

University of Mumbai



No. AAMS_UGS/ICC/2024-25/179

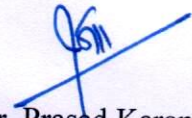
CIRCULAR:-

Attention of the Principals of the Affiliated Colleges and Directors of the Recognized Institutions in Faculty of Science & Technology is invited to this office Circular No. AAMS_UGS/ICC/2023-24/68 dated 24th November, 2023 relating to the B.E. (Automation and Robotics) (Sem – V & VI) (CBCS).

They are hereby informed that the recommendations made by the Board of Deans at its meeting held on 23rd October, 2024 vide item No. 6.7 (N) has been accepted by the Hon'ble Vice Chancellor as per the powers confirmed upon him under Section 12 (7) of the Maharashtra Public Universities Act, 2016 and that in accordance therewith syllabus of **B.E. (Automation and Robotics) (Sem – VII & VIII)** is introduced and the same has been brought into force with effect from the academic year 2024-25.

(The said circular is available on the University's website www.mu.ac.in).

MUMBAI – 400 032
30th October, 2024


(Dr. Prasad Karande)
REGISTRAR

To,

The Principals of the Affiliated Colleges and Directors of the Recognized Institutions in Faculty of Science & Technology.

BOD/6.7(N) /23/10/2024

Copy forwarded with Compliments for information to:-

- 1) The Chairman, Board of Deans,
- 2) The Dean and Associate Dean, Faculty of Science & Technology,
- 3) The Chairman, Board of Studies,
- 4) The Director, Board of Examinations and Evaluation,
- 5) The Director, Department of Students Development,
- 6) The Director, Department of Information & Communication Technology,
- 7) The Director, Institute of Distance and Open Learning (IDOL Admin), Vidyanagari.
- 8) The Deputy Registrar, Admissions, Enrolment, Eligibility & Migration Department (AEM).

Copy forwarded for information and necessary action to :-	
1	The Deputy Registrar, (Admissions, Enrolment, Eligibility and Migration Dept)(AEM), dr@eligi.mu.ac.in
2	The Deputy Registrar, Result unit, Vidyanagari drresults@exam.mu.ac.in
3	The Deputy Registrar, Marks and Certificate Unit,. Vidyanagari dr.verification@mu.ac.in
4	The Deputy Registrar, Appointment Unit, Vidyanagari dr.appointment@exam.mu.ac.in
5	The Deputy Registrar, CAP Unit, Vidyanagari cap.exam@mu.ac.in
6	The Deputy Registrar, College Affiliations & Development Department (CAD), deputyregistrar.uni@gmail.com
7	The Deputy Registrar, PRO, Fort, (Publication Section), Pro@mu.ac.in
8	The Deputy Registrar, Executive Authorities Section (EA) eau120@fort.mu.ac.in He is requested to treat this as action taken report on the concerned resolution adopted by the Academic Council referred to the above circular.
9	The Deputy Registrar, Research Administration & Promotion Cell (RAPC), rapc@mu.ac.in
10	The Deputy Registrar, Academic Appointments & Quality Assurance (AAQA) dy.registrar.tau.fort.mu.ac.in ar.tau@fort.mu.ac.in
11	The Deputy Registrar, College Teachers Approval Unit (CTA), concolsection@gmail.com
12	The Deputy Registrars, Finance & Accounts Section, fort draccounts@fort.mu.ac.in
13	The Deputy Registrar, Election Section, Fort drelection@election.mu.ac.in
14	The Assistant Registrar, Administrative Sub-Campus Thane, thanesubcampus@mu.ac.in
15	The Assistant Registrar, School of Engg. & Applied Sciences, Kalyan, ar.seask@mu.ac.in
16	The Assistant Registrar, Ratnagiri Sub-centre, Ratnagiri, ratnagirisubcentar@gmail.com
17	The Director, Centre for Distance and Online Education (CDOE), Vidyanagari, director@idol.mu.ac.in
18	Director, Innovation, Incubation and Linkages, Dr. Sachin Laddha pinkumanno@gmail.com
19	Director, Department of Lifelong Learning and Extension (DLLE), dlleuniversityofmumbai@gmail.com

Copy for information :-	
1	P.A to Hon'ble Vice-Chancellor, vice-chancellor@mu.ac.in
2	P.A to Pro-Vice-Chancellor pvc@fort.mu.ac.in
3	P.A to Registrar, registrar@fort.mu.ac.in
4	P.A to all Deans of all Faculties
5	P.A to Finance & Account Officers, (F & A.O), camu@accounts.mu.ac.in

To,

1	The Chairman, Board of Deans pvc@fort.mu.ac.in
2	Faculty of Humanities, Dean 1. Prof.Anil Singh Dranilsingh129@gmail.com Associate Dean 2. Dr.Suchitra Naik Naiksuchitra27@gmail.com 3.Prof.Manisha Karne mkarne@economics.mu.ac.in
	Faculty of Commerce & Management, Dean 1. Dr.Kavita Laghate kavitalaghate@jbims.mu.ac.in Associate Dean 2. Dr.Ravikant Balkrishna Sangurde Ravikant.s.@somaiya.edu 3. Prin.Kishori Bhagat kishoribhagat@rediffmail.com

	Faculty of Science & Technology Dean 1. Prof. Shivram Garje ssgarje@chem.mu.ac.in Associate Dean 2. Dr. Madhav R. Rajwade Madhavr64@gmail.com 3. Prin. Deven Shah sir.deven@gmail.com
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3	Chairman, Board of Studies,
4	The Director, Board of Examinations and Evaluation, dboee@exam.mu.ac.in
5	The Director, Board of Students Development, dsd@mu.ac.in DSW directr@dsw.mu.ac.in
6	The Director, Department of Information & Communication Technology, director.dict@mu.ac.in

AC –
Item No. –

University of Mumbai



B.E. (Automation and Robotics)

Syllabus for

Semester – Sem. VII & VIII

(with effect from the academic year 2024–2025)

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

University of Mumbai



Sr. No.	Heading	Particulars
1	Title of program O: _____	B.E. (Automation and Robotics)
2	Eligibility for Admission O: _____	as per the University Ordinance
3	Standards of Passing R: _____	40%
4	Semesters	Sem. VII & VIII
5	Program Academic Level	U.G.
6	Pattern	Semester
7	Status	Revised 2019 'C' Scheme
8	To be implemented from Academic Year	2024-25

BoS-Chairman
Dr. S. K. Shinde
BoS-Chairman-Computer
Engineering
Faculty of Science & Technology
University of Mumbai

Offg. Associate Dean
Dr. Deven Shah
Faculty of Science and
Technology
University of Mumbai

Offg. Dean
Prof. Shivram S. Garje
Faculty of Science and
Technology
University of Mumbai

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 170, where in 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 Final Year of Engineering from the academic year 2024-25. Subsequently this will be carried forward for final year Engineering in the academic years 2024-25 respectively.

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 this particular syllabus wherever possible additional resource links of platforms such as NPTEL, Swayam are appropriately provided. Efforts were made to use online contents more appropriately as additional learning materials to enhance learning of students.

In the current syllabus based on the recommendation of AICTE model curriculum overall credits are reduced to 170, to provide opportunity of self-learning to learner. Learners are now getting sufficient time for self-learning either through online courses or additional projects for enhancing their knowledge and skill sets.

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

Dr. Deven Shah

Associate Dean

Faculty of Science and Technology

University of Mumbai

Program Structure for Final Year Automation and Robotics Engineering
University of Mumbai (With Effect from 2024-2025)
Semester VII

Course Code	Course Name	Teaching Scheme (Contact Hours)		Theory	Pract	Total
		Theory	Pract.			
ARC701	Machine Vision System	3	...	3	--	3
ARC702	AI for Robots	3	...	3		3
ARDLO703X	Department Level Optional Course – 3	3	...	3	--	3
ARDLO704X	Department Level Optional Course – 4	3	...	3	--	3
ILO701X	Institute Level Optional Course – I*	3	...	3	--	3
ARL701	Machine Vision system	...	2	--	1	1
ARL702	AI for Robots	...	2	--	1	1
ARL703	Industrial Skills	...	2	--	1	1
ARP701	Major Project -I	...	6#	--	3	3
Total		15	12	15	06	21

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract/ Oral	Total
		Internal Assessment			End Sem. Exam	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
ARC701	Machine Vision system	20	20	20	80	3		--	100
ARC702	AI for Robots	20	20	20	80	3	--	--	100
ARDLO703X	Department Level Optional Course – 3	20	20	20	80	3	--	--	100
ARDLO704X	Department Level Optional Course – 4	20	20	20	80	3	--	--	100
ILO701X	Institute Level Optional Course – I*	20	20	20	80	3	--	--	100
ARL701	Machine Vision system	--	--	--	--	--	25	25	50
ARL702	AI for Robots	--	--	--	--	--	25	25	50
ARL703	Industrial Skills	--	--	--	--	--	25	25	50
ARP701	Major Project – I	--	--	--	--	--	50	--	50
Total		--	--	100	400	--	125	75	700

indicates work load of Learner & Faculty, for Major project

* Common with all branches

Semester VIII

Course Code	Course Name	Theory	Pract.	Theory	Pract.	Total
ARC801	Industrial Internet of Things	3	...	3	...	3
ARDLO805X	Department Level Optional Course – 5	3	...	3	...	3
ARDLO806X	Department Level Optional Course – 6	3	...	3	...	3
ILO802X	Institute Level Optional Course – 2*	3	...	3	...	3
ARL801	Laboratory based on IoT	...	2	...	1	1
ARL802	Product Design and Development	...	2	...	1	1
ARP801	Major Project - II	...	12#	...	6	6
Total		12	14	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 .					
ARC801	Industrial Internet of Things	20	20	20	80	3	...	...	100
ARDLO805X	Department Level Optional Course – 5	20	20	20	80	3	...	...	100
ARDLO806X	Department Level Optional Course – 6	20	20	20	80	3	...	...	100
ILO802X	Institute Level Optional Course – 2*	20	20	20	80	3	...	...	100
ARL801	Laboratory based on IoT	...	...	...	...	...	25	25	50
ARL802	Product Design and Development	...	...	...	...	...	25	25	50
ARP801	Major Project - II	...	...	...	...	...	100	50	150
Total		--	...	80	320	...	150	100	650

\$ indicates work load of Learner and Faculty, for Major Project

* Common with all branches

Students group and load of faculty per week.

Major Project 1 and 2:

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

Faculty Load:

In Semester VII – ½ hour per week per project group

In Semester VIII – 1 hour per week per project group

Department Optional Courses

Course Code	Sem. VII: Departmental Level optional course -3
ARDLO7031	Mobile Robotics
ARDLO7032	Advanced Computational Techniques
ARDLO7033	Natural Language Processing
ARDLO7034	Internet Communication Engineering

Course Code	Sem. VII: Department Level Optional Course – 4
ARDLO7041	Machinery Diagnostics
ARDLO7042	Big Data Analytics
ARDLO7043	Augmented and Virtual Reality
ARDLO7044	Block chain

Course Code	Sem. VIII: Department Level Optional Course – 5
ARDLO8051	Product Design and Development
ARDLO8052	Wireless Networks
ARDLO8053	Micro Electro Mechanical Systems
ARDLO8054	Deep Learning

Course Code	Sem. VIII: Department Level Optional Course – 6
ARDLO8061	Operation Planning and Control
ARDLO8062	Autonomous Vehicle
ARDLO8063	Total Quality Management
ARDLO8064	Social Media Analytics

Institute Optional Courses

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

Common with all branches

Course Code	Course Name	Credits
ARC701	Machine Vision System	03

Course Objectives

1. To understand the need and significance Machine Vision.
2. To explore basics of image processing.
3. To explore the components of Machine Vision System.
4. To develop application using machine Vision.
5. To study transformation, interpolation, filters.

Course Outcomes

Students will be able to:

1. Elaborate the components of Machine Vision Application.
2. Perform image, video pre-processing operations.
3. Explain various transformations, interpolation. Realize the significance of digital image processing in automation.
4. Elaborate motion tracking in video.
5. Analyse and Implement appropriate filtering techniques for a given problem.
6. Develop applications based on machine vision.

Module	Contents	Hours	CO mapping
Prerequisite: Computer Graphics, Sensors Technology, Robot Programming, Artificial Intelligence for Robotics			
1.	Introduction to Machine Vision : Computer and Human Vision Systems, the Human Eye, Computer versus Human Vision Systems, Evolution of Computer Vision, Computer/Machine Vision and Image Processing, Applications of Computer Vision.	04	CO1
2.	Digital Image Fundamentals : Digital Image Fundamentals Elements of visual perception, Monochrome and Colour Images, Image Brightness and Contrast., 2D, 3D, and 4D Images, Digital Image Representation , Digital Image File Formats, Fundamental Image Operations, Points, Edges, and Vertices, Point Operations, Thresholding, Brightness, Geometric Transformations, Spatial Transformation, Affine Transformation, Image Interpolation, Nearest-Neighbour Interpolation, Bilinear Interpolation, Bi-cubic Interpolation, Fundamental Steps in Digital Image Processing.	08	CO2
3.	Machine Vision and System Components : Machine Vision System, Machine Vision Camera: CCD and CMOS Image Sensors, TDI Sensor, Camera Type - Area Scan Cameras, Line Scan Cameras, Smart Cameras, Camera Lens Resolution, Contrast and Sharpness, Lenses and their parameters: Types of Lenses, Lens Mounts, Lens Selection Examples-Field of View Much larger than Camera sensor size or Smaller or close to Camera Sensor size, Machine Vision Lighting: Lighting: Light Sources in Machine Vision, Illumination Techniques-Backlighting, Front Lighting, Diffused Lighting, Oblique Lighting, Dark Field Lighting, Infrared and Ultraviolet Light, Filters, Machine Vision Software, Machine Vision Automation, Integration of Machine vision Components.	08	CO3

4.	Digital Image Processing for Machine Vision Applications : Pre-processing, Image Filtering, Normalized Box Filter Gaussian Filter Bilateral Filter, Comparison of Filter Techniques, Sub sampling/Scaling Histogram, Image Segmentation, Threshold Based Segmentation Edge-Based Segmentation First-Order Derivative Edge Detection. Second-Order Derivative Operators, Comparison of Edge Detection Techniques, Region-Based Segmentation Region Growing Methods, Region Split and Merge Method, Morphological Image Processing: Dilation, Erosion, Opening, Closing, Hit-or-Miss transformation, Object Recognition. Template Matching. Blob Analysis.	10	CO4
5.	Motion Analysis: Differential motion Analysis, Optical Flow, Analysis based on correspondence of interest points, Detection of specific motion Patterns, Video Tracking.	04	CO5
6.	Emerging Trends in Machine Vision : History of Industrial Revolution(s), Machine Vision and Industry 4.0, Emerging Vision Trends in Manufacturing, 3D Imaging, Emerging Vision Trends in Manufacturing, Applications in Machine/ Computer Vision: Face detection, face recognition, Eigen faces, car on roads.	05	CO6

Internal 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). Duration of each test shall be one hour.

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. Question1 will be compulsory and should cover maximum contents of the curriculum
3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only Four questions need to be solved.

Reference Books:

1. Chiranjil Lal Chowdhary, Mamoun Alazab, Ankit Chaudhary, Saqib Hakak and Thippa Reddy Gadekallu, Computer Vision and Recognition Systems Using Machine and Deep Learning Approaches, Fundamentals, technologies and applications, IET COMPUTING SERIES 42
2. Joe Minichino Joseph Howse, learning Open CV
3. Computer Vision with Python, Second Edition, Packet Publishing Ltd.
4. Alexander Hornberg, — Handbook of Machine and Computer Vision the Guide for Developers and Users.

Text Books:

1. Sheila Anand and L. Priya, —A Guide for Machine Vision in Quality Control, Taylor & Francis Inc., Imprint CRC Press Inc., Dec 2019.
2. Rafael C. Gonzalez and Richard E. Woods, —Digital Image Processing, Pearson
3. Carsten Stegar, Markus Ulrich, and Christian Wiedemann , —Machine Vision Algorithms and

Applications, Second completely Revised and Enlarged Edition.

4. Milan Sonka, Vaclav Hlavac, Roger Boyle, —Image Processing Analysis and Machine Vision, Second Edition, Cengage Learning.

Useful Links

1. <https://nptel.ac.in/courses/108103174>
2. <https://www.coursera.org/learn/introduction-computer-vision-watson-opencv>
3. <https://www.udacity.com/course/introduction-to-computer-vision--ud810>
4. https://onlinecourses.nptel.ac.in/noc21_ee23/preview

Course Code	Course Name	Credits
ARC702	Artificial Intelligence (AI) for Robots	03

Course Objectives

1. To conceptualize the basic ideas and techniques underlying the design of intelligent systems.
2. To make students understand and explore the mechanism of mind that enables intelligent thought and action.
3. To make students understand advanced representation formalism and search techniques.
4. To make students understand how to deal with uncertain and incomplete information.

Course Outcomes

Students will be able to:

1. Ability to develop a basic understanding of AI building blocks presented in intelligent agents.
2. Ability to choose an appropriate problem-solving method and knowledge representation technique.
3. Ability to analyze the strength and weaknesses of AI approaches to knowledge-intensive problem solving.
4. Ability to design models for reasoning with uncertainty as well as the use of unreliable information.
5. Ability to plan and learn Active & Passive reinforcement Learning.
6. Ability to design and develop AI applications in real world scenarios.

