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)

University of Mumbai

Title of Course	B.E. (Mechatronics Engineering)
Eligibility	Ordinance 0.6244
Passing Marks	**40%**
No. of years/Semesters:	**8 semesters**
Level:	P.G. / U.G./ Diploma / Certificate
Pattern:	Yearly / Semester
Status:	New / Revised
To be implemented from Academic Year :	2022-23

Dr. Vivek Sunnapwar
Chairman
of Board of Studies in Mechanical
Engineering

Dr. Suresh K. Ukarande
Associate Dean,
Faculty of Science and Technology

Dr Anuradha Majumdar
Dean,
Faculty of Science and
Technology

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   Dr Anuradha Muzumdar

Associate Dean   Dean

Faculty of Science and Technology   Faculty of Science and Technology

University of Mumbai   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.

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

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
Dr. V. M. Phalle   : Member
Dr. Siddappa Bhusnoor   : Member
Dr. S.S. Pawar   : Member
Dr. Sanjay U. Bokade   : Member
Dr. Dhanraj Tambuskar   : Member
Dr. V. B. Tungikar   : Member
Dr. K.P. Karunakaran   : Member
Dr. S. S. Thipse   : Member
Dr. Milind Deshmukh   : Member

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

Semester VIII

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
MTC801	Industrial Automation and Industry 4.0	3	--	--	3	--	--	3
MTDLO805X	Department Optional Course – 5	3	--	--	3	--	--	3
MTDLO806X	Department Optional Course – 6	3	--	--	3	--	--	3
ILO802X	Institute Optional Course – 2	3	--	--	3	--	--	3
MTL801	Robotics and Machine Vision Laboratory	--	2	--	--	1	--	1
MTL802	Industrial Automation and Industry 4.0 Laboratory	--	2	--	--	1	--	1
MTP801	Major Project II#	--	12$	--	--	6	--	6
		12	16		12	8		20

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract/Oral	Total
		Internal Assessment			End Sem. Exam	Exam. Duration (in Hrs)			
		Test1	Test2	Avg.					
MT1C801	Industrial Automation and Industry 4.0	20	20	20	80	3	--	--	100
MTDLO805X	Department Optional Course – 5	20	20	20	80	3	--	--	100
MTDLO806X	Department Optional Course – 6	20	20	20	80	3	--	--	100
ILO802X	Institute Optional Course – 2	20	20	20	80	3	--	--	100
MTL801	Robotics and Machine Vision Laboratory	--	--	--	--	--	25	25	50
MTL802	Industrial	--	--	--	--	--	25	25	50

	Automation and Industry 4.0 Laboratory								
MTP801	Major Project II	--	--	--	--	--	50	100	150
Total		**--**	**--**	**80**	**320**	**--**	**100**	**150**	**650**

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

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

Course Code	Sem. VIII: Department Optional Course- 5	Course Code	Sem. VIII: Department Optional Course - 6
MTDLO8051	Industrial IOT	MTDLO8061	Robotics and Machine Vision
MTDLO8052	Communication Systems	MTDLO8062	UAV Systems
MTDLO8053	AI and Machine Learning	MTDLO8063	Engineering Management and Economics

Institute Optional Courses

Course Code	Institute Optional Course-I #	Course Code	Institute Elective Course-II #
ILO7011	Product Lifecycle Management	ILO8021	Project Management
ILO7012	Reliability Engineering	ILO8022	Finance Management
ILO7013	Management Information System	ILO8023	Entrepreneurship Development and Management
ILO7014	Design of Experiments	ILO8024	Human Resource Management
ILO7015	Operation Research	ILO8025	Professional Ethics and CSR
ILO7016	Cyber Security and Laws	ILO8026	Research Methodology
ILO7017	Disaster Management and Mitigation Measures	ILO8027	IPR and Patenting
ILO7018	Energy Audit and Management	ILO8028	Digital Business Management
ILO7019	Development Engineering	ILO8029	Environmental Management

 # 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**	4
	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,	
04	**Servo Control of Actuators**	8
	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	
05	**5.1 Motion Profile**, Kinematics: Basic Concepts, Common Motion Profiles: Trapezoidal Velocity Profile, S-curve Velocity Profile	8
	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	

	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):** 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	**07**
02	**Fast Fourier Transform (FFT) and Inverse Fast Fourier Transform (IFFT) Algorithms:** 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	**07**
03	**Finite Impulse Response (FIR) Digital Filters:** 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	**08**

04	**Infinite Impulse Response (IIR) Digital Filters:**	08
	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	
05	**Multirate Signal Processing and Filter Banks:**	05
	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	
06	**DSP Processors and Applications:**	04
	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	

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)

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. 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**	6
	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	
03	**Therapeutic and Prosthetic Equipments**	7
	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	
04	**Fundamentals of medical imaging**	7
	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.	
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**	4
	6.1 Macroshocks and microshocks hazards, electrical safety and EMI/RFI interference and its testing	
	6.2 Biomedical telemetry, wireless and multi patient telemetry	

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: 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.	06
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; Institutionalization; resource mapping, resource mobilization including social mobilization; Information Technology and rural planning; Need for further amendments.	04

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:
  - o Project orientation can be given at the end of sixth semester.
  - o Students should be informed about the domain and domain experts whose guidance can be taken before selecting projects.
  - o 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.
  - o 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:
  - o **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.
  - o **Technology Used:** Use of latest technology or modern tools can be encouraged**.**
  - o 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. Term work evaluation:

Term work evaluation for Project 1 should be conducted by Internal examiner on continuous basis throughout 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

Course Code	Course Name	Credits
MTC801	**Industrial Automation and Industry 4.0**	**03**

Prerequisite: MTC502 Sensors and Actuators, MTC603 Instrumentation and Control, , MTC604 Applied Hydraulics and Pneumatics

Objectives
1) To prepare the learner for a career in modern manufacturing using industrial automation
2) Introduce technologies related to upcoming Industry 4.0 paradigm

Outcomes: Learner will be able to...
1) Identify opportunities for automation in manufacturing
2) Plan design and implement automation systems
3) Program industrial controller for automation application
4) Explain scope and benefit of industry 4.0 technologies

Module	Detailed Contents	Hrs.
01	**Need and Types of Automation, Industry 4.0** 1.1 Productivity in Manufacturing, Work Study, Need for Automation, Evolution of automation, Automation hierarchy. 1.2 Industrial Revolutions 1,2,3,4, How manufacturing changed at each IR Relentless increase in computational power (Moore's law), basket of technologies which make up Industry 4.0. Reference Architecture Model of Industry 4.0 (RAMI)	5

02	**Machine Systems**
	2.1 Structure and Framing: Aluminum profiles, piping and other. Electrical Enclosures NEMA Ratings
	2.2 Material Handling (Types, working and application)
	  - Feeders: Vibratory Bowls and Feeders, Escapement
	  - Bearings: Linear Motion Bearings,
	  - Conveyors: Belt, Roller, Chain and mat, Vibrating, Pneumatic
	2.3 Common Mechanisms (Types, working and application)
	  - Indexers: Ratchet and Pawl, Cam driven, Geneva, Walking beam
	  - Ball Screws and Belt-Driven Linear Actuators
	  - Clutches and brakes
	2.4 Assembly Techniques Fasteners , couplings.
		6

03	**Automation Circuits** 3.1 Introductory Principles in Designing Automation Circuits: Latch, Command 3.2 Circuits for Motor Operation with Thermal Overload Protection, Machine operation with (a) Fault Indication, (b)Starting Delay (c) Stopping Delay, (d) Automatic or Manual control. Electrical and mechanical latch, Sequential start of machines (Chain latch) Automation Circuits for Motors: Motor with Inversion in Rotation (Permanent and instantaneous), Motor with Star delta start. 3.3 Introduction to Logical Design of Automation Circuits: State Diagrams, Sequential Automation Systems.	6

