UNIVERSITY OF MUMBAI

Bachelor of Engineering

in

Mechatronics Engineering

Final Year with Effect from AY 2022-23

(REV- 2019 'C' Scheme) from Academic Year 2019 – 20

Under

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2019–2020)

Preamble

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education. The major emphasis of accreditation process is to measure the outcomes of the program that is being accredited. In line with this Faculty of Science and Technology (in particular Engineering) of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

Faculty resolved that course objectives and course outcomes are to be clearly defined for each course, so that all faculty members in affiliated institutes understand the depth and approach of course to be taught, which will enhance learner's learning process. Choice based Credit and grading system enables a much-required shift in focus from teacher-centric to learner-centric education since the workload estimated is based on the investment of time in learning and not in teaching. It also focuses on continuous evaluation which will enhance the quality of education. Credit assignment for courses is based on 15 weeks teaching learning process, however content of courses is to be taught in 12-13 weeks and remaining 2-3 weeks to be utilized for revision, guest lectures, coverage of content beyond syllabus etc.

There was a concern that the earlier revised curriculum more focused on providing information and knowledge across various domains of the said program, which led to heavily loading of students in terms of direct contact hours. In this regard, faculty of science and technology resolved that to minimize the burden of contact hours, total credits of entire program will be of 171, wherein focus is not only on providing knowledge but also on building skills, attitude and self learning. Therefore in the present curriculum skill based laboratories and mini projects are made mandatory across all disciplines of engineering in second and third year of programs, which will definitely facilitate self learning of students. The overall credits and approach of curriculum proposed in the present revision is in line with AICTE model curriculum.

The present curriculum will be implemented for Second Year of Engineering from the academic year 2020-21. Subsequently this will be carried forward for Third Year and Final Year Engineering in the academic years 2021-22, 2022-23, respectively.

Dr. S. K. Ukarande
Associate Dean
Faculty of Science and Technology
University of Mumbai

Dr Anuradha Muzumdar
Dean
Faculty of Science and Technology
University of Mumbai

Incorporation and implementation of Online Contents from NPTEL/ Swayam Platform

The curriculum revision is mainly focused on knowledge component, skill based activities and project based activities. Self learning opportunities are provided to learners. In the revision process this time in particular Revised syllabus of 'C' scheme wherever possible additional resource links of platforms such as NPTEL, Swayam are appropriately provided. In an earlier revision of curriculum in the year 2012 and 2016 in Revised scheme 'A' and 'B' respectively, efforts were made to use online contents more appropriately as additional learning materials to enhance learning of students.

In the current revision based on the recommendation of AICTE model curriculum overall credits are reduced to 171, to provide opportunity of self learning to learner. Learners are now getting sufficient time for self learning either through online courses or additional projects for enhancing their knowledge and skill sets.

The Principals/ HoD's/ Faculties of all the institute are required to motivate and encourage learners to use additional online resources available on platforms such as NPTEL/ Swayam. Learners can be advised to take up online courses, on successful completion they are required to submit certification for the same. This will definitely help learners to facilitate their enhanced learning based on their interest.

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Dean
Faculty of Science and Technology
University of Mumbai

Preface

Engineering education in India has to prepare budding minds for applying multidisciplinary knowledge for product and process innovation. Mechatronics is a new branch of engineering introduced in University of Mumbai from 2015, which synergistically applies the fundamentals of Mechanical, Electrical, Electronics and Information systems engineering to develop new products and processes. Thus Mechatronics focuses on development of products and processes that require combined application of multiple engineering domains.

Several changes in technological trends have happened since the introduction of last syllabus of Mechatronics in 2015. New avenues for synergistic application of fundamentals from multiple disciplines are opening up every day with technologies such as 3D Printing, Drones, IOT, Machine learning etc. are becoming popular. The curriculum is designed for preparing the students for a career in four major focus areas (a) Industrial Automation, (b) Embedded Systems (c) Digital Design and Manufacturing (d) Intelligent Control and Machine learning. There are upcoming career opportunities in all these domains. A conscious effort is made to include several technologies that are being promoted under the Industry 4.0 revolution.

The Updated Program Educational Objectives for this syllabus revision of the undergraduate program in Mechatronics Engineering are listed below;

1. To prepare the Learner in building technology systems through interdisciplinary approach.
2. To prepare the Learner to use modern tools embedding different disciplines of engineering in order to solve real life problems and prepare them for the fourth industrial revolution.
3. To prepare the Learner for career in Indian and Multinational Organisations and to excel in their Postgraduate studies; furthermore, to encourage and motivate the art of self-learning.
4. To inculcate a professional and ethical attitude, good leadership qualities in the Learner's thought process.

We trust this revised version of syllabus come up to the expectations of all stakeholders. We wish to place on record our sincere thanks and appreciations to the various contributors from the academia and industry for their most learned inputs in framing this syllabus.

Board of Studies in Mechanical Engineering

Dr. Vivek K. Sunnapwar : Chairman
Dr. S. M. Khot : Member
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Program Structure for Final Year Engineering
Semester VII & VIII
UNIVERSITY OF MUMBAI
(With Effect from 2022-2023)

Semester VII

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
MTC701	Automotive Mechatronics	3	--	--	3	--	--	3
MTC702	Design of Mechatronic Systems	3	--	--	3	--	--	3
MTDLO703X	Department Optional Course – 3	3	--	--	3	--	--	3
MTDO704X	Department Optional Course – 4	3	--	--	3	--	--	3
ILO701X	Institute Optional Course – 1	3	--	--	3	--	--	3
MTL701	Automotive Mechatronics Laboratory	--	2	--	--	1	--	1
MTL702	Mechatronics Laboratory	--	2	--	--	1	--	1
MTL703X	Department Optional Course – 3 Laboratory	--	2	--	--	1	--	1
MTP701	Major Project I[#]	--	6[$]	--	--	3	--	3
					--	**6**		**21**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract /Oral	Total
		Internal Assessment			End Sem. Exam	Exam. Duration (in Hrs)			
		Test1	Test2	Avg.					
MTC701	Automotive Mechatronics	20	20	20	80	3	--	--	100
MTC702	Design of Mechatronic Systems	20	20	20	80	3	--	--	100
MTDLO703X	Department Optional Course – 3	20	20	20	80	3	--	--	100
MTDO704X	Department Optional Course – 4	20	20	20	80	3	--	--	100

ILO701X	Institute Optional Course – 1	20	20	20	80	3	--	--	100
MTL701	Automotive Mechatronics Laboratory	--	--	--	--	--	25	25	50
MTL702	Mechatronics Laboratory	--	--	--	--	--	25	25	50
MTL703X	Department Optional Course – 3 Laboratory	--	--	--	--	--	25	25	50
MTP701	Major Project I	--	--	--	--	--	50	--	50
Total		**--**	**--**	**100**	**400**	--	**125**	**75**	**700**

$ indicates work load of Learner (Not Faculty), for Major Project

Course Code	**Sem. VII: Department Optional Course- 3 Laboratory**
MTL7031	Digital Signal Processing
MTL7032	Neural Network and Fuzzy Logic
MTL7033	Finite Element Analysis

Students group and load of faculty per week.

Major Project 1 and 2:

Students can form groups with minimum 2 (Two) members and not more than 4 (Four) members

Faculty Load: In Semester VII – ½ hour per week per project group

In Semester VIII – 1 hour per week per project group

Department Optional Courses

Course Code	Sem. VII: Department Optional Course- 3		Course Code	Sem. VII: Department Optional Course - 4
MTDLO7031	Digital Signal Processing		MTDLO7041	Product Design and Development
MTDLO7032	Neural Network and Fuzzy Logic		MTDLO7042	Medical Mechatronics
MTDLO7033	Finite Element Analysis		MTDLO7043	Micro-Electro Mechanical Systems

Institute Optional Courses

Course Code	Institute Optional Course-I #
ILO7011	Product Lifecycle Management
ILO7012	Reliability Engineering
ILO7013	Management Information System
ILO7014	Design of Experiments
ILO7015	Operation Research
ILO7016	Cyber Security and Laws
ILO7017	Disaster Management and Mitigation Measures
ILO7018	Energy Audit and Management
ILO7019	Development Engineering

 # Common with all branches

Course Code	Course Name	Credits
MTC701	Automotive Mechatronics	03

Prerequisite: MTC502 Sensors and Actuators, MTC504 Embedded Systems

Objectives

1) Introduce the learners to application of mechatronics in automobiles
2) To develop understanding of working of various mechatronic systems in automobiles
3) To introduce vehicle networking and communication

Outcomes: Learner will be able to...

1) Explain Vehicle architecture and Electronic Control units
2) Explain electronic transmission control and its types
3) Explain working of Driving assistance systems such as Active Steering, Antilock braking, Traction control and electronic stability program
4) Explain working of adjustment systems and fault diagnostics
5) Demonstrate understanding of basic principles of vehicular networking and communication
6) Explain electric vehicles and autonomous vehicles

Module	Detailed Contents	Hrs.
01	**1.1 Vehicle system architecture:** Functional structure, Levels in the vehicle motion domain. Software architecture, Network architecture **1.2 Electronic Control Unit**: Operating conditions, Design, Data processing, Digital modules in the control unit.	5
02	**Sensors and Actuator Application in Vehicles** **2.1 Sensors:** Features of vehicle sensors, Sensor classification , Error types and tolerance requirements ,Reliability Main requirements, trends Wheel-speed sensors, Steering-angle sensors, Position sensors for transmission control, Torque sensor, oxygen concentration sensor, crankshaft angular position sensor, cam position sensor, Mass air flow (MAF) rate, Manifold absolute pressure (MAP), Throttle plate angular position, vehicle speed sensor, Automotive Radar Sensors, Automotive Lidar Sensors, Tire Pressure sensor **2.2 Actuators:** **Electromechanical actuators:** Electrodynamic and Electromagnetic, Characteristics and application, **Fluid-mechanical actuators**, Electrohydraulic Actuators typical characteristics for switching and proportional valves	7

03	**Electronic Transmission Control Drivetrain** Management Control of Automated Shift Transmission (AST), Control of Automatic Transmissions, Control of Continuously Variable Transmission, ECUs for Electronic Transmission Control	5
04	**4.1 Active steering:** Purpose, Design, Method of operation, Safety concept, Benefits of active steering for the driver **4.2 Antilock Braking System (ABS): System** overview, Requirements placed on ABS, Dynamics of a braked wheel, ABS control loop, Typical control cycles **4.3 Traction Control System (TCS) Tasks**, Function description, Structure of traction control system (TCS) , Typical control situations , Traction control system (TCS) for four wheel drive vehicles **4.4 Electronic Stability Program (ESP) Requirements** Tasks and method of operation, Maneuvers, Closed-loop control system and controlled Variables	10
05	**5.1 Drive and adjustment systems:** Power windows, Power sunroofs, Seat and steering column adjustment. **5.2 Fault diagnostics:** Monitoring during vehicle operation (on-board diagnosis) Basic principles of networking: Network topology, Network organization, OSI reference model, Control mechanisms Requirements for bus systems, Classification of bus systems Applications in the vehicle **5.3 Bus systems:** CAN bus, LIN bus , Bluetooth	7
06	**6.1 Electric and Hybrid Vehicles** Layout of an electric vehicle, traction motor characteristics, tractive effort Transmission requirements, vehicle performance, energy consumption, advantage and limitations, specifications, system components, electronic control system **6.2 Introduction to Autonomous Vehicles**.	5

Assessment:

Internal Assessment for 20 marks:
Consisting **Two Compulsory Class Tests**
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Theory Examination:

1. Question paper will comprise of total 06 questions, each carrying 20marks.
2. Total 04 questions need to be solved.
3. Question No: 01 will be compulsory and based on entire syllabus wherein sub- questions of 2 to 5 marks will be asked.
4. Remaining questions will be mixed in nature.(e.g. Suppose Q.2 has part (a) from module3 then part (b) will be from any module other than module 3)
5. In question paper weightage of each module will be proportional to number of respective lecture hrs as mentioned in the syllabus.