Module	Contents	Hours	CO mapping
Prerequisite: Discrete Mathematics, Data Structures			
1.	Introduction to Artificial Intelligence Introduction, History of Artificial Intelligence, Intelligent Systems: Categorization of Intelligent System, Components of AI Program, Foundations of AI, Sub-areas of AI, Applications of AI, Current trends in AI.	04	CO1
2.	Intelligent Agents Agents and Environments, The concept of rationality, The nature of environment, The structure of Agents, Types of Agents, Learning Agent. Solving problem by Searching: Problem Solving Agent, Formulating Problems, Example Problems.	04	CO2
3.	Problem solving Uninformed Search Methods: Breadth First Search (BFS), Depth First Search (DFS), Depth Limited Search, Depth First Iterative Deepening (DFID), Informed Search Methods: Greedy best first Search, A* Search, Memory bounded heuristic Search. Local Search Algorithms and Optimization Problems: Hill climbing search Simulated annealing, Genetic algorithms. Adversarial Search: Game Playing, Min-Max Search, Alpha Beta Pruning	10	CO3

4.	Knowledge and Reasoning Knowledge based Agents, Brief Overview of propositional logic, First Order Logic: Syntax and Semantic, Inference in FOL, Forward chaining, backward Chaining. Knowledge Engineering in First-Order Logic, Unification, Resolution. Uncertain Knowledge and Reasoning: Uncertainty, Representing knowledge in an uncertain domain, The semantics of belief network, Simple Inference in belief network.	12	CO4
5.	Planning and Learning The planning problem, Planning with state space search, Partial order planning, Hierarchical planning, Conditional Planning. Learning: Forms of Learning, Theory of Learning, PAC learning. Introduction to statistical learning (Introduction only) Introduction to reinforcement learning: Learning from Rewards, Passive Reinforcement Learning, Active reinforcement Learning	05	CO5
6.	AI Applications A. Introduction to NLP- Language models, Grammars, Parsing B. Robotics - Robots, Robot hardware, Problems Robotics can solve C. AI applications in Healthcare, Retail, Banking	04	CO6

Internal 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). Duration of each test shall be one hour.

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. Question1 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.

Textbooks:

1. Stuart J. Russell and Peter Norvig, “Artificial Intelligence: A Modern Approach”, Fourth Edition” Pearson Education, 2020.
2. Saroj Kaushik, “Artificial Intelligence”, Cengage Learning, First edition, 2011
3. George F Luger, “Artificial Intelligence” Low Price Edition, Fourth edition, Pearson Education.,2005

References:

1. Nils J. Nilsson, Principles of Artificial Intelligence, Narosa Publication.
2. Deepak Khemani, A First Course in Artificial Intelligence, McGraw Hill Publication
3. Patrick H. Winston, Artificial Intelligence, 3rd edition, Pearson Education.
4. Elaine Rich and Kevin Knight, “Artificial Intelligence”, Third Edition, McGraw Hill Education,2017.

Course Code	Course Name	Credits
ARDLO7031	Mobile Robotics	03

Course Objectives	1. Familiarize with essential elements of robotic locomotion. 2. Comprehend challenges in realizing robotic locomotion. 3. Familiarize with the concepts of path planning and navigation. 4. Impart knowledge on the basics of robot learning and collective robotics.
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Course Outcomes	Student will be able to: 1. Understand the fundamental principles of mobile robotics. 2. Design, analyze, and implement efficient and agile robotic systems. 3. Enable effective perception, sensing, localization, and mapping for autonomous mobile robot navigation. 4. Designing and implementing efficient robotic systems capable of autonomous localization, navigation, and coordination in diverse environments. 5. Apply design of feedback control system. 6. Comprehensive understanding of Advance Mobile Robotics.
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Module	Contents	Hours	CO mapping
Prerequisite: 1. Knowledge of robotics fundamentals, including kinematics, dynamics, and control systems. 2. Understanding of programming languages like Python, C++, or MATLAB. 3. Familiarity with linear algebra, calculus, and probability theory.			
1.	Introduction to Mobile Robotics: Overview of Mobile Robotics: Definition, scope, and applications, Historical perspective and evolution of mobile robots, Types of mobile robots: Wheeled, tracked, legged, aerial, underwater, Challenges and constraints in mobile robotics: Power, mobility, sensing, control.	06	CO1
2.	Kinematics & Dynamics of Mobile Robots: Kinematic modelling: Forward and inverse kinematics for mobile platforms, Differential drive and holonomic motion, Dynamics of mobile robots: Newton- Euler equations, motion control, stability analysis, Trajectory planning and obstacle avoidance algorithms.	06	CO2
3.	Perception and Sensing for Mobile Robots: Sensor technologies for mobile robots: Cameras, LIDAR, ultrasonic sensors, IMUs, encoders, Sensor fusion techniques: Kalman filtering, Bayesian methods, Simultaneous Localization and Mapping (SLAM) algorithms, Environmental modelling and mapping techniques.	07	CO3
4.	Localization and Navigation : Localization methods: Odometry, landmark-based localization, Monte Carlo Localization (MCL), Path planning algorithms: Dijkstra's algorithm, A*, RRT, potential fields, Reactive and deliberative navigation strategies, Collaborative and multi-robot coordination in navigation	07	CO4

5.	Control Systems for Mobile Robots : Control architectures for mobile robots: Behaviour-based, hierarchical, and hybrid systems, Feedback control design for motion and trajectory tracking, PID control and its application in mobile robotics, Model Predictive Control (MPC) and its relevance in mobile robot control.	07	CO5
6.	Advanced Topics in Mobile Robotics: Swarm robotics and collective behaviours in mobile robot teams, Human-robot interaction and social robotics, Autonomous systems and artificial intelligence in mobile robots, Ethical considerations and societal impact of mobile robotics.	06	CO6

Internal 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). Duration of each test shall be one hour.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 Marks.
2. Total 4 questions need to be solved.
3. Question No. 1 will be compulsory and based on entire syllabus wherein sub questions of 4 to 5 marks will be asked.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Reference Books:

1. "Introduction to Autonomous Mobile Robots" by Roland Siegwart, Illah R. Nourbakhsh, and Davide Scaramuzza.
2. "Probabilistic Robotics" by Sebastian Thrun, Wolfram Burgard, and Dieter Fox.
3. "Robotics: Modelling, Planning, and Control" by Bruno Siciliano and Lorenzo Sciavicco.
4. "Mobile Robotics: Mathematics, Models, and Methods" by Alonzo Kelly and Vladimir Sukhoy.
5. "Mobile Robots: Navigation, Control, and Remote Sensing" by Gerald Cook.
6. "Modern Robotics: Mechanics, Planning, and Control" by Kevin M. Lynch and Frank C. Park.
7. "Robotics: Everything You Need to Know About Robotics from Beginner to Expert" by Peter Mckinnon.

Course Code	Course Name	Credits
ARDLO7032	Advanced Computational Techniques	03

Course Objectives	1. To introduce advanced computational techniques applicable to Automation and Robotics 2. To develop skills in numerical methods for problem-solving in robotics and automation 3. To enable students to implement algorithms and models for control systems and machine learning applications
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Course Outcomes	Student will be able to: 1. Implement numerical methods to analyze and optimize control systems 2. Analyze and manipulate signals or functions in both continuous and discrete domains. 3. Effectively solve boundary value problems and analyze eigenvalue equations in mathematical and computational contexts. 4. Apply methods to solve parabolic and hyperbolic partial differential equations. 5. Analyze complex physical phenomena in various scientific and engineering applications. 6. Effectively optimize robotic systems, improving their performance and efficiency across various applications.
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Module	Contents	Hours	CO mapping
Prerequisite: 1. Knowledge of basic programming languages (e.g., Python, C++, MATLAB) 2. Understanding of calculus, linear algebra, and differential equations 3. Familiarity with basic algorithms and data structures.			
1.	Numerical Methods for Control Systems: Fixed point iteration for a non-linear system, Newton Raphson method for solving system of non-linear equations, criteria for convergence, error analysis.	06	CO1
2.	Fourier approximations: Curve fitting with sinusoidal functions, Continuous Fourier series, Fourier integral and transforms, Discrete Fourier transforms, Fast Fourier transforms	06	CO2
3.	Boundary value and Eigen value problems: Shooting method for solving boundary value problems, Finite difference approximation of boundary value problems, Polynomial method to determine Eigen values, power method, LR method and QR method.	07	CO3

4.	Solution of partial differential equations-I: Finite difference methods: Parabolic: Forward time central space & Crank Nicolson method Hyperbolic: Lax-Friedrichs method & Mac Cormack method Finite volume methods: Monotonic upstream-cantered (MUSCL), Riemann Solver	07	CO4
5.	Solution of partial differential equations-II: Finite element methods: hp-FEM, Discontinuous Galerkin (DG) Meshfree Methods: Smoothed-particle hydrodynamics, Moving particle semi-implicit method.	07	CO5
6.	Optimization Techniques in Robotics: Gradient-based and metaheuristic optimization algorithms: Sequential quadratic programming, Genetic algorithms, simulated annealing.	06	CO6

Internal 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). Duration of each test shall be one hour.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 Marks.
2. Total 4 questions need to be solved.
3. Question No. 1 will be compulsory and based on entire syllabus wherein sub questions of 4 to 5 marks will be asked.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Text Books:

1. "Numerical solutions for Differential Equations" by Smith G.D, Mc Graw Hill
2. "Modern Methods for Engineering Computations" by Ketter and Prawel, Mc Graw Hill
3. "Numerical Methods for Initial and Boundary value problems," by Rajasekharan S. Khanna publishers 2003.
4. "Optimization Theory and applications" by S.S. Rao, Wiley Eastern
5. "Numerical Methods for Engineers" by Steven C. Chapra and Raymond P. Canale
6. "Optimization Techniques in Engineering" by G. S. R. Murthy

Reference Books:

1. "Numerical Optimization" by Jorge Nocedal and Stephen J. Wright
2. "Pattern Recognition and Machine Learning" by Christopher M. Bishop
3. "Introduction to Autonomous Robots" by Nikolaus Correll and Michael A. Goodrich
4. "Control Systems Engineering" by Norman S. Nise
5. "Introduction to Robotics: Mechanics and Control" by John J. Craig

Course Code	Course Name	Credits
ARDLO7033	Natural Language Processing	03

Course Objectives: The course aims

1. To define natural language processing and to learn various stages of natural language processing.
2. To describe basic concepts and algorithmic description of the main language levels: Morphology, Syntax, Semantics, and Pragmatics & Discourse analysis.
3. To design and implement various language models and POS tagging techniques.
4. To design and learn NLP applications such as Information Extraction, Question answering.
5. To design and implement applications based on natural language processing.

Course Outcomes: Students will be able

1. To describe the field of natural language processing.
2. To design language model for word level analysis for text processing.
3. To design various POS tagging techniques and parsers.
4. To design, implement and test algorithms for semantic and pragmatic analysis.
5. To formulate the discourse segmentation and anaphora resolution.
6. To apply NLP techniques to design real world NLP applications.
- 7.

Module	Contents	Hours	CO mapping
Prerequisite: Theory of Computer Science, System Programming & Compiler Construction			
1.	Introduction to NLP: Origin & History of NLP; Language, Knowledge and Grammar in language processing; Stages in NLP; Ambiguities and its types in English and Indian Regional Languages; Challenges of NLP; Applications of NLP Self-Learning topics: Variety types of tools for regional languages pre-processing and other functionalities	03	CO1
2.	Word Level Analysis : Basic Terms: Tokenization, Stemming, Lemmatization; Survey of English Morphology, Inflectional Morphology, Derivational Morphology; Regular expression with types; Morphological Models: Dictionary lookup, finite state morphology; Morphological parsing with FST (Finite State Transducer);Lexicon free FST Porter Stemmer algorithm; Grams and its variation: Bigram, Trigram; Simple (Unsmoothed) N-grams; N-gram Sensitivity to the Training Corpus; Unknown Words: Open versus closed vocabulary tasks; Evaluating N-grams: Perplexity; Smoothing: Laplace Smoothing, Good-Turing Discounting;	09	CO2

	Self-Learning topics: Noisy channel models, various edit distance, Advance Issues in Language Modelling		
3.	Syntax analysis : Part-Of-Speech tagging(POS); Tag set for English (Upenn Treebank); Difficulties /Challenges in POS tagging; Rule-based, Stochastic and Transformation-based tagging; Generative Model: Hidden Markov Model (HMM Viterbi) for POS tagging; Issues in HMM POS tagging; Discriminative Model: Maximum Entropy model, Conditional random Field (CRF);Parsers: Top down and Bottom up; Modelling constituency; Bottom Up Parser: CYK, PCFG (Probabilistic Context Free Grammar), Shift Reduce Parser; Top Down Parser: Early Parser, Predictive Parser Self-Learning topics: Evaluating parsers, Parsers based language modelling, Regional languages POS tree banks	10	CO3
4.	Semantic Analysis : Introduction, meaning representation; Lexical Semantics; Corpus study; Study of Various language dictionaries like WorldNet, Babelnet; Relations among lexemes & their senses –Homonymy, Polysemy, Synonymy, Hyponymy; Semantic Ambiguity; Word Sense Disambiguation (WSD); Knowledge based approach(Lesk’s Algorithm), Supervised (Naïve Bayes, Decision List),Introduction to Semi-supervised method (Yarowsky) Unsupervised (Hyperlex) Self-Learning topics: Dictionaries for regional languages, Distributional Semantics, Topic Models	07	CO4
5.	Pragmatic & Discourse Processing : Discourse: Reference Resolution, Reference Phenomena, Syntactic & Semantic constraint on coherence; Anaphora Resolution using Hobbs and Canterling Algorithm Self-Learning topics: Discourse segmentation, Conference resolution	05	CO5
6.	Applications of NLP : Case studies on (preferable in regional language):Machine translation; Text Summarization; Sentiment analysis; Information retrieval; Question Answering system Self-Learning topics: Applications based on Deep Neural Network with NLP such as LSTM network, Recurrent Neural network etc.	05	CO6

Internal 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). Duration of each test shall be one hour.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 Marks.
2. Total 4 questions need to be solved.
3. Question No. 1 will be compulsory and based on entire syllabus wherein sub questions of 4 to 5 marks will be asked.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Text Books:

1. Daniel Jurafsky, James H. and Martin, Speech and Language Processing, Second Edition, Prentice Hall, 2008.
2. Christopher D.Manning and HinrichSchutze, Foundations of Statistical Natural Language Processing, MIT Press, 1999.

Reference Books:

1. Siddiqui and Tiwary U.S., Natural Language Processing and Information Retrieval, Oxford University Press, 2008.
2. Daniel M Bikel and ImedZitouni — Multilingual natural language processing applications: from theory to practice, IBM Press, 2013.
3. Alexander Clark, Chris Fox, Shalom Lappin — The Handbook of Computational Linguistics and Natural Language Processing, John Wiley and Sons, 2012.
4. Nitin Indurkha and Fred J. Damerau, —Handbook of Natural Language Processing, Second Edition, Chapman and Hall/CRC Press, 2010.
5. Niel J le Roux and SugnetLubbe, A step by step tutorial: An introduction into R application and programming.
6. Steven Bird, Ewan Klein and Edward Loper, Natural language processing with Python: analyzing text with the natural language toolkit, O_Reilly Media, 2009.

Useful Links:

1. <http://www.cse.iitb.ac.in/~cs626-449>
2. <http://cse24-iiith.virtual-labs.ac.in/#>
3. <https://nptel.ac.in/courses/106105158>

Course Code	Course Name	Credits
ARDLO7034	Internet Communication Engineering	03

Course Objectives	1. To focus on Internet protocol, standards, services and administration. 2. To discuss the Internet security protocol and security services 3. To discuss multimedia communication standards and compression techniques 4. To add insights on software defined network & network automation 5. To introduce Internet of Things
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Course Outcomes	After successful completion of the course student will be able to: 1. Explain the protocols at each layer of TCP/IP protocol suite. 2. Explain the internet security aspects of protocols at various layers of TCP/IP protocol suite. 3. Apply the various compression algorithms for audio, image & video coding. 4. Design simple networked multimedia systems. 5. Evaluate integrated & differentiated services for quality of service. 6. Explain a software defined Network.
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Module	Contents	Hours	CO mapping
Prerequisite: Analog communication, Digital Communication and Computer Communication and Networks			
1.	Introduction to Internet: What is the Internet, Evolution of the Internet, service description, Network protocol? Overview of TCP/IP, layer functions	03	CO1
2.	Application Layer in the Internet : Application Layer- Host configuration, DHCP, Domain Name System (DNS), Multicast DNS, Remote Login, TELNET and SSH, HTTPS, electronic mail	06	CO2
3.	Internet Security: Network layer security (AH, ESP, IPsec) Transport layer security (SSL), Application layer security (secure E mail- PGP, S/MIME), VPN Firewall, Intrusion Detection System.	05	CO3
4.	Multimedia Communications: Information Representation- text, images, audio and video, Text and image compression, Audio and video compression. compression standards: H.261, H.263, P1.323, MPEG 1, MPEG 2, Other coding formats for text, speech, image and video Multimedia transport across IP networks and relevant protocols such as RSVP, RTP, RTCP, DVMRP, Signalling Protocols: Real-Time Streaming Protocol (RTSP). VoIP, IPTV	10	CO4
5.	Quality of Services (QoS): Integrated services (intserv): Architecture and Service Model, Resource Reservation Protocol (RSVP), Packet Scheduling Disciplines in the Internet Differentiated Services (diffserv): Framework and Concept, Assured and Expedited Services, Packet Classification, Routers Internals and Packet Dropping Techniques.	07	CO5

6.	Network Industry Trends & Automation: Introduction to software defined networking, OPENFLOW, Why network automation? Simplified Architectures, Deterministic outcomes, Business Agility, Types of network automation, Device Provisioning, Data collection, Migrations, Configuration Management, Compliance, Reporting, Troubleshooting, Evolving from the management plane from SNMP to device APIs--- Impact of open networking, Network Automation in the SDN era. Introduction to Internet of Things (IoT): Definition and characteristics of IoT, Physical design of IoT: Things in IoT, IoT Protocols.	08	CO6
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Internal 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). Duration of each test shall be one hour.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 Marks.
2. Total 4 questions need to be solved.
3. Question No. 1 will be compulsory and based on entire syllabus wherein sub questions of 4 to 5 marks will be asked.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Text Books:

1. B. Forouzan, —TCP/IP Protocol Suite, 4th Edition, McGraw-Hill Publication
2. K. R. Rao, Zoran S. Bojkovic, Dragorad A. Milovanovic, Multimedia Communication Systems, Prentice Hall India, 2002. ISBN: 81-203-2145-6.
3. Network Programmability & Automation---Jason Edelman, Scott S. Lowe & Matt Oswalt, O'REILLY.

