UNIVERSITY OF MUMBAI

Bachelor of Engineering

in

Mechatronics Engineering

Final Year with Effect from AY 2022-23

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

Under

FACULTY OF SCIENCE & TECHNOLOGY

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

Preamble

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

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

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

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

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

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Incorporation and implementation of Online Contents from NPTEL/ Swayam Platform

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

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

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

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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
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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 Automation and Industry 4.0 Laboratory	--	--	--	--	--	25	25	50
MTP801	Major Project II	--	--	--	--	--	50	100	150
Total		**--**	**--**	**80**	**320**	--	**100**	**150**	**650**

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

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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. 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

Svv lab

Institute Optional Courses

Course Code	Institute Elective Course-II #
ILO8021	Project Management
ILO8022	Finance Management
ILO8023	Entrepreneurship Development and Management
ILO8024	Human Resource Management
ILO8025	Professional Ethics and CSR
ILO8026	Research Methodology
ILO8027	IPR and Patenting
ILO8028	Digital Business Management
ILO8029	Environmental Management

 # Common with all branches

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

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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. 2.3Implementation 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.

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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

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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	6

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	framework for Industry 4.0, Industrial IoT (IIoT) - Introduction, Business 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.
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3. Question No: 01 will be compulsory and based on entire syllabus wherein sub- questions of 2 to 5 marks will be asked.
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.

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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/

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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

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	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** 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	10
05	**Antennas and Wave Propagation** 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	4
06	**Wireless Communication Systems and application** 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	5

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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

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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

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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 Alpaydin, “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**

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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	4

Draft Syllabus

	Calibration Homogeneous Transformation	
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 Blaži ˇc, 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

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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

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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

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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

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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

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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

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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	6

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	positive and negative risks	
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

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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	10

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	Criterion—Accounting Rate of Return, Payback Period, Discounted 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.

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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

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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

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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

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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**.

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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

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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

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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. 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.

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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**

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	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, (2nd ed), Singapore, Pearson Education

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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

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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**
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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

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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.

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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

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	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

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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

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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

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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.

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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.

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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

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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.

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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

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

Desirable

- Students should be encouraged
  - to participate in various project competition.
  - to write minimum one technical paper & publish in good journal.
  - 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

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