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(Accredited by NAAC)

GU/Acad–PG/BoS-ENGG-Minor/2023/764 Date:16/02/2023

C I R C U L A R

The Scheme of Instruction and Examination along with the Syllabus for the Honours/ Minor Degree Programme in the various branches of Engineering recommended by the Boards of Studies and approved by the Academic Council is attached.

The Scheme is open to all Engineering/ Technology Undergraduates who have registered for the B.E. Programme under RC 2019-20, for the academic year 2021-22 onwards.

a) Students shall be eligible to register for the Honours/Minor Programme at the beginning of Semester IV provided s/he has acquired a minimum of 6.5 CGPA at the end of Semester II.

b) Students who have been admitted in the 2nd year on completion of a Diploma/B.Sc, with an aggregate of 60% or equivalent Grade Point in the final year (excluding marks obtained in Training) shall be eligible to register for the Honours/Minor Programme.

The Dean, Faculty of Engineering and the Principals of Affiliated Colleges offering Bachelor of Engineering Programmes are requested to take note of the above and bring the contents of the Circular to the notice of all concerned.

Digitally signed by DONALD AGNELO ERASMO RODRIGUES
Date: 2023.02.16 '12:59:11 +05'30

(Donald A. E. Rodrigues)
Joint Registrar – Academic

To,
1. The Dean, Faculty of Engineering, Goa University.
2.. The Principals of Affiliated Colleges offering the Bachelor of Engineering Programme.

Copy to:
1. The Chairperson, All the Boards of Studies in Engineering.
2. The Controller of Examinations, Goa University.
3. The Assistant Registrar, Professional Examinations, Goa University.
4. Directorate of Internal Quality Assurance, Goa University for uploading the Syllabus on the University website.
5. The Director, Directorate of Technical Education, Government of Goa.

HONOURS/MINOR DEGREE CERTIFICATION SCHEME

I N D E X

Sr. No.	Engineering Branch	Minor/ Honours (Specialization) Subject	Page No.
1	Electronics and Computer Engineering/ Electronics and Computer Science Engineering	Robotics and Artificial Intelligence	3 – 8
2	Mechanical Engineering	Energy	9 – 19
		Smart Manufacturing	20 – 32
3	Civil Engineering	Lean Construction Technology	33 – 42
		Construction Management	43 – 52
4	Computer Engineering	Artificial Intelligence and Machine Learning	53 – 69
5	Electrical & Electronics Engineering	Electric	70 – 81
6	Electronics and Telecommunication Engineering/ Electronics and Communication Engineering	Internet of Things	82 – 96
7	Information Technology	Advanced Web Development	97 – 106
		Data Science	107 - 117

Engineering Branch: Electronics and Computer Engineering / Electronics and Computer Science

Minor/ Honours (Specialization) Subject: Robotics and Artificial Intelligence

Scheme of Instruction and Examination

Course Code	Semester	Nomenclature of the Course	Scheme of Instruction Hrs./Week			Scheme of Examination						
			L	T	P	Duration (Hrs.)	Marks					Credits
							Th	IA	TW	P/O	Total	
RAI-401	**IV**	**Introduction to Robotics**	3	0	2	3	100	25	--	25 (O)	150	4
RAI-501	**V**	**Fundamentals of Artificial Intelligence**	3	0	2	3	100	25	--	25 (P)	150	4
RAI-601	**VI**	**Robot Programming**	3	0	2	3	100	25	25 *	--	150	4
RAI-701	**VII**	**Robotic Vision and Control**	3	0	2	3	100	25	--	25 (O)	150	4
RAI-801	**VIII**	**Special topics in Artificial Intelligence**	4	0	0	3	100	25	25	--	150	4
		TOTAL	16	0	8		500	125	50	75	750	20

L-Lecture T-Tutorial P-Practical O- Oral Th-Theory TW-Term Work IA-Internal Assessment

*Mini Project to be given to assess the Term work

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Syllabus

Introduction to Robotics				
Course Code	**RAI - 401**		**Credits**	**4**
Scheme of Instruction	**L**	**T**	**P**	**Total**
Hours/ Week	**3**	**0**	**2**	**42 hrs/sem**
Scheme of Examination	**IA**	**TW**	**TA**	**P**
TOTAL = 150 marks	**25**	**0**	**100**	**25**

Course Objectives: The subject aims to provide the student with:
1. An understanding of all the subsystems and components of a robot.
2. An ability to solve problems related to kinematics of a robot.
3. An ability to design and program simple robotic platforms.

Course Outcomes:
The student after undergoing this course will be able to:

RAI01.1	Describe the subsystems of robot system and explain the anatomy and working of basic robot configurations.
RAI01.2	Evaluate different robot actuator drive systems and end effectors for given application.
RAI01.3	Evaluate different sensors used and integrate them in robotic systems.
RAI01.4	Analyze anatomy of simple robots and compute kinematic solutions.
RAI01.5	Explain control strategies used in robotic systems.
RAI01.6	Evaluate motion planning strategies for a given application

UNIT -1	
Basic Concepts in (Fundamentals of) robotics: Automation and robotics, Robot applications **Different classifications of the robot**: By application, by a coordinate system, by actuation system, by control method and by programming method. **Robot anatomy**: links and joints, Joint notation scheme. Degree of Freedom, Degree of Manipulability, Robot resolution, accuracy and repeatability. Concept of workspace/Work envelope. **Robot End Effectors**: Grippers and Tools.	**10 hrs**
UNIT - 2	
Drive systems: Pneumatic and hydraulic Drives. Electric: Relation between torque and voltage. AC and DC Servo motors, Stepper motors, BLDC motors. Electronic control of motor L293D **Sensors:** Characteristics of a sensor, Classification of Sensors, Touch sensors, Position Sensors: Potentiometer, LVDT, Optical Encoders, Force/Moment sensors, Range Sensor, Proximity Sensors- Inductive sensor, capacitive sensor, Hall effect sensor, Passive Sensor: RCC	**10 hrs**
UNIT – 3	

Kinematic: Coordinate frames, mapping and transforms, description of objects in space, transformation of vectors, fundamental rotation matrices. **Direct Kinematic model**: Kinematic model for Robotic Manipulator (2 DOF and 3 DOF) **Inverse Kinematics**: Solvability of inverse kinematic models, solution techniques, closed form solution **Control Scheme:** Partitioned control Scheme.	**11 hrs**
UNIT - 4	
Manipulator Dynamics: Determination of Robotic Joint Torques, Langrage-Euler formulation two approaches, Example with 2 link Manipulator. **Trajectory planning**: Definitions and planning tasks, joint space techniques, Cartesian space techniques, joint space v/s Cartesian space. **Motion planning:** Gross/Free Space Motion Planning **Introduction to wheeled robots and Biped robots:** Introduction, Staircase Ascending (SSP), Power Consumption, Dynamic Balances.	**11 hrs**

Text Books:

1. S. K. Saha; Introduction to Robotics, 2nd Ed.; McGraw Hill
2. M. P. Groover, M. Weiss, R. N. Nagel, N. G. Odrey; Industrial Robotics Technology: programming and Applications; Tata McGraw Hill Education; Special Indian; 2e; 2012.
3. Saeed B. Niku, Introduction to Robotics: Analysis, Control, Applications, 2nd Ed., Wiley Publications

Reference Books:

1. John J. Craig; Introduction to Robotics, Mechanics & Control, 4th edition, Pearson Education Inc.
2. Peter Corke; Robotics, Vision and Control, 1st Edition, Springer.
3. K. S. Fu, R. C. Gonzalex, C. S. G. Lee; Robotics Control Sensing, Vision and Intelligence, McGraw Hill Book co (1987).
4. Mittal &Nagrath; Robotics and Control,1st edition, 2003, McGrawHill.

List of Experiments: (At least 8 experiments should be conducted from the list of experiments.)

1. Electronic Control of a DC Servo motor
2. Electronic Control of a Stepper motor
3. Electronic control of BLDC motor
4. Interfacing of proximity and range sensors to Microcontroller
5. Interfacing of Accelerometers and Gyroscopes sensors to Microcontroller
6. Interfacing of force sensors to Microcontroller
7. Forward kinematics of a Robot
8. Inverse kinematics of a Robot
9. Programming a robot for straight line, circular and curved paths
10. Programming a robot arm for pick and place operation.
11. Programming a robot: Loops, branches and subroutines
12. Programming a robot: external events

Fundamentals of Artificial Intelligence				
Course Code	**RAI - 501**		**Credits**	**4**
Scheme of Instruction	**L**	**T**	**P**	**Total**
Hours/ Week	**3**	**0**	**2**	**42 hrs/sem**
Scheme of Examination	**IA**	**TW**	**TA**	**P**
TOTAL = 150 marks	**25**	**0**	**100**	**25**

Course Objective:

The subject aims to provide the student with:

1. An introduction to Artificial Intelligence techniques for solving real-world problems using AI.
2. A basic understanding of knowledge representation and predicate logic.
3. An introduction to planning, game playing and learning methods in AI.
4. Acquaint with knowledge of natural language processing, expert systems and machine learning techniques.

Course Outcome:

The student will be able to:

RAI02.1	Discuss the structure of an A.I., problem definition and implement search based algorithms.
RAI02.2	Understand the fundamentals of knowledge representation and logic in AI.
RAI02.3	Develop planning models and learning methods for AI.
RAI02.4	Understand the natural language processing techniques.
RAI02.5	Design and an expert system in any domain to transfer human expertise into machine.
RAI02.6	Analyze the suitability of machine learning algorithms to solve any AI application.

UNIT -1	
Introduction to AI: What is Intelligence? **Problem Solving:** Defining a problem **State Space Search:** Breadth First Search, Depth First Search, **Heuristic Search:** Heuristic Functions, Best First Search, Hill Climbing, **Randomized Search:** Simulated Annealing. Genetic Algorithm, Travelling Salesman Problem **Optimal Search:** A* algorithm, Iterative Deepening A*, Recursive Best First Search.	**10 hrs**
UNIT - 2	
Knowledge Representation: Representation and Mapping, Approaches to knowledge representation. **Predicate Logic:** Representing simple facts and logic, Representing instance and ISA relationship, Computable functions and predicates. **Logic and Inferences:** Formal Logic, Propositional Logic, Resolution method in Propositional Logic, and First Order Logic, Forward & Backward Chaining.	**10 hrs**
UNIT – 3	

Planning: STRIPS, Forward and Backward State Space Planning, Goal Stack Planning, Plan Space Planning. **Game Playing:** Mini-Max Search Procedure, Alpha-Beta Pruning. **Learning**: Introduction, Inductive learning, Learning Decision Trees. **Types of Learning:** Rote Learning, Learning by taking advice, Learning by Induction	**11 hrs**
UNIT - 4	
Natural Language Processing: Classic problems and schools of thought, basic NLP techniques, Applications **Expert System:** Architecture of Expert System, Role of Expert system in Knowledge acquisition. **Introduction to Machine Learning:** Supervised and Unsupervised Learning, Decision Trees, Naïve Bayes Classifiers, K-means Clustering, Support Vector Machines	**11 hrs**

Text Books:

1. Elaine Rich, Kevin Knight; Artificial Intelligence, 3/Ed, TMH
2. Struart Russell, Peter Norvig; Artificial Intelligence: a Modern Approach, 4th Edition, Pearson.