Reference Books:

1. Steve Heath, Multimedia and Communication Technology, Second Edition, Focal Press, 2003.
2. ISBN: 81-8147-145-8. Ted Wallingford, —Switching to VoIP, Oreilly Publication
3. Fred Halsall, —Multimedia Communications, Pearson education, 2001
4. K. R. Rao, Zoran S. Bojkovic, Dragorad A. Milovanovic, —Multimedia Communication Systems, Pearson education, 2004.
5. Raif steinmetz, Klara Nahrstedt, —Multimedia: Computing, Communications and Applications, Pearson education, 2002.
6. Tay Vaughan, —Multimedia: Making it Work, 6th edition, Tata McGraw Hill, 2004
7. Pallapa Venkataram, —Multimedia information systems, Pearson education (InPress), 2005.
8. Multimedia Communication Techniques and Standards
9. Arshdeep Bagha, Vijay Madiseti “Internet of Things”, universities Press.

Course Code	Course Name	Credits
ARDLO7041	Machinery Diagnostics	03

Course Objectives

1. To study basic concepts of Vibration Monitoring
2. To study different Vibration Measuring Instruments
3. To study fault detection in Machines using vibration spectrum

Course Outcomes Student will be able to:

1. Relate basic concepts of Machinery Diagnostic.
2. Describe the working of Vibration Measuring Instruments.
3. Apply different Signal Processing Techniques in Vibration Measurement.
4. Identify common faults in Machinery using Vibration Spectrum.
5. Interpret the Vibration Signals for Monitoring and Prognosis.

Module	Contents	Hours	CO mapping
1.	Basics of Vibration : Periodic and random motion, Spectral Amplitude Scaling: RMS, Peak and Peak-to-Peak Conversion and Selection, Time and frequency domain analysis, Phase analysis, Orbit analysis, Understanding signal pattern, Importance of speed in accurate diagnosis, Importance of side bands in frequency spectrums. Introduction to Vibration based Condition Monitoring: Maintenance Principles, Vibration based fault Prognosis, Goal of Vibration Monitoring, Steps in Vibration Monitoring, Benefits of Vibration based condition monitoring.	07	CO1
2.	Vibration Measurement : Vibration measuring instruments: displacement, velocity, acceleration; Force measurement, Laser based measurements: laser vibrometer Sensor Selection Criteria , Sensor – Mounting Locations and Techniques	07	CO2
3.	Data Acquisition & Signal Processing : Classification of signals, Signal analysis, Fast Fourier Transform (FFT), Essential Settings in Data Acquisition System (Plot Formats, Frequency Span and Frequency Resolution, Average Types and Number of Averages, Windowing, Spectrum Scaling), Signal conditioning	07	CO3
4.	Machinery Fault Diagnosis I : Natural frequency and resonance tests (Practical approach), Time and Frequency domain analysis to identify unbalance, bent shaft, Misalignment, Soft foot conditions, Mechanical looseness	06	CO4
5.	Machinery Fault Diagnosis II: Rolling element bearing and Journal Bearing fault diagnosis, Faults related to Gearbox, vane defects in pumps, Fault in Fans and Blowers.	06	CO4

6.	Applications of Condition Monitoring: Case studies related Balancing Problems in Turbines, Condition Monitoring in Sugar mills, Health Monitoring of Journal Bearing, Condition Monitoring of Industrial Pumps. (Aspects to be covered : Selection of sensors, recommended location of sensor, direction of measurement, selection of plot type, Data validation and Identification of Faults)	06	CO5
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Internal 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). Duration of each test shall be one hour.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 Marks.
2. Total 4 questions need to be solved.
3. Question No. 1 will be compulsory and based on entire syllabus wherein sub questions of 4 to 5 marks will be asked.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Reference / Text Books:

1. R.B. Randall, "Vibration-based Condition Monitoring", Wiley 2021, ISBN: 978-1-119-47755-6
2. A.R. Mohanty, "Machine Condition Monitoring: Principles and Practices", CRC Press 2017, ISBN: 9781138748255
3. R.A. Collacott, "Mechanical Fault Diagnosis and Condition Monitoring", 1st Edition, Chapman and Hall, ISBN: 978-94-009-5723-7
4. J.S. Rao, "Vibratory Condition Monitoring of Machine", Narosa Publishing House.

Useful Links:

<https://nptel.ac.in/courses/112105232> – Machinery Fault Diagnosis and Signal Processing, IIT, Kharagpur.

Course Code	Course Name	Credits
ARDLO7042	Big Data Analytics	03

Course Objectives

1. To provide an overview of the big data platforms, its use cases and Hadoop ecosystem.
2. To introduce programming skills to build simple solutions using big data technologies such as MapReduce, Scripting for No SQL and R.
3. To learn the fundamental techniques and principles in achieving big data analytics with scalability and streaming capability.
4. To enable students to have skills that will help them to solve complex real-world problems for decision support.

Course Outcomes

Student will be able to:

1. Understand the building blocks of Big Data Analytics.
2. Apply fundamental enabling techniques like Hadoop and MapReduce in solving real world.
3. Understand different NoSQL systems and how it handles big data.
4. Apply advanced techniques for emerging applications like stream analytics.
5. Achieve adequate perspectives of big data analytics in various applications like recommender systems, social media applications, etc.
6. Apply statistical computing techniques and graphics for analyzing big data.

Module	Contents	Hours	CO mapping
Prerequisite: Database, Data mining.			
1.	Introduction to Big Data and Hadoop Introduction to Big Data - Big Data characteristics and Types of Big Data Traditional vs. Big Data business approach Case Study of Big Data Solutions Concept of Hadoop, Core Hadoop Components; Hadoop Ecosystem	02	CO1
2.	Hadoop HDFS and MapReduce Distributed File Systems: Physical Organization of Compute Nodes, Large- Scale File-System Organization. MapReduce: The Map Tasks, Grouping by Key, The Reduce Tasks, Combiners, Details of MapReduce Execution, Coping With Node Failures. Algorithms Using MapReduce: Matrix-Vector Multiplication by MapReduce, Relational-Algebra Operations, Computing Selections by MapReduce, Computing	08	CO2

	Projections by MapReduce, Union, Intersection, and Difference by MapReduce, Hadoop Limitations.		
3.	NoSQL Introduction to NoSQL, NoSQL Business Drivers. NoSQL Data Architecture Patterns: Key-value stores, Graph stores, Column family (Bigtable) stores, Document stores, Variations of NoSQL architectural patterns, NoSQL Case Study. NoSQL solution for big data, Understanding the types of big data problems; Analyzing big data with a shared-nothing architecture; Choosing distribution models: master-slave versus peer-to-peer; NoSQL systems to handle big data problems.	10	CO3
4.	Mining Data Streams The Stream Data Model: A Data-Stream-Management System, Examples of Stream Sources, Stream Queries, Issues in Stream Processing. Sampling Data techniques in a Stream. Filtering Streams: Bloom Filter with Analysis. Counting Distinct Elements in a Stream, Count-Distinct Problem, Flajolet-Martin Algorithm, Combining Estimates, Space Requirements. Counting Ones in a Window: The Cost of Exact Counts, The Datar-Gionis-Indyk-Motwani Algorithm, Query Answering in the DGIM Algorithm, Decaying Windows.	11	CO4
5.	Real-Time Big Data Models A Model for Recommendation Systems, Content-Based Recommendations, Collaborative Filtering. Case Study: Product Recommendation Social Networks as Graphs, Clustering of Social-Network Graphs, Direct Discovery of Communities in a social graph	04	CO5
6.	Data Analytics with R Exploring Basic features of R, Exploring RGUI, Exploring RStudio, Handling Basic Expressions in R, Variables in R, Working with Vectors, Storing and Calculating Values in R, Creating and using Objects, Interacting with users, Handling data in R workspace, Executing Scripts, Creating Plots, Accessing help and documentation in R. Reading datasets and Exporting data from R, Manipulating and Processing Data in R, Using functions instead of script, built-in functions in R. Data Visualization: Types, Applications	04	CO6

Internal 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). Duration of each test shall be one hour.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 Marks.
2. Total 4 questions need to be solved.
3. Question No. 1 will be compulsory and based on entire syllabus wherein sub questions of 4 to 5 marks will be asked.

4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Text Books:

1. Cre Anand Rajaraman and Jeff Ullman —Mining of Massive Datasets, Cambridge University Press
2. Alex Holmes —Hadoop in Practice, Manning Press, Dreamtech Press.
3. Dan Mcary and Ann Kelly —Making Sense of NoSQL – A guide for managers and the rest of us, Manning Press.
4. DT Editorial Services, “Big Data Black Book”, Dreamtech Press
5. EMC Education Services, ”Data Science and Big Data Analytics”, Wiley

Reference Books:

1. Bill Franks, —Taming The Big Data Tidal Wave: Finding Opportunities In Huge Data Streams With Advanced Analytics,Wiley.
2. Chuck Lam, —Hadoop in Action, Dreamtech Press
3. Jared Dean, —Big Data, Data Mining, and Machine Learning: Value Creation for Business Leaders and Practitioners, Wiley India Private Limited, 2014.
4. Jiawei Han and Micheline Kamber, —Data Mining: Concepts and Techniques, Morgan Kaufmann Publishers, 3rd ed, 2010.
5. Lior Rokach and Oded Maimon, —Data Mining and Knowledge Discovery Handbook, Springer, 2nd edition, 2010.
6. Ronen Feldman and James Sanger, —The Text Mining Handbook: Advanced Approaches in Analyzing Unstructured Data, Cambridge University Press, 2006.
7. Vojislav Kecman, —Learning and Soft Computing, MIT Press, 2010.

Useful Links:

1. <https://nptel.ac.in/courses/106104189>
2. <https://www.coursera.org/specializations/big-data#courses>
3. <https://www.digimat.in/nptel/courses/video/106106169/L01.html>
4. <https://www.coursera.org/learn/nosql-databases#syllabus>
5. <https://www.coursera.org/learn/basic-recommender-systems#syllabus>

Course Code	Course Name	Credits
ARDLO7043	Augmented and Virtual Reality	03

Course Objectives

1. To learn the underlying concepts of Augmented and Virtual Reality and primitives of computer graphics.
2. To understand the use of hardware devices in AR-VR system.
3. To understand the tracking system in AR.
4. To apply concept of calibration and registration of different components in AR system
5. To design AR-VR applications.
6. To understand the use of AR-VR in interdisciplinary immersive applications

Course Outcomes

Students will be able to:

1. Identify and compare different Virtual and Augmented Reality Technologies and apply modelling techniques.
2. Identify and use AR-VR hardware components.
3. Apply concepts of Computer Vision for tracking in AR Systems.
4. Apply calibration techniques and registration for components in AR.
5. Design AR-VR application
6. Apply insights of AR-VR in different applications.

Module	Contents	Hours	CO mapping
Prerequisite: Programming Language, Computer Graphics			
1.	Introduction to Augmented and Virtual Reality Definition and Scope, A Brief History of Augmented and Virtual Reality, AR-VR Architecture, Challenges with AR-VR, AR-VR systems and functionality, Types of Augmented Reality Application (Location Based AR Apps Marker-Based AR Applications). Understanding Virtual Space and Geometry: coordinate systems, Geometric Modelling, 2D transformations, 3D rotation and 6 degree of freedom, View Transformation, projective transformation, Related fields: MR, XR and ubiquitous computing and their comparison.	05	CO1
2.	Visual Physiology, perception and Interaction Mechanics of Sight: the visual pathway, spatial vision and depth cues. Display fundamentals, optical architecture. Augmenting displays. Multimodal Displays; Visual Perception; Spatial Display Model; Visual Displays. Mechanics of hearing, audio displays. Augmented and Virtual reality Hardware.	05	CO2
3.	Tracking and Computer Vision for AR Characteristics of Tracking Technology; Stationary Tracking Systems; Mobile Sensors; Optical Tracking; Sensor Fusion; Marker Tracking, infrared tracking, Natural feature tracking by detection.	10	CO3

4.	Calibrations and Registration Camera projection and setup for AR. Camera calibration techniques. Registration	06	CO4
5.	AR-VR Application Development AR-VR Application Requirements, Software engineering requirements, AR-VR Design Principles, Data Flow, Scene Graphs; Developer Support: Parameter Configuration, Tools used in AR-VR development.	07	CO5
6.	Applications of AR-VR and Human Factors, Legal and Social Considerations Applications of AR-VR in: Edutainment, Medical, Military, Production and Manufacturing, Navigation, Astronomical Observation, E-commerce; What are Human Factors, Physical Side Effects, Visual Side Effects, Legal Considerations, Moral and Ethical Considerations	06	CO6

Internal 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). Duration of each test shall be one hour.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 Marks.
2. Total 4 questions need to be solved.
3. Question No. 1 will be compulsory and based on entire syllabus wherein sub questions of 4 to 5 marks will be asked.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Text Books:

1. John Vince, "Virtual Reality Systems", Pearson publication
2. Tony Parisi, "Learning Virtual Reality", O'REILLY'
3. Dieter Schmalsteig and Tobias Hollerer, "Augmented Reality- Principles and Practice", Pearson Education, Inc. 2016 Edition.
4. Chetankumar G Shetty, "Augmented Reality- Theory, Design and Development", Mc Graw Hill, 2020 Edition.
5. Alan B. Craig, "Understanding Augmented Reality – Concepts and Applications", Morgan Kaufmann, Elsevier, 2013 Edition.

References Books:

1. Borko Furht, "Handbook of Augmented Reality", Springer.
2. Erin Pangilinan, Steve Lukas, and Vasanth Mohan, "Creating Augmented and Virtual Realities Theory and Practice for Next-Generation Spatial Computing", O'Reilly Media, Inc., 2019 Edition.
3. Jens Grubert, Dr. Raphael Grasset, "Augmented Reality for Android Application Development", PACKT Publishing.

Useful Links:

1. www.nptel.ac.in
2. www.coursera.org

Course Code	Course Name	Credits
ARDLO7044	Block Chain	03

- Course Objectives**
1. Understand blockchain platforms and its terminologies.
 2. Understand the use of cryptography required for blockchain.
 3. Understand smart contracts, wallets, and consensus protocols.
 4. Design and develop blockchain applications

- Course Outcomes** Student will be able to:
1. Explain blockchain concepts.
 2. Apply cryptographic hash required for blockchain.
 3. Apply the concepts of smart contracts for an application.
 4. Design a public blockchain using Ethereum.
 5. Design a private blockchain using Hyperledger.
 6. Use different types of tools for blockchain applications.