04	**Industrial Controllers and Programming** 2.1 Types of industrial controllers, Differences in architecture, power, programming, applications of PLCs, Microcontrollers, Computer numeric controller, PC Based control, Edge controllers. 2.2 IL, Ladder, FBD implementation of PLC programming for AND, OR logic and its combination, self-holding logic using S and R, Applications with timer and counter. PID control in PLC. 2.3 Implementation of Industrial automation tasks (stamping, sorting, etc. a) with electro-pneumatic circuit, PLC wiring diagram and ladder diagram. (3 hrs) 2.4 Implementation of Industrial automation tasks (Using Conveyor, Valves etc) with PLC wiring and ladder diagrams. (3 Hrs)	8
05	2.3 HMI Types: Control Panel, Display panels, Touch screen. New age AR/VR, Multiverse. 2.4 Supervisory control SCADA, DCS	4
06	**Communication in Automation** PLC Networks, Topology: Star, Ring and Bus. Communication Protocols: Master /Slave, CSMA CD, Token Passing. Communication Task in PLC, Total communication time, Actuator-Sensor Interface (AS-I) Network, Profibus Network IIoT (4 layer structure), Communication media – industrial bus systems, Blue tooth, WiFi, 3G/4G/5G Open protocols – OPC-UA ; REST API Industrial Communication standards , IOT Cloud computing, Block Chain and security, Cyber security	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 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) "Industrial Automation Hands-On" by Frank Lamb, McGraw-Hill Education 2013
2) "Introduction to Industrial Automation" Stamatios Manesis, George Nikolakopoulos CRC Press 2018
3) "Industrial Automation and Robotics" A K Gupta, S K Arora University Science Press
4) "Industrial Automation Technologies" Chanchal Dey, Sunit Kumar Sen CRC Press
5) "Industrial Automation Solutions For Plc, Scada, Drive And Field Instruments: Easy To Learn Industrial Automation" Kataria Sanjay
6) "The Internet of Things in the Industrial Sector Security and Device Connectivity, Smart Environments, and Industry 4.0" Zaigham Mahmood Editor, Springer 2019
7) "Internet of Things A Hands-ON Approach" Arshadeep Bagha , Vijay Madisetti Universities Press 2018

Links for online NPTEL/SWAYAM courses:
https://nptel.ac.in/courses/108105088
https://nptel.ac.in/courses/106105195

Course Code	Course Name	Credits
MTDLO8051	Industrial IOT	03

Prerequisite: MTC504 Embedded Systems

Objectives:

1.To equip students with the fundamental knowledge and basic technical competence in the field of Industrial Internet of Things (IoT).

2. To explore and analyze the protocols, process and, frameworks required for deployment of Industrial IoT.

3. To understand the impact of Industrial IoT applications and challenges associated with it.

Outcomes: Learner will be able to...

1. Understand the concepts of IoT and building blocks of IoT.

2. To elaborate the principles and process involve in Industrial IoT.

3. To identify the required protocols, tools and frameworks for Industrial IoT.

4. To analyze the impact of Industrial IoT-based applications.

5. To explore the different challenges associated with deployment of Industrial IoT.

Module	Detailed Contents	Hrs.
01	**A review of IoT Technologies:** What is IoT? –IoT and Digitization, IoT Impact –Connected Roadways, Connected Factory, Smart Connected Buildings, Smart Creatures, Convergence of IT and OT, The oneM2M, IoT Standardized Architecture, IoT Data Management and Compute Stack –Design considerations and Data related problems, Fog Computing, Edge Computing, The Hierarchy of Edge, Fog and Cloud	6
02	**Building Blocks of IoT:** Characteristics of IOT, Physical Design of IOT: Things, Communication protocol stacks: IOT Protocols used in Link, Network, Transport and Application layer, Logical Design of IOT: IOT functional blocks, IOT Communication models, APIs. IOT Enabling Technologies: Wireless Sensor Networks, Cloud Computing, Big Data Analytics, Communication Protocols, Embedded Systems. IOT Levels and Deployment Templates: IOT Levels 1 to 6.	6
03	**Industrial Internet of Things (IIoT): Principles, Processes and Protocols** Industry 4.0: Managing the Digital Transformation, Conceptual framework for Industry 4.0, Industrial IoT (IIoT) - Introduction, Business	6

		Model and Reference Architecture, Industrial IoT Layers, Sensing, Processing, Communication, Cyber Physical Systems and Next Generation Sensors, Collaborative Platform and Product Lifecycle Management,	
04	**Communication and Networking for the Industrial Internet of Things** Enabling IoT Technologies -Radio Frequency Identification Technology, Micro-Electro-Mechanical Systems (MEMS), NFC (Near Field Communication), Bluetooth Low Energy (BLE), LTE-A (LTE Advanced), IEEE 802.15.4–Standardization and Alliances, ZigBee. Messaging Protocol Standards: MQTT, MQTT-SN,AMQP, XMPP, COAP, HTTP , OPC-UA , LWM2M. Tools and Frameworks for Modeling, Development, and Deployment, IoT Cloud Integration Platforms	8
05	**Applications of Industrial IoT:** Internet of Things and New Value Proposition, Examples for IoTs Value Creation in Different Industries like Healthcare, Power Plants, Inventory Management & Quality Control, Plant Safety and Security, Facility Management.	05
06	**Challenges in Industrial IoT: :** Wireless Coexistence, Latency, Interoperability, Sensor Data Streaming, Safety, Security and Privacy, Intrusion Detection, Intrusion Prevention, Runtime Security Monitoring	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 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. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton, Jerome Henry, "IoT Fundamentals –Networking Technologies, Protocols, and Use Cases for the Internet of Things", 1stEdition, Publishedby Pearson Education, Inc, publishing as Cisco Press,2017.

2. Arshdeep Bahga, Vijay Madisetti, "Internet of Things –Hands-On Approach", 2ndEdition, Universities Press, 2016.

3. Giacomo Veneri, Antonio Capasso," Hands-On Industrial Internet of Things: Create a powerful Industrial IoT infrastructure using Industry 4.0", Packt

4. Sabina Jeschke, Christian Brecher Houbing Song, Danda B. Rawat Edited "Industrial Internet of Things Cyber Manufacturing Systems", Springer Publications

5. Zaigham Mahmood edited, "The Internet of Things in the Industrial Sector- Security and Device Connectivity, Smart Environments, and Industry 4.0" Springer Publications

6. Ismail Butun edited, "Industrial IoT- Challenges, Design Principles, Applications, and Security", Springer Publications

Suggested MOOCs:

1. https://onlinecourses.nptel.ac.in/noc20_cs69 - Introduction to Industry 4.0 and Industrial Internet of Things, By Prof. Sudip Misra, IIT Kharagpur
2. https://www.edx.org/course/industry-40-how-to-revolutionize-your-business - Industry 4.0: How to Revolutionize your Business
3. https://onlinecourses.nptel.ac.in/noc21_cs17 - Introduction to internet of things, by Prof. Sudip Misra , IIT Kharagpur
4. https://onlinecourses.nptel.ac.in/noc21_cs08 - Embedded Systems Design
5. By Prof. Anupam Basu, IIT Kharagpur

Recommended list of tools for self learning:

1. Node Red - https://nodered.org/
2. M2MLabs Mainspring - http://www.m2mlabs.com/
3. Tensor Flow - https://www.tensorflow.org/
4. Things Speak - https://thingspeak.com/

Course Code	Course Name	Credits
MTDLO8052	**Communication Systems**	**03**

Prerequisite: MTC301 Engineering Mathematics-III, MTC305: Applied Electrical and Electronics Engineering, MTC502: Sensors and Actuators

Objectives:

1. To teach fundamental principles of basic communication systems.

2. To teach the various characteristics of different types of antennas.

3. To teach the cellular concepts.

Outcomes: Learner will be able to...

1. Compare and contrast the significance and limitations of analog and digital communication systems.

2. Demonstrate the knowledge of antennas in communication systems

3. Demonstrate a clear understanding of fundamentals of wireless and mobile communication systems and standards.

Module	Detailed Contents	Hrs.
01	**Basics of Communication System** 1.1 Block diagram, electromagnetic spectrum, types of communication channels 1.2 Types of noise, signal to noise ratio, noise figure, and noise temperature	4
02	**Analog Communication** 2.1 **Amplitude Modulation:** Basic concept, signal representation, need for modulation, **S**pectrum, waveforms, modulation index, bandwidth, voltage distribution, and power calculation. 2.2 **DSBFC, DSB suppressed carrier,Single Side Band (SSB):**Principle,low level and high level transmitters **Amplitude modulators:**switching modulator, balanced/product modulator, phase shift method and third Method. 2.3 **Amplitude demodulation:** Diode detector,square law detector.	8
03	3.1 **Frequency modulation (FM):** Basic concept, mathematical analysis, frequency spectrum of FM wave, sensitivity, phase deviation and modulation index, frequency deviation and percent modulated waves,	8

	3.2 **Transmitter:** Direct FM transmitter, indirect FM Transmitter, noise triangle in FM, pre-emphasis and de-emphasis.	
	3.3 **FM demodulation:** Balance slope detector, Foster-Seely discriminator, ratio detector, Phase lock loop(PLL) FM demodulator, amplitude limiting and thresholding, comparison between FM demodulators,	
04	**Digital Communication**	10
	4.1 Introduction to digital communication system, significance of AWGN channel,	
	4.2 Digital Modulation formats, coherent and non-coherent reception.	
	4.3 **Binary Modulation Techniques:** BPSK, BFSK and BASK.	
	4.4 **M-ary Modulation techniques:** QPSK, M-ary PSK, MSK, M-ary FSK, M-ary QAM	
05	**Antennas and Wave Propagation**	4
	5.1 **Antenna Parameters:** Radiation intensity, directive gain, directivity, power gain, beam width, band width,	
	5.2 Reciprocity principle, effective length and effective area,	
	5.3 **Antenna Types: Wire** antenna,Aperture Antennas,Microstrip Antennas,Reflector Antennas,Traveling-wave Antennas,Array Antennas	
06	**Wireless Communication Systems and application**	5
	6.1 Description of cellular system, Frequency Reuse, Co-channel and Adjacent channel interference,	
	6.2 Evolution of Modern Mobile Wireless Communication System, GSM in Wireless Communication, Wireless Local Area Networks (WLANs), Communication protocols.	
	6.3 Case study on Applications of communication in mechatronics	

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. Kennedy and Davis, "*Electronics Communication System*", Tata McGraw Hill, Fourth edition.