References:

1. Nils J. Nillson; Artificial Intelligence: A new Synthesis; Morgan Kauffman, (Harcourt Asia), 2002.
2. Patrick Winston; Artificial Intelligence, 3rd Edition, Pearson Education
3. Ivan Brakto ;Prolog Programming for Artificial Intelligence, 3rd Edition, Pearson Education.
4. Efraim Turban; Decision Support Systems and Intelligent Systems, 7th Edition Prentice Hall.
5. George F. Luger; Artificial Intelligence : Structures and strategies for complex problem solving, 6th Edition, Pearson education.
6. Deepak Khemani; A First Course in Artificial Intelligence, 1st Edition, McGraw Hill Education

List of Experiments

(Minimum 08 Experiments to be performed from the following list in C/Java/Python/R)

1. Program to implement breadth first search algorithm.
2. Program to implement depth first search algorithm.
3. Program to implement Best First Search algorithm.
4. Program to implement Genetic Algorithm.
5. Program to implement alpha beta pruning.
6. Program for implementation Hill climbing problem.
7. Program to implement A* search algorithm.
8. Program to solve water jug problem.
9. Program to simulate tic – tac – toe game using min-max algorithm.

10. Program to implement Naïve Bayes classifier
11. Program to implement Decision Trees
12. Program to implement K-means clustering
13. Program to implement SVM

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Engineering Branch: Mechanical Engineering
Minor/ Honours (Specialization) Subject: Energy Engineering

SCHEME OF INSTRUCTION AND EXAMINATION

Course Code	Semester	Nomenclatureof the Course	Scheme of Instruction Hrs/Week			Scheme of Examination							
						Duration (Hrs)	Marks						Credits
			L	T	P		Th	IA	TW	P	O	Total	
MEE 410	IV	Energy Resources, Economics & Environment	3	1	--	3	100	25	25	--		150	4
MEE 510	VI VV	Introduction to Renewable Energy Technologies	3	1	--	3	100	25	25	--		150	4
MEE 610	VI	Biomass Energy Systems	3	--	2	3	100	25	--	--	25	150	4
MEE 710	VII	Energy Management	3	--	2	3	100	25	--	--	25	150	4
MEE 810	VIII	Advancement in IC Engines and Basics of Electric Vehicles	3	--	2	3	100	25	--	--	25	150	4
		TOTAL	15	2	6	--	500	125	50	--	75	750	20

LEGEND

Abbreviation	Description
L	Lecture
T	Tutorial
P	Practical
O	Oral
Th	Theory
TW	Term Work
IA	Internal Assessment

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Syllabus

ENERGY RESOURCES, ECONOMICS AND ENVIRONMENT					
Course Code	**MEE 410**		**Credits**	**4**	
Scheme of Instructions (Hours / week)	**L**	**T**	**P**	**TOTAL**	
	3	**1**	**0**	**42 hrs/sem**	
Scheme of Examination TOTAL = 150 marks	**IA**	**TW**	**TM**	**P**	**O**
	25	**25**	**100**	**0**	**0**

Course Objectives:

1. To provide knowledge on various sources of energy and the status of power generation
2. To make the students acquire knowledge of economics of power generation
3. To sensitize students as regards to environmental effects of energy usage

Course Outcomes:

On completing this course student will be able to:

CO 1	Understand the overview of power generation and scenario
CO 2	Analyze the economics of conventional and renewable power generation
CO 3	Apply concept of Energy Economics
CO 4	Analyze Environmental Impacts of energy use

UNIT-1	**10 Hrs**
Overview of World Energy Scenario, Dis- aggregation by end-use, by supply Fossil Fuel Reserves - Estimates, Duration Overview of India`s Energy Scenario - Dis-aggregation by end-use, by supply, reserves Country Energy Balance Construction - Examples Trends in energy use patterns, energy and development linkage. **Power Generation**: Global Scenario, Present status of power generation in India, Role of private and governmental organizations, Carbon credits, Pitfalls in power reforms, concept of cascade efficiency, Introduction to the Sources of Energy – Resources and Development of Power in India.	
UNIT-2	**11 Hrs**
Economics of Power Generation: Introduction, load curve and load duration curves and terminology. Cost of generation of electrical energy with numerical, Selection and Type of generation, Selection of generating equipment and electrical energy Tariff methods. **Economics of Solar and Wind Power Generation**: Capital costs, Economic concepts, Revenue requirements, Value of wind generated electricity, Hidden costs in Industrialized and developing nations.	
UNIT-3	**11 Hrs**

Energy Economics - Simple Payback Period, Time Value of Money, IRR, NPV, Life Cycle Costing, Cost of Saved Energy, Cost of Energy generated, Examples from energy generation and conservation, Energy Chain, Primary energy analysis Life Cycle Assessment, Net Energy Analysis.	
UNIT -4	**10 Hrs**
Environmental Impacts of energy use: - Air Pollution - SOx, NOx, CO, particulates Solid and Water Pollution, Formation of pollutants, measurement, and controls; sources of emissions, effect of operating and design parameters on emission, control methods, Exhaust emission test, procedures, standards and legislation; environmental audits; Emission factors and inventories Global Warming, CO_2 Emissions, Impacts, Mitigation Sustainability, Externalities, Future Energy System.	
Eight assignments, two on each unit to be submitted within the given deadline. Of these, one assignment per unit to be based on a topics selected as case study.	

Text Books	
1	**Energy and the environment**, Fowler, J. M; McGraw Hill, New York, 2nd Edn. (1984)
2	**Power Plant Engineering**, Domkundwar & Arora; Dhanpat Rai & Sons, New Delhi, 8th Edn (2016)
Reference Books	
1	**Energy and the Challenge of Sustainability**, World energy assessment, UNDP, New York (2000).
2	**Energy after Rio, Prospects and challenges**, UNDP, AKN Reddy, RH Williams, TB Johansson United Nations Publications, New York (1997).
3	**Global energy perspectives** / edited by Nebojsa Nakicenovic, Arnulf Grubler and Alan McDonald Cambridge University Press (1998).

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INTRODUCTION TO RENEWABLE ENERGY TECHNOLOGIES					
Course Code	**MEE 510**		**Credits**	**4**	
Scheme of Instructions (Hours / week)	**L**	**T**	**P**	**TOTAL**	
	3	**1**	**0**	**42 hrs/sem**	
Scheme of Examination TOTAL = 150 marks	**IA**	**TW**	**TM**	**P**	**O**
	25	**25**	**100**	**0**	**0**

Course Objectives:

1. To provide knowledge of various forms of renewable energy sources
2. To prepare the students to analyze the energy requirements and design simple renewable energy systems to meet these requirements

Course Outcomes:

On completing this course students will be able to:

CO 1	Describe the energy scenario and the role of solar energy as a source of renewable energy with applications
CO 2	Outline the technical systems designed for utilization of wind energy
CO 3	Undertake simple analysis of energy potential of geothermal and ocean energy
CO 4	Interpret the biomass conversion techniques and describe the fuel cell technology

UNIT-1	**11 Hrs**
Introduction to world energy scenario, Renewable energy resources, **Solar Thermal System** Radiation, Solar Geometry, radiation models; Solar Thermal, Optical efficiency, thermal efficiency, concentrators, testing procedures, introduction to thermal systems (flat plate collector), solar architecture, solar still, air heater, panel systems	
UNIT-2	**11 Hrs**
Solar Photovoltaic System Introduction to semiconductor physics, doping, P_N junction, Solar cell and its I_V characteristics, PV systems components, design of a solar PV systems. **Bioenergy** Biomass, Biomass resources, wood composition, pyrolysis, gasifiers, biogas, biodiesel, ethanol.	
UNIT-3	**10 Hrs**
Wind Energy, Introduction, types of wind machines, Cp-l curve & betz limits, wind recourse analysis; Systems, components of wind turbine systems, stand alone, grid connected, hybrid, system design.	
UNIT -4	**10 Hrs**
Hydro systems, Hydro resources, types of hydro turbine, small hydro systems. **Introduction to Alternate Energy systems** Geothermal – resources, types of power plants. Wave energy – energy and power density from sinusoidal wave form, oscillating	

column, dolphin type wave energy generator. Ocean energy – Ocean thermal energy conversion (OTEC), types of OTEC systems, energy from tides, power plants based on various tidal basins.	
Eight assignments, two on each unit to be submitted within the given deadline. Of these, one assignment per unit to be based on a topics selected as case study.	

TEXTBOOKS	
1	**Solar Energy - Principles of thermal collection and storage**, S. P. Sukhatme; Tata McGraw-Hill, New Delhi, 3rd edition (2009)
2	**Renewable Energy Resources**, J. Twidell and T. Weir; E & F N Spon Ltd, London (2015)
REFERENCES	
1	**Solar Engineering of Thermal Processes**, J. A. Duffie and W. A. Beckman; second edition, John Wiley, New York (1991)
2	**Biomass Regenerable Energy**, D. Hall and R. P. Grover; John Wiley, New York, (1987)

BIOMASS ENERGY SYSTEMS					
Course Code	**MEE 610**		**Credits**	**4**	
Scheme of Instructions (Hours / week)	**L**	**T**	**P**	**TOTAL**	
	3	**0**	**2**	**42 hrs/sem**	
Scheme of Examination TOTAL = 150 marks	**IA**	**TW**	**TM**	**P**	**O**
	25	**0**	**100**	**0**	**25**

Course Objectives:

1. To impart thorough understanding of Bio mass energy sources
2. To provide detailed study on Biomass conversion methods and processes
3. To provide thorough understanding of power generation using Biogas, Bio Diesel etc and study of Bio Power plants

Course Outcomes:

On completing this course students will be able to:

CO 1	Understand the fundamental of conversion processes of any carbonaceous fuel
CO 2	Learn how to characterization of any carbonaceous fuel and analyze technology application
CO 3	Apply the concepts of thermo-chemical conversion process of any dry solid fuel and bio-chemical process conversion of any wet solid fuel.
CO 4	Analyze the concepts of thermo and bio-chemical process along with newer technologies to conversion biomass to fuel.