References:

1. "Automotive Mechatronics, Automotive Networking, Driving Stability Systems, Electronics" Bosch Professional Automotive Information Springer 2015

2. David A. Johns, Ken Martin, "Analog Integrated Circuit Design" John Wiley & Sons, 2002.
3. M. A. Mazadi and J. C. Mazadi, "The 8051 Microcontroller and Embedded Systems", Pearson Education, New Delhi
4. Robert Bosch, "Automotive Hand Book" SAE, 5th edition, 2000.
5. William B.Riddens -Understanding Automotive Electronics, 5th edition- Butter worth Heinemann Woburn- 1998.
6. Crouse W.H. "Automobile Electrical Equipment" McGraw Hill Book Co., Inc., New York 3rd edition,1986
7. Mehrdad Ehsani, Yimin Gao, sebastien E. Gay and Ali Emadi, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design", CRS Press, 2004

Links for online NPTEL/SWAYAM courses:

https://nptel.ac.in/courses/107106088
https://nptel.ac.in/courses/108102121

Course Code	Course Name	Credits
MTC702	Design of Mechatronic Systems	03

Prerequisite: MTC502 Sensors and Actuators, MTC503 Mechatronic Systems Modelling and Control, MTC504 Embedded Systems, MTC603 Instrumentation and Control,

Objectives:

1. To present architecture of the mechatronics system design
2. To familiarize with multi-domain modelling and simulation
3. Selection of Actuators and transmission for design of mechatronic systems
4. Understanding programming for motion control

Outcomes: Learner will be able to...

1. Explain Design Process, structure, elements and application of Mechatronics
2. Modelling and simulation of Mechatronic system including system identification
3. Implement Servo control and controller tuning.
4. Actuator selection and drive train design for motion control applications
5. Motion control programming for industrial applications
6. Indigenously design and develop a mechatronic system.

Module	Detailed Contents	Hrs.
01	**Mechatronic Design and Applications:** Historical development of industrial systems (from Mechanical to Mechatronic). Basic building blocks of mechatronic systems. Key Elements of Mechatronics: Information Systems, Mechanical Systems, Electrical Systems, Computer Systems, Sensors and Actuators, Real Time Interfacing. Generalized Mechatronics Design Process: Phase I Modelling and Simulation, Phase II Prototyping, Phase III Deployment/Lifecycle Performance characteristics of sensors and transducers. Selection criteria for sensors and actuators, interfacing of sensors and actuators. Mechatronics in home, office and industrial automation.	7
02	**Modelling and Simulation** Why Bond graph for mechatronics? Review of Bond graph modelling. **2.1 Bond graph modelling of Actuators** Mechanisms and Linkages, (Example of belt drive) Electrical Actuators (Example of PM DC Motors,), Hydraulic / Pneumatic Actuators (Example of double acting pneumatic actuator) 2.2**Bond graph modelling of Sensors:** Activated bond, Position, Velocity, Acceleration, Force and Pressure sensor bond graph modelling **2.3 Bond graph modelling of Circuits** (Example of H Bridge Circuit, Operational Amplifier Inverting and non-Inverting) **2.4 Introduction to Simulation**	6

03	**Introduction to System Identification** **3.1 System Theory**: Open systems, Input, Disturbance, State, Output. Basic Problems in system theory, Mathematical models, properties, Convolution integral, System Identification procedure. **3.2 System response methods** : Impulse Response Model Representation, Transfer function model representation , direct impulse response identification , Direct Step Response Identification,	4
04	**Servo Control of Actuators** **4.1 DC Servo:** Types of DC Servo, DC Servo Motors in Open and Closed Loop Velocity Control, DC Servo Motors in Closed Loop Position Control. **4.2 Stepping Servo:** Stepping motor for position control applications **4.3 AC Servo Motors**, Rotor, Stator, Sinusoidal Commutation Torque Generation with Sinusoidal Commutation Six-Step Commutation of AC Servo Motors Motor Phasing with Encoders and Hall Sensors. AC Induction Motors, Stator, Rotor, Motor Operation, Constant Speed Operation Directly Across-the-Line, Variable Speed Operation with a VFD AC Drives: Drive Electronics, Converter and DC Link, Inverter. **AC Servo Basic Control Structures:** Cascaded Velocity and Position Loops, Single-Loop PID Position Control, Cascaded Loops with Feedforward Control, Inner Loop, Inner Loop for AC Induction Motors, Inner Loop for AC Servo Motors **AC Servo Tuning:** Tuning a PI Controller, Tuning a PID Position Controller **4.4 Electrohydraulic Servo Motors:** Mechanically controlled servo, Electro hydraulic servo valves, Hydraulic servo motors	8
05	**5.1 Motion Profile**, Kinematics: Basic Concepts, Common Motion Profiles: Trapezoidal Velocity Profile, S-curve Velocity Profile Multiaxis Motion: Slew Motion, Interpolated Motion, Problems**.** **5.2 Drive-Train Design:** Inertia and Torque Reflection, Gearbox Ratio Reflected Inertia, Reflected Torque, Efficiency Total Inertia, Inertia Ratio, Targeted Practical Inertia Ratio. Transmission Mechanisms, Load and Inertia Reflection through Transmission Mechanisms, Pulley-and-Belt, Lead Screw, Rack-and-Pinion Drive, Belt-Drive for Linear Motion, Conveyor Torque Required for the Motion, Acceleration (Peak) Torque, Running Torque, Deceleration Torque, Continuous (RMS) Torque **5.3 Comparison and selection of Servo Motors:** Theory and Performance Criteria, Comparison of result and design procedure **AC Servo Motor Selection:** Torque–Speed Curves for AC Servomotors Motor	8

	Sizing Process, Motor Selection for Direct Drive, Motor and Transmission Selection, Gearboxes Planetary Servo Gearheads, Worm Gear Speed Reducers, Servo Motor and Gearhead Selection, AC Induction Motor and Gearbox Selection Problems on Motor, Gearbox, and Transmission Mechanism Selection for industrial applications.	
06	**Motion Control** Motion Controller Programming and Applications, Move Modes: Linear Moves, Circular Moves, Contour Moves **Programming:** Motion Programs, PLC Functionality, Single-Axis Motion, Jogging, Homing Multiaxis Motion: Multiple Motors Driving One Axis, Coordinated Motion of Two or More Axes, Following Using Master/Slave Synchronization: Electronic Gearing, Electronic Camming, Ratio Following, Time-base Control. Motion control algorithm development for industrial applications	6

Assessment:

Internal Assessment for 20 marks:
Consisting **Two Compulsory Class Tests**
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Theory Examination:

1. Question paper will comprise of total 06 questions, each carrying 20marks.
2. Total 04 questions need to be solved.
3. Question No: 01 will be compulsory and based on entire syllabus wherein sub- questions of 2 to 5 marks will be asked.
4. Remaining questions will be mixed in nature. (e.g. Suppose Q.2 has part (a) from module3 then part (b) will be from any module other than module 3)
5. In question paper weightage of each module will be proportional to number of respective lecture hrs as mentioned in the syllabus.

References:

1) Mechatronics System Design, Shetty and Kolk CENGAGE Learning, India Edition
2) Industrial Motion Control Motor Selection, Drives, Controller Tuning, Applications Hakan Gürocak 2016, John Wiley & Sons, Ltd
3) "Intelligent Mechatronic Systems Modeling, Control and Diagnosis" Rochdi Merzouki , Arun Kumar Samantaray, Pushparaj Mani Pathak , Belkacem Ould Bouamama Springer.
4) Servo Motors and Industrial Control Theory, Riazollah Firoozian, Springer 2009
5) Applied Mechatronics- A. Smaili and F. Mrad, OXFORD university press.
6) System Identification: An Introduction Karel J. Keesman Springer-Verlag London Limited 2011
7) System Identification: Theory for the User (2nd Edition), Lennart Ljung
8) Introduction to Mechatronics and Measurement Systems, Alciatore and Histand Tata McGraw-Hill
9) Mechatronics, Necsulescu, Pearson education.
10) Mechatronics - Electromechanics and Control Mechanics, Mill Springer-Verlag
11) Mechatronics - Electronic Control Systems in Mechanical Engineering, Bolton Pearson eduaction
12) Mechatronics - Electronics in products and processes, Bradley, et al. Chapman and Hall
13) Mechatronics - Mechanical System Interfacing, Auslander and Kempf, Prentice Hall
14) Introduction to Mechatronics, Appu Kuttan K.K., OXFORD Higher Education
15) The Art of Electronics, Horowitz and Hill Cambridge, University Press
16) Electromechanical Design Handbook, Walsh, McGraw-Hill
17) Electro-mechanical Engineering - An Integrated Approach, Fraser and Milne

Links for online NPTEL/SWAYAM courses:

https://nptel.ac.in/courses/112101304
https://nptel.ac.in/courses/112107298
https://ocw.tudelft.nl/courses/mechatronic-system-design/

Course Code	Course Name	Credits
MTDLO7031	Digital Signal Processing	03

Prerequisite: MTDO501 Signals and Systems

Objectives:

1. To teach the design techniques and performance analysis techniques of digital filters
2. To introduce the students to advanced signal processing techniques, digital signal processors and applications

Outcomes: Learner will be able to…

1. Understand algorithms for computation of DFT
2. Efficient computation of DFT using FFT Algorithm
3. Design FIR Digital Filters for processing of Discrete Time Signals
4. Design IIR Digital Filters for processing of discrete time signals
5. Analyze multirate signal processing techniques
6. Understand DSP Processors and Applications

Module	Detailed Contents	Hrs.
01	**N-point Discrete Fourier Transform (DFT):**	07
	Need of DFT, Definition of N-point DFT/IDFT, Twiddle Factor and its properties, Define N-point DFT/IDFT using Twiddle Factor, Computation of N-point DFT/IDFT Basis Function, Properties of N-point DFT (Without Proof), Computation of Linear Convolution using Circular Convolution, Computation of Frequency Spectrum using N-point DFT, Introduction to Discrete Cosine Transform (DCT) A linear filtering approach to computation of the DFT- The Goertzel Algorithm, The Chirp-z transform Algorithm	
02	**Fast Fourier Transform (FFT) and Inverse Fast Fourier Transform (IFFT) Algorithms:**	07
	Need of FFT Algorithm, Decimation In Time (DIT) Domain-, Decimation In Frequency (DIF) Domain- using Radix 2 FFT Algorithm, Composite Radix FFT Algorithm, Computation of N-point DFT using FFT Algorithms (N = 4, N = 8) Circular Convolution using FFT Algorithms Linear Filtering using Overlap Add- and Overlap Save- Techniques	
03	**Finite Impulse Response (FIR) Digital Filters:**	08
	Characteristics of FIR Digital Filters, Minimum Phase, Maximum Phase, Mixed Phase and Linear Phase Filters Frequency response, location of the zeros of linear phase FIR Filters FIR Filter Designing Using Windowing Techniques: Rectangular Window, Hamming Window, Hanning Window, Blackman Window,	