2. Taub Schilling and Saha, "*Principles Of Communication Systems*", Tata Mc-Graw Hill,Third Ed.

3. R.K. Shevgaonkar, "*Electromagnetic Waves*", TATA McGraw Hill Companies, 3rd Edition, 2009.

4. Theodore S. Rappaport, "Wireless Communications", Prentice Hall of India, PTR publication.

5. Vijay Garg, "Wireless Communications & Networking (The Morgan Kaufmann Series in Networking)", Morgan Kaufmann Publishers, 1st Edition

Links for online NPTEL/SWAYAM courses:
https://nptel.ac.in/courses/108104091
https://nptel.ac.in/courses/117102059

Course Code	Course Name	Credits
MTDLO8053	AI and Machine Learning	03

Prerequisite: MTC401 Engineering Mathematics IV, MTC302 Data Structure and Algorithms

Objectives

1. Identify the various characteristics of Artificial Intelligence and Machine Learning
2. Solve the problems using suitable searching methods.
3. Solve the problems using suitable reasoning and knowledge representation methods.

Outcomes: Learner will be able to…

1) Choose an appropriate problem solving method for an agent to find a sequence of actions to reach the goal state.
2) Analyze the strength and weakness of AI approaches to knowledge representation, reasoning and planning.
3) Solve a planning problem by selecting the appropriate planning type.
4) Identify and select Learning type for given problem
5) Apply suitable machine learning techniques for a given problem
6) Solve the problems using various machine learning techniques

Module	Detailed Contents	Hrs.
01	**Introduction to Artificial Intelligence(AI) and Machine Learning** 1.1 Introduction and Definition of Artificial Intelligence. 1.2 Intelligent Agents: Agents and Environments, Rationality, Nature of Environment, Structure of Agent, types of Agent 1.3 Introduction to Machine Learning, Types of Machine Learning, Issues in Machine Learning, Application of Machine Learning, Steps in developing a Machine Learning Application.	4
02	**Problem Solving** 2.1 Problem Solving Agent, Formulating Problems, Example Problems 2.2 Uninformed Search Methods: Depth Limited Search, Depth First Iterative Deepening (DFID), Informed Search Method: A* Search 2.3 Optimization Problems: Hill climbing Search, Simulated annealing, Genetic algorithm	6
03	**Knowledge, Reasoning and Planning** 3.1 Knowledge based agents 3.2 First order logic: syntax and Semantic, Knowledge Engineering in FOL Inference in FOL: Unification, Forward Chaining, Backward Chaining and Resolution 3.3 Planning Agent, Types of Planning: Partial Order, Hierarchical Order, Conditional Order	10
04	**Learning with Regression and trees** 4.1 Learning with Regression: Linear Regression, Logistic Regression. 4.2 Learning with Trees: Decision Trees, Constructing Decision Trees using Gini Index, Classification and Regression Trees (CART).	4

05	**Classification:** 5.1 Rule based classification, classification by Bayesian Belief networks, Hidden Markov Models. **Support Vector Machine:** 5.2 Maximum Margin Linear Separators, Quadratic Programming solution to finding maximum margin separators, Kernels for learning non-linear functions. **Clustering:** 5.3 Expectation Maximization Algorithm, Supervised learning after clustering, Radial Basis functions.	10

06	**Implementing Mechatronic Applications with AI**
	    6.1 Mechatronics in rescue
	    6.2 The Intelligent Robotic Car
		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. Stuart J. Russell and Peter Norvig, "Artificial Intelligence A Modern Approach Second Edition" Pearson Education.
2. N.P.Padhy, "Artificial Intelligence and Intelligent Systems", Oxford University Press.
3. Tom M.Mitchell, "Machine Learning‖", McGraw Hill
4. Ethem Alpaydın, "Introduction to Machine Learning", MIT Press
5. Elaine Rich and Kevin Knight, "Artificial Intelligence" Third Edition, Tata McGraw-Hill Education Pvt. Ltd., 2008.
6. Han Kamber, "Data Mining Concepts and Techniques", Morgann Kaufmann Publishers
7. Margaret.H.Dunham, "Data Mining Introductory and Advanced Topics", Pearson Education
8. Jeffrey Johnson and Philip Picton, "Concepts in Artificial Intelligence, Designing Intelligent Machines"

Links for online NPTEL/SWAYAM courses:
1. **https://nptel.ac.in/courses/106106139**

2. **https://nptel.ac.in/courses/106105078**

Course Code	Course Name	Credits
MTDLO8061	**Robotics and Machine Vision**	**03**

Prerequisite: MTC402 Kinematics of Machinery, MTC502 Sensors and Actuators, MTC503 Mechatronic Systems Modelling and Control,

Objectives

1. To familiarize the students with the significance of robotic system in agile and automated manufacturing processes.

2. To prepare the students to be conversant with robotic elements/ peripherals, their selection and interface with manufacturing equipment's.

3. To familiarize the students with the basics of robot kinematics.

Outcomes: Learner will be able to...

1. Select robot for industrial task and identify areas in which robot can be deployed in industry.

2. Program wheeled mobile robots for industrial tasks.

3. Select, deploy and program industrial robot arms for industrial tasks.

4. Develop skills in machine vision

5. Develop skills in applying machine vision for robot control.

Module	Detailed Contents	Hrs.
01	Robot ISO Definition, Types: Industrial, Automatic Guided Vehicles, Walking, Parallel Special Purpose etc. Robot Subsystems: Motion, Recognition, Control Industrial Robot Anatomy, 4 Common Configurations, Robot Motions, Joint Notation Scheme, Work Volume, Drive Systems, Speed, Load Carrying Capacity, Precision of Movement (Resolution, Accuracy, Repeatability, Compliance). Motion Control Programming, Industrial Applications for Material Handling , Processing , Assembling.	5
02	**Wheeled Mobile Robot Vehicles:** Kinematics of Wheeled Mobile Robots: Forward and inverse kinematics of Differential Drive, Car (Ackermann) Drive, Synchronous Drive, Omnidirectional Drive. **Wheeled Mobile Robot Control**: Control to Reference Pose, Orientation Control for Differential Drive, Ackermann Drive, Forward-Motion Control, Following a Line, following a Path, Moving to a Pose.	9
03	**Arm-Type Robots:** Coordinate Frames, Rotations, Homogeneous Coordinates, DH parameters, Arm Equation of Planer Robot, Four axis SCARA Robot, TCV, Inverse Kinematics of Planer Robot, Four Axis SCARA Robot, 6 Axis Robot Arm, Jacobian, Singularity, and Statics. **Trajectory Planning & Robot Dynamics:** Manipulator Path Control- Linear, Quadratic and Cubic Interpolation, Work Space Analysis, Robot Dynamics –Langrangian Dynamics of one and two link robot arm. **Programming** Robot languages and programming for industrial applications.	10
04	**Computer Vision Light and Color,** Spectral Representation of Light Absorption, Reflection, Color, Reproducing Colors, Chromaticity Space, Color Names, Other Color Spaces, Transforming between Different Primaries. Image Formation ,Perspective Transform , Lens Distortion , Camera Calibration Homogeneous Transformation	4

05	**Image Processing** Obtaining an Image from Files, Camera, Movie and Web. Monadic Operations, Diadic Operations, Spatial Operations, Convolution Template Matching, Non-Linear Operations Image Feature Extraction: Region Features, Classification, Representation Description, Recap, Line Features, Point Features, Classical Corner Detectors, Scale-Space Corner Detectors.	6
06	**Vision-Based Control** , Position-Based Visual Servoing ,Image-Based Visual Servoing ,Camera and Image Motion Controlling.	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. "Introduction to Robotics", S. K. Saha McGraw Hill
2. "Industrial Robotics Technology Programming and Applications", MP Groover, M. Weiss, R. N. Nagel, N. G. Odrey
3. "Wheeled Mobile Robotics From Fundamentals Towards Autonomous Systems", Gregor Klanˇcar ,Andrej Zdešar, Sašo Blažiˇc, Igor Škrjanc, Elesvier Butterworth-Heinemann 2017
4. "Robotics, Vision and Control Fundamental Algorithms In Matlab®" Peter Corke Springer.
5. "Robot Dynamics and Control", Mark Spong, Wiley India
6. "Introduction to Robotics Mechanics and Control" John Craig, Pearson

Links for online NPTEL/SWAYAM courses:
https://nptel.ac.in/courses/112105249
https://nptel.ac.in/courses/107106090

Course Code	Course Name	Credits
MTDLO8062	UAV Systems	03

Prerequisite: MTC304 Basic Electronics and Digital Circuit Design, MTC502 Sensors and Actuators, MTC503 Mechatronic Systems Modelling and Control.