UNIT-1	**10 Hrs**
Introduction: Biomass energy sources, energy content of various Bio – fuels, Energy plantation, origin of Biomass photo synthesis process, Biomass Characteristics, sustainability of Biomass. **Biomass Conversion Methods:** Agrochemical, Thermochemical, Biochemical (flowchart) & Explanation.	
UNIT-2	**11 Hrs**
Physical & Agrochemical Conversion: Briquetting, Pelletization, Agrochemical, fuel Extraction, Thermo chemical Conversion: Direct combustion for heat, domestic cooking & heating. **Biomass Gasification:** Chemical reaction in gasification, Producer gas& the constituents, Types of gasifiers. Fixed and Fluidized bed gasifiers. Liquefaction: Liquefaction through pyrolysis & Methanol synthesis, application of producer gas in I C Engines.	
UNIT-3	**10 Hrs**

Bio-Methanization: Anaerobic digestion, Basic principles, factors influencing Biogas yield, classification of Biogas digester, floating gasholder & fixed dome type.(Working Principle with diagram), Calculations for sizing the Biogas plant. **Biogas For Power Generation:** Ethanol as an automobile fuel, Ethanol production & its use in engines.	
UNIT-4	**11 Hrs**
Bio - Diesel: Bio Diesel from edible & non-edible oils, Production of Bio diesel from Honge & Jatropha seeds, use of bio diesel in I C engines, Engine power using Bio diesel, Blending of Bio diesel, Performance analysis of diesel engines using bio diesel. Effect of use of bio diesel in I C engines. **Bio Power Plants:** Bio Power generation routes, Basic Thermodynamic cycles in Bio power generation; Brayton cycle, Sterling cycle, Rankine cycle, Co-generation cycle. Biomass based steam power plant.	
Eight assignments, two on each unit to be submitted within the given deadline. Of these, one assignment per unit to be based on a topics selected as case study.	

TEXTBOOKS	
1	**Bio Gas Technology**, B.T. Nijaguna; New Age International- New Delhi (2001-02).
2	**Energy Technology**, S. Rao & B. B. Parulekar; Khanna Publishers, Delhi (1999).
3	**Non-Conventional Energy Sources**, G. D. Rai; Khanna Publishers. Delhi (1988)
REFERENCES	
1	**Greenhouse Technology for Controlled Environment**, G.N. Tiwari; Alpha Science International Ltd., Pangbourne.England (2003).
2	**Renewable Energy Resources**, John.W.Twidell, Anthony. D. Weir; EC BG (2001).
3	**BioMass**, Deglisc. X and P. Magne; Millennium Enterprise, New Delhi

ENERGY MANAGEMENT					
Course Code	**MEE710**		**Credits**	**4**	
Scheme of Instructions (Hours / week)	**L**	**T**	**P**	**TOTAL**	
	3	**0**	**2**	**42 hrs/sem**	
Scheme of Examination TOTAL = 150 marks	**IA**	**TW**	**TM**	**P**	**O**
	25	**0**	**100**	**0**	**25**

Course Objectives:

1. To inculcate the spirit of energy economics amongst students
2. To make the students grasp and use the principles of energy management in steam operated systems, electrical systems etc.

Course Outcomes:

On completing this course students will be able to:

CO 1	To understand energy management, economics and auditing concepts and to examine the outcome of energy audit
CO 2	To analyze financial methods in energy management
CO 3	To assess the need of air conditioning, steam generation, waste heat recovery and cogeneration
CO 4	To understand and apply various techniques of improving efficiency in thermal and electrical utilities

UNIT-1	**10 Hrs**
Importance of energy management. Energy auditing: methodology, analysis of past trends (plant data), closing the energy balance, laws of thermodynamics, measurements, portable and on line instruments. Energy economics - discount rate, payback period, internal rate of Return, life cycle costing.	
UNIT-2	**11 Hrs**
Steam Systems: Boiler -efficiency testing, excess air control, Steam distribution & use- steam traps, condensate recovery, flash steam utilization. **Thermal Insulation** – Types, economic thickness of insulation. Advanced vacuum insulation Energy conservation in Pumps, Fans (flow control), Compressed Air Systems, Refrigeration & air conditioning systems.	
UNIT-3	**10 Hrs**
Electrical Systems: Demand control, power factor correction, load scheduling / shifting, Motor drives- motor efficiency testing, energy efficient motors, motor speed control. Energy efficiency of a LED lighting system using a Peltier module	

thermal converter. **Lighting**- Lighting levels, efficient options, fixtures, day lighting, timers, Energy efficient windows.	
UNIT -4	**11 Hrs**
Waste heat recovery: Recuperators, heat wheels, heat pipes, heat pumps. **Cogeneration** - Concept, options (steam/gas turbines/diesel engine based), selection criteria, control strategy. **Heat exchanger networking**- Concept of pinch, target setting, problem table approach, composite curves. Demand side management. Financing energy conservation	
ASSIGNMENTS Eight assignments, two on each unit to be submitted within the given deadline. **Of these, at least one assignment per unit to be based on topic selected as case study.**	

TEXTBOOKS	
1	**Industrial Energy Management and Utilisation**, L. C. Witte, P. S. Schmidt, D. R. Brown; Hemisphere Publishing Corp., New York (1988).
2	**Industrial Energy Conservation Manuals**, Published: Cambridge, Mass.: MIT Press (1982).
REFERENCES	
1	**The Efficient Use of Energy**, London, I. G. C. Dryden : Butterworth Scientific in collaboration with the Institute of Energy acting on behalf of the United Kingdom Department of Energy (1982).
2	**Energy Management Handbook**, W. C. Turner; John Wiley and Sons, Inc., New York, Second Edition (1992).

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ADVANCEMENT IN IC ENGINES AND BASICS OF ELECTRIC VEHICLES					
Course Code	**MEE810**		**Credits**	**4**	
Scheme of Instructions (Hours / week)	**L**	**T**	**P**	**TOTAL**	
	3	**0**	**2**	**42 hrs/sem**	
Scheme of Examination TOTAL = 150 marks	**IA**	**TW**	**TM**	**P**	**O**
	25	**0**	**100**	**0**	**25**

Course Objectives:

1. To familiarize the students with the working of contemporary SI and CI engines
2. To provide knowledge on need and availability of alternate fuels for IC engines
3. To sensitize students on effect of IC engine pollution and technologies for emission control
4. To acquire knowledge on latest trends in Automotive technology

Course Outcomes:

On completing this course students will be able to:

CO 1	Understand combustion in IC Engines
CO 2	Study Recent advancement in Internal Combustion engines, Gas turbine and Electric vehicles
CO 3	Apply the knowledge of Internal Combustion engines, Gas turbine and Electric vehicles
CO 4	Analyze the advancement in IC engines and basics of Electric Vehicles

UNIT-1	**10 Hrs**
Combustion in IC Engines: Combustion in spark Ignition engines, stages of combustion, flame propagation, rate of pressure rise, abnormal combustion, Phenomenon of Detonation in SI engines, effect of engine variables on Detonation, Gasoline Direct Injection (GDI), Multi Point Fuel Injection (MPFI). Rating of fuels in SI engines, Additives, Combustion in compression ignition engines, stages of combustion, factors affecting combustion, Phenomenon of knocking in CI engine. Effect of knocking, rating of fuels in CI engines. CRDi Engine, Dopes & Additives, Comparison of knocking in SI & CI engines	
UNIT-2	**11 Hrs**
Alternative Potential Engines: Super Charging/ Turbo-charging, MPFi Engine, CRDi Engine, Fuel cells, VCR engine, Dual fuel engines, Multi fuel engines, concept of hybrid vehicles, Homogeneous Charge Compression Ignition (HCCI), Variable valve timing and lift, Rotating Liner Engine, Modern Trends in I C Engines, The Future of Internal Combustion Engine Design. **Alternate Fuels and Emissions Control:** Important qualities of the Engine fuels - (SI & CI engines), Alternate fuels (SI & CI engines), Engine emissions, Euro norms , Bharat stage norms, Introduction to EDC and IDC , Emission control methods for SI and CI engines, Electronic control unit, Cat con, EGR. Modern Trends in Emissions Control.	
UNIT-3	**11 Hrs**

Gas Turbine Engines: Open cycle gas turbine, Methods for improvement of thermal efficiency of open cycle gas turbine plant, Effect of operating variables on thermal efficiency, Gas turbine fuels. Derivation & calculations. **Jet and Rocket Propulsion:** Theory, Classification of jet engines, Thermodynamic cycle - Ram-jet, turbo-jet, turbo prop, I and II law analysis on each cycle, thermal efficiency.	
UNIT -4	**10 Hrs**
Electric Vehicles: Introduction; History of Electric Vehicles; Social and Environmental importance of Electric Vehicles; Components, Vehicle mechanics: Roadway, fundamentals, Vehicle kinetics, Dynamics of vehicle motion; Propulsion System Design. **Hybrid Electric Vehicles:** Evolution of Hybrid Electric vehicles, Advanced Electric drive vehicle technology, Electric vehicles (EV), Hybrid Electric drive (HEV), Plug in Electric vehicle (PIEV), Components used Hybrid Electric Vehicle, Economic and environmental impacts of Electric hybrid vehicle, Parameters affecting Environmental and economic analysis, Comparative study of vehicles for economic, environmental aspects.	
ASSIGNMENTS Study of one patent in Energy Engineering and make a report and presentation as seminar	

TEXTBOOKS	
1	**Internal Combustion Engine**, V. Ganesan; TataMcGraw Hill, 4th Edition (2017).
2	**Gas turbines**, V. Ganesan; Tata McGraw-Hill, 2nd Edition (2003).
3	**Electric & Hybrid Vehicles** – A.K. Babu; Khanna Publishing House, New Delhi (2018).
REFERENCES	
1	**Internal Combustion Engines**, Willard W.Pulkrabek; Pearson Education (2013).
2	**Gas Turbines Theory**, Cohen and Rogers; Wesley Longman (1996).
3	**Electric Vehicle Technology Explained**, James Larminie; John Wiley & Sons (2003).