	Bartlett Triangular Window, Kaiser Window Design of FIR Filter using Frequency Sampling Technique	
04	**Infinite Impulse Response (IIR) Digital Filters:** Concept of Analog Filter Design, IIR Filter design by approximation of derivatives, IIR Filter design by impulse invariance method, Bilinear Transformation Method, Warping Effect Butterworth Filter Design, Characteristics of Butterworth Filters Chebyshev Filter Design and Elliptic Filter Design IIR Filter realization using Direct Form, Cascade Form and Parallel Form Finite Word Length Effect in IIR Filter Design Comparison of IIR and FIR Filters	**08**
05	**Multirate Signal Processing and Filter Banks:** Introduction and Concept of Multirate Signal Processing Basic Operations of Multirate Processing: Sampling Rate Conversion, Decimation, Expansion, Sampling rate conversion by a rational factor Analysis and Synthesis Filter Banks, Subband Decomposition, Subband Coding and Multiresolution Analysis Introduction to Wavelets	**05**
06	**DSP Processors and Applications:** Introduction to General Purpose and Special Purpose DSP processors, fixed point and floating point DSP processor, Computer architecture for signal processing, Harvard Architecture, Pipelining, multiplier and accumulator(MAC) Applications of DSP: Radar Signal Processing and Speech Processing	**04**

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Theory Examination:

1. Question paper will comprise Total 06 questions, each carrying 20 marks.
2. Total 04 questions need to be solved.
3. Question No: 01 will be compulsory and based on the entire syllabus wherein sub- questions of 2 to 5 marks will be asked.
4. Remaining questions will be mixed in nature.(e.g. Suppose Q.2 has part (a) from module3 then part (b) will be from any module other than module 3)
5. In question paper weightage of each module will be proportional to number of respective lecture hrs as mentioned in the syllabus.

Text Books:

1. John G. Proakis and Dimitris G. Manolakis, Digital Signal Processing, Principles, Algorithms and Applications, 4th, Pearson Education / PHI, 2007
2. Mithra, Digital Signal Processing, 3rd, McGraw Hill Publications, 2008

References:

1. S Salivahanan, Digital Signal Processing, 4th, TMH, 2019
2. Nagoorkhani A, Digital Signal Processing, 2nd, TMH, 2012
3. Ramesh Babu P, Digital Signal Processing, 4th, SciTech, 2013

Links for online NPTEL/SWAYAM courses:

1. https://www.classcentral.com/course/youtube-electronics-digital-signal-processing-47676
2. https://www.classcentral.com/course/youtube-electrical-digital-signal-processing-47650
3. https://www.classcentral.com/course/youtube-jan-2021-digital-signal-processing-and-its-applications-47497

Course Code	Course Name	Credits
MTDLO7032	Neural Network and Fuzzy Logic	03

Prerequisite: Engineering Mathematics□I, Engineering Mathematics□II, MTC302 Data Structure and Algorithm

Objectives

1. To conceptualize the working of human brain using Artificial Neural Network.
2. To become familiar with neural networks that can learn from available examples and generalize to form appropriate rules for inference systems.
3. To introduce the ideas of fuzzy sets, fuzzy logic and use of heuristics based on human experience.

Outcomes: Learner will be able to...

1. Analyze and appreciate the applications which can use Neural Network and fuzzy logic.
2. Identify and describe NNFL techniques and their roles in building intelligent machines.
3. Design inference systems for decision making in manufacturing industries.
4. Realize the difference between learning and programming and explore practical applications of Neural networks (NN).
5. Demonstrate the use of Neuro-fuzzy network for various industry applications.

Module	Detailed Contents	Hrs.
01	**Introduction: S**oft computing techniques**.** 1.1 **Basics of Neural Networks:** Introduction to Neural Networks, Biological Neural Networks, McCulloch Pitt model. **Fuzzy Logic: Introduction to fuzzy logic:** 1.2 **Classical Sets (Crisp sets):** Crisp Sets and Fuzzy Sets, Operations on crisp sets, Properties of crisp sets.	**07**
02	2.1 **Supervised Learning algorithms:** Perceptron (Single Layer, Multi-layer), Linear separability, Delta learning rule, Back Propagation algorithm. 2.2 **Un-Supervised Learning algorithms:** Hebbian Learning, Winner take all, Self-Organizing Maps, Learning Vector Quantization. 2.3 Neural networks as pattern classifiers	**08**
03	**3.1 Fuzzy Sets:** Membership functions, Basic Fuzzy set operations, Properties of Fuzzy sets. **3.2 Fuzzy Relations:** **Crisp Relations:** Cartesian product, operations on Relations. **Fuzzy Relations:** Fuzzy Cartesian product, Operations on Fuzzy Relations.	**07**
04	**Fuzzy System:** **Fuzzy Logic and application:** Fuzzy qualifiers, Fuzzy inference, Fuzzy Inference System(FIS), Types of FIS, Fuzzification ,defuzzification methods, design of fuzzy controllers. Applications : Fuzzy Controller design for Metro Train, Expert System design for sensor and actuator selection,	08

05	**Hybrid system:** **Introduction to genetic algorithm** 5.1 Integration of Neural networks, Fuzzy logic and genetic algorithms: Introduction to Adaptive Neuro Fuzzy Inference System(ANFIS) and its application for electromechanical industries.	05
06	**Hybrid system:** **Fuzzy back propagation (Fuzzy BP) Network:** Fuzzy Neuron, Fuzzy BP Architecture, Learning in Fuzzy BP. Application : Model for color recipes prediction.	04
	Case Studies using Neural network and Fuzzy Logic: Fuzzy Controller design for Washing Machine, Refrigerator, Air Conditioners., Applications of fuzzy logic in pattern recognition and Image processing for electromechanical industries, Model for computing Automobile Fuel Efficiency ,	

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

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1. Question paper will comprise of total 06 questions, each carrying 20marks.
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3. Question No: 01 will be compulsory and based on entire syllabus wherein sub- questions of 2 to 5 marks will be asked.
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5. In question paper weightage of each module will be proportional to number of respective lecture hrs as mentioned in the syllabus.

References:

1. Timothy J.Ross "Fuzzy Logic With Engineering Applications" Wiley.
2. S.N.Sivanandam, S.N.Deepa "Principles of Soft Computing" Second Edition, Wiley Publication.
3. S.Rajasekaran and G.A.Vijayalakshmi Pai "Neural Networks, Fuzzy Logic and Genetic Algorithms" PHI Learning.
4. J.-S.R.Jang "Neuro-Fuzzy and Soft Computing" PHI 2003.
5. Satish Kumar "Neural Networks A Classroom Approach" Tata McGrawHill.
6. Zimmermann H.S "Fuzzy Set Theory and its Applications"Kluwer Academic Publishers.
7. Hagan, Demuth, Beale,"Neural Network Design" CENGAGE Learning, India Edition.

Links for online NPTEL/SWAYAM courses:

https://nptel.ac.in/courses/127105006

Course Code	Course Name	Credits
MTDLO7033	Finite Element Analysis	03

Prerequisite: MTC301: Engineering Mathematics-III, MTC401: Engineering Mathematics-IV, MTC404 Strength of Material, MTC501 CAD&CAE

Objectives:

1. To introduce the concepts of Mathematical Modeling of Engineering Problems.
2. To solve ordinary and partial differential equations of second order.
3. To study the applicability of FEM to a range of Engineering Problems.
4. To apply numerical techniques for solving problems.

Outcomes: Learners will be able to

1. Model the engineering problems mathematically.
2. Apply the basic finite element analysis (FEA) formulation techniques to solve engineering problems.
3. Translate FEA formulation into computer code
4. Use commercial FEA software, to solve engineering problems.

Module	Detailed Contents	Hrs.
01	**Introduction:** 1.1 Engineering Problems, Boundary value problems, Initial value problem 1.2 Mathematical solutions techniques, Governing differential equations, Boundary conditions, solution algorithms, Errors and convergence, computer code formulation 1.3 General FEA procedure, Definitions of various terms used in FEA like element, Order of element, Internal and external node/s, Degree of freedom, Primary and secondary variables, Advantages, Limitations of FEA 1.4 FEA Software, selection of element type, meshing and convergence of solution	8
02	**Approaches In FEA** 2.1 Direct approach**:** Formulation of stiffness matrix, transformation and assembly concepts. 2.2 Elements of calculus of variations: Minimization of a functional, Principle of minimum total potential, Piecewise Rayleigh-Ritz method. 2.3 Weighted Residual Methods : Least squares, Galerkin methods	6
03	**Finite Element Formulation for One Dimensional Problems** 3.1 Bar element, Stepped and taper bars, Derivation of shape functions 3.2 Beam element, Derivation of shape functions 3.3 One dimensional truss problems 3.4 One dimensional thermal problems	8
04	**Finite Element Formulation for Two Dimensional Problems:** 4.1 Natural coordinates and coordinates transformations, Triangular elements, Rectangular elements	6

	4.2 Plane stress, Plane strain, Analysis of CST, Axisymmetric problems 4.3 Jacobian matrix, Higher order two dimensional elements	
05	**Finite Element Formulation for Three Dimensional Problems:** 5.1 Different types of three dimensional elements 5.2 Derivation of shape function in three dimension 5.3 Examples of three dimension problem	5
06	**Finite Element Formulation of Dynamic System** 6.1 Dynamic problems and finite element solutions techniques 6.2 Free vibration problems of rod and beam, Lumped and consistent mass matrix methods, Natural frequencies of beams 6.3 Longitudinal vibration frequencies and mode shapes, Transverse deflections	6

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Theory Examination:

1. Question paper will comprise of a total 06 questions, each carrying 20 marks.
2. Total 04 questions need to be solved.
3. Question No: 01 will be compulsory and based on the entire syllabus wherein sub- questions of 2 to 5 marks will be asked.
4. Remaining questions will be mixed in nature.(e.g. Suppose Q.2 has part (a) from module3 then part (b) will be from any module other than module 3)
5. In question paper weightage of each module will be proportional to number of respective lecture hrs as mentioned in the syllabus.

References:

1. Seshu. P. "Textbook of Finite Element Analysis" Prentice Hall of India, 2003.
2. J.N. Reddy, "Finite Element Method" Tata McGraw Hill, 2003.
3. Chandrupatla and Belegundu, "Introduction to Finite Elements in Engineering" PHI /Pearson Education, 2003.
4. Logan. D.L. "A first course in Finite Element Method", Thomson Asia Pvt. Ltd., 2002.
5. Cook R.D., Malkus. D.S. Plesha, ME., "Concepts and Applications of Finite Element Analysis", John – Wiley Sons 2003.
6. S.S. Rao, "The Finite Element Method in Engineering "Butter worth Heinemann, 2001.
7. M. Asghar Bhatti, "FUNDAMENTAL Finite Element Analysis and Applications with Mathematica and MATLAB Computations", Wiley India Pvt. Ltd.

Links for online NPTEL/SWAYAM courses:

https://onlinecourses.nptel.ac.in/noc21_me109/preview

Course Code	Course Name	Credits
MTDLO7041	Product Design and Development	03

Prerequisite: 1. MTC501: CAD & CAE

Objectives

1. To understand fundamental of product design concepts
2. To understand product design methodologies
3. To understand product design needs and issues in industry

Outcomes: Learner will be able to...