Module	Contents	Hours	CO mapping
Prerequisite: Cryptography and System Security			
2.	Introduction to Blockchain What is a blockchain, Origin of blockchain (cryptographically secure hash functions), Foundation of blockchain: Merkle trees. Components of blockchain, Block in blockchain, Types: Public, Private, and Consortium, Consensus Protocol, Limitations and Challenges of blockchain	06	CO1
2.	Cryptocurrency Cryptocurrency: Bitcoin, Altcoin, and Tokens (Utility and Security), Cryptocurrency wallets: Hot and cold wallets, Cryptocurrency usage, Transactions in Blockchain, UTXO and double spending problem. Bitcoin blockchain: Consensus in Bitcoin, Proof-of-Work (PoW), Proof-of-Burn (PoB), Proof-of-Stake (PoS), and Proof-of-Elapsed Time (PoET), Life of a miner, Mining difficulty, Mining pool and its methods	06	CO2
3.	Programming for Blockchain Introduction to Smart Contracts, Types of Smart Contracts, Structure of a Smart Contract, Smart Contract Approaches, Limitations of Smart Contracts. Introduction to Programming: Solidity Programming – Basics, functions, Visibility and Activity Qualifiers, Address and Address Payable, Bytes and Enums, Arrays-Fixed and Dynamic Arrays, Special Arrays-Bytes and strings, Struct, Mapping, Inheritance, Error handling. Case Study – Voting Contract App, Preparing for smart contract development	08	CO3
4.	Public Blockchain Introduction to Public Blockchain, Ethereum and its Components, Mining in Ethereum, Ethereum Virtual Machine (EVM), Transaction, Accounts, Architecture and Workflow, Comparison between Bitcoin	08	CO4

	and Ethereum Types of test-networks used in Ethereum, Transferring Ethers using Metamask, Mist Wallet, Ethereum frameworks, Case study of Ganache for Ethereum blockchain. Exploring etherscan.io and ether block structure		
5.	Private Blockchain Introduction, Key characteristics, Need of Private Blockchain, Smart Contract in a Private Environment, State Machine Replication, Consensus Algorithms for Private Blockchain - PAXOS and RAFT, Byzantine Faults: Byzantine Fault Tolerant (BFT) and Practical BFT. Introduction to Hyperledger, Tools and Frameworks, Hyperledger Fabric, Comparison between Hyperledger Fabric & Other Technologies. Hyperledger Fabric Architecture, Components of Hyperledger Fabric: MSP, Chain Codes, Transaction Flow, Working of Hyperledger Fabric, Creating Hyperledger Network, Case Study of Supply Chain Management using Hyperledger.	08	CO5
6.	Tools and Applications of Blockchain Corda, Ripple, Quorum and other Emerging Blockchain Platforms, Blockchain in DeFi: Case Study on any of the Blockchain Platforms.	03	CO6

Internal 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). Duration of each test shall be one hour.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 Marks.
2. Total 4 questions need to be solved.
3. Question No. 1 will be compulsory and based on entire syllabus wherein sub questions of 4 to 5 marks will be asked.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Text Books:

1. Blockchain Technology, Chandramouli Subramanian, Asha A. George, Abhillash K. A and Meena Karthikeyan, Universities Press.
2. Mastering Ethereum, Building Smart Contract and Dapps, Andreas M. Antonopoulos Dr. Gavin Wood, O'reilly.
3. Imran Bashir, Mastering Blockchain: A deep dive into distributed ledgers, consensus protocols, smart contracts, DApps, cryptocurrencies, Ethereum, and more, 3rd Edition, Packt Publishing

Reference Books:

1. Blockchain for Beginners, Yathish R and Tejaswini N, SPD.
2. Blockchain Basics, A non-Technical Introduction in 25 Steps, Daniel Drescher, A press.
3. Blockchain with Hyperledger Fabric, Luc Desrosiers, Nitin Gaur, Salman A. Baset, Venkatraman Ramakrishna, Packt Publishing

Useful Links:

1. Blockchain By Example, Bellaj Badr, Richard Horrocks, Xun (Brian) Wu, November 2018, Implement decentralized blockchain applications to build scalable Dapps.
2. Blockchain for Business, <https://www.ibm.com/downloads/cas/3EGWKGX7>.
3. <https://www.hyperledger.org/use/fabric>
4. NPTEL: https://onlinecourses.nptel.ac.in/noc19_cs63/preview

Course Code	Course Name	Credits
ILO7011	Product Life Cycle Management	03

Objectives:

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

Outcomes: Learner will be able to...

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

Sr. No.	Contents	Hrs
01	Introduction to Product Lifecycle Management (PLM): Product Lifecycle Management (PLM), Need for PLM, Product Lifecycle Phases, Opportunities of Globalization, Pre-PLM Environment, PLM Paradigm, Importance & Benefits of PLM, Widespread Impact of PLM, Focus and Application, A PLM Project, Starting the PLM Initiative, PLM Applications PLM Strategies: Industrial strategies, Strategy elements, its identification, selection and implementation, Developing PLM Vision and PLM Strategy, Change management for PLM	10
02	Product Design: Product Design and Development Process, Engineering Design, Organization and Decomposition in Product Design, Typologies of Design Process Models, Reference Model, Product Design in the Context of the Product Development Process, Relation with the Development Process Planning Phase, Relation with the Post design Planning Phase, Methodological Evolution in Product Design, Concurrent Engineering, Characteristic Features of Concurrent Engineering, Concurrent Engineering and Life Cycle Approach, New Product Development (NPD) and Strategies, Product Configuration and Variant Management, The Design for X System, Objective Properties and Design for X. Tools, Choice of Design for X Tools and Their Use in the Design Process	09
03	Product Data Management (PDM): Product and Product Data, PDM systems and importance, Components of PDM, Reason for implementing a PDM system, financial justification of PDM, barriers to PDM implementation	05
04	Virtual Product Development Tools: For components, machines, and manufacturing plants, 3D CAD systems and realistic rendering techniques,	05

	Digital mock-up, Model building, Model analysis, Modeling and simulations in Product Design, Examples/Case studies	
05	Integration of Environmental Aspects in Product Design: Sustainable Development, Design for Environment, Need for Life Cycle Environmental Strategies, Useful Life Extension Strategies, End-of-Life Strategies, Introduction of Environmental Strategies into the Design Process, Life Cycle Environmental Strategies and Considerations for Product Design	05
06	Life Cycle Assessment and Life Cycle Cost Analysis: Properties, and Framework of Life Cycle Assessment, Phases of LCA in ISO Standards, Fields of Application and Limitations of Life Cycle Assessment, Cost Analysis and the Life Cycle Approach, General Framework for LCCA, Evolution of Models for Product Life Cycle Cost Analysis	05

Internal 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). Duration of each test shall be one hour.

End Semester Examination:

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

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

References:

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

Course Code	Course Name	Credits
ILO7012	Reliability Engineering	03

Objectives:

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

Outcomes: Learner will be able to...

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

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

Internal 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). Duration of each test shall be one hour.

End Semester Examination:

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

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

References:

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

Course Code	Course Name	Credits
ILO7013	Management Information System	03

Objectives:

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

Outcomes: Learner will be able to...

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

Sr. No.	Detailed Contents	Hrs
01	Introduction To Information Systems (IS): Computer Based Information Systems, Impact of IT on organizations, Importance of IS to Society. Organizational Strategy, Competitive Advantages and IS	04
02	Data and Knowledge Management: Database Approach, Big Data, Datawarehouse and Data Marts, Knowledge Management Business intelligence (BI): Managers and Decision Making, BI for Data analysis and Presenting Results	07
03	Ethical issues and Privacy: Information Security. Threat to IS, and Security Controls	07
04	Social Computing (SC): Web 2.0 and 3.0, SC in business-shopping, Marketing, Operational and Analytic CRM, E-business and E-commerce – B2B B2C. Mobile commerce.	07
05	Computer Networks Wired and Wireless technology, Pervasive computing, Cloud computing model.	06
06	Information System within Organization: Transaction Processing Systems, Functional Area Information System, ERP and ERP support of Business Process. Acquiring Information Systems and Applications: Various System development life cycle models.	08

Internal Assessment:

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End Semester Examination:

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

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3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved.**

References:

1. Kelly Rainer, Brad Prince, Management Information Systems, Wiley
2. K.C. Laudon and J.P. Laudon, Management Information Systems: Managing the Digital Firm, 10th Ed., Prentice Hall, 2007.
3. D. Boddy, A. Boonstra, Managing Information Systems: Strategy and Organization, Prentice Hall, 20

Course Code	Course Name	Credits
ILO7014	Design of Experiments	03

Objectives:

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

Outcomes: Learner will be able to...

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

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

	4.4 Resolution III Designs 4.5 Resolution IV and V Designs 4.6 Fractional Factorial Split-Plot Designs	
05	Response Surface Methods and Designs 5.1 Introduction to Response Surface Methodology 5.2 The Method of Steepest Ascent 5.3 Analysis of a Second-Order Response Surface 5.4 Experimental Designs for Fitting Response Surfaces	07
06	Taguchi Approach 6.1 Crossed Array Designs and Signal-to-Noise Ratios 6.2 Analysis Methods 6.3 Robust design examples	04

Internal 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). Duration of each test shall be one hour.

End Semester Examination:

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3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved.**

References:

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

Course Code	Course Name	Credits
ILO7015	Operations Research	03

Objectives:

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

Outcomes: Learner will be able to...

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

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

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

Internal 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). Duration of each test shall be one hour.

End Semester Examination:

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

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

References:

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

Course Code	Course Name	Credits
ILO7016	Cyber Security and Laws	03

Objectives:

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

Outcomes: Learner will be able to...

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

Sr. No.	Detailed Contents	Hrs
01	Introduction to Cybercrime: Cybercrime definition and origins of the world, Cybercrime and information security, Classifications of cybercrime, Cybercrime and the Indian ITA 2000, A global Perspective on cybercrimes.	04
02	Cyber offenses & Cybercrime: How criminal plan the attacks, Social Engg, Cyber stalking, Cybercafe and Cybercrimes, Botnets, Attack vector, Cloud computing, Proliferation of Mobile and Wireless Devices, Trends in Mobility, Credit Card Frauds in Mobile and Wireless Computing Era, Security Challenges Posed by MobileDevices, Registry Settings for Mobile Devices, Authentication Service Security, Attacks on Mobile/Cell Phones, Mobile Devices: Security Implications for Organizations, Organizational Measures for Handling Mobile, Devices-Related Security Issues, Organizational Security Policies and Measures in Mobile Computing Era, Laptops	09
03	Tools and Methods Used in Cyberline Phishing, Password Cracking, Key loggers and Spywares, Virus and Worms, Steganography, DoS and DDoS Attacks, SQL Injection, Buffer Over Flow, Attacks on Wireless Networks, Phishing, Identity Theft (ID Theft)	06
04	The Concept of Cyberspace E-Commerce, The Contract Aspects in Cyber Law, The Security Aspect of cyber Law, The Intellectual Property Aspect in Cyber Law , The Evidence Aspect in Cyber Law , The Criminal Aspect in Cyber Law, Global Trends in Cyber Law , Legal Framework for Electronic Data Interchange Law Relating to Electronic Banking , The Need for an Indian CyberLaw	08

05	Indian IT Act. Cyber Crime and Criminal Justice: Penalties, Adjudication and Appeals Under The IT Act, 2000, IT Act. 2008 and its Amendments	06
06	Information Security Standard compliances SOX, GLBA, HIPAA, ISO, FISMA, NERC, PCI.	06

Internal 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). Duration of each test shall be one hour.

End Semester Examination:

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

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

References:

1. Nina Godbole, Sunit Belapure, *Cyber Security*, Wiley India, New Delhi
2. The Indian Cyber Law by Suresh T. Vishwanathan; Bharat Law House New Delhi
3. The Information technology Act, 2000; Bare Act- Professional Book Publishers, New Delhi.
4. Cyber Law & Cyber Crimes By Advocate Prashant Mali; Snow White Publications, Mumbai
5. Nina Godbole, *Information Systems Security*, Wiley India, New Delhi
6. Kenneth J. Knapp, *Cyber Security & Global Information Assurance* Information Science Publishing.
7. William Stallings, *Cryptography and Network Security*, Pearson Publication
8. Websites for more information is available on : The Information Technology ACT, 2008- TIFR : <https://www.tifrh.res.in>
9. Website for more information , A Compliance Primer for IT professional : <https://www.sans.org/reading-room/whitepapers/compliance/compliance-primer-professionals-3353>

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

Objectives:

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

Outcomes: Learner will be able to...

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

Sr. No.	Detailed Contents	Hrs
01	Introduction 1.1 Definition of Disaster, hazard, global and Indian scenario, general perspective, importance of study in human life, Direct and indirect effects of disasters, long term effects of disasters. Introduction to global warming and climate change.	03
02	Natural Disaster and Manmade disasters: 2.1 Natural Disaster: Meaning and nature of natural disaster, Flood, Flashflood, drought, cloud burst, Earthquake, Landslides, Avalanches, Volcanic eruptions, Mudflow, Cyclone, Storm, Storm Surge, climate change, global warming, sea level rise, ozone depletion 2.2 Manmade Disasters: Chemical, Industrial, Nuclear and Fire Hazards. Role of growing population and subsequent industrialization, urbanization and changing lifestyle of human beings in frequent occurrences of manmade disasters.	09

03	Disaster Management, Policy and Administration 3.1 Disaster management: meaning, concept, importance, objective of disaster management policy, disaster risks in India, Paradigm shift in disaster management. 3.2 Policy and administration: Importance and principles of disaster management policies, command and co-ordination of in disaster management, rescue operations-how to start with and how to proceed in due course of time, study of flowchart showing the entire process.	06
04	Institutional Framework for Disaster Management in India: 4.1 Importance of public awareness, Preparation and execution of emergency management program. Scope and responsibilities of National Institute of Disaster Management (NIDM) and National disaster management authority (NDMA) in India. Methods and measures to avoid disasters, Management of casualties, set up of emergency facilities, importance of effective communication amongst different agencies in such situations. 4.2 Use of Internet and softwares for effective disaster management. Applications of GIS, Remote sensing and GPS in this regard.	06
05	Financing Relief Measures: 5.1 Ways to raise finance for relief expenditure, role of government agencies and NGO's in this process, Legal aspects related to finance raising as well as overall management of disasters. Various NGO's and the works they have carried out in the past on the occurrence of various disasters, Ways to approach these teams. 5.2 International relief aid agencies and their role in extreme events.	09
06	Preventive and Mitigation Measures: 6.1 Pre-disaster, during disaster and post-disaster measures in some events in general 6.2 Structural mapping: Risk mapping, assessment and analysis, sea walls and embankments, Bio shield, shelters, early warning and communication 6.3 Non Structural Mitigation: Community based disaster preparedness, risk transfer and risk financing, capacity development and training, awareness and education, contingency plans. 6.4 Do's and don'ts in case of disasters and effective implementation of relief aids.	06

Internal 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). Duration of each test shall be one hour.

End Semester Examination:

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

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

References:

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

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

Course Code	Course Name	Credits
ILO7018	Energy Audit and Management	03

Objectives:

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

Outcomes: Learner will be able to...

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

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

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

Internal Assessment:

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End Semester Examination:

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4. Only **Four questions need to be solved**

References:

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

Course Code	Course Name	Credits
ILO7019	Development Engineering	03

Objectives:

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

Outcomes: Learner will be able to...

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

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

04	Post 73rd Amendment Scenario 73rd Constitution Amendment Act, including - XI schedule, devolution of powers, functions and finance; Panchayati Raj institutions - organizational linkages; Recent changes in rural local planning; Gram Sabha - revitalized Panchayati Raj; Institutionalization; resource mapping, resource mobilization including social mobilization; Information Technology and rural planning; Need for further amendments.	04
05	Values and Science and Technology Material development and its values; the challenge of science and technology; Values in planning profession, research and education. Types of Values Psychological values — integrated personality; mental health; Societal values — the modern search for a good society; justice, democracy, rule of law, values in the Indian constitution; Aesthetic values — perception and enjoyment of beauty; Moral and ethical values; nature of moral judgment; Spiritual values; different concepts; secular spirituality; Relative and absolute values; Human values — humanism and human values; human rights; human values as freedom, creativity, love and wisdom.	10
06	Ethics Canons of ethics; ethics of virtue; ethics of duty; ethics of responsibility; Work ethics; Professional ethics; Ethics in planning profession, research and education	04

Internal 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). Duration of each test shall be one hour.

End Semester Examination:

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

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

References:

1. ITPI, Village Planning and Rural Development, ITPI, New Delhi
2. Thooyavan, K.R. Human Settlements: A 2005 MA Publication, Chennai
3. GoI, Constitution (73rd GoI, New Delhi Amendment) Act, GoI, New Delhi
4. Planning Commission, Five Year Plans, Planning Commission

5. Planning Commission, Manual of Integrated District Planning, 2006, Planning Commission New Delhi
6. Planning Guide to Beginners
7. Weaver, R.C., The Urban Complex, Doubleday.
8. Farmer, W.P. et al, Ethics in Planning, American Planning Association, Washington.
9. How, E., Normative Ethics in Planning, Journal of Planning Literature, Vol.5, No.2, pp. 123-150.
10. Watson, V., Conflicting Rationalities: -- Implications for Planning Theory and Ethics, Planning Theory and Practice, Vol. 4, No.4, pp.395 – 407

Lab Code	Lab Name	Credits
ARL701	Machine Vision System Lab	1

Prerequisite: Computer Graphics, Image Processing, Python

Lab Objectives:

1. To perform basic image processing operations.
2. To explore different pre-processing technique.
3. To develop application related to Machine vision.
4. To detect and recognize objects.

Lab Outcomes:

1. Students will be able to read image and video file, perform different processing.
2. Students will be able to do edge detection, depth estimation.
3. Students will be able to choose appropriate algo for segmentation.
4. Students will be able to implement object detection technique.

Suggested Experiments:

Students are required to complete at least 8 experiments.

Sr. No.	Name of the Experiment
1	Handling Files, Cameras, and GUIs Basic I/O scripts, Reading/writing an image file, converting between an image and raw bytes, Accessing image data with numpy. array, Reading/writing a video file, Capturing camera frames, Displaying images in a window, Displaying camera frames in a window.
2	Processing Images with Open CV3 Converting between different colour spaces, The Fourier Transform, High pass filter, Low pass filter
3	Edge detection with Canny Contour detection, Contours – bounding box, minimum area rectangle, and minimum enclosing circle, Contours – convex contours and the Douglas-Peucker algorithm, Line and circle detection
4	Depth Estimation Capturing frames from a depth camera Creating a mask from a disparity map Masking a copy operation Depth estimation with a normal camera
5	Object segmentation using the Watershed and GrabCut algorithms, Example of foreground detection with GrabCut, Image segmentation with the Watershed algorithm

6	Detecting and Recognizing Faces Conceptualizing Haar cascades Getting Haar cascade data Using OpenCV to perform face detection Performing face detection on a still image
7	Performing face detection on video Performing face recognition Generating the data for face recognition Recognizing faces Preparing the training data Loading the data and recognizing faces Performing an Eigenfaces recognition
8	Retrieving Images and Searching Using Image Descriptors, Feature detection algorithms, Defining features Detecting features – corners Feature extraction and description using DoG and SIFT Anatomy of a key point
9	Detecting and Recognizing Objects Object detection and recognition techniques HOG descriptors The scale issue The location issue Non-maximum (or non-maxima) suppression Support vector machines People detection
10	Creating and training an object detector Bag-of-words BOW in computer vision Detecting cars in a scene

Term Work:

1. Term work should consist of 8 experiments.
2. Journal must include at least 2 assignments.
3. The final certification and acceptance of term work ensures that satisfactory performance of laboratory work and minimum passing marks in term work.

4. Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks)

Practical Oral Examination:

Oral examination will be based on entire syllabus.

Reference & Useful Links:

1. Learning OpenCV 3 Computer Vision with Python Second Edition, by Joe Minichino Joseph Howse
Published by Packt Publishing Ltd.
2. <http://iitk.ac.in/ee/computer-vision-lab>
3. <https://nptel.ac.in/courses/108103174>
4. https://docs.opencv.org/3.4/d9/df8/tutorial_root.html

Lab Code	Lab Name	Credit
ARL702	Artificial Intelligence for Robot Lab	1

Prerequisite: Discrete Mathematics, Data Structure

Lab Objectives:

- 1 To realize the basic techniques to build intelligent systems
- 2 To apply appropriate search techniques used in problem solving
- 3 To create knowledge base for uncertain data

Lab Outcomes: At the end of the course, the students will be able to

- 1 Identify languages and technologies for Artificial Intelligence
- 2 Understand and implement uninformed and informed searching techniques for real world problems.
- 3 Create a knowledge base using any AI language.
- 4 Design and implement expert systems for real world problems.

Suggested List of Experiments (programming in python)

Sr. No.	Title of Experiment
1	One case study on AI applications published in IEEE/ACM/Springer or any prominent journal.
2	Assignments on State space formulation and PEAS representation for various AI applications
3	Program on uninformed search methods.
4	Program on informed search methods.
5	Program on Game playing algorithms.
6	Program for first order Logic
7	Planning Programming
8	Implementation for Bayes Belief Network

Note: Any other practical covering the syllabus topics and subtopics can be conducted.

The programming assignment for First order logics could be in the form of a mini project

Term Work:

- 1 Term work should consist of a minimum of 8 experiments.
- 2 Journal must include at least 2 assignments on content of theory and practical of “Artificial Intelligence”
- 3 The final certification and acceptance of term work ensures that satisfactory performance of laboratory work and minimum passing marks in term work.

4 Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks)

Oral & Practical exam: Based on the entire syllabus of **Artificial** Intelligence for Robot

Course Code	Course Name	Credits
ARL703	Industrial Skills	01

Course Rationale: This course has been designed to prepare final year mechanical engineering students for placements, as well as to build computer skills and advanced soft skills to make them ready for a career in the industry.

Objectives:

1. To familiarise mechanical engineering students with basic computer/IT skills in the industry.
2. To practise soft skills and communication to be industry-ready.
3. To inculcate critical thinking and problem-solving abilities for efficient team and project outcomes.
4. To be prepared for campus placements by practising aptitude, logical reasoning, Group discussion and personal interview rounds.

Outcomes: At the end of the course, **the learners will be able to**

1. Skilfully prepare and edit documents and slides on MS Word and MS PowerPoint etc.
2. Execute functions on MS Excel.
3. Learn how to navigate tasks and execute functions in G-suite.
4. Understand and practice metacognitive skills of creativity and problem solving.
5. Hone team building and leadership skills.

Perform well in campus placement rounds by practising Aptitude, Logical reasoning, Group Discussion and Personal Interviews

Module	List of Experiments and Activities	No. of Lab sessions (*2hrs)
1	Computer/IT skills	6
1.1	Basics of Computers- Desktop/Laptop operations	
1.2	Microsoft Office	
1.2.1	• MS Word- Assignment to Create and use various commands in a Word document (Page setup, text formatting, templates, SmartArt, Title and Ribbon bar, Editing etc.)	
1.2.2	• MS Excel- Assignment to Create and tabulate a spreadsheet (Excel- data analysis, charts, pivot tables, VBA, etc.)	
1.2.3	• MS- Power point- Assignment to design and use a Presentation Software (MSPPT, Prezi, etc. – Presentation	

1.2.4	design, templates, custom slides, animation, graphs, charts, troubleshooting etc.) • MS Outlook (Navigation, archiving, tasks distribution, filters,scheduling etc.)	
1.3	• G-Suite (Gmail, G-Meet, Calendar, Sheets, Docs, Slides etc.)	
1.4	• An introduction to the typesetting package LATEX.	
2	Aptitude and Logical Reasoning	2
2.1	Aptitude – Aptitude training, types of questions, mock tests	
2.2	Logical Reasoning – Verbal and Non-verbal reasoning, Types of questions, Mock tests	
3	Developing Metacognitive skills	2
3.1	Task orientation and Goal setting (can be based on Final year Project):	
3.2	Creativity and Problem-solving	
4	Collaborative Techniques: Team building skills	1
4.1	Activities on Team building	
4.2	Case studies on Leadership, Decision making and Team building	
5	GD – PI	2
5.1	Group Discussion – Factual, Strategic, Abstract, Case study, Picture based	
5.2	Personal Interview – Types of Interview Questions, Strategies, Sample answers, Mock Interviews	

Assignments: Assignments and activities should enable a steady progress in developing the afore mentioned skills. A record of the conducted activities can be attached in journal as image printouts, and write up of case studies.

1. Application of MS Office skills (Individual)
 - Create and edit Word documents
 - Create and execute MS Excel functions
 - Create and enhance MS PPT
2. Writing a simple document in LATEX editor and running the typesetter program to produce finished document
3. Aptitude and Logical reasoning tests/practice sheets
4. Team building skills: Activities/Tasks to be performed as a team of 3 or 4 students.
5. Group Discussions

Case studies on problem-solving to be done as a team activity.

Personal Interview questions log book

Assessment: Total – 50 Marks

Marks distribution will be as follows:

FINAL TERM WORK – 25 Marks

Assignments (Journal) – 20

Marks Attendance - 05 Marks

ORALS/Written – 25 Marks

1. Aptitude Test (Written) - 15 Marks

2. Mock Interview (Orals) – 10 Marks

Books recommended/References/ Resources:

1. Meenakshi Raman, Prakash Singh. *Business Communication*, Oxford University Press, 2012
2. Claudyne Wilder. *The Presentations Kit: 10 steps for Selling Your Ideas*, John Wiley & Sons, 1994.
3. Lesikar, Flatley. *Basic Business Communication: Skills for Empowering the Internet Generation*, Tata McGraw Hill, 2008.
4. Flavell, J. H. *Cognitive development: Past, present, and future*. 1992.
5. Thorpe, Edgar and Showick Thorpe. *Objective English*, Pearson, 2013. (7th edition Amazon)
6. Thorpe, Edgar. *Test of Reasoning: for All Competitive Examination*. 7th edition., Amazon
7. Sinha, Nishit K., *Reasoning*, Pearson.
8. Aggarwal, R.S., *A Modern Approach to Logical Reasoning*, S. Chand.
9. Weblinks - <https://cambridge-community.org.uk/professional-development/gswmeta/index.html>
10. Various Quantitative aptitude books and websites list <https://eduly.in/best-quantitative-aptitude-books/>
<https://prepinsta.com/learn-aptitude/>
<https://www.simplilearn.com/learn-ms-excel-free-training-course-skillup>

NPTEL

Creativity <https://nptel.ac.in/courses/109101017>

Course Era

MS Excel <https://www.coursera.org/projects/introduction-microsoft-excel> G-suite

<https://www.coursera.org/projects/collaborating-g-suite-apps> Problem solving

<https://www.coursera.org/learn/problem-solving> Udemy G-suite

<https://www.udemy.com/course/learn-gsuite>

Course Code	Course Name	Credits
ARP701	Major Project 1	03

Objectives: The course aims:

The Project work facilitates the students to develop and prove Technical, Professional and Ethical skills and knowledge gained during graduation program by applying them from problem identification, analyzing the problem and designing solutions.

Outcomes:

1	Students will be able to develop the understanding of the problem domain through extensive review of literature.
2	Students will be able to identify and analyze the problem in detail to define its scope with problem specific data.
3	Students will be able to identify various techniques to be implemented for the selected problem and related technical skills through feasibility analysis.
4	Students will be able to design solutions for real-time problems that will positively impact society and environment.
5	Students will be able to develop clarity of presentation based on communication, teamwork and leadership skills.
6	Students will be able to inculcate professional and ethical behavior.

Guidelines:

1. Project Topic Selection and Allocation:

- Project topic selection Process to be defined and followed:
 - Project orientation can be given at the end of sixth semester.
 - Students should be informed about the domain and domain experts whose guidance can be taken before selecting projects.
 - Student's should be recommended to refer papers from reputed conferences/ journals like IEEE, Elsevier, ACM etc. which are not more than 3 years old for review of literature.
 - Students can certainly take ideas from anywhere, but be sure that they should evolve them in the unique way to suit their project requirements. Students can be informed to refer Digital India portal, SIH portal or any other hackathon portal for problem selection.

- Topics can be finalized with respect to following criterion:
- **Topic Selection:** The topics selected should be novel in nature (Product based, Applicationbased or Research based) or should work towards removing the lacuna in currently existingsystems
- **Technology Used:** Use of latest technology or modern tools can be encouraged.
 - Students should not repeat work done previously (work done in the last three years).
- Project work must be carried out by the group of at least 2 students and maximum 4.
- The project work can be undertaken in a research institute or organization/Industry/any businessestablishment. (out-house projects)
- The project proposal presentations can be scheduled according to the domains and should be judgedby faculty who are expert in the domain.
- Head of department and senior staff along with project coordinators will take decision regardingfinal selection of projects.
- Guide allocation should be done and students have to submit weekly progress report to the internalguide.
- Internal guide has to keep track of the progress of the project and also has to maintain attendancereport. This progress report can be used for awarding term work marks.
- In case of industry/ out-house projects, visit by internal guide will be preferred and externalmembers can be called during the presentation at various levels

2. Project Report Format:

At the end of semester, each group need to prepare a project report as per the guidelines issued by the University of Mumbai.

A project report should preferably contain at least following details:

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

Desirable

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

3. Term Work:

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

- a. Weekly Log Report
- b. Project Work Contribution
- c. Project Report (Spiral Bound) (both side print)
- a. Term End Presentation (Internal)

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

4. Term work evaluation:

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

Suggested quality evaluation parameters are as follows:

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

Course Code	Course Name	Credits
ARC801	Industrial Internet of Things	03

Prerequisites: Systems in Mechanical Engineering, Programming and Problem Solving, Basic Electronics Engineering, Solid Mechanics, Solid Modeling and Drafting, Electrical and Electronics Engineering, Mechatronics, Measurement Laboratory, Fluid Power & Control Laboratory

Course Objectives:

1. Introduction to IoT, Overview of IoT Building Blocks
2. Build small applications in IoT for Mechanical Engineering Applications using Sensors, Actuators, Microcontrollers and Cloud
3. Learn commonly used IoT Simulation Hardware platforms
4. Understand different Communication Technologies used in IoT
5. Development of application-level protocol and Security of IoT Ecosystem
6. Understand IoT applications in different domains

Course Outcomes:

On completion of the course the learner will be able to;

1. EXPLAIN the Applications/Devices, Protocols and Communication Models of IoT
2. DEMONSTRATE small Mechanical Engineering IoT oriented applications using Sensors, Actuators, Microcontrollers and Cloud
3. SELECT commonly used IoT Simulation Hardware platforms
4. APPLICATION of Interfacing and Communication Technologies for IoT.
5. ILLUSTRATE IoT Application Development and Security of IoT Ecosystem
6. EVALUATE Present and Future Domain specific Applications of IoT Ecosystem

Module	Details	Hrs	CO mapping
01	Overview, History, Definition and Characteristics, Connectivity Terminologies, Building blocks, Types of technologies used in IoT System, Baseline Technologies (Machine-to-Machine (M2M) communications, Cyber-Physical-Systems (CPS)), IoT Vs M2M, IoT enabled Technologies, IoT Levels and Templates, Design Methodology, The Physical Design Vs Logical Design of IoT, Functional blocks of IoT and Communication Models/Technologies, Development Tools used in IoT, IoT Architecture and Protocols, Various Platforms for IoT, Real time Examples of IoT, Challenges in IoT, The process flow of an IoT application, Evolution of Connected Devices, Applications of IoT, IoT Enablers, Overview of Governance, Privacy and Security Issues.	07	CO1
02	Measuring physical and virtual quantities in digital world, Overview of Sensors working, Analog Vs Digital Sensors, Wired Vs Wireless Sensors, Types of Sensors, Types of Converters Types of Transducers and Actuator, Controlling Hardware, Types	07	CO2

	of Controller, Role of microcontroller as gateway to interfacing sensors and actuators, Microcontroller Vs Microprocessor, Type of microcontrollers in embedded System		
03	IoT supported Hardware platforms: Introduction to IoT Simulation Environment and Devices (Raspberry Pi, Espressif Processors, Arduino), Architecture, Setup, IDE, Installation, Interfaces (serial, SPI, I2C), Programming with focus on interfacing for reading input from pins, connecting external gadgets/sensors/actuators, Controlling and Displaying Output, Libraries, Basics of Embedded C programming Interfacing: Interfacing Input, Intermediate, Output and Display Sensors, Converters, Actuators, Controlling Hardware, Controllers and Network Devices, IoT Architecture: Building architecture and Open-source architecture (OIC), Main design principles and needed capabilities, An IoT architecture outline, Standards Considerations	07	CO3
04	Communication: Overview and Working of Controlled Systems, Connectivity models - TCP/IP Vs OSI model, IoT Communication Models, IoT Communication APIs, Serial Vs Parallel Communication, Wires Vs Wireless Communication, their Technologies and Hardware IoT Communication Protocols: Protocol Standardization for IoT, Role of M2M in IoT, M2M Value Chains, IoT Value Chains, M2M and WSN Protocols (SCADA and RFID) Physical Servers and Cloud Platforms: Web server, Posting sensor(s) data to web server, Introduction to Cloud Storage models and Communication APIs Webserver, API Virtualization concepts and Cloud Architecture, Advantages and limitations of Cloud computing, IoT Cloud platforms, Cloud services enabled devices, IoT security for consumer devices, Security levels, protecting IoT devices, Security, Privacy and Trust in IoT-Data-Platforms	07	CO4
05	Application Protocols: MQTT, REST/HTTP, SQL Back-end Application Designing (Designing with Apache, MySQL, HTML, CSS), Non SQL Back-end Application Designing (MongoDB Object Type Database, jQuery for UI Designing), JSON lib for data processing Security: Need of security in IoT, Security & Privacy during development, Privacy for IoT	05	CO5

06	IoT applications for industry: Future Factory Concepts, Brownfield IoT, Smart Objects, Smart Applications. Study of existing IoT platforms /middleware, Business, Manufacturing, Smart Homes/Home automation, Surveillance applications, Connected Vehicles, Agriculture, Healthcare, Activity Monitoring, Retail, Logistics, Security, Health and Lifestyle, Legal challenges, IoT in Environmental Protection Modern Day IoT Applications, Smart Grid, Smart Cities - Security, Privacy and Trust in IoT-Data-Platforms for Smart Cities, First Steps Towards a Secure Platform, Smartie Approach. Data Aggregation for the IoT in Smart Cities Future: Future IoT ecosystem, Need of powerful core for building secure algorithms, Examples for new trends (AI, ML penetration to IoT)	07	CO6
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Text Books:

1. Bahga, A. and Madisetti, V., (2015), "Internet of Things - A Hands-on Approach," Universities Press, ISBN: 9788173719547
2. Hajjaj, S S H. and Gsangaya, K. R., (2022), "The Internet of Mechanical Things: The IoT Framework for Mechanical Engineers," CRC Press, ISBN: 9781032110950
3. Raj, P. and Raman, A. C., (2017), "The Internet of Things: Enabling Technologies, Platforms, and Use Cases," Auerbach Publications/CRC Press, ISBN: 9781498761284
4. Adrian McEwen, A. and Cassimally, H., (2013), "Designing the Internet of Things," John Wiley and Sons, ISBN:
5. Veneri, G., Capasso, A., (2018), "Hands-On Industrial Internet of Things: Create a powerful Industrial IoT infrastructure using Industry 4.0," Packt Publishing, ISBN: 9781789537222
6. Hersent, O, Boswarthick, D., Elloumi, O., (2012), "The Internet of Things: Key Applications and Protocols", Wiley, ISBN: 9781119994350
7. Uckelmann, D., Harrison, M., Michahelles, F., (2011), "Architecting the Internet of Things," Springer, ISBN: 9781119994350

References Books:

1. daCosta, F., (2013), "Rethinking the Internet of Things: A Scalable Approach to Connecting Everything", Apress Publications, ISBN: 9781430257417
2. Waher, P., (2015), "Learning Internet of Things," Packt Publishing, ISBN: 9781783553532
3. Ovidiu, V. and Friess, P., (2014), "Internet of Things - From Research and Innovation to Market Deployment," River Publishers, ISBN: 9788793102941, https://www.riverpublishers.com/pdf/ebook/RP_E9788793102958.pdf
4. Ida, N., (2020), "Sensors, Actuators and Their Interfaces," SciTech Publishers, ISBN: 9781785618352
5. Pfister, C., (2011), "Getting Started with the Internet of Things," O'Reilly Media, ISBN:

6. Wallace, S., Richardson, M., Wolfram Donat, W., (2021), “Getting Started With Raspberry Pi: Getting to Know the Inexpensive ARM-Powered Linux Computer,” Make Community, LLC, ISBN: 9781680456998
7. Elangovan, U., (2019), “Smart Automation to Smart Manufacturing: Industrial Internet of Things,” Momentum Press, ISBN: 9781949449266
8. Jha, S., Tariq, U., Joshi, G. P., Solanki, V. K., (2022), “Industrial Internet of Things: Technologies, Design, and Applications,” CRC Press, ISBN: 9780367607777
9. Schwartz, M., (2016), “Internet of Things with Arduino Cookbook,” Packt Publishing, ISBN: 9781785286582
10. Kurniawan, A., (2019), “Internet of Things Projects with ESP32: Build exiting and powerful IoT projects using the all-new Expressif ESP32,” Packt Publishing, ISBN: 9781789956870

Web References:

1. <https://nptel.ac.in/courses/106105166>
2. <https://www.udemy.com/internet-of-things-iot-for-beginners-getting-started/>
3. <http://playground.arduino.cc/Projects/Ideas>
4. <http://www.megunolink.com/articles/arduino-garage-door-opener>
5. <http://www.willward1.com/arduino-wifi-tutorial>
6. <http://www.toptechboy.com/arduino-lessons>
7. <https://www.eprolabs.com>
8. <http://www.makeuseof.com/tag/pi-overdose-heres-5-raspberry-pi-alternatives>

Course Code	Course Name	Credits
ARDLO8051	Product Design and Development	03

Course Objectives:

1. To understand the basic concepts of engineering design and product design & development, focusing on the front-end processes.
2. To demonstrate an understanding of the overview of all the product design & development processes.
3. To demonstrate knowledge of concept generation and the selection of tools.
4. To study the applicability of product design & development in industrial applications.