Objectives
1) Introduce different small aircraft and their construction
2) Introduce design of Airframe for fixed-wing and multicopters
3) Familiarize with modelling and evaluation of Propulsion System
4) Introduce Sensors and perception used in UAV Systems
5) Introduce stability and controllability
6) Introduce autonomous control of UAV Systems

Outcomes: Learner will be able to...
1) Explain construction of various types of unmanned aerial vehicles
2) Perform design of Airframe with various considerations for fixed-wing and multicopter systems
3) Model the propulsion system of fixed-wing and multicopter systems.
4) Select sensors based on requirements of perception for UAV system.
5) Implement control for stable operation.
6) Implement autonomous control for UAV systems.

Module	Detailed Contents	Hrs.
01	**Introduction** Classification of Commonly Used unmanned aerial systems, Fixed wing, multirotor and hybrid. **Components:** Basic Composition, Introduction Airframe, Control Surfaces, Fuselage, Landing Gear, Duct, Propulsion System, Propeller, Motor, Electronic Speed Controller, Battery. **Command and Control System** ,RC Transmitter and Receiver Autopilot , Ground Control Station, Radio Telemetry.	5
02	**Airframe Design**, Configuration Design, Airframe Configuration, Aerodynamic Configuration, Control Surfaces, Structural Design, Design Principles of Airframe, Anti-Vibration Consideration , Noise Reduction Consideration	6
03	**Modeling and Evaluation of Propulsion System,** Problem Formulation. Power sources for propulsion, Propulsion System Modeling, Propeller Modeling, **Electrical Propulsion:** Motor Modeling, Electronic Speed Controller Modeling, Battery Modeling	6
04	**Perception** **Sensor Calibration and Measurement Model**, Fundamental Principle, Calibration, Measurement Model of Three-Axis Accelerometer, Three-Axis Gyroscope, Magnetometer, Ultrasonic Range Finder, Barometer, 2D Laser Range Finder Supplement: LiDAR, Global Positioning System Supplement: Latitude-and-Longitude Distance and Heading Calculation Camera Fundamental Principle , Calibration, Measurement Model	8

05	**Stability and Controllability**, Definition of Stability, Stability Criteria, Stability of Fixed wing and multicopters , Basic Concepts of Controllability , Classical Controllability, Positive Controllability , Controllability of Fixed wing and Multicopters , Fixed wing and Multicopter System Modeling , Framework of Low-Level Flight Control of Multicopters, Closed-loop structure of a low-level fight control system for multicopters.	8
06	**Communication Technologies for RC:** Radio**,** WiMax, Zigbee **Mission Decision-Making** , Fully-Autonomous Control , Brief Introduction ,Mission Planning , Path Planning, Semi-Autonomous Control, Three Modes of SAC ,Radio Control , Automatic Control Switching Logic Between RC and AC.	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) "Introduction to Multicopter Design and Control" Quan Quan, Springer
2) "Unmanned Aircraft Systems UAVs Design, Development and Deployment" Reg Austin Wieley 2010
3) "Introduction to Unmanned Aircraft Systems" Douglas M. Marshall • R. Kurt Barnhart
   Eric Shappee • Michael Most, CRC Press 2016
4) "Theory, Design and Applications of Unmanned Aerial Vehicles" A. R,. Jha CRC Press 2017

Links for online NPTEL/SWAYAM courses:
https://www.digimat.in/nptel/courses/video/101104073/L01.html
https://www.digimat.in/nptel/courses/video/101104083/L01.html
https://nptel.ac.in/courses/101104062

Course Code	Course Name	Credits
MTDLO8063	**Engineering Management and Economics**	**03**

Prerequisite: MTL504 Professional Communication and Ethics-II,

Objectives-

1.To prepare the students to understand and appreciate the basic fundamentals of management concepts, theory and application.

2. To make the students understand the building blocks of various management processes in organizations.

3. To give the students an exposure to concepts of project management.

4.To prepare the students, such that they are able to comprehend the need, definition,

functions and economic significance of financial institutions and markets.

Outcomes: Learner will be able to…

1. Understand and appreciate the basics of managerial concepts and practices used in day to day practices in organizations.

2.Creating organization structure and use insight to make more effective decisions

3. Appreciate the need to prepare oneself for holistic thinking and effectively managing organizations.

4.Develop competency in project management.

5.Understand economics and correlate economic concepts.

6. Understand and apply basic financial management in industrial context.

Module	Detailed Contents	Hrs.
01	**Introduction to management:** Brief history of Indian business scenario and recent changes, Globalization and competition, Need for managerial knowledge and skills. **Management:** Science, Theory and Practice: Definition of Management, Its nature and purpose, Managing- Science or Art? Contributions of F.W. Taylor and Henry Fayol to management theory, Functions of managers, Management and Society: Social responsibility of managers, Ethics of managing.	5
02	**Decision making:** Importance and limitations of rational decision making, Rationality in decision making, Evaluation of alternatives, Selecting an alternative- three approaches, Programmed and Non-programmed decisions. **Organizing:** The nature and purpose of organizing, formal and informal organization. Organization levels and Span of management, Principle of span of management and the factors determining an effective span. The structure and process of organizing, Matrix organization, Strategic business units, Line & staff concepts, Functional authority, Benefits and limitations of staff, Decentralization of authority, Delegation of authority.	7

03	**Planning:** Types of plans, Steps in planning, The planning process, Objectives-Nature of objectives. Concept in Management By Objectives (MBO), Process of MBO, Benefits and weakness of MBO. **Staffing:** HRM and selection: Definition of Staffing, Systems approach to HRM: Overview of staffing, Situational factors affecting staffing. Selection matching the person with the job, Systems approach to selection, Position requirements and job design, Skills and personal characteristics needed by managers, Performance appraisal and its purpose. **Leading:** Human factors in managing, Behavioral models, Motivation: Motivation and motivators. Theory of Maslow's Hierarchy of needs, Motivation-Hygiene approach to motivation, Theory X and Theory Y, Special Motivational techniques. **Leadership:** Definition, Ingredients of leadership, Leadership behavior and styles, Communication: Communication process, Communication in an enterprise, Barriers and breakdowns in communications. **Controlling:** Basic control process, Critical control points and standards, Control as a feedback system, Feed forward control, Requirements for effective control.	9
04	**Project management:** Gantt Charts, concepts of project planning, monitoring and control, elements of network analysis –PERT & CPM, cost analysis & crashing.	8
05	**Introduction to economics:** Definition of Economy, Central problems of an economy: what, how and for whom to produce; concepts of production possibility frontier and opportunity cost. Economics, its scope and importance. Introduction to Micro and Macroeconomics and their comparison.	4
06	**Financial Management:** Function of financial management, Nature of risk; interrelationship between risk and return; Project Costing, Costs and profits, Return on Investment, Balance Sheet statements, Analysis and interpretation of standard financial statements.	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. Principles of Management, Harold Koontz, H. Weihrich, and A.R. Aryasri, Tata McGrawHill, New Delhi.
2. Essential of Management, Harold Koontz and H. Weihrich,Tata Mc Graw-Hill, New Delhi.
3. Management of Organizational Behavior, Hersy, Paul and Kenneth Blanchard, PHI
4. Essentials of Microeconomics, Krister Ahlersten
5. Essentials of Macroeconomics, Peter Jochumzen
6. Operation Research by J K Sharma, Macmillan
7. Operation Research by Hamdy H. Taha, Pearson/Prentice Hall
8. "Fundamentals of Engineering Economics" Chan S. Park Pearson 2013

Links for online NPTEL/SWAYAM courses:
https://nptel.ac.in/courses/110104073
https://nptel.ac.in/courses/112107209
https://nptel.ac.in/courses/110106062
https://nptel.ac.in/courses/110107144

Course Code	Course Name	Credits
ILO8021	Project Management	03

Objectives:
1. To familiarize the students with the use of a structured methodology/approach for each and every unique project undertaken, including utilizing project management concepts, tools and techniques.
2. To appraise the students with the project management life cycle and make them knowledgeable about the various phases from project initiation through closure.

