. No	**Code**	**Course Name**	**Contact hours per week**		**Scheme of Examination**		**Credits**	**SEM**
			L	**P**	**CIE**	**SEE**		
1.	HR 501 BM	Biostatistics	3	-	40	60	3	V
2.	HR 601 BM	Micro Electro-Mechanical Systems	3	-	40	60	3	VI
3.	HR 602 BM	Bio-microfluidics	3	-	40	60	3	VI
4.	HR 701 BM	Product Design and Development	3	-	40	60	3	VII
5.	HR 702 BM	Systems Engineering	3	-	40	60	3	VII
		PRACTICALS						
1.	HR 851 BM	***Project work***	-	6	-	100	3	VIII
		TOTAL	**15**	**6**	**200**	**400**	**18**	

Note:
1. The students should pursue the above listed courses in addition to the regular curriculum.
2. The student may choose any other 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
SEE-Semester End Evaluation

HR 501 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 601 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 ofmicro-engineering. Technological advancements in MEMS, advantages and disadvantagesofMEMS.

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. Design and 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 602 BM

BIOMICROFLUIDICS

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

Course Objectives

- Understand various approaches for the development of novel drug delivery systems
- Formulate and evaluate novel drug delivery systems
- Understand criteria for the selection of drugs and polymers for development of the delivering system.
- 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, Wafer bonding.

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 701 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 702 BM

SYSTEMS ENGINEERING

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

Course Objective:

- Students with a comprehensive understanding of systems engineering principles, methodologies, and tools.
- It aims to equip students with the skills necessary to design, analyze, and manage complex systems effectively.
- Students will learn to integrate various components and processes to achieve optimal system performance.

Course Outcomes:

Upon completion of the course, the students will be able to

1. Understand the fundamental concepts and principles of systems engineering.
2. Can develop clear and concise requirement specifications.
3. Understand how to utilize modeling and simulation tools for systemdesign and analysis.
4. Develop and implement verification and validation plans to ensure system performance.
5. Apply systems engineering techniques to real-world problems and case studies.

UNIT-I

Analog and digital circuit design of circuits for biomedical applications using operational amplifiers, active filters, data acquisition, conversion, and interface to microcomputers. Patient safety, patient isolation circuits. Operating principles of various types of patient isolation circuitry. Most suitable isolation circuit for a given application. Test isolation circuits.

UNIT-II

Data acquisition, Sample and Hold Conversion, Multi Channel acquisition, High speed sampling in ADC, Selection of drive amplifier for ADC performance, Gain setting and level shifting, ADC input protection, Multichannel channel applications for data acquisition systems, External protection of amplifiers, High speed ADC architectures.

UNIT-III

Interference and noise reduction techniques. Types of noise-Thermal noise, shot noise, excess noise, Burst, Internal noise in OPAMPs, Noise issues in high speed applications, . Causes of noise and interference encountered in medical equipment. Manifestation of noise or interference. Techniques for minimizing the impact of noise or interference when using various types of medical equipment.

UNIT-IV

Hardware approach to digital signal processing, Coherent and non-coherent sampling, Digital signal processing techniques, FFT hardware implementation system – DSP hardware, ALU, Multipliers, accumulators, data address generators, serial ports, system interfacing ADC's and DAC's to DSPs. Interfacing IO ports to DSPs, DSP based cochlear implants.

UNIT-V

Use of telemetry in a medical environment.. Available frequency bands and licensing requirements for RF telemetry environments. Typical telemetry methods used in medical applications. Common problems with telemetry installations.

Battery management procedures. Types of batteries used in medical equipment. Typical shelf life of common batteries. Applications for common batteries. Techniques to improve life of batteries. Test equipment for correct function after battery replacement.

Suggested Reading:

1. Halit Eren, *Electronic portable instruments-Design and applications*, CRC Press, 2004.
2. Robert B. Northrop, *Analysis and application of analog electronic circuits to biomedical instrumentation*, CRC Press, 2004.
3. Reinaldo J . Perez, *Design of medical electronic devices*, Academic press, 2002.

HR 851 BM

PROJECT WORK

SEE :	100 Marks
Credits:	3

COURSE OBJECTIVES:

- To enhance practical and professional skills.
- To expose the students to industry practices and team work.
- To encourage students to work with innovative and entrepreneurial ideas

COURSE OUTCOMES: At the end of the course, students will be able to:

- Conceive a problem statement either from rigorous literature survey or from the requirements raised from need analysis.
- Demonstrate the ability to synthesize and apply the knowledge and skills acquired in the academic program to solve the conceived problem.
- Write comprehensive report on mini project work and demonstrate effective written and oral communication skills

1. The aim of mini project is to develop solutions to real time problems by applying the knowledge and skills obtained in different courses, new technologies and current industry practices.
2. The mini-project is a team activity having 3-4 students in a team.
3. The mini project may be a complete hardware or a combination of hardware and software. The software part in mini project should be less than 50% of the total work.
4. Based on special lectures by faculty members or industry personnel/comprehensive literature survey/ need analysis, the student shall identify the title, and define the aim and objectives of mini-project.
5. The students are expected to identify specifications, methodology, resources required, critical issues involved in design and implementation and submit the proposal within first 2 weeks of the semester to the mini project coordinator.
6. The students are expected to design, develop and test the proposed work as per the schedule.
7. Seminar schedule will be prepared by the coordinator for all the students from the 5th week to the last week of the semester which should be strictly adhered to.
8. Each group will be required to:
   i. Submit a one-page synopsis before the seminar to the coordinator.
   ii. Give a 30-minute presentation followed by 10 minutes discussion.
   iii. Submit a technical write-up on the mini project work.
9. At least two teachers will be associated with the mini project to evaluate students for the award of sessional marks which will be on the basis of performance in all the 3 items stated above.

10. The seminar presentation and technical write-up (mini project report) should include: Problem definition and specification, Literature survey, Broad knowledge of available techniques to solve a particular problem, Planning of the work, preparation of bar (activity) charts, Presentation- oral and written.