1. Design the products as per the customer/industry requirements
2. Apply product design tools and techniques

Module	Detailed Contents	Hrs.
01	1.1 Introduction to Product Design: Tangible and Intangible product, specifications of product, product life cycle. 1.2 Concurrent engineering & Sequential engineering 1.3 Modern product development process, Product design process, Product analysis.	7
02	2.1 Conceptual Design: generation, selection & embodiment of concepts. 2.2 Product architecture: Integral architecture and modular architecture, classification 2.3 Industrial Design: Process and Need, Design Optimization	6
03	3.1 Introduction and Process: Design for Manufacturing (DFM) and Design for Assembly (DFA) Designs for Maintainability(DFM) Designs for Environment (DFE) 3.2 Design of Experiments (DOE).	8
04	4.1 DFMA guidelines, Product design for manual assembly, Design guidelines for metallic and nonmetallic products to be manufactured by different processes such as casting, machining, injection molding etc., 4.2 Rapid prototyping, needs, advantages, working principle of SLA, LOM and SLS	6
05	5.1 Value Engineering / Value Analysis. : definition, methodology- FAST, Case studies. 5.2 Failure Mode Effect Analysis (FMEA) 5.3 Ergonomics in product design	6
06	6.1 Design for quality 6.2 Design and Process Failure Mode Effect Analysis (FMEA) 6.3 Design for Six Sigma 6.4 Patents and IP acts	6

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Theory Examination:

1. Question paper will comprise of total 06 questions, each carrying 20marks.
2. Total 04 questions need to be solved.
3. Question No: 01 will be compulsory and based on entire syllabus wherein sub- questions of 2 to 5 marks will be asked.
4. Remaining questions will be mixed in nature.(e.g. Suppose Q.2 has part (a) from module3 then part (b) will be from any module other than module 3)
5. In question paper weightage of each module will be proportional to number of respective lecture hrs as mentioned in the syllabus.

References:

1. " Product Design & Development." Karl T Ulrich, Steven D Eppinger , Tata McGrawhill New Delhi 2003
2. "Techniques in Reverse Engineering and new Product Development." Kevin Otto & Kristin Wood Product Design: 2004, Pearson Education New Delhi
3. "Value Engineering." L D Miles
4. "Successful Product Design." Hollins B & Pugh S ,Butter worths London.
5. "Product Design and Manufacturing", A K Chitale & R C Gupta, PHI, 2012.

Links for online NPTEL/SWAYAM courses:

https://nptel.ac.in/courses/112107217
https://nptel.ac.in/courses/112104230
https://nptel.ac.in/courses/107103082

Course Code	Course Name	Credits
MTDLO7042	Medical Mechatronics	03

Prerequisite: MTC405 Application of Integrated Circuit, MTC502 Sensors and Actuators, MTC603 Instrumentation and Control

Objectives

1. To teach the significance of biomedical signal and the challenges in picking the signal
2. To educate students the different mechanism to measure and monitor different biomedical parameters
3. To identify different types of biomedical units such as therapeutic and prosthetic devices.
4. To help students in enhancing their knowledge about different imaging techniques
5. To introduce robotic surgery
6. Mechanical design of the electrodes, prosthetic devices and the miniature as well as EMI

   /RFI protected cabinet is a major challenge to be looked into by this course.

Outcomes: Learner will be able to …

1. Select proper electrodes and electrolyte for different measurement of parameters
2. Explain the principle and working of any biomedical equipment
3. Design suitable orthotic and prosthetic devices and applications
4. Explain the working of different imaging techniques in Biomedical Engineering
5. Explain technological aspects of robotic surgery.
6. Demonstrate the significance of safety, telemetry in biomedical Instrumentation

Module	Detailed Contents	Hrs.
01	**Sources of Bioelectric potential, Electrodes and Transducers** 1.1 Understand generation of electrical signal in human cell, Resting and Action potential 1.2 Different types of Electrodes, Electrolytes and their significance, Biosensors 1.3 Classification of Biomedical Instruments, 1.4 Macroshocks and microshocks hazards, electrical safety and EMI/RFI interference and its testing	6

02	**Biopotential Amplifiers and recorders** 2.1 The origin of bio-potential, ECG, ENG, EMG, EEG, MEG, ERG etc. The signal conditioners and amplifiers 2.2 Recording systems for the bio-potential listed above and patient monitoring system, Foetal heart rate monitor	6
03	**Therapeutic and Prosthetic Equipments** 3.1 Hemodialisis machine, Ventilators, Infant incubator, drug delivery devices, 3.2 Orthotic and Prosthetic devices Definition, Need and Classification, Normal Human Locomotion . Gait Cycle, Biomaterials: Definition, Need and Classification, Biological Testing and Biocompatibility, Upper and Lower limb Prosthetic devices. Upper and Lower limb Orthotic devices, Study of various biomaterials and applications	7
04	**Fundamentals of medical imaging** 4.1 X-ray computed Tomography, Spiral or Helical C T: Slip Ring Technology, C T Angiography. Clinical use & Biological effects and safety, Magnetic resonance imaging Biological effects and safety. Nuclear medical imaging Biological effects and safety, Infrared imaging, Liquid crystal thermography. Microwave hermography. 4.2 Endoscopy, gastroscope, bronchoscope, cystoscope, colonoscope, Enteroscope Lithotripsy.	7
05	**Robot Assisted Surgery** Minimally invasive surgery and robotic integration, Definitions and development of surgical robotic systems Localization and tracking technologies for medical robotics: Requirements for position sensors , Dynamic referencing , Types of position sensors **Case Study :** Robotic-assisted vitreoretinal surgery	9
06	**Electrical safety and Telementry** 6.1 Macroshocks and microshocks hazards, electrical safety and EMI/RFI interference and its testing 6.2 Biomedical telemetry, wireless and multi patient telemetry	4

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Theory Examination:

1. Question paper will comprise of total 06 questions, each carrying 20marks.
2. Total 04 questions need to be solved.
3. Question No: 01 will be compulsory and based on entire syllabus wherein sub- questions of 2 to 5 marks will be asked.
4. Remaining questions will be mixed in nature. (e.g. Suppose Q.2 has part (a) from module3 then part (b) will be from any module other than module 3)
5. In question paper weightage of each module will be proportional to number of respective lecture hrs as mentioned in the syllabus.

References:

1. Khandpur R. S., Handbook of Biomedical Instrumentation, Tata McGraw Hill, second edition, 2003
2. Carr and Brown, Introduction to biomedical equipment technology, fourth edition, Pearson press, 2003
3. Sujata V. Bhat, Biomaterials, Narosa Publishing House, 2002.
4. W.R.Hendee & E.R.Ritenour, Medical Imaging Physics (3rd eds), Mosbey Year-Book, Inc., 1992.
5. Medical robotics Minimally invasive surgery Edited by Paula Gomes, Woodhead Publishing Series in Biomaterials: Number 51
6. Lesslie Cromwell, Fred J. Weibell, rich J. Pfeiffer Biomedical Instrumentation and Measurements, 2nd Edition, PHI
7. John G. Webster, Bioinstrumentation John Wiley and sons, 2004
8. Joseph Bronzino (Editor-in-Chief), Handbook of Biomedical Engineering, CRC Press, 1995.
9. L.A.Geddes and L.E.Baker,.Principles of Applied Bio-Medical Instrumentation. John Wiley & Sons 1975.
10. Harold E. Smalley, .Hospital Management Engineering . A guide to the improvement of hospital management system. PHI

Links for online NPTEL/SWAYAM courses:

https://nptel.ac.in/courses/108105101

Course Code	Course Name	Credits
MTDLO7043	Micro Electro Mechanical Systems	03

Prerequisite: MTC303 Engineering Materials and Metallurgy, MTC403 Thermal and Fluid Engineering, MTC502 Sensors and Actuators

Objectives

1. To introduce the concept of MEMS, NEMS and its applications
2. To provide an understanding of the fundamental principles behind the operation of MEMS sensors and actuators.
3. To demonstrate the fabrication processes and materials used in development of MEMS devices.
4. To introduce modeling and simulation of MEMS devices.
5. To provide an understanding of the technique used for characterization of MEMS devices.

Outcome: Learner will be able to…

1. Understand the underlying fundamental principles of MEMS devices.
2. To understand the construction and working of MEMS sensors and actuators.
3. To choose appropriate materials and fabrication processes for MEMS devices.
4. Develop a physics-based model of MEMS devices.
5. Identify characterization and assembly techniques for fabricated MEMS devices.

Module	Detailed Contents	Hrs.
01	**Introduction to MEMS & Applications:** ● Introduction to Micro-Electro-Mechanical Systems, Nano-mechanical Systems (NEMS), Real world applications of MEMS, NEMS	3
02	**Sensors and Actuators in Micro-domain:** ● Concept of sensors & actuators, ● Sensing & Actuation principles: Mechanical Sensing, Capacitive, Electrostatic, Electromagnetic, PiezoResistive, PiezoElectric, Thin Films, Shape Memory Alloys ● Comb Drive Actuation & Sensing. Micro-mechanisms, Air-Bag Sensors, Chemical Sensors ● Sensors & Actuators for Automotive, Biomedical, Industrial applications	9
03	**Materials and Properties for MEMS:** ● Materials (eg. Si, SiO2, SiN, Cr, Au, Ti, SU8, PMMA, Pt); Important properties: Young modulus, Poisson's ratio, density, piezoresistive coefficients, TCR, Thermal Conductivity, Material Structure. Understanding Selection of materials based on applications.	5

04	**Fabrication Processes for MEMS** • Microfabrication Methods (VLSI Techniques) • Deposition techniques such as CVD (Chemical Vapor Deposition), Physical Vapor Deposition (Metallization Techniques) • Oxidation, Diffusion, Ion Implantation • Positive and Negative Photoresists, Lithography • Etching (Isotropic and Anisotropic), Wet, Dry • Deep Reactive Ion Etching • Bulk Micromachining • Surface Micromachining • LIGA • Understanding Selection of processes based on applications	10
05	**Modelling and Simulation Techniques:** • Scaling Laws, Governing Equations • Micro-mechanism modelling and analysis techniques : Lumped Parameter Modelling and Distributed Parameter Modeling • Modelling of Mechanical Structures via classical methods, Newton's Laws, Thermal Laws, Fluid Flow Analysis • Modelling of Micro-channel as heat exchanger	6
06	**Characterization Techniques:** • STM (Scanning Tunneling Microscopes), SEM (Scanning Electron Microscopes), AFM (Atomic Force Microscopes) • Stiffness, Adhesion, Vibration, Resonant frequency characterization	6
	Self-Learning Topics: Architecture, working and basic quantitative behaviour of Accelerometers, Pressure Sensors, Micromirrors in DMD, Inkjet printer-head. Understanding steps involved in Fabricating above devices.	

Assessment:

Internal Assessment for 20 marks:
Consisting **Two Compulsory Class Tests**
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Theory Examination:
1. Question paper will comprise of a total of 06 questions, each carrying 20 marks.
2. Total 04 questions need to be solved.
3. Question No: 01 will be compulsory and based on the entire syllabus wherein sub-questions of 2 to 5 marks will be asked.
4. Remaining questions will be mixed in nature. (e.g. Suppose Q.2 has part (a) from module3 then part (b) will be from any module other than module 3)
5. In question paper weightage of each module will be proportional to number of respective lecture hrs as mentioned in the syllabus.