Outcomes: Learner will be able to…
1. Apply selection criteria and select an appropriate project from different options.
2. Write work break down structure for a project and develop a schedule based on it.
3. Identify opportunities and threats to the project and decide an approach to deal with them strategically.
4. Use Earned value technique and determine & predict status of the project.
5. Capture lessons learned during project phases and document them for future reference

Module	Detailed Contents	Hrs
01	**Project Management Foundation:** Definition of a project, Project Vs Operations, Necessity of project management, Triple constraints, Project life cycles (typical & atypical) Project phases and stage gate process. Role of project manager, Negotiations and resolving conflicts, Project management in various organization structures, PM knowledge areas as per Project Management Institute (PMI)	5
02	**Initiating Projects:** How to get a project started, selecting project strategically, Project selection models (Numeric /Scoring Models and Non-numeric models), Project portfolio process, Project sponsor and creating charter; Project proposal. Effective project team, Stages of team development & growth (forming, storming, norming &performing), team dynamics.	6
03	**Project Planning and Scheduling:** Work Breakdown structure (WBS) and linear responsibility chart, Interface Co-ordination and concurrent engineering, Project cost estimation and budgeting, Top down and bottoms up budgeting, Networking and Scheduling techniques. PERT, CPM, GANTT chart, Introduction to Project Management Information System (PMIS).	8
04	**Planning Projects:** Crashing project time, Resource loading and levelling, Goldratt's critical chain, Project Stakeholders and Communication plan Risk Management in projects: Risk management planning, Risk identification and risk register, Qualitative and quantitative risk assessment, Probability and impact matrix. Risk response strategies for positive and negative risks	6

05	**5.1 Executing Projects:** Planning monitoring and controlling cycle, Information needs and reporting, engaging with all stakeholders of the projects, Team management, communication and project meetings **5.2 Monitoring and Controlling Projects:** Earned Value Management techniques for measuring value of work completed; Using milestones for measurement; change requests and scope creep, Project audit **5.3 Project Contracting** Project procurement management, contracting and outsourcing,	8
06	**6.1 Project Leadership and Ethics:** Introduction to project leadership, ethics in projects, Multicultural and virtual projects **6.2 Closing the Project:** Customer acceptance; Reasons of project termination, Various types of project terminations (Extinction, Addition, Integration, Starvation), Process of project termination, completing a final report; doing a lessons learned analysis; acknowledging successes and failures; Project management templates and other resources; Managing without authority; Areas of further study.	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. Project Management: A managerial approach, Jack Meredith & Samuel Mantel, 7th Edition, Wiley India

2. A Guide to the Project Management Body of Knowledge (PMBOK® Guide), 5th Ed, Project Management Institute PA, USA

3. Project Management,Gido Clements, Cengage Learning

4. Project Management,Gopalan, Wiley India

5. Project Management,Dennis Lock, 9th Edition, Gower Publishing England

Course Code	Course Name	Credits
ILO8022	**Finance Management**	03

Objectives:
1. Overview of Indian financial system, instruments and market
2. Basic concepts of value of money, returns and risks, corporate finance, working capital and its management
3. Knowledge about sources of finance, capital structure, dividend policy

Outcomes: Learner will be able to…
1. Understand Indian finance system and corporate finance
2. Take investment, finance as well as dividend decisions

Module	Detailed Contents	Hrs
01	**Overview of Indian Financial System:** Characteristics, Components and Functions of Financial System. **Financial Instruments:** Meaning, Characteristics and Classification of Basic Financial Instruments — Equity Shares, Preference Shares, Bonds-Debentures, Certificates of Deposit, and Treasury Bills. **Financial Markets:** Meaning, Characteristics and Classification of Financial Markets — Capital Market, Money Market and Foreign Currency Market **Financial Institutions:** Meaning, Characteristics and Classification of Financial Institutions — Commercial Banks, Investment-Merchant Banks and Stock Exchanges	06
02	**Concepts of Returns and Risks:** Measurement of Historical Returns and Expected Returns of a Single Security and a Two-security Portfolio; Measurement of Historical Risk and Expected Risk of a Single Security and a Two-security Portfolio. **Time Value of Money:** Future Value of a Lump Sum, Ordinary Annuity, and Annuity Due; Present Value of a Lump Sum, Ordinary Annuity, and Annuity Due; Continuous Compounding and Continuous Discounting.	06
03	**Overview of Corporate Finance:** Objectives of Corporate Finance; Functions of Corporate Finance—Investment Decision, Financing Decision, and Dividend Decision. **Financial Ratio Analysis:** Overview of Financial Statements—Balance Sheet, Profit and Loss Account, and Cash Flow Statement; Purpose of Financial Ratio Analysis; Liquidity Ratios; Efficiency or Activity Ratios; Profitability Ratios; Capital Structure Ratios; Stock Market Ratios; Limitations of Ratio Analysis.	09
04	**Capital Budgeting:** Meaning and Importance of Capital Budgeting; Inputs for Capital Budgeting Decisions; Investment Appraisal Criterion—Accounting Rate of Return, Payback Period, Discounted	10

	Payback Period, Net Present Value(NPV), Profitability Index, Internal Rate of Return (IRR), and Modified Internal Rate of Return (MIRR) **Working Capital Management:** Concepts of Meaning Working Capital; Importance of Working Capital Management; Factors Affecting an Entity's Working Capital Needs; Estimation of Working Capital Requirements; Management of Inventories; Management of Receivables; and Management of Cash and Marketable Securities.	
05	**Sources of Finance:** Long Term Sources—Equity, Debt, and Hybrids; Mezzanine Finance; Sources of Short Term Finance—Trade Credit, Bank Finance, Commercial Paper; Project Finance. **Capital Structure:** Factors Affecting an Entity's Capital Structure; Overview of Capital Structure Theories and Approaches— Net Income Approach, Net Operating Income Approach; Traditional Approach, and Modigliani-Miller Approach. Relation between Capital Structure and Corporate Value; Concept of Optimal Capital Structure	05
06	**Dividend Policy:** Meaning and Importance of Dividend Policy; Factors Affecting an Entity's Dividend Decision; Overview of Dividend Policy Theories and Approaches—Gordon's Approach, Walter's Approach, and Modigliani-Miller Approach	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. Fundamentals of Financial Management, 13th Edition (2015) by Eugene F. Brigham and Joel F. Houston; Publisher: Cengage Publications, New Delhi.
2. Analysis for Financial Management, 10th Edition (2013) by Robert C. Higgins; Publishers: McGraw Hill Education, New Delhi.
3. Indian Financial System, 9th Edition (2015) by M. Y. Khan; Publisher: McGraw Hill Education, New Delhi.
4. Financial Management, 11th Edition (2015) by I. M. Pandey; Publisher: S. Chand (G/L) & Company Limited, New Delhi.

Course Code	Course Name	Credits
ILO8023	**Entrepreneurship Development and Management**	**03**

Objectives:

1. To acquaint with entrepreneurship and management of business
2. Understand Indian environment for entrepreneurship
3. Idea of EDP, MSME

Outcomes: Learner will be able to…

1. Understand the concept of business plan and ownerships
2. Interpret key regulations and legal aspects of entrepreneurship in India
3. Understand government policies for entrepreneurs