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

1. Describe the process of product design & development.
2. Employ engineering, scientific, and mathematical principles to develop and execute a design project from a concept to a finished product.
3. Create 3D solid models of mechanical components using CAD software.
4. Demonstrate individual skills using selected manufacturing techniques such as rapid prototyping.
5. Fabricate an electromechanical assembly of a product from engineering drawings.
6. Work collaboratively in a team to complete a design project.
7. Effectively communicate the results of projects and other assignments both in a written and oral format.

Module	Details	Hours	CO Mapping
01	Need for developing products, The importance of Engineering and Industrial design, The design process, Relevance of product lifecycle issues in design, Societal considerations in Engineering and Industrial Design, Generic product development process, Various phases of product development, planning for products, Establishing markets - market segments - relevance of market research.	07	CO1
02	The design processes, Descriptive and prescriptive design models, Concept development & evaluation, Pugh's total design activity model, Concept generation and selection method, Embodiment design, Product architecture, and Steps in developing product architecture.	07	CO2
03	Identifying customer needs, Voice of Customer (VoC), Customer populations, Hierarchy of human needs, Need gathering methods, Establishing engineering characteristics, Competitive benchmarking, Quality Function Deployment (QFD), House of Quality (HoQ), Product design specification, Development of product design with specifications using QFD, Relevant case studies.	07	CO3
04	Creative thinking, Creativity and problem-solving methods, Creative thinking methods, Brainstorming technique, Gordon technique, Check listing technique, Synectic technique, Morphological Analysis, and Attribute Listing technique. Generating design concepts, Systematic	07	CO4

05	Industrial design, Basic forms & elements, Integrating basic forms & methods of designing elements such as balance, rhythm, proportion, The golden rule of proportions, human factors, and design, User-friendly design, Design for serviceability, Design for environment.	07	CO5
06	Concept of Design for Manufacturing and Assembly (DFMA). Role of computers in product design and manufacturing process, Prototyping techniques such as Stereolithography (SLA), Selective laser sintering (SLS), Fused disposition Modelling (FDM), Laminated object manufacturing (LOM), 3-D printing, and Ballistic Particle Manufacturing (BPM).	07	CO6

Books:

1. Anita Goyal, Karl T Ulrich, Steven D Eppinger, "Product Design and Development," 4th Edition, 2009, Tata McGraw-Hill Education, ISBN-10-007-14679-9.
2. Kevin Otto, Kristin Wood, "Product Design," Indian Reprint 2004, Pearson Education, ISBN 9788177588217.

Reference Books:

1. Clive L Dym, Patrick Little, "Engineering Design: A Project-based Introduction," 3rd Edition, John Wiley & Sons, 2009, ISBN 978-0-470-22596-7.
2. George E. Dieter, Linda C. Schmidt, "Engineering Design," 4th Edition, McGraw-Hill International Edition, 2009, ISBN 978-007-127189-9.
3. Yousef Haik, T. M. M. Shahin, "Engineering Design Process," 2nd Edition Reprint, Cengage Learning, 2010, ISBN 0495668141

Course Code	Course Name	Credits
ARDLO8052	Wireless Networks	03

Course Objectives:

1. To analyze the fundamental architecture, design issues and standards of wireless networks.
2. To compare Personal Area Network (PAN) technologies such as ZigBee, Bluetooth, UWB, NFC and 6LoWPAN.
3. To classify different LAN topologies and technologies and ad hoc networks.
4. To classify network protocols, ad hoc vehicle networks and Wireless MANs.
5. To understand planning and design of GSM and CDMA system in Wireless WANs.
6. To apply Wireless sensor networks concepts to develop an IoT applications.

Course Outcomes:

After successful completion of the course student will be able to:

1. Explain fundamental architecture, design issues and standards of wireless networks.
2. Compare different types of Personal Area Network (PAN) technologies such as ZigBee, Bluetooth, UWB, NFC and 6LoWPAN.
3. Analyze different LAN topologies and technologies and ad hoc networks.
4. Compare various types of network protocols, ad hoc vehicle networks and Wireless MANs.
5. Evaluate the performance of GSM and CDMA system in Wireless WANs.
6. Apply the concepts of basic network architecture of Wireless sensor networks to develop an IoT applications.

Module	Contents	Hours	CO mapping
Prerequisite: Pre-requisite: Computer Communication and Networks, Mobile Communication System			
1.	Overview of wireless networks Wireless Networks: Architecture, Classifications, Switching technology, Communication Problems, Reference Models. Networking issues and Networking Standard. Wireless Body Area Networks: Properties, Network Architecture, Network components and Applications	04	CO1
2.	Wireless Personal Area Networks WPAN: Bluetooth (802.15.1): Radio Specifications, Protocol Stack, Link Types, Security, Topologies, Applications.	12	CO2

	ZigBee (802.15.4): Radio Specifications, Components, Topologies, Protocol Stack, Applications. RFID: Radio Specifications, Architecture, Types and applications. Near Field Communication & UWB (802.15.3 a): Introduction and working. LoWPAN: Features, Architecture, protocol stack and applications		
3.	Wireless Local Area Network & Wireless Adhoc Networks Wireless Local Area Network: Equipment, Topologies, Technologies, Applications, Main features of IEEE802.11a,b, i and n, Protocol Architecture of WLAN Wireless Adhoc Networks: Features, advantages & Applications Mobile Adhoc Networks: Network Architecture, MAC Protocol.	06	CO3
4.	Wireless Metropolitan & Vehicular Adhoc Networks WMAN(IEEE802.16): Introduction, WMAN Network Architecture, Network Protocols, Broadband Wireless Networks, Applications Vehicular Adhoc Networks (VANETs): Characteristics, Protocols & Applications	05	CO4
5.	Wireless Wide Area Networks Planning and design of Wireless Networks, Radio design for a cellular Network Receiver sensitivity, Link budget for GSM and CDMA Systems, HSDPA	06	CO5
6.	Advanced Technologies of Wireless Networks Wireless Sensor Networks: Network Architecture, Design Considerations, Network Protocol Stack, and Applications Wireless Mesh Network: Network architecture, Protocols technologies & Applications Internet of Things: IoT Conceptual Framework, Architecture, Technology & Examples. M2M Communication	08	CO6

Internal 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). Duration of each test shall be one hour.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 Marks.
2. Total 4 questions need to be solved.
3. Question No. 1 will be compulsory and based on entire syllabus wherein sub questions of 4 to 5 marks will be asked.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Text Books & References:

1. Vijay K. Garg, "Wireless Communication and Networking", Morgan -Kaufmann Series in Networking—Elsevier.
2. Kazem Sohraby, Daniel Minoli, and Taieb Znati, "Wireless Sensor Networks: Technology, Protocols, and Applications", Wiley Student Edition
3. Dr Sunilkumar S. Manvi, Mahabaleshwar S. Kakkasageri, "Wireless and Mobile Networks Concepts and Protocol" Wiley India Pvt Ltd
4. Raj Kamal, "Internet of Things Architecture & Design Principles" McGraw Hill

Course Code	Course Name	Credits
ARDLO8053	Micro Electro Mechanical Systems (MEMS)	03

Course Objectives:

1. To realize the benefits and effects of scaling.
2. To understand properties and crystallography of Silicon
3. To learn the microfabrication techniques
4. To understand the principles and uses of micro systems

Course Outcomes:

After taking this course, learner should be able to:

1. Apply laws of scaling for development of a MEMS device
2. Understand the materials and their processing to make MEMS
3. Select and use microfabrication techniques for microsystems
4. Understand the development of micro sensors and actuators
5. Analyze microsystems technology for technical feasibility as well as practicality
6. Develop useful applications of MEMS.

Module	Contents	Hrs.	CO mapping
1	Introduction to MEMS Unique characteristics of MEMS, Microsystems Technology- An Overview, typical MEMS and Microsystem Products, Scaling effects - scaling laws in miniaturization- Application of MEMS	05	CO1
2	Material for MEMS and manufacturing Structure of silicon and other materials - Silicon wafer processing - Bulk micromachining and Surface micromachining, Wafer-bonding. Thin-film deposition, Lithography, wet etching and dry etching.	07	CO2
3	Micro-fabrication methods LIGA and other moulding techniques- Soft lithography and polymer processing- Thick-film processing; Low temperature co-fired ceramic processing.	06	CO3
4	MEMS components-micro sensors Micro sensors - Basic principles and working of micro sensors- Acoustic wave micro sensors- Bio-medical micro sensors- Bio-sensors- Chemical microsensors – Optical Sensors – Pressure micro sensors- Thermal micro sensors-acceleration micro sensors;	08	CO4
5	Micro-actuators Basic principles and working of micro actuators- Electrostatic micro actuators- Piezoelectric micro actuators- Thermal micro actuators- SMA micro actuators- Electromagnetic micro actuators, micro valves, micro pumps.	06	CO5
6	Case studies /research based on MEMS applications-impact of materials, processes and design, Actuation using Shape Memory Alloys, Medical device, micropumps	04	CO6

Text books:

1. MEMS and Microsystems Design and Manufacture by Tai-Ran Hsu, Tata McGraw-Hill Publishing Company Ltd.
2. Foundation of MEMS by Chang Liu, Pearson Education

References:

- Fundamentals of Microfabrication and Nanotechnology, by Marc J. Madou, CRC Press, 2011, ISBN: 9780849331800
- Micromachined Transducers Sourcebook, by Gregory Kovacs, WCB McGraw-Hill, Boston, 1998, ISBN: 9780071164627
- Micromechanical Transducers: Pressure sensors, accelerometers, and gyroscopes, by M.H. Bao, Elsevier, New York, 2000, ISBN: 978-0444505583
- Microsystem Design, by Stephen D Senturia, Springer Publication, 2000, ISBN: 9780792372462.
- Micro sensors - Principles and Applications, by Julian W. Gardner, John Wiley & Sons, Inc. 1994, ISBN: 9780471941361.

Course Code:	Course Title	Credit
ARDLO8054	Deep Learning	3

Prerequisite: Basic mathematics and Statistical concepts, Linear algebra, Machine Learning

Course Objectives:

- 1 To learn the fundamentals of Neural Network.
- 2 To gain an in-depth understanding of training Deep Neural Networks.
- 3 To acquire knowledge of advanced concepts of Convolution Neural Networks, Autoencoders and Recurrent Neural Networks.
- 4 Students should be familiar with the recent trends in Deep Learning.

Course Outcomes:

- 1 Gain basic knowledge of Neural Networks.
- 2 Acquire in depth understanding of training Deep Neural Networks.
- 3 Design appropriate DNN model for supervised, unsupervised and sequence learning applications.
- 4 Gain familiarity with recent trends and applications of Deep Learning.

Module	Content	Hrs
1	Fundamentals of Neural Network Biological neuron, Mc-Culloch Pitts Neuron, Perceptron, Perceptron Learning, Delta learning, Multilayer Perceptron: Linearly separable, linearly non-separable classes. Deep Networks: Fundamentals, Brief History, Three Classes of Deep Learning Basic Terminologies of Deep Learning	04
2	Training, Optimization and Regularization of Deep Neural Network Training Feedforward DNN Multi Layered Feed Forward Neural Network, Learning Factors, Activation functions: Tanh, Logistic, Linear, Softmax, ReLU, Leaky ReLU, Loss functions: Squared Error loss, Cross Entropy, Choosing output function and loss function Optimization Learning with backpropagation, Learning Parameters: Gradient Descent (GD), Stochastic and Mini Batch GD, Momentum Based GD, Nesterov	10

	Accelerated GD, AdaGrad, Adam, RMSProp Regularization Overview of Overfitting, Types of biases, Bias Variance Tradeoff Regularization Methods: L1, L2 regularization, Parameter sharing, Dropout, Weight Decay, Batch normalization, Early stopping, Data Augmentation, adding noise to input and output	
3	Autoencoders: Unsupervised Learning Introduction, Linear Autoencoder, Undercomplete Autoencoder, Overcomplete Autoencoders, Regularization in Autoencoders Denoising Autoencoders, Sparse Autoencoders, Contractive Autoencoders Application of Autoencoders: Image Compression	06
4	Convolutional Neural Networks (CNN): Supervised Learning Convolution operation, Padding, Stride, Relation between input, output and filter size, CNN architecture: Convolution layer, Pooling Layer, Weight Sharing in CNN, Fully Connected NN vs CNN, Variants of basic Convolution function Modern Deep Learning Architectures: LeNET: Architecture, AlexNET: Architecture	07
5	Recurrent Neural Networks (RNN) Sequence Learning Problem, Unfolding Computational graphs, Recurrent Neural Network, Bidirectional RNN, Backpropagation Through Time (BTT), Vanishing and Exploding Gradients, Truncated BTT Long Short Term Memory: Selective Read, Selective write, Selective Forget, Gated Recurrent Unit	08
6	Recent Trends and Applications Generative Adversarial Network (GAN): Architecture, Applications: Image Generation, DeepFake	04

Assessment:

Internal Assessment:

The assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus is completed. Duration of each test shall be one hour.

End Semester Theory Examination:

- 1 Question paper will comprise a total of six questions.
- 2 All questions carry equal marks.
- 3 Question 1 and question 6 will have questions from all modules. Remaining 4 questions will be based on the remaining 4 modules.
- 4 Only four questions need to be solved.

- 5 In question paper weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.

Textbooks:

- 1 Ian Goodfellow, Yoshua Bengio, Aaron Courville. “Deep Learning”, MIT Press Ltd, 2016
- 2 Li Deng and Dong Yu, “Deep Learning Methods and Applications”, Publishers Inc.
- 3 Satish Kumar "Neural Networks A Classroom Approach" Tata McGraw-Hill.
- 4 JM Zurada “Introduction to Artificial Neural Systems”, Jaico Publishing House
- 5 M. J. Kochenderfer, Tim A. Wheeler. “Algorithms for Optimization”, MIT Press.

References:

- 1 Buduma, N. and Locascio, N., “Fundamentals of deep learning: Designing next-generation machine intelligence algorithms" 2017. O'Reilly Media, Inc."
- 2 François Chollet. “Deep learning with Python “(Vol. 361). 2018 New York: Manning.
- 3 Douwe Osinga. “Deep Learning Cookbook”, O'REILLY, SPD Publishers, Delhi.
- 4 Simon Haykin, Neural Network- A Comprehensive Foundation- Prentice Hall International, Inc
- 5 S. N. Sivanandam and S. N. Deepa, Principles of soft computing-Wiley India

Useful Links

- 1 <https://nptel.ac.in/courses/106/106/106106184/>
- 2 <http://www.cse.iitm.ac.in/~miteshk/CS6910.html>
- 3 <https://nptel.ac.in/courses/106/106/106106184/>
- 4 <https://www.deeplearningbook.org/>

Course Code	Course Name	Credits
ARDLO8061	Operations Planning and Control	3

Course Objectives:

1. To provide an exposure to Operations Planning & Control (PPC) and its significance in manufacturing and service organizations
2. To appraise about need and benefits of planning functions related to products and processes
3. To provide exposure to production scheduling, sequencing and project management so as to optimize resources
4. To provide insights into MRP and ERP to minimize the total cost and to manage operations functions in a better way
5. To demonstrate different techniques used for facility planning and assembly line balancing
6. To develop an understanding of JIT, Lean, Agile and Synchronous Manufacturing system

Course Outcomes: Learner will be able to...

1. Illustrate operations functions and manage operations in a better way.
2. Apply various strategies to develop aggregate production plans based on the demand forecasting.
3. Apply various algorithms in scheduling and sequencing of manufacturing and service operations
4. Develop Material Requirements Plans (MRP) to estimate the planned order releases.
5. Apply various techniques for facility layout planning and line balancing to optimize the resources
6. Demonstrate the importance of implementation of JIT, Lean, Agile and Synchronous manufacturing in manufacturing and service organizations.