References:

1. Microsystem Design - by S. Senturia; Publisher: Springer
2. Nadim Mulaf and Kirt Williams, “An Introduction to Microelectromechanical Systems Engineering”, Artech House.
3. Micro Electro Mechanical System Design - by J. Allen; Publisher: CRC Press
4. Nicolae Lobontiu and Ephrahim Garcia, “Mechanics of Microelectromechanical systems”, Kluwer Academic Publication.
5. Julian W. Garden, Vijay K. Varadan and Osama O. Awadelkarim “Microsensors MEMS and Smart devices”, John Wiley and sons, Ltd.
6. Stanley Wolf and Richard Tauber, “Silicon Processing for the VLSI era Volume -1 Technology”, Lattice press.
7. Vijay K. Varadan, K.J.Vinoy and S. Gopalkrishnan, “Smart Material Systems and MEMS: Design and Development Methodologies”, John Wiley and sons Ltd.
8. Bhushan, “Springer Handbook of Nanotechnology”, Springer Inc.

Links for online NPTEL/SWAYAM courses:
https://nptel.ac.in/courses/117105082
https://nptel.ac.in/courses/108108113

Course Code	Course Name	Credits
ILO7011	**Product Life Cycle Management**	**03**

Objectives:

1. To familiarize the students with the need, benefits and components of PLM
2. To acquaint students with Product Data Management & PLM strategies
3. To give insights into new product development program and guidelines for designing and developing a product
4. To familiarize the students with Virtual Product Development

Outcomes: Learner will be able to…

1. Gain knowledge about phases of PLM, PLM strategies and methodology for PLM feasibility study and PDM implementation.
2. Illustrate various approaches and techniques for designing and developing products.
3. Apply product engineering guidelines / thumb rules in designing products for moulding, machining, sheet metal working etc.
4. Acquire knowledge in applying virtual product development tools for components, machining and manufacturing plant

Sr. No.	Detailed Contents	Hrs
01	**Introduction to Product Lifecycle Management (PLM):**Product Lifecycle Management (PLM), Need for PLM, Product Lifecycle Phases, Opportunities of Globalization, Pre-PLM Environment, PLM Paradigm, Importance & Benefits of PLM, Widespread Impact of PLM, Focus and Application, A PLM Project, Starting the PLM Initiative, PLM Applications **PLM Strategies:** Industrial strategies, Strategy elements, its identification, selection and implementation, Developing PLM Vision and PLM Strategy , Change management for PLM	10
02	**Product Design:** Product Design and Development Process, Engineering Design, Organization and Decomposition in Product Design, Typologies of Design Process Models, Reference Model, Product Design in the Context of the Product Development Process, Relation with the Development Process Planning Phase, Relation with the Post design Planning Phase, Methodological Evolution in Product Design, Concurrent Engineering, Characteristic Features of Concurrent Engineering, Concurrent Engineering and Life Cycle Approach, New Product Development (NPD) and Strategies, Product Configuration and Variant Management, The Design for X System, Objective Properties and Design for X Tools, Choice of Design for X Tools and Their Use in the Design Process	09

03	**Product Data Management (PDM):**Product and Product Data, PDM systems and importance, Components of PDM, Reason for implementing a PDM system, financial justification of PDM, barriers to PDM implementation	05
04	**Virtual Product Development Tools:** For components, machines, and manufacturing plants, 3D CAD systems and realistic rendering techniques, Digital mock-up, Model building, Model analysis, Modeling and simulations in Product Design, Examples/Case studies	05
05	**Integration of Environmental Aspects in Product Design:** Sustainable Development, Design for Environment, Need for Life Cycle Environmental Strategies, Useful Life Extension Strategies, End-of-Life Strategies, Introduction of Environmental Strategies into the Design Process, Life Cycle Environmental Strategies and Considerations for Product Design	05
06	**Life Cycle Assessment and Life Cycle Cost Analysis:** Properties, and Framework of Life Cycle Assessment, Phases of LCA in ISO Standards, Fields of Application and Limitations of Life Cycle Assessment, Cost Analysis and the Life Cycle Approach, General Framework for LCCA, Evolution of Models for Product Life Cycle Cost Analysis	05

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions**, **each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**.

REFERENCES:

1. John Stark, "Product Lifecycle Management: Paradigm for 21st Century Product Realisation", Springer-Verlag, 2004. ISBN: 1852338105
2. Fabio Giudice, Guido La Rosa, Antonino Risitano, "Product Design for the environment-A life cycle approach", Taylor & Francis 2006, ISBN: 0849327229
3. Saaksvuori Antti, Immonen Anselmie, "Product Life Cycle Management", Springer, Dreamtech, ISBN: 3540257314
4. Michael Grieve, "Product Lifecycle Management: Driving the next generation of lean thinking", Tata McGraw Hill, 2006, ISBN: 0070636265

Course Code	Course Name	Credits
ILO7012	Reliability Engineering	03

Objectives:

1. To familiarize the students with various aspects of probability theory
2. To acquaint the students with reliability and its concepts
3. To introduce the students to methods of estimating the system reliability of simple and complex systems
4. To understand the various aspects of Maintainability, Availability and FMEA procedure

Outcomes: Learner will be able to…

1. Understand and apply the concept of Probability to engineering problems
2. Apply various reliability concepts to calculate different reliability parameters
3. Estimate the system reliability of simple and complex systems
4. Carry out a Failure Mode Effect and Criticality Analysis

Sr. No	Detailed Contents	Hrs
01	**Probability theory:** Probability: Standard definitions and concepts; Conditional Probability, Baye's Theorem. **Probability Distributions:** Central tendency and Dispersion; Binomial, Normal, Poisson, Weibull, Exponential, relations between them and their significance. **Measures of Dispersion:**Mean, Median, Mode, Range, Mean Deviation, Standard Deviation, Variance, Skewness and Kurtosis.	08
02	**Reliability Concepts:** Reliability definitions, Importance of Reliability, Quality Assurance and Reliability, Bath Tub Curve. **Failure Data Analysis:** Hazard rate, failure density, Failure Rate, Mean Time To Failure (MTTF), MTBF, Reliability Functions. **Reliability Hazard Models:** Constant Failure Rate, Linearly increasing, Time Dependent Failure Rate, Weibull Model. Distribution functions and reliability analysis.	08
03	**System Reliability:** System Configurations: Series, parallel, mixed configuration, k out of n structure, Complex systems.	05
04	**Reliability Improvement:** Redundancy Techniques: Element redundancy, Unit redundancy, Standby redundancies. Markov analysis. System Reliability Analysis – Enumeration method, Cut-set method, Success Path method, Decomposition method.	08
05	**Maintainability and Availability:** System downtime, Design for Maintainability: Maintenance requirements, Design methods: Fault Isolation and self-diagnostics, Parts standardization and Interchangeability, Modularization and Accessibility, Repair Vs Replacement. Availability – qualitative aspects.	05
06	**Failure Mode, Effects and Criticality Analysis:** Failure mode effects analysis, severity/criticality analysis, FMECA examples. Fault tree construction, basic symbols, development of functional reliability block diagram, Fau1t tree analysis and Event tree Analysis	05

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions**, **each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**.

REFERENCES:

1. L.S. Srinath, "Reliability Engineering", Affiliated East-Wast Press (P) Ltd., 1985.
2. Charles E. Ebeling, "Reliability and Maintainability Engineering", Tata McGraw Hill.
3. B.S. Dhillion, C. Singh, "Engineering Reliability", John Wiley & Sons, 1980.
4. P.D.T. Conor, "Practical Reliability Engg.", John Wiley & Sons, 1985.
5. K.C. Kapur, L.R. Lamberson, "Reliability in Engineering Design", John Wiley & Sons.
6. Murray R. Spiegel, "Probability and Statistics", Tata McGraw-Hill Publishing Co. Ltd.

Course Code	Course Name	Credits
ILO7013	Management Information System	03

Objectives:

1. The course is blend of Management and Technical field.
2. Discuss the roles played by information technology in today's business and define various technology architectures on which information systems are built
3. Define and analyze typical functional information systems and identify how they meet the needs of the firm to deliver efficiency and competitive advantage
4. Identify the basic steps in systems development

Outcomes: Learner will be able to…

1. Explain how information systems Transform Business
2. Identify the impact information systems have on an organization
3. Describe IT infrastructure and its components and its current trends
4. Understand the principal tools and technologies for accessing information from databases to improve business performance and decision making
5. Identify the types of systems used for enterprise-wide knowledge management and how they provide value for businesses

Sr. No.	Detailed Contents	Hrs
01	Introduction to Information Systems (IS): Computer Based Information Systems, Impact of IT on organizations, Importance of IS to Society. Organizational Strategy, Competitive Advantages and IS	4
02	Data and Knowledge Management: Database Approach, Big Data, Data warehouse and Data Marts, Knowledge Management Business intelligence (BI): Managers and Decision Making, BI for Data analysis and Presenting Results	7
03	Ethical issues and Privacy: Information Security. Threat to IS, and Security Controls	7
04	Social Computing (SC): Web 2.0 and 3.0, SC in business-shopping, Marketing, Operational and Analytic CRM, E-business and E-commerce – B2B B2C. Mobile commerce.	7
05	Computer Networks Wired and Wireless technology, Pervasive computing, Cloud computing model.	6
06	Information System within Organization: Transaction Processing Systems, Functional Area Information System, ERP and ERP support of Business Process. Acquiring Information Systems and Applications: Various System development life cycle models.	8

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions**, **each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**.

REFERENCES:

1. Kelly Rainer, Brad Prince, Management Information Systems, Wiley
2. K.C. Laudon and J.P. Laudon, Management Information Systems: Managing the Digital Firm, 10th Ed., Prentice Hall, 2007.
3. D. Boddy, A. Boonstra, Managing Information Systems: Strategy and Organization, Prentice Hall, 2008

Course Code	Course Name	Credits
ILO7014	Design of Experiments	03

Objectives:

1. To understand the issues and principles of Design of Experiments (DOE)
2. To list the guidelines for designing experiments
3. To become familiar with methodologies that can be used in conjunction with experimental designs for robustness and optimization

Outcomes: Learner will be able to…

1. Plan data collection, to turn data into information and to make decisions that lead to appropriate action
2. Apply the methods taught to real life situations
3. Plan, analyze, and interpret the results of experiments

Sr. No	Detailed Contents	Hrs
01	**Introduction** 1.1 Strategy of Experimentation 1.2 Typical Applications of Experimental Design 1.3 Guidelines for Designing Experiments 1.4 Response Surface Methodology	06
02	**Fitting Regression Models** 2.1 Linear Regression Models 2.2 Estimation of the Parameters in Linear Regression Models 2.3 Hypothesis Testing in Multiple Regression 2.4 Confidence Intervals in Multiple Regression 2.5 Prediction of new response observation 2.6 Regression model diagnostics 2.7 Testing for lack of fit	08
03	**Two-Level Factorial Designs** 3.1 The 2^2 Design 3.2 The 2^3 Design 3.3 The General2^k Design 3.4 A Single Replicate of the 2^k Design 3.5 The Addition of Center Points to the 2^k Design, 3.6 Blocking in the 2^k Factorial Design 3.7 Split-Plot Designs	07
04	**Two-Level Fractional Factorial Designs** 4.1 The One-Half Fraction of the 2^k Design 4.2 The One-Quarter Fraction of the 2^k Design 4.3 The General 2^{k-p} Fractional Factorial Design 4.4 Resolution III Designs 4.5 Resolution IV and V Designs 4.6 Fractional Factorial Split-Plot Designs	07

05	**Response Surface Methods and Designs** 5.1 Introduction to Response Surface Methodology 5.2 The Method of Steepest Ascent 5.3 Analysis of a Second-Order Response Surface 5.4 Experimental Designs for Fitting Response Surfaces	07
06	**Taguchi Approach** 6.1 Crossed Array Designs and Signal-to-Noise Ratios 6.2 Analysis Methods 6.3 Robust design examples	04

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions**, **each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**.