Module	Detailed Contents	Hrs
01	**Overview of Entrepreneurship:** Definitions, Roles and Functions/Values of Entrepreneurship, History of Entrepreneurship Development, Role of Entrepreneurship in the National Economy, Functions of an Entrepreneur, Entrepreneurship and Forms of Business Ownership Role of Money and Capital Markets in Entrepreneurial Development: Contribution of Government Agencies in Sourcing information for Entrepreneurship	04
02	**Business Plans And Importance Of Capital To Entrepreneurship:** Preliminary and Marketing Plans, Management and Personnel, Start-up Costs and Financing as well as Projected Financial Statements, Legal Section, Insurance, Suppliers and Risks, Assumptions and Conclusion, Capital and its Importance to the Entrepreneur **Entrepreneurship And Business Development:** Starting a New Business, Buying an Existing Business, New Product Development, Business Growth and the Entrepreneur Law and its Relevance to Business Operations	09
03	Women's Entrepreneurship Development, Social entrepreneurship-role and need, EDP cell, role of sustainability and sustainable development for SMEs, case studies, exercises	05
04	**Indian Environment for Entrepreneurship:** key regulations and legal aspects , MSMED Act 2006 and its implications, schemes and policies of the Ministry of MSME, role and responsibilities of various government organisations, departments, banks etc., Role of State governments in terms of infrastructure developments and support etc., Public private partnerships, National Skill development Mission, Credit Guarantee Fund, PMEGP, discussions, group exercises etc	08
05	**Effective Management of Business:** Issues and problems faced by micro and small enterprises and effective management of M and S enterprises (risk management, credit availability, technology innovation, supply chain management, linkage with large industries), exercises, e-Marketing	08
06	**Achieving Success In The Small Business:** Stages of the small business life cycle, four types of firm-level growth strategies, Options – harvesting or closing small business Critical Success factors of small business	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. Poornima Charantimath, Entrepreneurship development- Small Business Enterprise, Pearson
2. Education Robert D Hisrich, Michael P Peters, Dean A Shapherd, Entrepreneurship, latest edition, The McGrawHill Company
3. Dr TN Chhabra, Entrepreneurship Development, Sun India Publications, New Delhi
4. Dr CN Prasad, Small and Medium Enterprises in Global Perspective, New century Publications, New Delhi
5. Vasant Desai, Entrepreneurial development and management, Himalaya Publishing House
6. Maddhurima Lall, Shikah Sahai, Entrepreneurship, Excel Books
7. Rashmi Bansal, STAY hungry STAY foolish, CIIE, IIM Ahmedabad
8. Law and Practice relating to Micro, Small and Medium enterprises, Taxmann Publication Ltd.
9. Kurakto, Entrepreneurship- Principles and Practices, Thomson Publication
10. Laghu Udyog Samachar
11. www.msme.gov.in
12. www.dcmesme.gov.in
13. www.msmetraining.gov.in

Course Code	Course Name	Credits
ILO8024	**Human Resource Management**	**03**

Objectives:
1. To introduce the students with basic concepts, techniques and practices of the human resource management
2. To provide opportunity of learning Human resource management (HRM) processes, related with the functions, and challenges in the emerging perspective of today's organizations
3. To familiarize the students about the latest developments, trends & different aspects of HRM
4. To acquaint the student with the importance of inter-personal & inter-group behavioural skills in an organizational setting required for future stable engineers, leaders and managers

Outcomes: Learner will be able to…
1. Understand the concepts, aspects, techniques and practices of the human resource management.
2. Understand the Human resource management (HRM) processes, functions, changes and challenges in today's emerging organizational perspective.
3. Gain knowledge about the latest developments and trends in HRM.
4. Apply the knowledge of behavioural skills learnt and integrate it with in inter personal and intergroup environment emerging as future stable engineers and managers.

Module	Detailed Contents	Hrs
01	**Introduction to HR** • Human Resource Management- Concept, Scope and Importance, Interdisciplinary Approach Relationship with other Sciences, Competencies of HR Manager, HRM functions • Human resource development (HRD): changing role of HRM – Human resource Planning, Technological change, Restructuring and rightsizing, Empowerment, TQM, Managing ethical issues	5
02	**Organizational Behaviour (OB)** • Introduction to OB Origin, Nature and Scope of Organizational Behaviour, Relevance to Organizational Effectiveness and Contemporary issues • Personality: Meaning and Determinants of Personality, Personality development, Personality Types, Assessment of Personality Traits for Increasing Self Awareness • Perception: Attitude and Value, Effect of perception on Individual Decision-making, Attitude and Behaviour • Motivation: Theories of Motivation and their Applications for Behavioural Change (Maslow, Herzberg, McGregor); • Group Behaviour and Group Dynamics: Work groups formal and informal groups and stages of group development, Team Effectiveness: High performing teams, Team Roles, cross functional and self-directed team. • Case study	7

03	**Organizational Structure &Design** • Structure, size, technology, Environment of organization; Organizational Roles & conflicts: Concept of roles; role dynamics; role conflicts and stress. • Leadership: Concepts and skills of leadership, Leadership and managerial roles, Leadership styles and contemporary issues in leadership. • Power and Politics: Sources and uses of power; Politics at workplace, Tactics and strategies.	6
04	**Human resource Planning** • Recruitment and Selection process, Job-enrichment, Empowerment - Job-Satisfaction, employee morale • Performance Appraisal Systems: Traditional & modern methods, Performance Counselling, Career Planning • Training & Development: Identification of Training Needs, Training Methods	5
05	**Emerging Trends in HR** • Organizational development; Business Process Re-engineering (BPR), BPR as a tool for organizational development, managing processes & transformation in HR. Organizational Change, Culture, Environment • Cross Cultural Leadership and Decision Making**:** Cross Cultural Communication and diversity at work**,** Causes of diversity, managing diversity with special reference to handicapped, women and ageing people, intra company cultural difference in employee motivation	6
06	**HR & MIS:** Need, purpose, objective and role of information system in HR, Applications in HRD in various industries (e.g. manufacturing R&D, Public Transport, Hospitals, Hotels and service industries **Strategic HRM:** Role of Strategic HRM in the modern business world, Concept of Strategy, Strategic Management Process, Approaches to Strategic Decision Making; Strategic Intent – Corporate Mission, Vision, Objectives and Goals **Labor Laws & Industrial Relations:** Evolution of IR, IR issues in organizations, Overview of Labor Laws in India; Industrial Disputes Act, Trade Unions Act, Shops and Establishments Act	10

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. Stephen Robbins, Organizational Behavior, 16th Ed, 2013
2. V S P Rao, Human Resource Management, 3rd Ed, 2010, Excel publishing
3. Aswathapa, Human resource management: Text & cases, 6th edition, 2011
4. C. B. Mamoria and S V Gankar, Dynamics of Industrial Relations in India, 15th Ed, 2015, Himalaya Publishing, 15thedition, 2015
5. P. Subba Rao, Essentials of Human Resource management and Industrial relations, 5th Ed, 2013, Himalaya Publishing
6. Laurie Mullins, Management & Organizational Behavior, Latest Ed, 2016, Pearson Publications

Course Code	Course Name	Credits
ILO8025	**Professional Ethics and Corporate Social Responsibility (CSR)**	**03**

Objectives:

1. To understand professional ethics in business
2. To recognized corporate social responsibility

Outcomes: Learner will be able to…

1. Understand rights and duties of business
2. Distinguish different aspects of corporate social responsibility
3. Demonstrate professional ethics
4. Understand legal aspects of corporate social responsibility

Module	Detailed Contents	Hrs
01	**Professional Ethics and Business:** The Nature of Business Ethics; Ethical Issues in Business; Moral Responsibility and Blame; Utilitarianism: Weighing Social Costs and Benefits; Rights and Duties of Business	04
02	**Professional Ethics in the Marketplace:** Perfect Competition; Monopoly Competition; Oligopolistic Competition; Oligopolies and Public Policy **Professional Ethics and the Environment:** Dimensions of Pollution and Resource Depletion; Ethics of Pollution Control; Ethics of Conserving Depletable Resources	08
03	**Professional Ethics of Consumer Protection:** Markets and Consumer Protection; Contract View of Business Firm's Duties to Consumers; Due Care Theory; Advertising Ethics; Consumer Privacy **Professional Ethics of Job Discrimination:** Nature of Job Discrimination; Extent of Discrimination; Reservation of Jobs.	06
04	**Introduction to Corporate Social Responsibility:** Potential Business Benefits—Triple bottom line, Human resources, Risk management, Supplier relations; Criticisms and concerns—Nature of business; Motives; Misdirection. Trajectory of Corporate Social Responsibility in India	05
05	**Corporate Social Responsibility:** Articulation of Gandhian Trusteeship Corporate Social Responsibility and Small and Medium Enterprises (SMEs) in India, Corporate Social Responsibility and Public-Private Partnership (PPP) in India	08
06	**Corporate Social Responsibility in Globalizing India:** Corporate Social Responsibility Voluntary Guidelines, 2009 issued by the Ministry of Corporate Affairs, Government of India, Legal Aspects of Corporate Social Responsibility—Companies Act, 2013.	08

<u>Assessment:</u>

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. Business Ethics: Texts and Cases from the Indian Perspective (2013) by Ananda Das Gupta; Publisher: Springer.
2. Corporate Social Responsibility: Readings and Cases in a Global Context (2007) by Andrew Crane, Dirk Matten, Laura Spence; Publisher: Routledge.
3. Business Ethics: Concepts and Cases, 7th Edition (2011) by Manuel G. Velasquez; Publisher: Pearson, New Delhi.
4. Corporate Social Responsibility in India (2015) by Bidyut Chakrabarty, Routledge, New Delhi.