Module	Detailed Contents	Hrs.	CO Mapping
1.	1.1 Introduction: Production and Operations Function, Production systems, make to stock, Make to order, Assemble to order and Engineer to order, type of layouts, Phases in OPC like Preplanning, Planning, Action & Control. 1.2 Strategic Planning for Operations and Services: Approaches like Forced Choice model and Operations Model, Quality and Productivity strategy, Technology strategy. Operations Strategies for Services, Types or Service Operations: Quasi manufacturing, Customer as participants, Customer as product, Classification of Services, Service capacity.	6	CO1
2.	2.1 Forecasting: Forecasting and Prediction, Need for forecasting, role of forecasting in OPC, Methods of forecasting, Qualitative methods, Quantitative methods like time series analysis, least square method, moving average method, and exponential smoothing method. Forecasting Error; Mean Absolute Deviation, Forecasting Bias 2.2 Capacity Planning: Measurement of capacity, Measures of operating capacity, Factors influencing effective capacity, factors favoring over capacity and under capacity, short range, medium range and long range capacity planning. Capacity requirement Planning	8	CO2

	(CRP) 2.3 Aggregate planning: Concept of aggregate planning, Pure Strategy; Mixed Strategy; Level Strategy, Rough cut capacity planning, Aggregate planning for Services; Optimal Models for Aggregate Planning; Linear Programming; Linear Decision Rules Master Production Schedule			
3.	3.1 Job shop/Intermittent Manufacturing Scheduling: Factors influencing scheduling, Inputs for scheduling, Forward Scheduling, Backward Scheduling, Stages in Scheduling: Product sequencing, Loading and Dispatching, dispatching, progress report & expediting and control. Basic scheduling problems, Priority Sequencing, Gantt Charts, Johnson's Rule for optimal sequence of N jobs on 2 machines. Process N Jobs on 3 Machines (N/3 problem) and Jackson Algorithm. Processing of 2 Jobs on M Machine (2/M) problem, 3.2 Project scheduling: Network analysis - PERT & CPM, cost analysis & crashing, resource leveling and smoothening.	8	CO3	
4.	4.1 Material Requirement Planning: Introduction, Limitations of conventional EOQ, Objectives of MRP, Inputs of MRP-I, Outputs of MRP, MRP lot sizing and Estimation of planned order releases, Manufacturing resource planning (MRP-II) 4.2 Enterprise Resource Planning (ERP): Evolution, features, purpose of modeling an enterprise, ERP model for OPC, Modules in ERP, ERP Implementation Life Cycle, ERP packages like SAP-R3/Baan/PeopleSoft	6	CO4	
5.	5.1 Facility layout planning: Factors influencing Plant Layout, Material Flow Patterns, Tools and Techniques used for Plant Layout Planning. 5.2 Line Balancing: Objectives, constraints, terminology in assembly line, heuristic methods like Kilbridge-Wester, Largest Candidate rule, Rank positional weight	6	CO5	
6.	Introduction to JIT system, Lean, Agile and Synchronous manufacturing: Concept, Characteristics, Components and Implementation.	5	CO6	

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 the end semester examination will be proportional to the 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.

Text/Reference Books:

University of Mumbai

B. E. (Automation & Robotics)

1. “Production and Operations Management”, K. Aswathappa & K. Shridhara Rao, Himalaya Publishing House, Revised 2nd Edition (2008)
2. “Industrial Engineering and Production Management”, Martand Telsang, S. Chand, New Delhi (2009)
3. “Modern Production operations Management”, Elwood S Buffa and Rakesh K Sarin, 8th Edition, Wiley Eastern, New York (1999) ISBN: 978-0471819059
4. “Production and Operations Management”, Panneer Selvan R, 3rd Edition 2002 Prentice Hall India, New Delhi, ISBN: 978-8120345553
5. “Production Planning and Control”, Samuel Eilon, Universal Publication, ISBN: 9788185027548
6. “Production Planning and Control”, L C Jhamb ,12th Edition 2010, Everest Pub House.
7. “Production Planning and Control”, W. Bolton-Longman Scientific & Technical (1994), ISBN: 978-0582228207
8. “Production Systems- Planning, Analysis & Control”, James. L. Riggs, John, 4th Edition 1987, Wiley & Sons, ISBN: 9780471847939
9. Manufacturing Planning and Control Systems, Thomas E. Vollman, William L. Berry & Others,4th Edition 1997, McGraw Hill Pub, ISBN: 978-0786312092
10. “Manufacturing Process Planning and Systems Engineering”, Anand Bewoor, Dreamtech Press 2009, ISBN: 978-8177229967
11. “Production and Operations Management”, S.N. Chary, 3rd Edition 2004, TMH publishing company, ISBN: 978-0070583559
12. Modernization & Material Management, L.C. Jhamb - Everest Publishing House

Course Code	Course Name	Credits
ARDLO8062	Autonomous Vehicles	3

Course Objectives:

1. Introduction to Autonomous vehicles/SDC (Self Driving Cars), advantages and challenges in SDC's.
2. Gain Knowledge about the Sensors in SDC's.
3. Understand the in- vehicle communication aspects in SDC's
4. Understand perception and localization in SDC.
5. Get to grips with planning and control in SDC.
6. To know the various applications of SDC's.

Course Outcome:

After successful completion of the course student will be able to

1. Understand fundamentals of SDC (Self Driving Cars).
2. Compare different types of Sensors in SDC's.
3. Illustrate different protocols of In - vehicle communication for SDC's.
4. Identify perception and localization in SDC's.
5. Analyze planning and control in SDC.
6. Evaluate different applications and algorithms in SDC's.

Module	Detailed Contents	Hrs.	CO Mapping
1.	Introduction Introduction to Autonomous Vehicles /Self Driving cars (SDC), Benefits of SDCs, Challenges in Current Deployment. Levels of Autonomy	04	CO1
2.	Sensors in Autonomous Vehicles Camera (3D and stereo), LiDAR, Sensor Fusion Passive Perception with Sonar and Millimeter Wave Radar Vehicle-to-Everything Infrastructure	06	CO2
3.	In-Vehicle Communication Systems CAN: Introduction and architecture CAN open: Introduction and architecture FlexRay protocol: Introduction and architecture Introduction to Operating System for SDC's	08	CO3
4.	Perception and Localization in SDC Introduction to Computer vision in SDC. Artificial eyes VS human eyes. Four pillars of autonomous driving: Perception, Localization, Planning and Control. Perception: Object Detection and Line Lane detection Object/ obstacle Detection: Comparison of 2D and 3D object detection. Overview of ML algorithms for obstacle detection-Histogram of Oriented Gradients (HOG), Support Vector Machine (SVM). Object detection using deep learning algorithm: Architecture of YOLO Line Lane Detection: Introduction to Semantic Segmentation, architecture, overview of different semantic segmentation architecture.	09	CO4

	Localization: Introduction to GNSS, GNSS error analysis, Visual Odometry, SLAM Self-Learning: Implementation of YOLO for object Detection, Implementation of semantic segmentation for images.		
5.	Planning and Control in SDC Planning and Control: Architecture of planning and control, Traffic Prediction and routing. Behavioral decision, Motion Planning and feedback control.	06	CO5
6.	Applications of SDC DragonFly Model: Sensor Configuration and Software Architecture Enabling Commercial Autonomous Space Robotic Explorers: Sensor configuration and its working. Algorithm for YOLO object detection: Detecting objects in images and Detecting objects in videos	06	CO6

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 the end semester examination will be proportional to the 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.

Textbooks:

1. Sumit Ranjan, Dr. S. Senthamilarasu - Applied Deep Learning and Computer Vision for Self- Driving Cars , Packt Publishing Ltd. 2020.
2. Shaoshan Liu, Liyun Li , Jie Tang, Shuang Wu, Jean-Luc Gaudiot - Creating Autonomous Vehicle System , Second Edition , Morgan & Claypool Publishers , 2018.
3. William Ribbens - Understanding- Automotive-Electronics , Butterworth-Heinemann Publisher , Fifth Edition, 1998.

Reference Books:

1. Markus Maurer ,J. Christian Gerdes, Barbara Lenz , Hermann Winner - Autonomous Driving Technical, Legal, Social Aspects , Springer Open, 2015.
2. Shaoshan Liu - Engineering Autonomous Vehicles and Robots, Wiley, 2020.

E-Resources:

1. Open Innovation in EVs: A case study of Tesla Motors
<https://www.diva-portal.org/smash/get/diva2:635929/FULLTEXT01.pdf>
2. Autonomous vehicles Research report by MRCagney
https://drive.google.com/drive/folders/1nxROagqwDKUpVMDLFPPgG7_DKakuyItf
3. Reinventing Safety: A Joint Approach to Automated Driving Systems Mercedes Benz and Bosch
<https://www.daimler.com/documents/innovation/other/vssa-mercedes-benz-and-bosch.pdf>

Online Courses

1. <https://digitaldefynd.com/best-self-driving-cars-courses/>
2. <https://www.classcentral.com/course/intro-self-driving-cars-13140>

Course Code	Course Name	Credits
ARDLO8063	Total Quality Management	03

Course Objectives:

1. To understand the importance of Quality Management and principles of TQM
2. To understand seven basic QC tools and advanced QM tools
3. To understand the concept of Statistical Quality Control
4. To understand the concept of Continuous Improvement and TQM implementation
5. To understand different Quality Systems and Quality Standards
6. To understand the future trends in TQM and TQM strategies

Course Outcomes: The students will be able to use the tools and techniques of TQM in the manufacturing and service sectors.

1. To apply QM and principles of TQM in organizational development process.
2. To apply the QC & QM tools in process improvement.
3. To apply SQC techniques to improve process quality.
4. To apply Six Sigma project in TQM Implementation
5. To apply QMS and Certification for Quality Accreditation
6. To apply the advanced tools for Quality Sustainability.

Module	Contents	Hours	CO Mapping
1	Introduction to Quality Management : A) Definitions of Quality, product quality and service quality; the evolution of quality; need for Quality Management, Quality statements and Policy, Customer orientation & satisfaction, Customer complaints, customer retention; Supplier partnership, Supplier rating & selection, CSI, Costs of Quality, Prevention, appraisal and failure aspects, Use of COQ for improving quality and performance, Designing for quality, Quality of design, Quality of conformance. B) Basic concepts of TQM, TQM framework, Contributions of Deming, Juran and Crosby, Juran Trilogy, PDCA Cycle, Barriers to TQM; TQM principles; Strategic Quality Planning; Quality councils; employee involvement, motivation; Empowerment; Team and Teamwork; recognition and reward, performance appraisal.	08	CO1
2	QC Tools: A) Seven QC Tools: Check Sheet, Histogram, Pareto Chart, Fishbone Diagram, Run Charts, Scatter Diagram, Process Flow Chart. B) Seven QM Tools: Program Decision Process Chart, Tree Diagram, Affinity Diagram, Prioritization Matrix, etc. Bench Marking Types – Process, Product, Quality Improvement Tools: Why-Why Analysis, Root Cause Analysis, Poka Yoke (Mistake Proofing)	06	CO2

3	Statistical Quality Control: 100% Inspection versus Sampling Inspection, Reasons for SQC. A) Acceptance Sampling: Concept of Producer Risk and Consumers Risk. Operating Characteristics Curve. Sampling Plan – Single Sampling Plan versus Double Sampling Plan. Design Sampling Plan on the basis of MIL, ASQ Standards. B) Statistical Process Control: Variations – Concept, Causes – Random & Assignable, Difference – Process in Control versus Process is Capable, Control Charts, X-Bar, R, P and C Charts, Process Capability (Cp) & Process Capability Index (Cpk), Sigma Limits. Applications of Control Charts in Mass Production, Process Production.	06	CO3
4	A) Continuous Improvement: Quality Circles, Quality Function Development (QFD), Taguchi quality loss function, Parameter Design, Robust Design; TPM- concepts, 5S, Kaizen, FMEA- stages, Zero Defect. B) TQM Implementation: Manufacturing and Service sectors, Introduction to Six Sigma: Definition, Concept, Methodology. Six Sigma Approaches – Design for Six Sigma (DFSS) Approach & DMAIC Approach, Six Sigma Tools: Applications to manufacturing and service sector including IT, ITeS, and E Com.	08	CO4
5	Quality Management System & Certification: A) QMS: Elements and documentation, Quality auditing, Necessity for Certification & Certification Process, Benefits of Certification. Certifying Bodies & Accreditation Agencies, ISO 9000-2015 (5th Edition), Introduction to TS16949: Technical Specifications, QS9000, ISO14000- concepts, requirements and benefits. Case studies of TQM implementation in manufacturing and service sectors including IT and Environmental management systems- ISO 14000 Series Standards, Integration of ISO 14000 with ISO 9000. B) Quality Awards: Malcom Baldrige National Quality Award and Rajiv Gandhi National Quality award.	06	CO5
6	Future Trends in TQM : Strategic approach to leadership , Customer centric endeavors , Involvement & empowerment of all employees / stake holders , Decision making based on real time facts , Win-Win policy with suppliers , New paradigms of Green & sustainability , TQM beyond Manufacturing i.e. Healthcare, Education, Finance. Accountability through new tools and technologies, Quality Analytics.	06	CO6

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 the end semester examination will be proportional to the 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.

Text Books:

1. Besterfield D.H. et al.: Total quality Management, 3rd Edition, Pearson Education Asia, 2006.
2. Janakiraman B. and Gopal R.K.: Total Quality Management, Prentice Hall India, 2006.
3. Poornima M. Charantimath: Total Quality Management, 2nd Edition, Pearson Education Asia, 2006.
4. N. Logothetis: Managing for Total Quality, 6th Edition, Prentice Hall of India Pvt. Ltd. 2003.
5. Suganthi L. and Samuel A.: Total Quality Management, Prentice Hall India, 2006.
6. Evans J.R. and Lindsay W.M.: The Management and Control of Quality, 8th Edition, 1st Indian Edition, Cengage Learning, 2012.

Course Code	Course Name	Credit
ARDLO8064	Social Media Analytics	03

Prerequisite: Graph Theory, Data Mining, Python/R programming

Course Objectives: The course aims:

- 1 Familiarize the learners with the concept of social media.
- 2 Familiarize the learners with the concept of social media analytics and understand its significance.
- 3 Enable the learners to develop skills required for analyzing the effectiveness of social media.
- 4 Familiarize the learners with different tools of social media analytics.
- 5 Familiarize the learner with different visualization techniques for Social media analytics.
- 6 Examine the ethical and legal implications of leveraging social media data.

Course Outcomes:

- 1 Understand the concept of Social media
- 2 Understand the concept of social media Analytics and its significance.
- 3 Learners will be able to analyze the effectiveness of social media
- 4 Learners will be able to use different Social media analytics tools effectively and efficiently.
- 5 Learners will be able to use different effective Visualization techniques to represent social media analytics.
- 6 Acquire the fundamental perspectives and hands-on skills needed to work with social media data.

Module	Detailed Content	Hours	CO Mapping
1.	Social Media Analytics: An Overview Core Characteristics of Social Media, Types of Social Media, Social media landscape, Need for Social Media Analytics (SMA), SMA in small & large organizations. Purpose of Social Media Analytics, Social Media vs. Traditional Business Analytics, Seven Layers of Social Media Analytics, Types of Social Media Analytics, Social Media Analytics Cycle, Challenges to Social Media Analytics, Social Media Analytics Tools	06	CO1
2.	Social Network Structure, Measures & Visualization		

	Basics of Social Network Structure - Nodes, Edges & Tie Describing the Networks Measures - Degree Distribution, Density, Connectivity, Centralization, Tie Strength & Trust Network Visualization - Graph Layout, Visualizing Network features, Scale Issues. Social Media Network Analytics - Common Network Terms, Common Social Media Network Types, Types of Networks, Common Network Terminologies, Network Analytics Tools.	6	CO2
3.	Social Media Text, Action & Hyperlink Analytics Social Media Text Analytics - Types of Social Media Text, Purpose of Text Analytics, Steps in Text Analytics, Social Media Text Analysis Tools Social Media Action Analytics - What Is Actions Analytics? Common Social Media Actions, Actions Analytics Tools Social Media Hyperlink Analytics - Types of Hyperlinks, Types of Hyperlink Analytics, Hyperlink Analytics Tools	8	CO3
4.	Social Media Location & Search Engine Analytics Location Analytics - Sources of Location Data, Categories of Location Analytics, Location Analytics and Privacy Concerns, Location Analytics Tools Search Engine Analytics - Types of Search Engines, Search Engine Analytics, Search Engine Analytics Tools	6	CO4
5.	Social Information Filtering Social Information Filtering - Social Sharing and filtering, Automated Recommendation systems, Traditional Vs social Recommendation Systems Understanding Social Media and Business Alignment, Social Media KPI, Formulating a Social Media Strategy, Managing Social Media Risks	6	CO5
6.	Social Media Analytics Applications and Privacy Social media in public sector - Analyzing public sector social media, analyzing individual users, case study. Business use of social media - Measuring success, Interaction and monitoring, case study. Privacy - Privacy policies, data ownership and maintaining privacy online.	7	CO6

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 the end semester examination will be proportional to the 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.