REFERENCES:

1. Raymond H. Mayers, Douglas C. Montgomery, Christine M. Anderson-Cook, Response Surface Methodology: Process and Product Optimization using Designed Experiment, 3rd edition,John Wiley & Sons, New York, 2001
2. D.C. Montgomery, Design and Analysis of Experiments, 5th edition, John Wiley & Sons, New York, 2001
3. George E P Box, J Stuart Hunter, William G Hunter, Statics for Experimenters: Design, Innovation and Discovery, 2nd Ed. Wiley
4. W J Dimond, Peactical Experiment Designs for Engineers and Scintists, John Wiley and Sons Inc. ISBN: 0-471-39054-2
5. Design and Analysis of Experiments (Springer text in Statistics), Springer by A.M. Dean, and D. T.Voss

Course Code	Course Name	Credits
ILO7015	Operations Research	03

Objectives:

1. Formulate a real-world problem as a mathematical programming model.
2. Understand the mathematical tools that are needed to solve optimization problems.
3. Use mathematical software to solve the proposed models.

Outcomes: Learner will be able to…

1. Understand the theoretical workings of the simplex method, the relationship between a linear program and its dual, including strong duality and complementary slackness.
2. Perform sensitivity analysis to determine the direction and magnitude of change of a model's optimal solution as the data change.
3. Solve specialized linear programming problems like the transportation and assignment problems, solve network models like the shortest path, minimum spanning tree, and maximum flow problems.
4. Understand the applications of integer programming and a queuing model and compute important performance measures

Sr. No.	Detailed Contents	Hrs
01	**Introduction to Operations Research**: Introduction, , Structure of the Mathematical Model, Limitations of Operations Research **Linear Programming**: Introduction, Linear Programming Problem, Requirements of LPP, Mathematical Formulation of LPP, Graphical method, Simplex Method Penalty Cost Method or Big M-method, Two Phase Method, Revised simplex method, Duality, Primal – Dual construction, Symmetric and Asymmetric Dual, Weak Duality Theorem, Complimentary Slackness Theorem, Main Duality Theorem, Dual Simplex Method, Sensitivity Analysis **Transportation Problem**: Formulation, solution, unbalanced Transportation problem. Finding basic feasible solutions – Northwest corner rule, least cost method and Vogel's approximation method. Optimality test: the stepping stone method and MODI method. **Assignment Problem**: Introduction, Mathematical Formulation of the Problem, Hungarian Method Algorithm, Processing of n Jobs Through Two Machines and m Machines, Graphical Method of Two Jobs m Machines Problem Routing Problem, Travelling Salesman Problem **Integer Programming Problem**: Introduction, Types of Integer Programming Problems, Gomory's cutting plane Algorithm, Branch and Bound Technique. Introduction to Decomposition algorithms.	14
02	**Queuing models**: queuing systems and structures, single server and multi-server models, Poisson input, exponential service, constant rate service, finite and infinite population	05

03	**Simulation**: Introduction, Methodology of Simulation, Basic Concepts, Simulation Procedure, Application of Simulation Monte-Carlo Method: Introduction, Monte-Carlo Simulation, Applications of Simulation, Advantages of Simulation, Limitations of Simulation	05
04	**Dynamic programming**. Characteristics of dynamic programming. Dynamic programming approach for Priority Management employment smoothening, capital budgeting, Stage Coach/Shortest Path, cargo loading and Reliability problems.	05
05	**Game Theory**. Competitive games, rectangular game, saddle point, minimax (maximin) method of optimal strategies, value of the game. Solution of games with saddle points, dominance principle. Rectangular games without saddle point – mixed strategy for 2 X 2 games.	05
06	**Inventory Models**: Classical EOQ Models, EOQ Model with Price Breaks, EOQ with Shortage, Probabilistic EOQ Model.	05

Assessment:

Internal Assessment for 20 marks:
Consisting **Two Compulsory Class Tests**
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:
Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions**, **each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**.

REFERENCES:

1. Taha, H.A. "Operations Research - An Introduction", Prentice Hall, (7th Edition), 2002.
2. Ravindran, A, Phillips, D. T and Solberg, J. J. "Operations Research: Principles and Practice", John Willey and Sons, 2nd Edition, 2009
3. Hiller, F. S. and Liebermann, G. J. "Introduction to Operations Research", Tata McGraw Hill, 2002.
4. Operations Research, S. D. Sharma, KedarNath Ram Nath-Meerut
5. Operations Research, KantiSwarup, P. K. Gupta and Man Mohan, Sultan Chand & Sons

Course Code	Course Name	Credits
ILO7016	Cyber Security and Laws	03

Objectives:

1. To understand and identify different types cybercrime and cyber law
2. To recognized Indian IT Act 2008 and its latest amendments
3. To learn various types of security standards compliances

Outcomes: Learner will be able to…

1. Understand the concept of cybercrime and its effect on outside world
2. Interpret and apply IT law in various legal issues
3. Distinguish different aspects of cyber law
4. Apply Information Security Standards compliance during software design and development

Sr. No.	Detailed Contents	Hrs
01	**Introduction to Cybercrime:** Cybercrime definition and origins of the world, Cybercrime and information security, Classifications of cybercrime, Cybercrime and the Indian ITA 2000, A global Perspective on cybercrimes.	4
02	**Cyber offenses & Cybercrime:** How criminal plan the attacks, Social Engg, Cyber stalking, Cyber café and Cybercrimes, Botnets, Attack vector, Cloud computing, Proliferation of Mobile and Wireless Devices, Trends in Mobility, Credit Card Frauds in Mobile and Wireless Computing Era, Security Challenges Posed by Mobile Devices, Registry Settings for Mobile Devices, Authentication Service Security, Attacks on Mobile/Cell Phones, Mobile Devices: Security Implications for Organizations, Organizational Measures for Handling Mobile, Devices-Related Security Issues, Organizational Security Policies and Measures in Mobile Computing Era, Laptops	9
03	**Tools and Methods Used in Cyberline** Phishing, Password Cracking, Key loggers and Spywares, Virus and Worms, Steganography, DoS and DDoS Attacks, SQL Injection, Buffer Over Flow, Attacks on Wireless Networks, Phishing, Identity Theft (ID Theft)	6
04	**The Concept of Cyberspace** E-Commerce , The Contract Aspects in Cyber Law ,The Security Aspect of Cyber Law ,The Intellectual Property Aspect in Cyber Law , The Evidence Aspect in Cyber Law , The Criminal Aspect in Cyber Law, Global Trends in Cyber Law , Legal Framework for Electronic Data Interchange Law Relating to Electronic Banking , The Need for an Indian Cyber Law	8
05	**Indian IT Act.** Cyber Crime and Criminal Justice: Penalties, Adjudication and Appeals Under the IT Act, 2000, IT Act. 2008 and its Amendments	6
06	**Information Security Standard compliances** SOX, GLBA, HIPAA, ISO, FISMA, NERC, PCI.	6

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions**, **each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**.

REFERENCES:

1. Nina Godbole, Sunit Belapure, *Cyber Security*, Wiley India, New Delhi
2. The Indian Cyber Law by Suresh T. Vishwanathan; Bharat Law House New Delhi
3. The Information Technology Act, 2000; Bare Act- Professional Book Publishers, New Delhi.
4. Cyber Law & Cyber Crimes By Advocate Prashant Mali; Snow White Publications, Mumbai
5. Nina Godbole, *Information Systems Security,* Wiley India, New Delhi
6. Kennetch J. Knapp, *Cyber Security &Global Information Assurance* Information Science Publishing.
7. William Stallings, *Cryptography and Network Security,* Pearson Publication
8. Websites for more information is available on : The Information Technology ACT, 2008- TIFR : https://www.tifrh.res.in
9. Website for more information, A Compliance Primer for IT professional: https://www.sans.org/reading-room/whitepapers/compliance/compliance-primer-professionals-33538

Course Code	Course Name	Credits
ILO7017	Disaster Management and Mitigation Measures	03

Objectives:

1. To understand physics and various types of disaster occurring around the world
2. To identify extent and damaging capacity of a disaster
3. To study and understand the means of losses and methods to overcome /minimize it.
4. To understand role of individual and various organization during and after disaster
5. To understand application of GIS in the field of disaster management
6. To understand the emergency government response structures before, during and after disaster

Outcomes: Learner will be able to…

1. Get to know natural as well as manmade disaster and their extent and possible effects on the economy.
2. Plan of national importance structures based upon the previous history.
3. Get acquainted with government policies, acts and various organizational structure associated with an emergency.
4. Get to know the simple do's and don'ts in such extreme events and act accordingly.

Sr. No.	Detailed Contents	Hrs
01	Introduction 1.1 Definition of Disaster, hazard, global and Indian scenario, general perspective, importance of study in human life, Direct and indirect effects of disasters, long term effects of disasters. Introduction to global warming and climate change.	03
02	Natural Disaster and Manmade disasters: 2.1 Natural Disaster: Meaning and nature of natural disaster, Flood, Flash flood, drought, cloud burst, Earthquake, Landslides, Avalanches, Volcanic eruptions, Mudflow, Cyclone, Storm, Storm Surge, climate change, global warming, sea level rise, ozone depletion 2.2 Manmade Disasters: Chemical, Industrial, Nuclear and Fire Hazards. Role of growing population and subsequent industrialization, urbanization and changing lifestyle of human beings in frequent occurrences of manmade disasters.	09
03	Disaster Management, Policy and Administration 3.1 Disaster management: meaning, concept, importance, objective of disaster management policy, disaster risks in India, Paradigm shift in disaster management. 3.2 Policy and administration: Importance and principles of disaster management policies, command and co-ordination of in disaster management, rescue operations-how to start with and how to proceed in due course of time, study of flowchart showing the entire process.	06
04	Institutional Framework for Disaster Management in India:	06

	4.1 Importance of public awareness, Preparation and execution of emergency management program. Scope and responsibilities of National Institute of Disaster Management (NIDM) and National disaster management authority (NDMA) in India. Methods and measures to avoid disasters, Management of casualties, set up of emergency facilities, importance of effective communication amongst different agencies in such situations. 4.2 Use of Internet and softwares for effective disaster management. Applications of GIS, Remote sensing and GPS in this regard.	
05	Financing Relief Measures: 5.1 Ways to raise finance for relief expenditure, role of government agencies and NGO's in this process, Legal aspects related to finance raising as well as overall management of disasters. Various NGO's and the works they have carried out in the past on the occurrence of various disasters, Ways to approach these teams. 5.2 International relief aid agencies and their role in extreme events.	09
06	Preventive and Mitigation Measures: 6.1 Pre-disaster, during disaster and post-disaster measures in some events in general 6.2 Structural mapping: Risk mapping, assessment and analysis, sea walls and embankments, Bio shield, shelters, early warning and communication 6.3 Non Structural Mitigation: Community based disaster preparedness, risk transfer and risk financing, capacity development and training, awareness and education, contingency plans. 6.4 Do's and don'ts in case of disasters and effective implementation of relief aids.	06

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions**, **each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**.