List of Experiments:

(At least 6 experiments should be conducted from the list of experiments)

1. First law analysis on gas turbine.
2. Second law analysis on gas turbine.
3. Cycle analysis on gas turbine.
4. Performance Test on Gasoline Engine
5. Performance test on Diesel Engine
6. Emission analysis of Diesel Engine
7. Performance study of biofuels on IC Engines
8. Case study on Electric vehicles performance and Economics
9. Case study on Hydrogen fuel cell Vehicle

Engineering Branch: Mechanical Engineering

Minor/ Honours (Specialization) Subject: Smart Manufacturing

Scheme of Instructions and Examination

Course Code	Semester	Nomenclature of the Course	Scheme of Instruction Hrs/Week			Scheme of Examination							
			L	T	P	Duration (Hrs)	Marks						Credits
							Th	IA	TW	P	O	Total	
MES410	IV	Rapid Prototyping	3	1	--	3	100	25	--	--	25	150	4
MES510	V	Industry 4.0 and Industrial Internet of Things	3	--	2	3	100	25	--	25	--	150	4
MES610	VI	PLC and SCADA	3	--	2	3	100	25	--	25	--	150	4
MES710	VII	Advanced CNC Technology	3	--	2	3	100	25	--	25	--	150	4
MES810	VIII	Robotics and Artificial Intelligence	3	--	2	3	100	25	--	25	--	150	4
		TOTAL	15	1	8	--	500	125	00	100	25	750	20

LEGEND

Abbreviation	Description
L	Lecture
T	Tutorial
P	Practical
O	Oral
Th	Theory
TW	Term Work
IA	Internal Assessment

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Rapid Prototyping					
Course Code	**MES410**		**Credits**	**4**	
Scheme of Instructions (Hours / week)	**L**	**T**	**P**	**TOTAL**	
	3	**1**	**0**	**42 hrs/sem**	
Scheme of Examination TOTAL = 150 marks	**IA**	**TW**	**TM**	**P**	**O**
	25	**0**	**100**	**0**	**25**

Course Objectives:

1. To inculcate the knowledge and skills related to Rapid Prototyping technologies
2. To provide overview of selection of material, equipment and development of a Rapid Prototype for smart manufacturing in Industry 4.0

Course Outcomes:

On completing this course students will be able to:

CO 1	Understand various processes of additive manufacturing and their applications
CO 2	Select a specific material for the given application
CO 3	Select a Rapid Prototyping process for a given application
CO 4	Apply the concepts of 3D modelling and additive manufacturing to produce a component using a standard 3 D Printer

UNIT-1	**10Hrs**
Introduction to Rapid Prototyping: Introduction, Process, Classifications, Advantages, Additive v/s Conventional Manufacturing processes, CAD for Additive Manufacturing, CAD Data formats, Data translation, Data loss, STL format. **Vat Polymerization:** Principle of Working & Process parameters of Stereolithography (SLA), Digital Light Processing (DLP), Masked Stereolithography (MSLA), Lithography-based Metal Manufacturing (LMM), Light Enabled Additive Production (LEAP), Projection Micro Stereolithography (PμSL), Digital Composite Manufacturing (DCM)	
UNIT-2	**11Hrs**
Material Extrusion: Principal of Working & Process parameters of Fused Deposition Modelling (FDM) **Powder Bed Fusion**: Principle of Working & Process parameters of Selective laser sintering (SLS), selective laser melting (SLM), Electron beam melting (EBM), Direct metal laser sintering (DMLS), Multi Jet Fusion (MJF) **Material Jetting**: Principle of Working & Process parameters of Material Jetting (MJ), Nanoparticle Jetting (NPJ), BINDER JETTING: Sand Binder Jetting, Metal Binder Jetting, Plastic Binder Jetting,	
UNIT-3	**10Hrs**

Direct Energy Deposition: Principle of Working & Process parameters of Laser Engineered Net Shaping (LENS), Electron Beam Additive Manufacturing (EBAM), Direct Metal Deposition (DMD), Wire Arc Additive Manufacturing (WAAM), **Sheet Lamination:** Principle of Working & Process parameters of Laminated Object Manufacturing (LOM), Ultrasonic Consolidation (UC), Selective Lamination Composite Object Manufacturing (SLCOM), Plastic Sheet Lamination (PSL), Selective Deposition Lamination (SDL), Composite Based Additive Manufacturing (CBAM), InLay moulding, Vacuum Moulding, Silicon Moulding	
UNIT-4	**11Hrs**
Materials in additive manufacturing: Introduction, Nature of Material, Physical Properties, Chemical Properties, Mechanical Properties, Application, Processing temperature of PLA, ABS, Nylon 66, PP, PC-ABS, PEEK. **AM Applications**: 3D printing in Bioprinting tissues and organoids, Surgical Instruments, Custom made prosthetics, Dental applications. Prosthetic jaws and Implants, Blood vessels, organ printing, Tablet Printing, Automotive, Aerospace, Robotic and defence applications, 3D printing of a building Demonstration of Additive Manufacturing process and Reverse Engineering with a standard 3 D Printer by slicing STL file.	
Four assignments, one on each unit to be submitted within the given deadline.	

TEXTBOOKS	
1	**Rapid prototyping: Principles and applications**, Chua C.K., Leong K.F., and Lim C.S; Third Edition, World Scientific Publishers, 2010.
2	**Rapid Prototyping and Engineering applications: A tool box for prototype development**, Liou L.W. and Liou F.W; CRC Press, 2007.
3	**Rapid Manufacturing**, Flham D.T &Dinjoy S S; Verlog London 2001.
4	**Rapid Tooling: Technologies and Industrial Applications**, Hilton P.D. and Jacobs P.F; CRC press, 2000
5	**Fundamentals of Additive Manufacturing Technologies**, Prof. Sajan Kapi; NPTEL Course
REFERENCES	
1	**Rapid Prototyping: Theory and practice**, Kamrani A.K. and Nasr E.A; Springer, 2006
2	**Additive Manufacturing Technologies Rapid Prototyping to Direct Digital Manufacturing**, I. Gibson l D. W. Rosen l B; Stucker Springer New York Heidelberg Dordrecht, London ISBN: 978- 1-44191119-3 e- ISBN: 9781-44191120-9 DOI 10.1007/9781-44191120-9
3	**Understanding Additive Manufacturing**, Andreas Gebhardt; Hanser Publishers, 2011
4	**Additive Manufacturing Technology, rapid manufacturing**, Hari Prasad, A.V.Suresh; Cengage 2019

Industry 4.0 and Industrial Internet of Things					
Course Code	**MES510**		**Credits**	**4**	
Scheme of Instructions (Hours / week)	**L**	**T**	**P**	**TOTAL**	
	3	**0**	**2**	**42 hrs/sem**	
Scheme of Examination TOTAL = 150 marks	**IA**	**TW**	**TM**	**P**	**O**
	25	**0**	**100**	**25**	**0**

Course Objectives:

1. To provide an overview of the basic concepts of Smart Manufacturing and Internet of Things for Industry 4.0 and related technologies
2. To introduce to the standard programming tools for data analytics, machine learning and Internet of Things and interfacing IoT based applications

Course Outcomes:

On completing this course students will be able to:

CO 1	Understand the technologies like Cyber Physical Systems, Internet of Things, Data Analytics, Cloud Computing and Machine Learning which drive Industry 4.0
CO 2	Apply concepts of data analytics and machine learning for simple real-life applications
CO 3	Develop Industrial IoT based applications using Arduino/ Raspberry pi
CO 4	Implement solutions for Industry 4.0 by analysing and integrating various tools of smart manufacturing

UNIT-1	**10 Hrs**
Introduction to Industry 4.0 – Fourth Industrial Revolution, Definition and Megatrends in Industry 4.0, Design principles, Smart factory, PLM for Industry 4.0 **Industrial Internet of Things (IIoT)**: Introduction to Cyberphysical systems, Ubiquitous sensing and Advanced analytics, Data integration challenges, Smart sensor, Accessing sensors and actuators, Intel IOT device library, Futuristic industrial plant – 5C architecture for cyber physical systems, IIoT Reference Architecture-Introduction, Review of M2M communication, 3 tier architecture pattern, IIOT layer wise architecture, Sensing for manufacturing process in IIoT	
UNIT-2	**10 Hrs**
Communication in Industry 4.0: - IEEE 802.15.4, Zigbee, Wireless HART, Z wave, Bluetooth, RFID, MQTT, CoAP, LPWAN, Basics of 5G and API, Introduction to computing with Arduino & Raspberry Pi, Case studies of IIoT processing for self-driving car, AR drone-based precision agriculture, iRobot factory, Big data driven smart manufacturing, Issues with IoT Standardization **Cybersecurity:** Components, Elements, IIoT security issues, cybersecurity requirements, Challenges in IIoT, Cybersecurity for Industry 4.0, Cyber-attack detection	

Virtual Reality (VR) and Augmented Reality (AR): Introduction, Chronological order, Features, Applications, Types of AR & VR	
UNIT-3	**11 Hrs**
Big Data Analytics: Classification of digital data, Introduction to big data, Definition, Characteristics of big data, Data sources, Data acquisition, Typical data warehouse environment and Hadoop environment, Introduction to Big data analytics, Big data analytics for Industry 4.0, Cloud based methods, Types of analytics, Components of Python in data science **Data exploration:** Data pre-processing, Data quality, Data cleaning- Missing values, Binning, outliers, Data cleaning process, Data reduction- Dimensionality and numerosity reduction, Sampling, Data compression, Brief overview of data transformation strategies and data integration, Normalisation, Data visualisation- Relationship between features, Scatter plot, bar plots, histogram, box plots, Case study on data pre-processing and visualisation, Introduction to data mining	
UNIT-4	**11 Hrs**
Artificial Intelligence and Machine Learning: Introduction, Scope, Machine learning, Role of AI in Industry 4.0 & IIoT Types of ML algorithms-, Supervised and unsupervised learning, Clustering, Regression model Collaborative filtering, Association rule mining, Decision tree, applications of IIoT with ML, Introduction to Deep learning, Case study of big data analytics in an aircraft **Cloud computing in IIoT**: Introduction, Need for cloud, Cloud components, Full and para virtualisation, Cloud deployment models, Services, Applications, cloud based IIoT architecture, Industrial cloud providers- GE Predix, Siemens Mindsphere, Honeywell, Limitations, Cloud of Things, Introduction to Google cloud platform and Amazon Web services, fog computing, Industrial data management using Hadoop **IIoT and Industry 4.0 Case studies**: Smart factory applications (Kuka/Airbus), IoT in healthcare (oxygen saturation monitor), Predictive maintenance and asset condition monitoring with AWS IoT, IoT in oil and gas/pharma industry	

TEXTBOOKS	
1	**Introduction to Industrial Internet of Things and Industry 4.0**, Sudip Misra; NPTEL
2	**Introduction to Industrial Internet of Things and Industry 4.0**, S. Misra, C. Roy, and A. Mukherjee; 2020, CRC Press, 2020
3	**Data Mining Concepts and Techniques**, Jiwawei Han, Micheline Kamber, Jan Pei; Elsevier, 3rd Edition
REFERENCES	
1	**Industry 4.0: The Industrial Internet of Things**, Alasdair Gilchrist; Apress, 1st Edition
2	**Introduction to IoT**, S. Misra, A. Mukherjee, and A. Roy; Cambridge University Press, 2020.
3	**Big data analytics**, Seema Acharya, Subhashini Chellappan; Wiley, 2nd edition, 2019
4	**Fundamentals of Machine Learning for Predictive Data Analytics: Algorithms, Worked Examples, and Case Studies** , John D. Kelleher , Brian Mac Namee, Aoife D'Arcy; The MIT Press, 2015

5	**Cloud Computing**, Kris Jamsa; Jones and Bartlett Learning, Indian student Edition
6	**Cloud Computing , A Practical Approach**, Anthony Velte, Toby Velte, Robert Elsenpeter; McGraw Hill Education, Indian Edition
7	**Industrial Internet of Things: Cyber manufacturing Systems**, Sabina Jeschke, Christian Brecher, Houbing Song, Danda B. Rawat; Springer
8	**Learning Python**, Mark Lutz; O‟Reilly Publications
9	https://aws.amazon.com/
10	https://scipy.github.io

List of Experiments for Practical

Note: Any 8 Exercises/Experiments to be performed

I. IIOT
Tools: Arduino/Raspberry Pi

1. Write a program to interface Push button/Digital sensor (IR/LDR) and to turn ON LED /Buzzer for 1 sec after every 2 seconds.