Course Code	Course Name	Credits
ILO8026	**Research Methodology**	**03**

Objectives:

1. To understand Research and Research Process
2. To acquaint students with identifying problems for research and develop research strategies
3. To familiarize students with the techniques of data collection, analysis of data and interpretation

Outcomes: Learner will be able to…

1. Prepare a preliminary research design for projects in their subject matter   areas
2. Accurately collect, analyze and report data
3. Present complex data or situations clearly
4. Review and analyze research findings

Module	Detailed Contents	Hrs
01	**Introduction and Basic Research Concepts** **1.1** Research – Definition; Concept of Construct, Postulate, Proposition, Thesis, Hypothesis, Law, Principle.Research methods vs Methodology **1.2** Need of Research in Business and Social Sciences **1.3** Objectives of Research **1.4 Issues** and Problems in Research **1.5** Characteristics of Research:Systematic, Valid, Verifiable, Empirical and Critical	09
02	**Types of Research** **2.1**. Basic Research **2.2**. Applied Research **2.3**. Descriptive Research **2.4**. Analytical Research **2.5**. Empirical Research **2.6** Qualitative and Quantitative Approaches	07
03	**Research Design and Sample Design** **3.1** Research Design – Meaning, Types and Significance **3.2** Sample Design – Meaning and Significance Essentials of a good sampling Stages in Sample Design Sampling methods/techniques Sampling Errors	07
04	**Research Methodology** **4.1** Meaning of Research Methodology **4.2**. Stages in Scientific Research Process: **a.** Identification and Selection of Research Problem **b.** Formulation of Research Problem **c.** Review of Literature **d.** Formulation of Hypothesis **e.** Formulation of research Design **f**. Sample Design **g.** Data Collection	08

	h. Data Analysis **i.** Hypothesis testing and Interpretation of Data **j.** Preparation of Research Report		
05	**Formulating Research Problem** **5.1** Considerations: Relevance, Interest, Data Availability, Choice of data, Analysis of data, Generalization and Interpretation of analysis	**04**
06	**Outcome of Research** **6.1** Preparation of the report on conclusion reached **6.2** Validity Testing & Ethical Issues **6.3** Suggestions and Recommendation	**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. Dawson, Catherine, 2002, Practical Research Methods, New Delhi, UBS Publishers Distributors.
2. Kothari, C.R.,1985, Research Methodology-Methods and Techniques, New Delhi, Wiley Eastern Limited.
3. Kumar, Ranjit, 2005, Research Methodology-A Step-by-Step Guide for Beginners, (2nded), Singapore, Pearson Education

Course Code	Course Name	Credits
ILO8027	**IPR and Patenting**	**03**

Objectives:
1. To understand intellectual property rights protection system
2. To promote the knowledge of Intellectual Property Laws of India as well as International treaty procedures
3. To get acquaintance with Patent search and patent filing procedure and applications

Outcomes: Learner will be able to…
1. understand Intellectual Property assets
2. assist individuals and organizations in capacity building
3. work for development, promotion, protection, compliance, and enforcement of Intellectual Property and Patenting

Module	Detailed Contents	Hr
01	**Introduction to Intellectual Property Rights (IPR)**: Meaning of IPR, Different category of IPR instruments - Patents, Trademarks,Copyrights, Industrial Designs, Plant variety protection, Geographical indications,Transfer of technology etc. **Importance of IPR in Modern Global Economic Environment:** Theories of IPR, Philosophical aspects of IPR laws, Need for IPR, IPR as an instrument of development	05
02	**Enforcement of Intellectual Property Rights:** Introduction, Magnitude of problem, Factors that create and sustain counterfeiting/piracy, International agreements, International organizations (e.g. WIPO, WTO) active in IPR enforcement **Indian Scenario of IPR:**Introduction, History of IPR in India, Overview of IP laws in India, Indian IPR, Administrative Machinery, Major international treaties signed by India, Procedure for submitting patent and Enforcement of IPR at national level etc.	07
03	**Emerging Issues in IPR:**Challenges for IP in digital economy, e-commerce, human genome, biodiversity and traditional knowledge etc.	05
04	**Basics of Patents:** Definition of Patents, Conditions of patentability, Patentable and non-patentable inventions, Types of patent applications (e.g. Patent of addition etc), Process Patent and Product Patent, Precautions while patenting, Patent specification Patent claims, Disclosures and non-disclosures, Patent rights and infringement, Method of getting a patent	07
05	**Patent Rules:** Indian patent act, European scenario, US scenario, Australia scenario, Japan scenario, Chinese scenario, Multilateral treaties where India is a member (TRIPS agreement, Paris convention etc.)	08

06	**Procedure for Filing a Patent (National and International):** Legislation and Salient Features, Patent Search, Drafting and Filing Patent Applications, Processing of patent, Patent Litigation, Patent Publication, Time frame and cost, Patent Licensing, Patent Infringement **Patent databases:** Important websites, Searching international databases	07

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**.

REFERENCE BOOKS:

1. Rajkumar S. Adukia, 2007, A Handbook on Laws Relating to Intellectual Property Rights in India, The Institute of Chartered Accountants of India
2. Keayla B K, Patent system and related issues at a glance, Published by National Working Group on Patent Laws
3. T Sengupta, 2011, Intellectual Property Law in India, Kluwer Law International
4. Tzen Wong and Graham Dutfield, 2010, Intellectual Property and Human Development: Current Trends and Future Scenario, Cambridge University Press
5. Cornish, William Rodolph & Llewelyn, David. 2010, Intellectual Property: Patents, Copyrights, Trade Marks and Allied Right, 7th Edition, Sweet & Maxwell
6. Lous Harns, 2012, The enforcement of Intellactual Property Rights: A Case Book, 3rd Edition, WIPO
7. Prabhuddha Ganguli, 2012, Intellectual Property Rights, 1st Edition, TMH
8. R Radha Krishnan & S Balasubramanian, 2012, Intellectual Property Rights, 1st Edition, Excel Books
9. M Ashok Kumar and mohd Iqbal Ali, 2-11, Intellectual Property Rights, 2nd Edition, Serial Publications
10. Kompal Bansal and Praishit Bansal, 2012, Fundamentals of IPR for Engineers, 1st Edition, BS Publications

11. Entrepreneurship Development and IPR Unit, BITS Pilani, 2007, A Manual on Intellectual Property Rights,
12. Mathew Y Maa, 2009, Fundamentals of Patenting and Licensing for Scientists and Engineers, World Scientific Publishing Company
13. N S Rathore, S M Mathur, Priti Mathur, Anshul Rathi, IPR: Drafting,Interpretation of Patent Specifications and Claims, New India Publishing Agency
14. Vivien Irish, 2005, Intellectual Property Rights for Engineers,IET
15. Howard B Rockman, 2004, Intellectual Property Law for Engineers and scientists, Wiley-IEEE Press.

Course Code	Course Name	Credits
ILO8028	**Digital Business Management**	**03**

Objectives:
1. To familiarize with digital business concept
2. To acquaint with E-commerce
3. To give insights into E-business and its strategies

Outcomes: The learner will be able to …..
1. Identify drivers of digital business
2. Illustrate various approaches and techniques for E-business and management
3. Prepare E-business plan

Module	Detailed content	Hours
1	**Introduction to Digital Business-** Introduction, Background and current status, E-market places, structures, mechanisms, economics and impacts Difference between physical economy and digital economy, **Drivers of digital business**- Big Data & Analytics, Mobile, Cloud Computing, Social media, BYOD, and Internet of Things (digitally intelligent machines/services) Opportunities and Challenges in Digital Business,	09
2	**Overview of E-Commerce** **E-Commerce-** Meaning, Retailing in e-commerce-products and services, consumer behavior, market research and advertisement B2B-E-commerce-selling and buying in private e-markets, public B2B exchanges and support services, e-supply chains, Collaborative Commerce, Intra business EC and Corporate portals Other E-C models and applications, innovative EC System-From E-government and learning to C2C, mobile commerce and pervasive computing EC Strategy and Implementation-EC strategy and global EC, Economics and Justification of EC, Using Affiliate marketing to promote your e-commerce business, Launching a successful online business and EC project, Legal, Ethics and Societal impacts of EC	06
3	**Digital Business Support services**: ERP as e –business backbone, knowledge Tope Apps, Information and referral system **Application Development:** Building Digital business Applications and Infrastructure	06
4	**Managing E-Business**-Managing Knowledge, Management skills for e-business, Managing Risks in e –business Security Threats to e-business -Security Overview, Electronic Commerce Threats, Encryption, Cryptography, Public Key and Private Key Cryptography, Digital Signatures, Digital Certificates, Security Protocols over Public Networks: HTTP, SSL, Firewall as Security Control, Public Key Infrastructure (PKI) for Security, Prominent Cryptographic Applications	06
5	**E-Business Strategy**-E-business Strategic formulation- Analysis of Company's Internal and external environment, Selection of strategy,	04

		E-business strategy into Action, challenges and E-Transition (Process of Digital Transformation)	
6		**Materializing e-business: From Idea to Realization**-Business plan preparation **Case Studies and presentations**	08