REFERENCES:

1. 'Disaster Management' by Harsh K.Gupta, Universities Press Publications.
2. 'Disaster Management: An Appraisal of Institutional Mechanisms in India' by O.S.Dagur, published by Centre for land warfare studies, New Delhi, 2011.
3. 'Introduction to International Disaster Management' by Damon Copolla, Butterworth Heinemann Elsevier Publications.
4. 'Disaster Management Handbook' by Jack Pinkowski, CRC Press Taylor and Francis group.
5. 'Disaster management & rehabilitation' by Rajdeep Dasgupta, Mittal Publications, New Delhi.
6. 'Natural Hazards and Disaster Management, Vulnerability and Mitigation – R B Singh, Rawat Publications
7. Concepts and Techniques of GIS –C.P.Lo Albert, K.W. Yonng – Prentice Hall (India) Publications.

(Learners are expected to refer reports published at national and International level and updated information available on authentic web sites)

Course Code	Course Name	Credits
ILO7018	Energy Audit and Management	03

Objectives:

1. To understand the importance energy security for sustainable development and the fundamentals of energy conservation.
2. To introduce performance evaluation criteria of various electrical and thermal installations to facilitate the energy management
3. To relate the data collected during performance evaluation of systems for identification of energy saving opportunities.

Outcomes: Learner will be able to…

1. To identify and describe present state of energy security and its importance.
2. To identify and describe the basic principles and methodologies adopted in energy audit of an utility.
3. To describe the energy performance evaluation of some common electrical installations and identify the energy saving opportunities.
4. To describe the energy performance evaluation of some common thermal installations and identify the energy saving opportunities
5. To analyze the data collected during performance evaluation and recommend energy saving measures

Sr. No	Detailed Contents	Hrs
01	**Energy Scenario:** Present Energy Scenario, Energy Pricing, Energy Sector Reforms, Energy Security, Energy Conservation and its Importance, Energy Conservation Act-2001 and its Features. Basics of Energy and its various forms, Material and Energy balance	04
02	**Energy Audit Principles:** Definition, Energy audit- need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution. Elements of monitoring& targeting; Energy audit Instruments; Data and information-analysis. Financial analysis techniques: Simple payback period, NPV, Return on investment (ROI), Internal rate of return (IRR)	08
03	**Energy Management and Energy Conservation in Electrical System:** Electricity billing, Electrical load management and maximum demand Control; Power factor improvement, Energy efficient equipments and appliances, star ratings. **Energy efficiency measures in lighting system, Lighting control:** Occupancy sensors, daylight integration, and use of intelligent controllers. Energy conservation opportunities in: water pumps, industrial drives, induction motors, motor retrofitting, soft starters, variable speed drives.	10

04	**Energy Management and Energy Conservation in Thermal Systems:** Review of different thermal loads; Energy conservation opportunities in: Steam distribution system, Assessment of steam distribution losses, Steam leakages, Steam trapping, Condensate and flash steam recovery system. General fuel economy measures in Boilers and furnaces, Waste heat recovery, use of insulation- types and application. HVAC system: Coefficient of performance, Capacity, factors affecting Refrigeration and Air Conditioning system performance and savings opportunities.	10
05	**Energy Performance Assessment:** On site Performance evaluation techniques, Case studies based on: Motors and variable speed drive, pumps, HVAC system calculations; Lighting System: Installed Load Efficacy Ratio (ILER) method, Financial Analysis.	04
06	**Energy conservation in Buildings:** Energy Conservation Building Codes (ECBC): Green Building, LEED rating, Application of Non-Conventional and Renewable Energy Sources	03

Assessment:

Internal Assessment for 20 marks:
Consisting Two Compulsory Class Tests
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:
Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total six questions, each carrying 20 marks
2. Question 1 will be compulsory and should cover maximum contents of the curriculum
3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four questions need to be solved.

REFERENCES:

1. Handbook of Electrical Installation Practice, Geofry Stokes, Blackwell Science
2. Designing with light: Lighting Handbook, By Anil Valia, Lighting System
3. Energy Management Handbook, By W.C. Turner, John Wiley and Sons
4. Handbook on Energy Audits and Management, edited by A. K. Tyagi, Tata Energy Research Institute (TERI).
5. Energy Management Principles, C.B.Smith, Pergamon Press
6. Energy Conservation Guidebook, Dale R. Patrick, S. Fardo, Ray E. Richardson, Fairmont Press
7. Handbook of Energy Audits, Albert Thumann, W. J. Younger, T. Niehus, CRC Press
8. www.energymanagertraining.com
9. www.bee-india.nic.in

Course Code	Course Name	Credits
ILO7019	**Development Engineering**	**03**

Objectives:

1. To understand the characteristics of rural Society and the Scope, Nature and Constraints of rural Development.
2. To study Implications of 73rd CAA on Planning, Development and Governance of Rural Areas
3. An exploration of human values, which go into making a 'good' human being, a 'good' professional, a 'good' society and a 'good life' in the context of work life and the personal life of modern Indian professionals
4. To understand the Nature and Type of Human Values relevant to Planning Institutions

Outcomes: Learner will be able to…

1. Apply knowledge for Rural Development.
2. Apply knowledge for Management Issues.
3. Apply knowledge for Initiatives and Strategies
4. Develop acumen for higher education and research.
5. Master the art of working in group of different nature.
6. Develop confidence to take up rural project activities independently

Sr. No.	Module Contents	Hrs
01	Introduction to Rural Development Meaning, nature and scope of development; Nature of rural society in India; Hierarchy of settlements; Social, economic and ecological constraints for rural development Roots of Rural Development in India Rural reconstruction and Sarvodaya programme before independence; Impact of voluntary effort and Sarvodaya Movement on rural development; Constitutional direction, directive principles; Panchayati Raj - beginning of planning and community development; National extension services.	**08**
02	Post-Independence rural Development Balwant Rai Mehta Committee - three tier system of rural local Government; Need and scope for people's participation and Panchayati Raj; Ashok Mehta Committee - linkage between Panchayati Raj, participation and rural development	**04**
03	Rural Development Initiatives in Five Year Plans Five Year Plans and Rural Development; Planning process at National, State, Regional and District levels; Planning, development, implementing and monitoring organizations and agencies; Urban and rural interface - integrated approach and local plans; Development initiatives and their convergence; Special component plan and sub-plan for the weaker section; Micro-eco zones; Data base for local planning; Need for decentralized planning; Sustainable rural development.	**06**
04	Post 73rd Amendment Scenario 73rd Constitution Amendment Act, including - XI schedule, devolution of powers, functions and finance; Panchayati Raj institutions - organizational linkages; Recent changes in rural local planning; Gram Sabha - revitalized Panchayati Raj;	**04**

	Institutionalization; resource mapping, resource mobilization including social mobilization; Information Technology and rural planning; Need for further amendments.	
05	Values and Science and Technology Material development and its values; the challenge of science and technology; Values in planning profession, research and education. Types of Values Psychological values — integrated personality; mental health; Societal values — the modern search for a good society; justice, democracy, rule of law, values in the Indian constitution; Aesthetic values — perception and enjoyment of beauty; Moral and ethical values; nature of moral judgment; Spiritual values; different concepts; secular spirituality; Relative and absolute values; Human values— humanism and human values; human rights; human values as freedom, creativity, love and wisdom.	**10**
06	Ethics Canons of ethics; ethics of virtue; ethics of duty; ethics of responsibility; Work ethics; Professional ethics; Ethics in planning profession, research and education	**04**

Assessment:

Internal Assessment for 20 marks:
Consisting **Two Compulsory Class Tests**
First test based on approximately 40% of contents and second test based on remaining contents (approximately
40% but excluding contents covered in Test I)

End Semester Examination:
Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total six questions, each carrying 20 marks
2. Question 1 will be compulsory and should cover maximum contents of the curriculum
3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four questions need to be solved

References:

1. ITPI, Village Planning and Rural Development, ITPI, New Delhi
2. Thooyavan, K.R. Human Settlements: A 2005 MA Publication, Chennai
3. GoI, Constitution (73rd GoI, New Delhi Amendment) Act, GoI, New Delhi
4. Planning Commission, Five Year Plans, Planning Commission
5. Planning Commission, Manual of Integrated District Planning, 2006, Planning Commission
   New Delhi
6. Planning Guide to Beginners
7. Weaver, R.C., The Urban Complex, Doubleday.
8. Farmer, W.P. et al, Ethics in Planning, American Planning Association, Washington.
9. How, E., Normative Ethics in Planning, Journal of Planning Literature, Vol.5, No.2, pp. 123-150.
10. Watson, V., Conflicting Rationalities: -- Implications for Planning Theory and Ethics, Planning Theory andPractice, Vol. 4, No.4, pp.395 – 407

Course Code	Course Name	Credits
MTL701	Automotive Mechatronics Lab	01

Prerequisites: MTL501 Sensors and Actuators Laboratory, MTL503 Mechatronic Systems Modelling and Control Laboratory

Objectives:

1) Introduce Automotive Sensors and Actuators
2) Introduce CAN bus communication
3) Understand working of Automotive Mechatronic Systems

Outcomes: Students will be able to…

1) Implement battery charging / management
2) Communicate with sensors and actuators using CAN Bus
3) Implement and characterize automotive sensor and actuator
4) Implement automatic transmission.
5) Implement Automotive Mechatronic system.

Suggested List of laboratory experiments (Minimum Seven):

Sr. No.	Experiment List
PART A	**Basics**
01	Experiment on automobile charging system / Battery management system
02	Experiment on CAN bus training system
03	Experiment on characterization of automotive sensor.
04	Experiment on characterization of automotive actuator.
PART B	**Electronic Transmission**
05	Experiment on automatic transmission trainer/ simulator
PART C	**Driver Assistance**
06	Experiment on electric power steering demonstration setup
07	Experiment on Anti-lock braking system trainer/simulator
08	Experiment on electronic stability program Trainer / Simulator
09	Experiment on Adjustment systems (Power Window , Seat etc)

Term Work:

Term work consists of performing Part A and B and minimum 2 practicals from part C mentioned as above. Final certification and acceptance of the term work ensures satisfactory performance of laboratory work.

The distribution of marks for term work shall be as follows:

- Laboratory work (Experiment/journal) : 20 marks.
- Attendance (Theory and Practical) : 05Marks

End Semester Examination:

Pair of Internal and External Examiner should conduct Practical and Oral. Practical exam (15 marks) will be on any one of the experiments from the list and oral exam (10 marks) will be based on the entire syllabus of the laboratory.

Course Code	Course Name	Credits
MTL702	Mechatronics Lab	01

Prerequisites: MTL501 Sensors and Actuators Laboratory, MTL502 Mechatronic Systems Modelling and Control Laboratory

Objectives:

1) Introduce Modelling and simulation of Sensors and Actuators
2) Introduce Interfacing of sensors and actuators with control hardware
3) Introduce Mechatronic system development

Outcomes: Students will be able to…

1) Perform Modelling and simulation of Sensors and Actuators
2) Perform Interfacing of sensors and actuators with control hardware
3) Perform Mechatronic system development

Suggested List of laboratory experiments (Minimum Eight):

Sr. No.	Experiment List
PART A	**Modelling and Simulation**
01	Bond Graph Modelling of any one Sensor /Actuator and Transmission with Simulation using 20Sim or similar software
02	Modelling of AC Servo Motor using Matlab / SciLab
03	System Identification and PID Tuning for any actuator
PART B	**Interfacing and Control**
04	Interfacing with SPI /I2C protocol , Data acquisition and Experimental characterization of any sensor with Virtual Instrument
05	Waveform based control of DC servo motor
06	AC Servo Motor Speed / Position control implementation
07	Control of any mechatronic system using digital PID implementation on microcontroller
PART C	**System Development**
08	Implement DC Servo and Ultrasonic sensor based planer ranging system
09	Inertial sensors and DC Servo motor based auto leveling 3D printed gimbal development
10	Design and implement a linear actuation system for specified load and motion characteristics
11	Implementation of electronic gearing / camming with 2 AC servo motors

Term Work:

Term work consists of performing minimum 2 practical's each from part A, B and C mentioned as above. Final certification and acceptance of the term work ensures satisfactory performance of laboratory work.