2. Write a program to print temperature and humidity readings and generate weekly reports using SQL

3. Write a program to interface motor using relay turn ON motor when push button is pressed.

4. Write a program to interface OLED with Arduino/Raspberry Pi and write a program to print temperature and humidity readings on it.

5. Write a program to send sensor data to smartphone after ever 2 secs and turn ED ON/OFF when 1‟/‟0‟ is received from smartphone using Bluetooth

6. Write a program on Arduino/Raspberry Pi to upload & retrieve temperature and humidity data from thing speak cloud.

II. Data analytics
Tools: Python/ R programming

1, Data preparation and cleaning
2. Descriptive Statistics, Correlation, Simple Linear Regression
3. Data Visualization using matplotlib & Seaborn

III. AI/ML
Tools: Python/R Programming
1. Write a programme to predict the class of the flower based on available attributes.

Programmable Logic Controllers and SCADA					
Course Code	**MES610**		**Credits**	**4**	
Scheme of Instructions (Hours / week)	**L**	**T**	**P**	**TOTAL**	
	3	**0**	**2**	**42 hrs/sem**	
Scheme of Examination TOTAL = 150 marks	**IA**	**TW**	**TM**	**P**	**O**
	25	**0**	**100**	**25**	**0**

Course Objectives:

This course aims to familiarize with PLC and its programming. Theoretical inputs to architecture, instruction set, ladder logic programming, various industrial applications and the use of PLC

Course Outcomes:

On completing this course students will be able to:

CO 1	Recognize the fundamental principles of PLC and SCADA
CO 2	Understand the various elements and concepts of Ladder Logic Programming.
CO 3	Develop ladder program for sequential and continuous process
CO 4	Interface analog and digital input/ output devices with PLC using different communication protocol.

UNIT-1	**10 Hrs**
Introduction to PLC: Definition, advantages and Importance of PLC, Evolution history of PLC, architecture and block diagram, solid state memory; the processor; I/O modules; power supplies. PLC advantage & disadvantage; PLC versus Computers, PLC Application. **PLC Hardware:** The I/O section, Discrete I/O Modules, Analog I/O Modules, Special I/O Modules, I/O specifications, The CPU, Memory design, Memory Types, Programming Devices, Selection of wire types and size.	
UNIT-2	**10 Hrs**
PLC Programming: Basic Ladder logic, logic functions, electrical wiring diagram, scan cycle. Programming languages for PLC, PLC module addressing, registers basics, basic relay instructions, timer-counter instructions, arithmetic functions, comparison functions, data handling, data move functions, input-output instructions, sequencer instructions, Case studies.	
UNIT-3	**12 Hrs**
Timers: Mechanical Timing relay, Timer instructions, ON delay timer instruction, Off-Delay timer instruction, Retentive Timer, Cascading Timers, examples of timer function industrial application; industrial process timing application. **Counters:** Counter Instructions, Up-counter, down counter, UpDown counter, Cascading counters, Incremental encoder counter applications, Combining counter	

and timer functions, High Speed counter instruction, examples of counter function industrial application.	
UNIT-4	**10 Hrs**
PLC Networking: Introduction, Levels of Industrial Control, Types of Networking, Network communications, Interface Standard, Modbus and Modbus plus Protocols, CC-Link overview, HART, AS-interface (AS-i), DeviceNet overview, ProfiBus PA/DP/FMS protocol, Foundation Fieldbus, Industrial Ethernet overview, TCP/IP overview, OPC server client. **SCADA:** Introduction, Open system: Need and advantages, Building blocks of SCADA systems, Remote terminal unit (RTU): Evolution of RTUs, Components of RTU, Communication subsystem, Logic subsystem, Termination subsystem, Testing and human-machine interface (HMI) subsystem, Power supplies.	

TEXTBOOKS/ REFERENCES	
1	**Programmable Logic Controllers, Principles and Applications**: John W. Webb, Ronold A Reis; 5th Edition, Prentice Hall of India Pvt. Ltd
2	**Programmable Logic Controllers**, Frank Petruzzula; Tata Mc-Graw Hill Edition.
3	**Programmable Logic Controllers Industrial Automation an Introduction**, Madhuchannd Mitra and Samerjit Sengupta; Penram International Publishing Pvt. Ltd.
4.	**Programmable Logic Controllers Principles and Applications**, J. R. Hackworth and F. D. Hackworth; Pearson publication
5.	**Supervisory Control and Data Acquisition**, Boyar S A; ISA Publications New Delhi
REFERENCES BOOKS:	
1	**PLC and SCADA**, J Singh, M Deswal; USP(India) Pvt Ltd.
2	**Introduction to Programmable Logic Controllers**, Dunning G; Thomson/Delmer Learning, New Delhi, 2005
3	**Industrial Automation and Process Control**, Stenerson J; PHI Learning, New Delhi

List of Experiments for Practical

Note: Any 8 Exercises/Experiments to be performed

1. Introduction to ladder programming& to implement basic logic gates.
2. Temperature Control using PLC
3. Traffic light control system using PLC
4. Bottle filling automation system using PLC
5. DC Motor Control System using PLC
6. Speed measurement using counter
7. Elevator system control using PLC
8. Car Parking system control using PLC
9. Pneumatic Sequencing using PLC
10. Pneumatic actuation with Timers and Counters using PLC
11. Temperature Control using SCADA
12. Pressure Control using SCADA

Advanced CNC Technology					
Course Code	**MES710**		**Credits**	**4**	
Scheme of Instructions (Hours / week)	**L**	**T**	**P**	**TOTAL**	
	3	**0**	**2**	**42 hrs/sem**	
Scheme of Examination TOTAL = 150 marks	**IA**	**TW**	**TM**	**P**	**O**
	25	**0**	**100**	**25**	**0**

Course Objective: This course aims to inculcate thorough knowledge of CNC programming, testing and proving the program on the CNC Machine.

Course Outcomes: After completion of the course, students would be able:

CO 1	To understand the main features and working parts of CNC machines and accessories.
CO 2	To write a CNC Program for turning operations.
CO 3	To write a CNC Program for milling operations.
CO 4	To understand the computer technologies needed to automate the inspection procedures in manufacturing.

Course Contents:

UNIT-1	**10 Hrs**
Introduction to Computer Numerical Control (CNC): Numerical control, Functions of a machine tool, Concept of numerical control, Historical Development, Definition, Advantages of CNC machine tools, Evolution of CNC, Advantages of CNC, Limitations of CNC, Features of CNC, The Machine Control Unit (MCU) for CNC, Classification of CNC Machine Tools, CNC machining centres, Classification, Features of CNC Machining Centres	
UNIT-2	**10 Hrs**
Introduction to CNC cutting tool materials and Inspection technologies: Learn different types of Cutting tool materials used in CNC machine tools, understand milling tooling system, know the need for tool pre-setting and work holding. Automated Inspection. Contact v/s noncontact inspection techniques. CMM: construction, operation and programming. Understand the Touch trigger probes and their functions used for inspection on a CNC machine tool. Applications of probing: datuming of the workpiece, workpiece dimension measurement, tool probing.	
UNIT-3	**11 Hrs**
CNC programming-Turing: Plan and optimize programs for CNC turning operations. Calculate parameters like speed feed etc. and set references for the various operations. Prepare Process plan for the lathe operations. Prepare & set CNC lathe operations and test run programmed. Execute program and inspect simple geometrical forms / standard parts	

UNIT-4	11 Hrs
CNC programming-Milling: Plan and optimize programs for CNC Milling operations. Calculate parameters like speed feed, depth of cut etc. and set a reference for the various operations. Various methods of work process like edge finding block centre etc. Prepare & set CNC Milling operations and test run programmed. Execute program and inspect simple geometrical forms / standard parts.	

TEXTBOOKS	
1	**CAD/CAM: Principals and Applications**, P. N. Rao; Tata McGraw-Hill Publishing Company Ltd.; 2e; 2004.
2	**CAD/CAM, Theory & Practice**, Ibhrahim Zeid, R. Sivasubramanium; Tata McGraw-Hill Publishing Company Ltd.; 2e; 2009.
3	**Automation, Production systems and Computer Integrated Manufacturing**, M. P. Groover; Pearsen Education Asia;2e; 2001.
REFERENCES	
1	**Numerical control & computer aided manufacturing**, T.K. Kundra, P. N. Rao, N.K. Tewari; Tata McGraw Hill
2	**CAD/CAM/CIM**, Radhakrishnan P. Subramanyan S; New Age International publishers, 1994
3	**Computer aided manufacturing**, Tien Chien Chang, Rolland Wyst; HSU Pin Wang, Pearson Education

List of Experiments for Practical

Note: Any 8 Exercises/Experiments to be performed

1. Introduction to various G-codes, M-codes and Canned Cycles for milling and turning.
2. Writing Manual CNC program for turning operation with Cut plan and finishing.
3. Writing Manual CNC program for milling operation for 2D milling cycle.
4. Generation of CNC program using CNC software for milling operations with cycles for contour, pocket, facing and slot milling.
5. Generation of CNC program using CNC software for hole making operations (drilling, boring, reaming, tapping) on machining centre.
6. Generation of CNC program using CNC software for turning operations such as facing, grooving, parting and threading.
7. Generation of CNC program using CNC software for hole making operations (drilling, boring, reaming, tapping) on turning centre.
8. Generation of mill tool paths for finishing cycles (parallel, radial, contour) on 3D surface

Experiments on Turning and milling centre

9. Introduction to CNC turning centre and modes of Operation.
10. Introduction to CNC milling centre and modes of Operation.
11. Loading CNC program from software into CNC turning centre control Panel, program testing and debugging.

12. Work Piece setup and taking offset for various types of tools.
13. Machining of workpiece on CNC turning centre.
14. Machining of workpiece on milling centre.