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. A textbook on E-commerce**,** Er Arunrajan Mishra, Dr W K Sarwade,Neha Publishers & Distributors, 2011
2. E-commerce from vision to fulfilment, Elias M. Awad, PHI-Restricted, 2002
3. Digital Business and E-Commerce Management, 6th Ed, Dave Chaffey, Pearson, August 2014
4. Introduction to E-Business-Management and Strategy, Colin Combe, ELSVIER, 2006
5. Digital Business Concepts and Strategy, Eloise Coupey, 2nd Edition, Pearson
6. Trend and Challenges in Digital Business Innovation, VinocenzoMorabito, Springer
7. Digital Business Discourse Erika Darics, April 2015, Palgrave Macmillan
8. E-Governance-Challenges and Opportunities in : Proceedings in 2nd International Conference theory and practice of Electronic Governance
9. Perspectives the Digital Enterprise –A framework for Transformation, TCS consulting journal Vol.5
10. Measuring Digital Economy-A new perspective- DoI:10.1787/9789264221796-enOECD Publishing

Course Code	Course Name	Credits
ILO8029	**Environmental Management**	**03**

Objectives:

1. Understand and identify environmental issues relevant to India and global concerns
2. Learn concepts of ecology
3. Familiarise environment related legislations

Outcomes: Learner will be able to…

1. Understand the concept of environmental management
2. Understand ecosystem and interdependence, food chain etc.
3. Understand and interpret environment related legislations

Module	Detailed Contents	Hrs
01	Introduction and Definition of Environment: Significance of Environment Management for contemporary managers, Career opportunities, Environmental issues relevant to India, Sustainable Development, the Energy scenario	10
02	Global Environmental concerns : Global Warming, Acid Rain, Ozone Depletion, Hazardous Wastes, Endangered life-species, Loss of Biodiversity, Industrial/Man-made disasters, Atomic/Biomedical hazards, etc.	06
03	Concepts of Ecology: Ecosystems and interdependence between living organisms, habitats, limiting factors, carrying capacity, food chain, etc.	05
04	Scope of Environment Management, Role and functions of Government as a planning and regulating agency Environment Quality Management and Corporate Environmental Responsibility	10
05	Total Quality Environmental Management, ISO-14000, EMS certification.	05
06	General overview of major legislations like Environment Protection Act, Air (P & CP) Act, Water (P & CP) Act, Wildlife Protection Act, Forest Act, Factories Act, etc.	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. Environmental Management: Principles and Practice, C J Barrow, Routledge Publishers London, 1999
2. A Handbook of Environmental Management Edited by Jon C. Lovett and David G. Ockwell, Edward Elgar Publishing
3. Environmental Management V Ramachandra and Vijay Kulkarni, TERI Press
4. Indian Standard Environmental Management Systems — Requirements With Guidance For Use, Bureau Of Indian Standards, February 2005
5. Environmental Management: An Indian Perspective, S N Chary and Vinod Vyasulu, Maclillan India, 2000
6. Introduction to Environmental Management, Mary K Theodore and Louise Theodore, CRC Press
   Environment and Ecology, Majid Hussain, 3rd Ed. Access Publishing.2015

Course Code	Course Name	Credits
MTL801	**Robotics and Machine Vision Laboratory**	**01**

Prerequisites: MTC402 Kinematics of Machinery, MTC502 Sensors and Actuators, MTC503 Mechatronic Systems Modelling and Control, MTL702 Mechatronics Lab

Objectives:
1) Introduce Mobile robotics
2) Introduce Robotic manipulators
3) Introduce image acquisition and processing
4) Introduce Development of robotic systems

Outcomes: Students will be able to…
1) Program and control mobile robots
2) Program and control robotic manipulators
3) Implement basic image processing
4) Design and implement robotic system.

Suggested List of laboratory experiments (Minimum Eight):

	Sr. No.	Experiment List
Part A: Mobile Robotics	**1**	Study of mobile robot steering with Differential, Bicycle, Tricycle, Ackermann, Synchronous and Omnidirectional drives.
	2	Remote control of mobile robot implementation
	3	Program Mobile robot platform for line following based on vision sensor on hardware / simulator.
	4	Sensor based obstacle detection and autonomous driving of mobile robot.
Part B: Robotic Arm	**5**	Study components of a real robotic manipulator (Industrial / Cobot) and its DH parameters.
	6	Forward kinematics and validate using a software (Robo Analyser or any other software tool).
	7	Inverse kinematics of the real robotic arm and validation using any software. software (Robo Analyser or any other software tool).
	8	Positioning and orientation of robot arm end effector
Part C: Image Processing	**9**	Image acquisition and edge detection using convolution in OpenCV / Matlab
	10	Image Processing for color/shape detection using OpenCV / Matlab
	11	Object tracking using OpenCV /Matlab
Part D Course Project	**12**	Implement Robot task with integration of assorted sensors (IR, Potentiometer, strain gages etc.), camera and micro controllers and ROS (Robot Operating System) in a robotic system.

Term Work:

Term work consists of performing 3 experiments each from Part A and Part B and any 2 experiments from Part C and course project Part D 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)   :   15 marks.
- Course Project   :   05 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
MTL802	**Industrial Automation and Industry 4.0 Lab**	**01**

Prerequisites:

Objectives:

    1) Introduce Mechanical Assembly and wiring skills

    2) Introduce PLC Based Automation Systems

    3) Introduce HMI/SCADA/DCS implementation

    4) Introduce Industry 4.0 technologies in automation

Outcomes: Students will be able to…
1) Mechanical design and assembly of automation systems
2) Design control panel and perform electrical wiring
3) Interfacing and control of PLC based automation systems
4) Develop automation systems with Industry 4.0 technologies

Suggested List of laboratory experiments (Minimum Eight):

	Sr. No.	Experiment List
Part A: Basic	1	Experiment on mechanical design and assembly of aluminum profile based structures / Automation systems.
	2	Experiment on PLC control panel design using e-plan/ AutoCAD Electrical or similar software
	3	Control panel wiring for PLC and AC Servo / VFD based system
	4	Experiment on PLC controlled electro-pneumatic / electro-hydraulic automation (Simulation + Hardware)
Part B: Advanced	5	Experiment on AC Servo Motor control using PLC
	6	Experiment with multi axis motion control for industrial application
	7	Experiment on study of Industrial communication protocols and using any industry standard communication bus.
	8	PID control implementation in Industrial automation (Simulation + Hardware)
	9	Experiment on HMI Design with Alarm management
	10	Experiment on SCADA / DCS implementation
Part C: Industry 4.0	11	Experiment on RFID based service oriented automation
	12	Experiment on industrial IOT using OPC UA for Automation
	13	Experiment involving Digital Twin

Term Work:

Term work consists of performing any 3 Experiments each from Part A and Part B and any 2 Experiments from Part C 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)   :   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	Credit
MTP801	Major Project II	06

Course Objectives::	
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 to successful completion of the project by implementing the solution.	
Course Outcomes: Learner will able to	
1	Students will be able to implement solutions for the selected problem by applying technical and professional skills.
2	Students will be able to analyze impact of solutions in societal and environmental context for sustainable development.
3	Students will be able to collaborate best practices along with effective use of modern tools.
4	Students will be able to develop proficiency in oral and written communication with effective leadership and teamwork.
5	Students will be able to nurture professional and ethical behavior.
6	Students will be able to gain expertise that helps in building lifelong learning experience.

Guidelines:

1. 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.

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. Report should be submitted in hardcopy. Also, each group should submit softcopy of the report along with project documentation, implementation code, required utilities, software and user Manuals.

   A project report should preferably contain at least following details:
   - Abstract
   - Introduction
   - Literature Survey/ Existing system
   - Limitation Existing system or research gap
   - Problem Statement and Objective
   - Proposed System

- o Analysis/Framework/ Algorithm
- o Design details
- o Methodology (your approach to solve the problem) Proposed System
- o Experimental Set up
  - o Details of Database or details about input to systems or selected data
  - o Performance Evaluation Parameters (for Validation)
  - o Software and Hardware Set up
- o Results and Discussion
- o Conclusion and Future Work
- o References
- o Appendix – List of Publications or certificates

Desirable
- ● Students should be encouraged
  - o to participate in various project competition.
  - o to write minimum one technical paper & publish in good journal.
  - o to participate in national / international conference.

3. Term Work:

Distribution of marks for term work shall be done based on following:
a. Weekly Log Report
b. Completeness of the project and Project Work Contribution
c. Project Report (Black Book) (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 2 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 following:
1. Relevance to the specialization / industrial trends
2. Modern tools used
3. Innovation
4. Quality of work and completeness of the project
5. Validation of results
6. Impact and business value
7. Quality of written and oral presentation
8. Individual as well as team work