The distribution of marks for term work shall be as follows:

- Laboratory work (Experiment/journal) : 20 marks.
- Attendance (Theory and Practical) : 05Marks

End Semester Examination:

Pair of Internal and External Examiner should conduct Practical and Oral. Practical exam (15 marks) will be on any one of the experiments from the list and oral exam (10 marks) will be based on the entire syllabus of the laboratory.

Course Code	Course Name	Credits
MTL7031	Digital Signal Processing Laboratory	01

Pre-requisite: MTDO501: Signals and Systems

Objectives:

1. To simulate & analyze basic signals & systems for enhanced understanding of concepts studied during theory class for MTE7051 subject.
2. To implement basic algorithms for signal processing on a DSP processor based kit.

Outcomes: Learner will be able to ...

1. Demonstrate programming skills for enhanced understanding of digital signal processing concepts (e.g., convolution, correlation, DFT, FIR & IIR filters, etc.) by analyzing digital signals & systems in time & frequency domain.
2. Demonstrate application of DSP theory in practice by implementing a few real-time signal processing algorithms, such as filtering for noise reduction, generation of PWM signal, etc.

Teacher can conduct any ten experiments based on the syllabus of MTDO701 (Digital Signal Processing).

Suggested List of laboratory experiments (Minimum Ten):

Sr. No.	Experiment List
1	Generation of various basic digital signals and analyzing them in time & frequency domain.
2	Understanding concept of convolution by passing sum of sinusoidal through a digital low-pass filter.
3	Understanding concept of auto- and cross-correlation.
4	Simulating & analyzing notch/comb/all-pass/digital resonator filters in time & frequency domain.
5	Concept of minimum phase system.
6	Concept of frequency resolution & zero-padding.
7	Analyzing various types of windows with respect to transition width & stop band attenuation.
8	Design of basic FIR filter based on windowing.
9	Design of basic FIR filter based on frequency domain sampling method.
10	Design of basic IIR filter.
11	Design and implementation of IIR filter to meet given specifications.

12	Implementing linear filter using circular convolution.
13	Implementation of radix-2 FFT algorithm & demonstrating use of DFT properties.
14	Analyzing finite word length effect on a digital filter..
15	Computation of DFT using DSP processor.

Term Work:

Term work consists of performing minimum 10 practical's mentioned as above. Final certification and acceptance of the term work ensures satisfactory performance of laboratory work.

The distribution of marks for term work shall be as follows:

- Laboratory work (Experiment/journal) : 20 marks.
- Attendance (Theory and Practical) : 05Marks

End Semester Examination:

Pair of Internal and External Examiner should conduct Practical and Oral. Practical exam (15 marks) will be on any one of the experiments from the list and oral exam (10 marks) will be based on the entire syllabus of the laboratory.

Course Code	Course Name	Credits
MTL7032	Neural Network and Fuzzy Logic Laboratory	01

Pre-requisites: MTL404 Technical Computing Lab

Objectives:

1. To conceptualize the working of human brain using Artificial Neural Network.
2. To become familiar with neural networks that can learn from available examples and generalize to form appropriate rules for inference systems.
3. To introduce the ideas of fuzzy sets, fuzzy logic and use of heuristics based on human experience.

Outcomes: Learner will be able to…

1) Implement fuzzy controller for electromechanical systems
2) Implement Supervised and Unsupervised Learning algorithms

List of Experiments:

All the programs should be implemented in C/C++/Java/MATLAB under Windows or Linux or Ubuntu environment. Experiments can also be conducted using available open source tools like OCTAVE and SCILAB.

Suggested List of laboratory experiments (Minimum Eight):

Sr. No.	Experiment List
1	One case study on Fuzzy/Neural/GA based papers published in IEEE/ACM/Springer or any prominent journal.
2	To implement activation function and problems on linear separability
3	To implement Fuzzy sets and Relations.
4	To implement Fuzzy Controllers.(Application to be designed for electromechanical industry)
5	To implement Basic Neural Network learning rules.
6	To implement any Supervised Learning algorithm.
7	To implement any Unsupervised Learning algorithm.
8	To implement a simple application using ANFIS.(Eg. Color recipes prediction, Automobile Fuel Efficiency Prediction)

Any other practical's covering the syllabus topics and subtopics can be conducted.

Term Work:

Term work consists of performing minimum 8 practical's mentioned as above. Final certification and acceptance of the term work ensures satisfactory performance of laboratory work.

The distribution of marks for term work shall be as follows:

- Laboratory work (Experiment/journal) : 20 marks.
- Attendance (Theory and Practical) : 05Marks

End Semester Examination:

Pair of Internal and External Examiner should conduct Practical and Oral. Practical exam (15 marks) will be on any one of the experiments from the list and oral exam (10 marks) will be based on the entire syllabus of the laboratory.

Course Code	Course Name	Credits
MTL7033	Finite Element Analysis Laboratory	01

Prerequisites: MTC301: Engineering Mathematics-III, MTC401: Engineering Mathematics-IV, MTC404 Strength of Material, MTC501 CAD&CAE

Objectives:

1. To introduce the concepts of use of FEA software.
2. To study the applicability of FEM to a range of Engineering Problems.
3. To acquaint with applications of numerical techniques for solving problems.

Outcomes: Learner will be able to…

1. Use FEA software for solutions of various engineering problems.

List of Assignment:

Students should use the commercial software or programmes from the text-books or self- developed programs, to verify the results obtained by manual calculations. The input data and output results of the problem solved using the computer programs should be included in the Journal. The proposed list is as given below;

Suggested List of laboratory experiments (Minimum Six):

Sr. No.	Experiment List
1	Any two problem using bar element
2	Any two problems using truss element
3	Any two problems using CST element
4	Any one problem using axisymmetric element
5	Any one problem of free vibration analysis using bar element
6	Any one problem on Steady State Heat conduction.
7	**Course Project:** A group of not more than four (04) students, shall do Finite Element Analysis of any mechanical engineering element/system, which involves element selection, assigning properties, meshing, assigning loads and boundary conditions, analysis and result interpretation.

Term Work:

Term work consists of performing minimum 6 Exercises and course project as mentioned above. Final certification and acceptance of the term work ensures satisfactory performance of laboratory work.

The distribution of marks for term work shall be as follows:

- Laboratory work (Experiment/journal) : 10 marks.
- Course Project 10 marks
- Attendance (Theory and Practical) : 05Marks

End Semester Examination:

Pair of Internal and External Examiner should conduct Practical and Oral. Practical exam (15 marks) will be on any one of the experiments from the list and oral exam (10 marks) will be based on the entire syllabus of the laboratory.

Course Code	Course Name	Credit
MTP701	**Major Project I**	**03**

Course Objectives: The course aims:	
The Project work facilitates the students to develop and prove Technical, Professional and Ethical skills and knowledge gained during graduation program by applying them from problem identification, analyzing the problem and designing solutions.	
Course Outcomes:	
1	Students will be able to develop the understanding of the problem domain through extensive review of literature.
2	Students will be able to identify and analyze the problem in detail to define its scope with problem specific data.
3	Students will be able to identify various techniques to be implemented for the selected problem and related technical skills through feasibility analysis.
4	Students will be able to design solutions for real-time problems that will positively impact society and environment..
5	Students will be able to develop clarity of presentation based on communication, teamwork and leadership skills.
6	Students will be able to inculcate professional and ethical behavior..

Guidelines:

1. **Project Topic Selection and Allocation:**

- Project topic selection Process to be defined and followed:
  - Project orientation can be given at the end of sixth semester.
  - Students should be informed about the domain and domain experts whose guidance can be taken before selecting projects.
  - Student's should be recommended to refer papers from reputed conferences/ journals like IEEE, Elsevier, ACM etc. which are not more than 3 years old for review of literature.
  - Students can certainly take ideas from anywhere, but be sure that they should evolve them in the unique way to suit their project requirements. Students can be informed to refer Digital India portal, SIH portal or any other hackathon portal for problem selection.
- Topics can be finalized with respect to following criterion:
  - **Topic Selection**: The topics selected should be novel in nature (Product based, Application based or Research based) or should work towards removing the lacuna in currently existing systems.
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- **Technology Used:** Use of latest technology or modern tools can be encouraged**.**
- Students should not repeat work done previously (work done in the last three years).

- Project work must be carried out by the group of at least 2 students and maximum 4.
- The project work can be undertaken in a research institute or organization/Industry/any business establishment. (out-house projects)
- The project proposal presentations can be scheduled according to the domains and should be judged by faculty who are expert in the domain.
- Head of department and senior staffalong with project coordinators will take decision regarding final selection of projects.
- Guide allocation should be done and studentshave to submit weekly progress report to the internal guide.
- Internal guide has to keep track of the progress of the project and also has to maintain attendance report. This progress report can be used for awarding term work marks.
- In case of industry/ out-house projects, visit by internal guide will be preferred and external members can be called during the presentation at various levels

2. **Project Report Format:**
At the end of semester, each group need to prepare a project report as per the guidelines issued by the University of Mumbai.

A project report should preferably contain at least following details:

- Abstract
- Introduction
- Literature Survey
  - Survey of Existing systems
  - Limitations of Existing systems or research gaps
  - Motivation (Challenges that are encouraging to choose the problem)
  - Problem Statement and Proposed Solution
  - Scope of the system
- Proposed System
  - General Workflow/Block diagram
- Analysis and Modeling (only applicable diagrams)
- Design
  - Architectural View
  - Algorithms/ Methodology
- Experimental Set up
  - Details of Database or details about input to systemsor selected data
  - Performance Evaluation Parameters (for Validation)
  - Software and Hardware Set up
- Implementation Plan for Next Semester
  - Timeline Chart for Term1 and Term-II (Project Management tools can be used.)
- Summary
- References

Desirable

- Students can be asked to undergo some Certification course (for the technical skill set that will be useful and applicable for projects.)

3.Term Work:

Distribution of marks for term work shall be done based on following:

a. Weekly Log Report

b. Project Work Contribution

c. Project Report (Spiral Bound) (both side print)

d. Term End Presentation (Internal)

The final certification and acceptance of TW ensures the satisfactory performance on the above aspects.

4. Oral & Practical:

Oral &Practical examination (Final Project Evaluation) of Project 1 should be conducted by Internal and External examiners approved by University of Mumbai at the end of the semester.

Suggested quality evaluation parameters are as follows:

1. Quality of problem selected
2. Clarity of problem definition and feasibility of problem solution
3. Relevance to the specialization / industrial trends
4. Originality
5. Clarity of objective and scope
6. Quality of analysis and design
7. Quality of written and oral presentation
8. Individual as well as team work