Robotics and Artificial Intelligence					
Course Code	**MES810**		**Credits**	**4**	
Scheme of Instructions (Hours / week)	**L**	**T**	**P**	**TOTAL**	
	3	**0**	**2**	**42 hrs/sem**	
Scheme of Examination TOTAL = 150 marks	**IA**	**TW**	**TM**	**P**	**O**
	25	**0**	**100**	**25**	**0**

Course Objectives:

1. To learn the fundamentals of robotics, sensor and drive technologies
2. To comprehend and analyze the robot arm kinematics
3. To understand integration of Arduino and Raspberry Pi boards with ROS
4. To familiarize students with Artificial Intelligence principles and techniques

Course Outcomes:

On completing this course students will be able to:

CO 1	Understand the fundamentals and peripherals of robots.
CO 2	Model forward and inverse kinematics of robot manipulators.
CO 3	Apply integration of Arduino and Raspberry Pi boards with ROS.
CO 4	Implement appropriate searching strategies for few real world environments

UNIT-1	**11 Hrs**
Fundamentals of Robotics: Basic components of robotic system, Robot anatomy, Robot Joints, Degree of freedom, Robot configurations, Robot Body-arm and Wrist motions, End effectors- Grippers and Tools, Guidelines for design for robotic gripper. **Robot Kinematics:** Spatial Descriptions: position and orientation, Transformations and Euler angle representations, Homogeneous Transformation Matrices, Forward and Inverse Kinematics of Robots, Denavit - Hartenberg representation, Forward and Inverse Kinematic solution for simple robot configurations, Velocity analysis of serial robots, Jacobian, Singularities	
UNIT-2	**10 Hrs**
Trajectory Planning: Introduction, Path versus Trajectory, Basics of Trajectory planning, Joint space and Cartesian space Trajectories **Mobile Robots**: Introduction, Key issues for locomotion, Legged mobile robots:	

Types, leg configuration and stability, Wheeled mobile robots: Wheel configuration & wheel design, Path Planning	
UNIT-3	**10 Hrs**
Robot Programming: Methods of robot programming, Motion Interpolation, Defining Positions in Space, Robot programming languages, VAL II **Robot Operating System (ROS):** ROS Basics, ROS Equation, History of ROS, Sensors and Robots Supporting ROS, ROS Architecture and Concepts, ROS Filesystem Level, ROS Computation Graph Level, ROS Community Level. Python for Robotic programming- Basic Concepts with examples **ROS Programming:** Creating ROS Workspace and Package, Using ROS Client Libraries, Programming Embedded Board using ROS-Interfacing Arduino with ROS, ROS on a Raspberry Pi.	
UNIT-4	**11 Hrs**
Artificial Intelligence: Definitions - Importance of AI, Evolution of AI - Applications of AI, Classification of AI systems with respect to environment, Intelligent Agents, Different types of agents **Problem Solving:** Problem solving agents, Example Problems, Searching for solutions, Uniformed and Informed search strategies, Heuristic Functions **Uncertainty Knowledge and Reasoning:** Definition of uncertainty, Bayes Rule - Inference, Belief Network.	

TEXTBOOKS	
1	**Industrial Robotics Technology, Programming and Applications**, M. P. Groover, M. Weiss, R. N. Nagel, N. G. Odrey; Tata McGraw Hill Education; Special Indian; 2e; 2012.
2	**Robotics: Control, Sensing, Vision and Intelligence**, Fu. K.S., Gonzalez R.C. and Lee C.S.G; Tata McGraw Hill, 2008.
3	**Introduction to Autonomous Mobile Robots**, Roland Siegwart and Illah R. Nourbakhsh; The MIT Press (2004).
4	**Robot Operating System (ROS) for Absolute Beginners: Robotics Programming Made Easy**, Lentin Joseph; 1st Edition, A Press, 2018.
5	**Artificial Intelligence - A Modern Approach**, Stuart Russell and Peter Norvig; PrenticeHall, 3rd edition, 2016.
REFERENCES	
1	**Robotics: Fundamental Concepts and Analysis**, Ghosal A; Oxford University Press, 2006.
2	**Robotics and Control**, R. K. Mittal, I J Nagrath; McGraw Hill Education; 1e; 2003
3	**Introduction to Robotics – Mechanics and Control**, Craig J.J; Pearson Prentice Hall, 2005.

4	**Introduction to Robotics**, Saha. S.K; McGraw Hill Education (India) Private Limited, 2014.
5	**Mastering ROS for Robotics Programming: Design, build, and simulate complex robots using the Robot Operating System**, Jonathan Cacace; Lentin Joseph; 2nd Edition, Packt Publishing, 2018
6	**Programming Robots with ROS: a practical introduction to the Robot Operating System**, Quigley, M., Gerkey, B. and Smart, W.D; O'Reilly Media, Inc., 2015
7	**A First Course in Artificial Intelligence**, Deepak Khemani; McGraw Hill Education (India) 2013.
8	**Beginning Robotics with Raspberry Pi and Arduino: Using python and Open CV**, J. Cicolani; 2nd edition, Apress Inc.
9	**Open CV with Python by Example: Build real world computer vision applications and develop cool demos using OpenCV for python**, P. Joshi; Packt Publishing, 2015.

List of Experiments for Practical

Note: Any 8 Exercises/Experiments to be performed

Robot Kinematics (using Robo Analyser or any other standard software)

1. Exercises on analysing Forward Kinematics of a Robotic arm
2. Exercises on analysing Inverse Kinematics of a Robotic arm

Pick and Place Programming (No simulation)

3. Exercise on Pick and place programming using VAL-II

ROS (Using Python or any other standard software)

4. Simulation of Robotic arm using ROS
5. Exercise on integrating Sensors, Microcontroller and ROS in Robotic system
6. Exercise on Path planning using Arduino-ROS

Artificial Intelligence (Using Python or any other standard software)

7. Write a program to implement Breadth First Search algorithm
8. Write a program to implement Depth First Search algorithm
9. Write a program to implement Uniform Cost Search algorithm

Machine Vision (Using OpenCV or any other standard software)

10. Study of Machine Vision system
11. Exercise on Image Acquisition and processing
12. Exercise on Feature extraction and Object recognition

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Engineering Branch: Civil Engineering

Minor/ Honours (Specialization) Subject: Lean Construction Technology

SCHEME OF INSTRUCTION AND EXAMINATION

Course Code	Semester	Nomenclature of the Course	Scheme of Instruction Hrs/Week			Scheme of Examination						
			L	T	P	Duration (Hrs)	Marks					Credits
							TH	IA	TW	O	Total	
LCT-01	IV	Low Cost Construction Techniques	3	0	2	3	100	25	25	-	150	4
LCT-02	V	HVAC & Plumbing	3	1	2	3	100	25	25	25	175	5
LCT-03	VI	Formwork Design	3	1	2	3	100	25	25	25	175	5
LCT-04	VII	Smart Materials and structures	3	0	0	3	100	25	-	-	125	3
LCT-05	VIII	Construction Safety	3	0	0	3	100	25	-	-	125	3
		TOTAL	**15**	**2**	**6**	**-**	**500**	**125**	**75**	**50**	**750**	**20**

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Syllabus

Low Cost Construction Techniques					
Course Code	**LCT-01**		**Credits**	4	
Scheme of Instruction Hours/ Week	**L**	**T**	**P**	**Total**	
	3	0	2	42 hrs/sem	
Scheme of Examination TOTAL = 150 marks	**IA**	**TW**	**TH**	**P**	**O**
	25	25	100	-	-

Course Objective:	
•	To introduce concept of low cost materials and techniques for housing.
•	To understand the properties of natural resources and waste products for using in low cost housing.

Course Outcomes: After completion of course, students would be able to:	
CO1	Understand the low cost housing materials and techniques.
CO2	Learn low cost infrastructural services
CO3	Design a low cost house incorporating low cost materials and techniques.
CO4	Cost comparison of low cost and conventional materials and techniques

Course Contents:	
	Lectures
Total Theory Duration:	**42**
Unit 1	
Introduction: Need of low cost housing; qualitative and quantitative requirements of low cost housing. **Low Cost Construction materials and products:** Low cost materials - soil, flyash, slag, ferro-cement, lime, natural fibres, stones, stone dust, bitumen, etc. Low cost building products for walls – stabilised and sundried soil blocks and bricks, hollow blocks, stone masonry blocks, ferro-cement partitions; Low cost building products for roofs – precast RC planks and joists, precast channel roofs, precast L-panel roofs, precast funicular shells, ferro-cement shells, filler slabs, fibre roofs, improved country tiles and thatch roofs, use of bamboo in construction. Low cost alternative for natural wood.	**11**
Unit 2	
Low cost construction techniques and equipment: Rat-trap bond construction, precast RC and ferro-cement construction, mud technology, curved masonry roofs construction, filler slab construction technique. Brick moulding machine, stabilised soil block making machine, hollow concrete block making machine. Testing of low cost construction products.	**10**
Unit 3	
Low cost rural and urban housing: Present status housing requirement, housing the urban poor, national and international organisations dealing with low cost housing, mud housing technology, fire retarding treatment, houses in disaster prone areas.	**10**
Unit 4	
Low cost infrastructural services: Low cost waste water disposal system for rural and urban areas, water supply, roads, energy systems.	

Cost analysis and comparison: Cost analysis for low cost materials and techniques, comparison of costs with conventional materials and techniques.	**11**

Lab Work:	
1.	**Casting of any three items from Sr. No. 1 a to 1e** a. Casting of mud blocks/bricks, stabilised earth blocks, etc.
	b. Casting of rammed earth walls
	c. Casting of filler slabs with coconut shells or mangalore tiles
	d. Casting of ferro-cement shells, funicular shells, etc.
	e. Casting of mud slabs/beams with bamboo reinforcements
2.	Working out cost of above items , cost comparison
3.	Testing of above components cast.

Text Books	
1.	Lal, A. K.; Handbook of Low Cost Housing, New Age International (P) Ltd. Publishers, 1st Edition, 1995 (Reprint 2003).
2.	Jagadish, K. S., Venkatarama Reddy, B, Nanjunda Rao, K. S.; Alternative Building Materials and Technologies, New Age International Publishers, 2nd Edition, 2017.
3.	Jagadish, K. S.; Building with Stabilised Mud, Wiley India Pvt Ltd., 2020.

Reference books	
4.	Building Material for Low Income Houses, International Council for Building Research Studies and Documentation.
5.	Madhav Rao, A. G., Ramachandramurthy, D. S., Annamalai, G.; Modern Trends in Housing in Developing Countries.
6.	Ruiz, F. P.; Building An Affordable House: A Smart Guide to High-Value, Low-Cost Construction: Trade Secrets to High-value, Low-cost Construction, Taunton, 2005.
7.	Nunan, J.; The Complete Guide to Home Building Materials and Methods, Atlantic Publishing Group Inc., 1978.

Corresponding Online Resources:	
1.	Housing Policy & Planning, Prof. Uttam Kumar Roy, IIT Roorkee. https://onlinecourses.nptel.ac.in/noc20_ar14/preview
2.	Affordable Housing. https://www.remi.edu.in/affordable-housing

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HVAC & Plumbing					
Course Code	**LCT-02**		**Credits**	5	
Scheme of Instruction Hours/ Week	**L**	**T**	**P**	**Total**	
	3	1	2	42 hrs/sem	
Scheme of Examination TOTAL = 175 marks	**IA**	**TW**	**TH**	**P**	**O**
	25	25	100	-	25

Course Objective:	
•	To study and design the heat, ventilation and air conditioning system for a building.
•	To study and design plumbing, sanitary drainage and fire fighting system for a building.

Course Outcomes: After completion of course, students would be able to:	
CO1	Understand fundamentals of heat flow, ventilation, air-conditioning, plumbing and drainage system.
CO2	Apply the basic concept to select indoor and outdoor units for air distribution system and to plan plumbing distribution system in a building.
CO3	Analyse the ventilation requirements, heat load calculations and design air distribution system.
CO4	Design and draw plumbing, sanitary system and fire fighting system in building.