Textbooks:

1. Seven Layers of Social Media Analytics_ Mining Business Insights from Social Media Text, Actions, Networks, Hyperlinks, Apps, Search Engine, and Location Data, Gohar F. Khan,(ISBN-10: 1507823207).
2. Analyzing the Social Web 1st Edition by Jennifer Golbeck
3. Mining the Social Web_ Analyzing Data from Facebook, Twitter, LinkedIn, and Other Social Media Sites, Matthew A Russell, O'Reilly
- 4 Charu Aggarwal (ed.), Social Network Data Analytics, Springer, 2011

References:

1. Social Media Analytics [2015], Techniques and Insights for Extracting Business Value Out of Social Media, Matthew Ganis, Avinash Kohirkar, IBM Press
2. Social Media Analytics Strategy_ Using Data to Optimize Business Performance, Alex Gonçalves, APress Business Team
3. Social Media Data Mining and Analytics, Szabo, G., G. Polatkan, O. Boykin & A. Chalkiopoulos (2019), Wiley, ISBN 978-1-118-82485-6

Useful Links

- 1 <https://cse.iitkgp.ac.in/~pawang/courses/SC16.html>
- 2 https://onlinecourses.nptel.ac.in/noc20_cs78/preview
- 3 <https://nptel.ac.in/courses/106106146>
- 4 <https://7layersanalytics.com/>

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 stagegate process. Role of project manager, Negotiations and resolving conflicts, Project management in various organization structures, PM knowledge areas as per Project Management Institute (PMI)	05
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 projectteam, Stages of team development & growth (forming, storming, norming &performing), team dynamics.	06
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).	08
04	Planning Projects: Crashing project time, Resource loading and levelling, Goldratt's critical chain, Project Stakeholders and Communication plan Risk Management in projects: Risk management planning, Risk identification and risk register, Qualitative and quantitative risk assessment, Probability and impact matrix. Risk response strategies for positive and negative risks	06

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,	08
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.	06

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

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

End Semester Examination:

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

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

REFERENCES:

1. 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
ILO 8022	Finance Management	03

Objectives:

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

Outcomes: Learner will be able to...

1. Understand Indian finance system and corporate finance
2. Take investment, finance as well as dividend decisions

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

04	Capital Budgeting: Meaning and Importance of Capital Budgeting; Inputs for Capital Budgeting Decisions; Investment Appraisal Criterion—Accounting Rate of Return, Payback Period, Discounted 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.	10
05	Sources of Finance: Long Term Sources—Equity, Debt, and Hybrids; Mezzanine Finance; Sources of Short Term Finance—Trade Credit, Bank Finance, Commercial Paper; Project Finance. Capital Structure: Factors Affecting an Entity's Capital Structure; Overview of Capital Structure Theories and Approaches— Net Income Approach, Net Operating Income Approach; Traditional Approach, and Modigliani-Miller Approach. Relation between Capital Structure and Corporate Value; Concept of Optimal Capital Structure	05
06	Dividend Policy: Meaning and Importance of Dividend Policy; Factors Affecting an Entity's Dividend Decision; Overview of Dividend Policy Theories and Approaches—Gordon's Approach, Walter's Approach, and Modigliani-Miller Approach	03

Assessment:

Internal Assessment for 20 marks:

Consisting Two Compulsory Class Tests

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

End Semester Examination:

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

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

REFERENCES:

1. Fundamentals of Financial Management, 13th Edition (2015) by Eugene F. Brigham and Joel F. Houston; Publisher: Cengage Publications, New Delhi.
2. Analysis for Financial Management, 10th Edition (2013) by Robert C. Higgins; Publishers: McGraw Hill Education, New Delhi.
3. Indian Financial System, 9th Edition (2015) by M. Y. Khan; Publisher: McGraw Hill Education, New Delhi.
4. Financial Management, 11th Edition (2015) by I. M. Pandey; Publisher: S. Chand (G/L) & Company Limited, New Delhi.

Course Code	Course Name	Credits
ILO8023	Entrepreneurship Development and Management	03

Objectives:

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

Outcomes: Learner will be able to...

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

Module	Detailed Contents	Hrs
01	Overview Of Entrepreneurship: Definitions, Roles and Functions/Values of Entrepreneurship, History of Entrepreneurship Development, Role of Entrepreneurship in the National Economy, Functions of an Entrepreneur, Entrepreneurship and Forms of Business Ownership Role of Money and Capital Markets in Entrepreneurial Development: Contribution of Government Agencies in Sourcing information for Entrepreneurship	04
02	Business Plans And Importance Of Capital To Entrepreneurship: Preliminary and Marketing Plans, Management and Personnel, Start-up Costs and Financing as well as Projected Financial Statements, Legal Section, Insurance, Suppliers and Risks, Assumptions and Conclusion, Capital and its Importance to the Entrepreneur Entrepreneurship And Business Development: Starting a New Business, Buying an Existing Business, New Product Development, Business Growth and the Entrepreneur Law and its Relevance to Business Operations	09
03	Women's Entrepreneurship Development, Social entrepreneurship-role and need, EDP cell, role of sustainability and sustainable development for SMEs, case studies, exercises	05
04	Indian Environment for Entrepreneurship: key regulations and legal aspects , MSMED Act 2006 and its implications, schemes and policies of the Ministry of MSME, role and responsibilities of various government organisations, departments, banks etc., Role of State governments in terms of infrastructure developments and support etc., Public private partnerships, National Skill development Mission, Credit Guarantee Fund, PMEGP, discussions, group exercises etc	08
05	Effective Management of Business: Issues and problems faced by micro and small enterprises and effective management of M and S enterprises (risk management, credit availability, technology innovation, supply chain management, linkage with large industries), exercises, e-Marketing	08

06	Achieving Success In The Small Business: Stages of the small business life cycle, four types of firm-level growth strategies, Options – harvesting or closing small business Critical Success factors of small business	05
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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

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	05
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	07
03	Organizational Structure & Design Structure, size, technology, Environment of organization; Organizational Roles & conflicts: Concept of roles; role dynamics; role conflicts and stress.	06

	- 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.	
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	05
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	06
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.

- Question paper will comprise of total **six questions, each carrying 20 marks**
- Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
- 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)
- Only **Four questions need to be solved.**

References:

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

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

Objectives:

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

Outcomes: Learner will be able to...

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

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

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.

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	08

	f. Sample Design g. Data Collection h. Data Analysis i. Hypothesis testing and Interpretation of Data j. Preparation of Research Report	
05	Formulating Research Problem 5.1 Considerations: Relevance, Interest, Data Availability, Choice of data, Analysis of data, Generalization and Interpretation of analysis	04
06	Outcome of Research 6.1 Preparation of the report on conclusion reached 6.2 Validity Testing & Ethical Issues 6.3 Suggestions and Recommendation	04

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

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

End Semester Examination:

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

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

References:

1. Dawson, Catherine, 2002, Practical Research Methods, New Delhi, UBS Publishers Distributors.
2. Kothari, C.R., 1985, Research Methodology-Methods and Techniques, New Delhi, Wiley Eastern Limited.
3. Kumar, Ranjit, 2005, Research Methodology-A Step-by-Step Guide for Beginners, (2nded), Singapore, Pearson Education

Course Code	Course Name	Credits
ILO8027	IPR and Patenting	03

Objectives:

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

Outcomes: Learner will be able to...

1. understand Intellectual Property assets
2. assist individuals and organizations in capacity building
3. work for development, promotion, protection, compliance, and enforcement of Intellectual Property and Patenting

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

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

Reference Books:

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

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

Course Code	Course Name	Credits
ILO 8028	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, Ethicsand 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 KeyCryptography, Digital Signatures, Digital Certificates, Security Protocols overPublic 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, E-business strategy into Action, challenges and E-Transition (Process of Digital Transformation)	04
6	Materializing e-business: From Idea to Realization -Business plan preparation Case Studies and presentations	08

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

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

End Semester Examination:

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

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

References:

1. A textbook on E-commerce, Er Arunrajan Mishra, Dr W K Sarwade, Neha Publishers & Distributors, 2011
2. E-commerce from vision to fulfilment, Elias M. Awad, PHI-Restricted, 2002
3. Digital Business and E-Commerce Management, 6th Ed, Dave Chaffey, Pearson, August 2014
4. Introduction to E-business-Management and Strategy, Colin Combe, ELSVIER, 2006
5. Digital Business Concepts and Strategy, Eloise Coupey, 2nd Edition, Pearson
6. Trend and Challenges in Digital Business Innovation, VinocenzoMorabito, Springer
7. Digital Business Discourse Erika Darics, April 2015, Palgrave Macmillan

- 8.** E-Governance-Challenges and Opportunities in : Proceedings in 2nd International Conference theory and practice of Electronic Governance
- 9.** Perspectives the Digital Enterprise –A framework for Transformation, TCS consulting journal Vol.5
- 10.** Measuring Digital Economy-A new perspective- DoI:10.1787/9789264221796-enOECD Publishing

Course Code	Course Name	Credits
ILO8029	Environmental Management	03

Objectives:

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

Outcomes: Learner will be able to...

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

Module	Detailed Contents	Hrs
01	Introduction and Definition of Environment: Significance of Environment Management for contemporary managers, Career opportunities, Environmental issues relevant to India, Sustainable Development, the Energy scenario	10
02	Global Environmental concerns : Global Warming, Acid Rain, Ozone Depletion, Hazardous Wastes, Endangered life-species, Loss of Biodiversity, Industrial/Man-made disasters, Atomic/Biomedical hazards, etc.	06
03	Concepts of Ecology: Ecosystems and interdependence between living organisms, habitats, limiting factors, carrying capacity, food chain, etc.	05
04	Scope of Environment Management, Role and functions of Government as a planning and regulating agency Environment Quality Management and Corporate Environmental Responsibility	10
05	Total Quality Environmental Management, ISO-14000, EMS certification.	05
06	General overview of major legislations like Environment Protection Act, Air(P & CP) Act, Water (P & CP) Act, Wildlife Protection Act, Forest Act, Factories Act, etc.	03

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

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

End Semester Examination:

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

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

References:

1. Environmental Management: Principles and Practice, C J Barrow, Routledge Publishers London, 1999
2. A Handbook of Environmental Management Edited by Jon C. Lovett and David G. Ockwell, Edward Elgar Publishing
3. Environmental Management V Ramachandra and Vijay Kulkarni, TERI Press
4. Indian Standard Environmental Management Systems — Requirements with Guidance For Use, Bureau Of Indian Standards, February 2005
5. Environmental Management: An Indian Perspective, S N Chary and Vinod Vyasulu, Macmillan India, 2000
6. Introduction to Environmental Management, Mary K Theodore and Louise Theodore, CRC Press Environment and Ecology, Majid Hussain, 3rd Ed. Access Publishing, 2015

Course Code	Course Name	Credits
ARL801	Laboratory based on IoT	01

Objectives:

1. To learn microcontroller programming using 8051 and Arduino Development Board.
2. To acquaint with interfacing of simple peripheral devices to a microcontroller.
3. To acquaint with exchange of data using wireless communication.
4. To familiarize with logging the data on cloud platform.

Outcomes: Learner will able to...

1. Develop simple applications using microcontrollers 8051 and Arduino.
2. Interface simple peripheral devices to a Microcontroller.
3. Use microcontroller based embedded platforms in IoT.
4. Use wireless peripherals for exchange of data.
5. Setup cloud platform and log sensor data.

List of Experiments:

1. Interfacing experiments using 8051 Trainer kit and interfacing modules
 - a. display (LCD/LED/Seven Segment)
 - b. Stepper / DC Motor
2. Introduction to Arduino platform and programming
3. Simple Applications using Arduino Development Board (Any two)
 - a. Simple LED Blinking using development board
 - b. Building IOT Smart Switch using IOT
 - c. Pulse Width Modulation
 - d. Analog to Digital / Digital to Analog Conversion
4. Interfacing Arduino with a Sensor (Any one): Temperature Sensor / PIR/ Ultrasonic sensor/ IR Sensor/ Flame Sensor/ MQ6 Sensor/ Humidity sensor/ Raindrop Sensor, magnetometers, cameras, accelerometers etc.
5. Interfacing Arduino with an Actuator (Any One): Motors / solenoids / Controllers etc.
6. Communication using Wireless Medium (Any One): WiFi / Bluetooth / Zigbee / RFID etc.
7. Setting up and Cloud Platform and logging Sensor Data on the platform.

Assessment:

Term Work

Term work shall consist of the experiments as mentioned above. The distribution of marks for term work shall be as follows:

1. Laboratory work (Experiments): 20 marks
2. Attendance: 05 marks

End Semester Practical/Oral Examination:

Pair of Internal and External Examiner should conduct practical examination followed by Oral.

Course Code	Course Name	Credits
ARL802	Product Design and Development	01

Objectives:

1. To familiarize concepts in PD&D for practical implementation
2. To acquaint with the applicability of PD&D in industrial applications

Outcomes: Learner will be able to...

1. Identify the need for developing products
2. Select suitable PD&D processes
3. apply the creativity & industrial design methods to design & develop the chosen product
4. Work collaboratively in a team to complete a PD&D project.
5. Effectively communicate the results of projects and other assignments both in a written and oral format.

Assignments:

Total 3 to 4 assignments have to be given.

Assignments III and IV are compulsory and shall be treated like mini-projects. Two more could be covered from the remaining as case studies.

I. Based on Module No. 1 and 2.

1. Select any one consumer product, such as
 - a) a mobile
 - b) a laptop
 - c) a pencil sharpener
 - d) a table and chair
 - e) a stool
 - f) a bicycle
 - g) a pen
 - h) a storage device of any household items
 - i) a cupboard etc..... anything

Assume that you want to go for re-development of any one of the products.

How would you tackle by answering any 3 or 4 points that are given below?

Q1. How do you identify the need for developing the product?

Q2. What are the changes that you would like to incorporate?

Q3. Would it be Engineering Design or Industrial design factors or both?

Q4. What are the generic PD&D processes that you would like to adopt?

Q5. What are the methods that you would adopt for Market research?

Q6. If you would like to develop which design process you would like to adopt?

Q7. If you select descriptive design... then why? If you select prescriptive design... then why?

Q8. What are the steps that you would like to adopt while developing the product?

II. Based on Module No. 3.

2. Select any one consumer product, such as
 - a) a mobile
 - b) a laptop
 - c) a pencil sharpener
 - d) a table and chair
 - e) a stool
 - f) a bicycle
 - g) a pen
 - h) a storage device of any household items
 - i) a cupboard etc..... anything

Assume that you want to go for re-development of any one of the above products. How would you tackle by answering any 3 or 4 points that are given below?

Q1. How do you identify the customer needs for developing the product?

Q2. How do you ascertain/select the attributes that are to be tackled?

Q3. Would you like to go for Engineering Design factors or Industrial design factors or both?

Q4. How do you develop a correlation matrix?

Q5. How do you “Construct House of Quality”?

Q6. What are the generic PD&D processes that you would like to adopt in re-designing it using House of quality?

Q7. What are the methods that you would adopt for Market acceptance?

Q8. How do you document the entire design process?

III. Based on Module No. 4.

3. Select any one consumer product, such as
 - a) a mobile

- b) a laptop
- c) a pencil sharpener
- d) a table and chair
- e) a stool
- f) a bicycle
- g) a pen
- h) a storage device of any household items
- i) a cupboard etc.... anything

Assume that you want to go for re-development of any one of the above products.

How would you apply the creativity method to design the chosen product using any one creativity methods? Develop the product and document the entire process by answering some of the questions as shown in I or II.

IV. Based on Module No. 5.

- 4. Select any one consumer product, such as
 - a) a mobile
 - b) a laptop
 - c) a pencil sharpener
 - d) a table and chair
 - e) a stool
 - f) a bicycle
 - g) a pen
 - h) a storage device of any household items
 - i) a cupboard etc.... anything

Assume that you want to go for re-development of any one of the above products.

How would you apply the principles of Industrial Design methods to design the chosen product? Develop the product and document the entire process by answering some of the questions as shown in I or II.

V. Based on Module No. 6.

- 5. Select any one consumer product, such as
 - a) a mobile
 - b) a laptop

- c) a pencil sharpener
- d) a table and chair
- e) a stool
- f) a bicycle
- g) a pen
- h) a storage device of any household items
- i) a cupboard etc..... anything

Assume that you want to go for re-development of any one of the above products.

How would you apply the principles of DFMA to design the chosen product? Develop the exploded view of the product and document the entire process by answering some of the questions as shown in Ior II.

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

Assignments/Case studies:10 marks. Mini

Project:10 marks.

Attendance: 05 Marks.

End Semester Practical/Oral examination

1. Pair of Internal and External Examiner should conduct practical/viva based on contents
2. Distribution of marks for practical/viva examination shall be as follows:
 - a) Practical performance**15** marks
 - b) Oral**10** marks

Evaluation of practical examination to be done based on the practical performed.

Students work along with evaluation reports to be preserved till the next examination.

Text/Reference Books:

1. Baker, M. & Hart S. (2007), Product Strategy and Management, (2nd. Ed.) Edinburgh: Pearson Education.
2. Ulrich, K. & Eppinger, S. (2012), Product Design and Development. (5th. Ed.) Los Angeles: McGraw Hill Education.
3. Yousef Haik, T. M. M. Shahin (2010), Engineering Design Process, (2nd. Ed. Reprint), Cengage Learning, ISBN 0495668141.
4. Kevin Otto, Kristin Wood (2004), Product Design, (Indian Reprint), Pearson Education, ISBN 9788177588217.

Course Code	Course Name	Credits
ARP801	Major Project II	12

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.

Outcomes: Learner will able to

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

Guidelines:

1. Internal guide has to keep track of the progress of the project and also has to maintain attendance report. This progress report can be used for awarding term work marks.

2. Project Report Format:

At the end of semester, each group need to prepare a project report as per the guidelines issued by the University of Mumbai. Report should be submitted in hardcopy. Also, each group should submit softcopy of the report along with project documentation, implementation code, required utilities, software and user Manuals.

A project report should preferably contain at least following details:

- Abstract
- Introduction
- Literature Survey/ Existing system
- Limitation Existing system or research gap
- Problem Statement and Objective

- Proposed System
 - 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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