Course Contents:	
	Lectures
Total Theory Duration:	**42**
Unit 1	
Heat: Fundamentals, Types of Heat-Sensible Heat, Latent Heat. Mode of Heat Transfer –Conduction, Convection, Radiation, Codes and Standards, heat pumps. **Ventilation:** Types of Ventilation, Kitchen, Car parking and Toilet Exhaust Ventilation System.	**10**
Unit 2	
Air-conditioning: Properties of Air, Dry bulb Temperature, Wet bulb Temperature, Relative Humidity, Dew Point Temperature, Ton of Refrigeration. **Types of air-conditioning:** Direct System, Window AC, Split AC, VRF System, Indirect System, Air Handling Unit, Fan Coil Unit, Chilled Water System. **Heat load calculation:** Glass, Wall, Roof & Floor, Partition, Ceiling, Lighting, Electronics Equipment, Occupancy. **Air terminal System-**Types of diffuser and Grill **Selection of indoor & outdoor units air distribution system**: Duct, Types of duct, Designing of duct, Flexible Duct, Plenum Box. **Air distribution system:** Chiller, Cooling Tower, Pipe Design, GPM Calculation, Pump Head Calculation.	**12**
Unit 3	
Plumbing Systems **Fundamentals of Plumbing System:** Introduction, Definitions & Concepts, List of codes & Standards, Fixtures, Faucets and Fixture fittings – (Wash basin, Water Closet, Bath tub, Shower, Urinals, Kitchen sink, tank-less water heaters, hot water recirculation, leak detectors, grey water systems, touchless faucets). **Design of Water Supply and Distribution System:** Requirements of Water Supply system, Water Supply Schematic Layout, Water Demand Calculations, Storage Calculations- Underground sump sizing, Elevated storage Reservoir (ESR) sizing,	**10**

Internal and External Water Supply System, Flow rate, Hazen-Williams nomograms for Head loss Calculation. Pipe sizing calculations, Material used, etc.	
Unit 4	
Design of Sanitary Drainage System: Requirements and types of Sanitary Drainage System, Sanitary Drainage Schematic Layout, Sanitary Drainage Pipe Sizing Calculations, Calculation of Slope by Manning's formula, Calculating Depth of Inspection Chamber/Manholes, Material used in Sanitary Drainage system **Drawings – Plumbing Layouts**: Legends used in Plumbing, Typical Floor Plan-Plumbing Layout for multi storied buildings. **Fundamentals of Fire Fighting System**: Fire Fighting Standards According to NFDA**,** Requirements of Fire Protection System, Calculation of Fire Hydrant System, Design of Fire Water and Pumping Calculations	**10**

Lab Work:	
1.	Study of different components of air handling systems, heat pump, ventilation system, and AC units
2.	Heat load calculations for glass, wall, roof & floor, partition, ceiling, lighting, electronics equipment, occupancy, etc.
3.	Study of pipes and fittings, hand tools and joints in pipes and perform pipe fitting tasks.
4.	Develop and draw basic plumbing layout for a building.

Text Books	
1.	Khurmi, R. S. and Gupta, J. K.; Textbook of Refrigeration and Air-Conditioning, S Chand Publishers, New Delhi, 2019.
2.	Steve, M.; Plumbing, 2nd Edition, T and F India, 2014.
3.	Gupta, N. C.; Comprehensive HVAC System Design, Viva Books Originals, 2016.

Reference books	
4.	Arora, C. P. Refrigeration and Air Conditioning, 3rd Edition, McGraw Hill India Publishers, 2012.
5.	Deolalikar, S.; Plumbing Design and Practice, Mc Graw Hill Education, 2001
6.	ASHRAE Handbook (Fundamentals), ASHRAE

Corresponding Online Resources:	
1.	https://onlinecourses.nptel.ac.in/noc19_me58/preview
2.	https://www.mepcentre.com/course/plumbing-design

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Formwork Design					
Course Code	**LCT-03**		**Credits**	5	
Scheme of Instruction Hours/ Week	**L**	**T**	**P**	**Total**	
	3	1	2	42 hrs/sem	
Scheme of Examination TOTAL = 175 marks	**IA**	**TW**	**TH**	**P**	**O**
	25	25	100	-	25

Course Objective:	
•	To select appropriate material for manufacturing false work and form work for specific requirements.
•	To design the formwork for various components

Course Outcomes: After completion of course, students would be able to:	
CO1	Understand different types of formworks and forces acting on them.
CO2	Select a right material for manufacturing false work and form work suiting specific requirements.
CO3	Plan the safety steps involved in the design of form work and false work.
CO4	Design form work.

Course Contents:	
	Lectures
Total Theory Duration:	**42**
Unit 1	
Introduction: Objectives of Form Building, Technical Terms, Planning for Formwork, Requirements of Formwork, Materials of Formwork, Types of Form work, Indian Standards on Formwork, Treatment of Formwork, Formwork Functions, Basic Principles of Formwork Making, Occupational Health and Safety Requirements **Principles of Formwork Design:** Types of loading on formwork, Design Considerations, Structural Design	**10**
Unit 2	
Pressure of Concrete on Formwork: Behaviour of Concrete, Lateral Pressure of Concrete on Formwork, Lateral Pressure of Concrete on Wall Forms, Relationship between Rate of Fill, Temperature, and Pressure for Wall Forms, Lateral Pressure of Concrete on Column Forms, Relationship between Rate of Fill, Temperature, and Pressure for Column Forms, Graphical Illustration of Pressure Equations for Walls and Columns, Effects of Weight of Concrete on Pressure, Vertical Loads on Forms, Placement and Consolidation of Freshly Placed Concrete, Wind Loads on Formwork Systems	**10**
Unit 3	
Formwork of Timber and Timber Derived Materials: Elements of Formwork, Defects Commonly Found in Formwork, Construction of Formwork, Forms for Foundations, Forms for Walls, Forms for Columns, Forms for Lintels and Simple Beams, Forms for Staircase, Forms for Slab or floor, Modular Slab Formwork **Formwork of Steel and Aluminium:** Steel Formwork - Elements and Accessories of Steel Formwork, Strength and Durability of Formwork. Aluminium Formwork – for Slab, Walls, Column, Stairs, Domes and Shell Roofs, Table or Flying Form Systems Conventional and Proprietary (timber and steel) Formwork Design: Foundation, Wall, Column, Slab and Beam formworks. Design of Decks and False works. Effects of various loads. Loading and moment on formwork, IS Code provisions.	**11**

Unit 4	
Formwork for Special Structures such as Shells, Domes, Folded Plates, Overhead Water Tanks, Natural Draft Cooling Tower, Nuclear Reactor, Tunnel, and Lift Shaft. **Formwork for Thin-Shell Roof Slabs:** Forms for Circular Shell Roofs, Design of Forms and Centering for a Circular Shell Roof, Centering for Shell Roofs, Use of Trusses as Centering, Decentering and Form Removal. **Formwork for Architectural Concrete:** Forms for Architectural versus Structural Concrete, Forms for Corners, Forms for Parapets, Forms for Roof Members **Slipforms:** Introduction, The Forms, Operation of Slipforms, Constructing a Sandwich Wall, Slipforms for Special Structures **Formwork Failure:** Construction Sequence and Safety in use of Formwork: Sequence of construction, Safety use of formwork and false work. Cases in Failure of Temporary Support Structures of Bridges	**11**

Lab Work:	
1.	Design Example of form for column
2.	Design example of form for footing
3.	Design example of form for slab and beam
4.	Design example of form for water tank
5.	Design example of form for circular shell roof
6.	Case study of formwork failure

Text Books	
1.	Jha, K. N. ; Formwork for Concrete Structures, 1st Edition, McGraw Hill, 2012.
2.	Peurifoy, R. L., Oberlender, G. D.; Formwork for Concrete Structures, McGraw- Hill, 1996.
3.	Austin, C. K.; Formwork for concrete, Cleaver - Hume Press Ltd., London, 1996.

Reference books	
4.	Hurst, M. P.; Construction Press, London and New York., 2003
5.	Dinescu, T., Radulescu, C.; Slip Form Techniques, Abacus Press, Turn Bridge Wells, Kent, 2004.

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Smart Materials and structures					
Course Code	**LCT-04**		**Credits**	3	
Scheme of Instruction Hours/ Week	**L**	**T**	**P**	**Total**	
	3	0	0	42 hrs/sem	
Scheme of Examination TOTAL = 125 marks	**IA**	**TW**	**TH**	**P**	**O**
	25	-	100	-	-

Course Objective:	
•	This course is designed to give an insight into the latest developments regarding smart materials and their use in structures

Course Outcomes: After completion of course, students would be able to:	
CO1	Understand various smart materials and devices.
CO2	Learn about different measuring techniques
CO3	Develop familiarity with piezoelectric materials and their use as sensors and actuators in various configurations
CO4	Process signals and control systems for use in civil engineering structures.

Course Contents:	
	Lectures
Total Theory Duration:	**42**
Unit 1	**12**
Introduction Smart Materials and Structures – Instrumented structures functions and response –Sensing systems – Self diagnosis – Signal processing consideration – Actuation systems and effectors. **Measuring techniques** Strain Measuring Techniques using Electrical strain gauges, Types – Resistance – Capacitance – Inductance – Wheatstone bridges – Pressure transducers – Load cells – Temperature Compensation – Strain Rosettes.	
Unit 2	**10**
Sensors Sensing Technology – Types of Sensors – Physical Measurement using Piezo Electric Strain measurement – Inductively Read Transducers – The LVDT – Fibre optic Techniques. Chemical and Bio-Chemical sensing in structural Assessment – Absorptive chemical sensors – Spectroscopes – Fibre Optic Chemical Sensing Systems.	
Unit 3	**10**
Actuators Actuator Techniques – Actuator and actuator materials – Piezoelectric and Electrostrictive Material – Magnetostructure Material – Shape Memory Alloys – Electro-rheological Fluids– Electro magnetic actuation.	
Unit 4	**10**
Signal processing and control systems Data Acquisition and Processing – Signal Processing and Control for Smart Structures – Sensors as Geometrical Processors – Signal Processing – Control System – Linear and Non-Linear. Applications of sensors and actuators in civil engineering structures	

Text Books	
1.	Culshaw, B.; Smart Structure and Materials, Artech House; Borton. London, 1996.
2.	Srinath, L. S.; Experimental Stress Analysis; Tata McGraw-Hill, 1998.
3.	Dally, J. W., Riley, W. F.; Experimental Stress Analysis, Tata McGraw-Hill, 1998.

Reference books	
4.	Gandhi, M. V., Thompson, B. S.; Smart Materials and Structures, Springer, May 1992
5.	Srinivasan, A.V., McFarland, M. D.; Smart Structures - Analysis and Design, Cambridge University Press, 2001.

Corresponding Online Resources:	
1.	NPTEL Course – Smart Material, Adaptive Structures and Intelligent Mechanical Systems - https://nptel.ac.in/courses/112104173

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Construction Safety					
Course Code	**LCT-05**		**Credits**	3	
Scheme of Instruction Hours/ Week	**L**	**T**	**P**	**Total**	
	3	0	0	42 hrs/sem	
Scheme of Examination TOTAL = 125 marks	**IA**	**TW**	**TH**	**P**	**O**
	25	-	100	-	-

Course Objective:	
•	To make the students well-versed with the latest safety and health regulations.
•	To make students technically competent in the field of construction safety by following relevant Indian standard construction safety practices.

Course Outcomes: After completion course, students would be able to:	
CO1	Understand importance of safety and occupational hazards in construction works.
CO2	Practice safety measures in handling materials, tools and equipment.
CO3	Plan for safety budget and create safety culture.
CO4	Create awareness and practice measures to prevent accidents at the sites.

Course Contents	**Lectures**
Total Theory Duration:	**42**
Unit 1	**10**
Basic terminology in safety, types of injuries, safety pyramid, Role of stakeholders in safety. Importance and contents of first aid kit. Planning for safety budget, safety culture, Introduction to OSHA regulations	
Unit 2	**12**
Importance of safety in construction work; Cases of accidents and remedial measures. Precautions to be taken to avoid accidents; List of safety clothing and equipment needed at the construction site; List of safety measures adopted at the work site for excavations, formwork, fabrication, erection and demolition.	
Unit 3	**10**
Site safety programs – Analysis of construction hazards and accidents; Construction hazards and safety guidelines; Prevention techniques for construction accidents; Site management with regard to safety recommendations; Training for safety awareness and implementation; Construction safety and health manual.	
Unit 4	**10**
Occupational hazards in the construction industry. SOPs (Safe Operating Procedures) – Construction equipment, materials handling-disposal & hand tools, Other hazards – fire safety, confined spaces, electrical safety, fall protection. BIM	

Text Books	
1.	Bhattacharjee, S. K.; Safety Management in Construction, Khanna Publishers, 2011.
2.	Holt, A. S. J.; Principles of Construction Safety, Wiley-Blackwell Publishers, 2005.
3.	MacCollum, D.V.; Construction Safety Engineering Principles, McGraw Hill Publishers, 2007.
Reference books	
4.	Reese, C. D., Eidson, J. V.; Handbook of OSHA Construction Safety and Health, Taylor & Francis, 2006.
5.	Lingard, H. and Rowlinson, H,: Occupational Health and Safety in Construction Project Management, Spon Press, 2005.
6.	SP 70 : 2001, Handbook on construction safety practices
7.	IS 7969 : 1975, Safety code for handling and storage of building materials
8.	IS 7293 : 1974, Safety code for working with construction machinery

Corresponding Online Resources:	
1.	Safety in Construction, https://onlinecourses.nptel.ac.in/noc21_ce16/preview

Engineering Branch: Civil Engineering

Minor/ Honours (Specialization) Subject: Construction Management

SCHEME OF INSTRUCTION AND EXAMINATION

Course Code	Semester	Nomenclature of the Course	Scheme of Instruction Hrs/Week			Scheme of Examination						
			L	T	P	Duration (Hrs)	Marks					Credits
							TH	IA	TW	O	Total	
CM-01	IV	Construction Economics, Finance and Budgeting	3	1	2	3	100	25	25	25	175	5
CM-02	V	Construction Contracts Management and Specifications	3	0	2	3	100	25	25	-	150	4
CM-03	VI	Corporate Laws and Arbitration	3	0	-	3	100	25	-	-	125	3
CM-04	VII	Quality & Safety Management in Construction	3	0	-	3	100	25	-	-	125	3
CM-05	VIII	Infrastructure Planning and Management	3	1	2	3	100	25	25	25	175	5
		TOTAL	**15**	**2**	**6**	**-**	**500**	**125**	**75**	**50**	**750**	**20**

L-Lecture, T-Tutorial, P-Practical, O-Oral, Th-Theory, TW-Term Work, IA-Internal Assessment

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Construction Economics, Finance and Budgeting					
Course Code	CM-01		**Credits**	5	
Scheme of Instruction Hours/ Week	**L**	**T**	**P**	**Total**	
	3	1	2	42 hrs/sem	
Scheme of Examination TOTAL = 175 marks	**IA**	**TW**	**TH**	**P**	**O**
	25	25	100	-	25

Course Objective:	
•	To understand concept of financial management
•	To understand the time value of money
•	To understand the importance of budgeting

Course Outcomes: After completion of course, students would be able to:	
CO1	Prepare income, profit and loss statements and implement construction accounting
CO2	Evaluate construction project economics, cost-benefit analysis and breakeven analysis.
CO3	Analyse and evaluate construction risks and uncertainties.
CO4	Understand the importance of working capital management, budgeting and control.

Course Contents:	
	Lectures
Total Theory Duration:	**42**
Unit 1	
Financial Management: Meaning and Scope, Economics and Scope, Supply and Demand Mechanism, analysis and forecasting. Balance sheet, profit & loss account, fund flow statement.	**10**
Unit 2	
Production and Cost theory, analysis. Pricing; objectives, determinants, absorption, marginal costing. Financial analysis, Decisions. Capital Budgeting, budgetary control, standard costing and variance, investment appraisal	**10**
Unit 3	
Engineering economics, Time value of money, discounted cash flow, NPV, ROR, Bases of comparison, Incremental analysis, Benefit-Cost analysis, Replacement analysis, Break-even analysis.	**10**
Unit 4	
Construction Finance: Accounting information and application, project appraisal. Project yield, risk and uncertainty, Turnkey activities; finance and working capital, cost control, equipment rentals.	**12**

Lab Work (Any 5):	
1.	Prepare a balance sheet for a construction firm.
2.	Prepare a fund flow statement for a construction firm.
3.	Prepare a budget for a construction project.
4.	Case study on Cost Benefit analysis in construction Projects.
5.	Case study on Break-even Analysis in Construction Projects.
6.	Working out of Equipment rentals in construction Projects

Text Books	
1.	Myers, D.; Construction Economics: A New Approach, Taylor and Francis Publisher, 2004.
2.	Ofori, G.; The Construction Industry Aspects of its economics and Management, Singapore University Press, 1990.
3.	Parkin, M., Bade, R.; Modern Macroeconomics, 4th Edition, Prentice Hall, 1996

Reference books	
4.	de Valence, G.; Modern Construction Economics-Theory and Application, 1st Ed., Routledge, Taylor Francis Group, 2011.
5.	Chandra, P.; Financial Management: Theory and Practice; 10th Ed., McGraw Hill Education, New Delhi, 2017.
6.	Panneerselvam, R.; Engineering Economics, PHI Learning Pvt. Ltd., 2012.

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Construction Contracts and Specifications					
Course Code	CM-02		**Credits**	4	
Scheme of Instruction Hours/ Week	**L**	**T**	**P**	**Total**	
	3	0	2	42 hrs/sem	
Scheme of Examination TOTAL = 175 marks	**IA**	**TW**	**TH**	**P**	**O**
	25	25	100	-	-

Course Objective:	
•	To understand basics of contracts and the acts related to contracts
•	To understand EPC and other contracts
•	To understand the drafting of specification
•	To understand different types of contracts MES, CPWD, FIDIC, EPC, PPP.
•	To understand different provisions of contracts: Scope, GCC, SCC, Specifications, Drawings, Site-data

Course Outcomes: After completion of course, students would be able to:	
CO1	Understand basics on construction contracts.
CO2	Carry out the tendering process.
CO3	Draft the specifications and relating them to the site conditions & estimates
CO4	Create awareness about RERA

Course Contents:	
	Lectures
Total Theory Duration:	**42**
Unit 1	
Construction Contracts Overview: a) Indian Contract Act (1872): Definition of the contract as per the ACT. Valid, Voidable, Void contracts, Objectives of the act. b) Brief introduction to Clauses of Contract - its performance and valid reasons for non-performance. Breach of contract, effects of breach- understanding the clauses and applying them to situations/scenarios on construction projects. Importance of the Workmen's Compensation Act on construction projects.	10
Unit 2	
Overview of Contract Formation: a) Standard forms of contracts, methods of inviting tenders, pre-bid meetings, pre-qualification system, scrutiny of tenders and comparative statement. b) conditions of contracts, contracts with various stakeholders on a major construction project, contract pricing by the client, project management consultants and the contractor, contract correspondence and contract closure.	10
Unit 3	
Overview of Contract Conditions: a) General, Special and Particular conditions b) Conditions of Ministry of Statistics and Program Implementation- Government of India. Model forms of contract. c) Standard Forms of Contracts in MES, CPWD, NHAI (EPC contract). Design Build (Own) Operate and Transfer contract. d) FIDIC Form of Contracts: Introduction, FIDIC conditions- evolution of FIDIC document, types based on whether design is of employer or contractor, Colour Code. Various conditions of Red Book.	12
Unit 4	

Specifications for building works: Preparation of specifications, types, organisation of specifications, examples of wordings, planning specification for workmanship and material discretionary powers of engineer, specification of special items. RERA: Establishment and incorporation of RERA, offences, penalties and Adjudication.	**10**

Lab Work:	**28 hrs.**
1.	Drafting of tender notice and report on detailed procedure of tendering including filling procedure by taking one sample tender.
2.	Drafting of Contract document as per CPWD guidelines for any construction project
3.	Drafting of Contract document as per FIDIC for any construction project
4.	Drafting of specifications for any two items of major building works.
5.	Study of legal & technical interpretation of contract clauses.

Text Books	
1.	Patil, B. S. ; Civil Engineering Contracts and Estimates, Universities Press, 2009.
2.	The Indian Contract Act (9 of 1872), 1872- Bare Act, Professional Book Publishers, 2006.
3.	Bangia, R.K.; Law of contract Part I and Part II, Allahabad Law Agency, 2005.
4.	Markanda, P.C.; Building and Engineering Contracts: Law and Practice, 5th Edition, Lexis Nexis, 2017.

Reference books	
5.	Bureau of Indian Standard Specifications: Relevant specifications
6.	Latest Goa Schedule of Rates
7.	RERA User Manual, Govt. of India
8.	The Workmen‘s Compensation Act, 1923 (8 of 1923) Bare Act- 2005- Professional Book Publishers.
9.	Standard General Conditions for Domestic Contracts, Ministry Of Statistics and Program Implementation, Government of India, 2005.
10.	Bockrath, J., Plotnick, F.; Contracts and Legal Environment for Engineers and Architects, 7th Edition, Mc Graw Hill Education (India) Private Ltd.
11.	Contract Labour & Minimum Wages Act.
12.	CPWD: Publications: Specifications, Analysis of Rates, Forms of Contracts, Works Manual & SOP.

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Corporate Laws and Arbitration					
Course Code	CM-03		**Credits**	3	
Scheme of Instruction Hours/ Week	**L**	**T**	**P**	**Total**	
	3	0	-	42 hrs/sem	
Scheme of Examination TOTAL = 125 marks	**IA**	**TW**	**TH**	**P**	**O**
	25	-	100	-	-

Course Objective:	
•	To understand the basics and importance of corporate laws.
•	To introduce fundamental aspects of Intellectual Property Rights and to disseminate knowledge on patents, trademarks and copyrights
•	To provide necessary solution to settle the disputes between people.
•	To understand concept of disputes and methods of resolving them
•	To ensure that the rules are laid down for international as well as domestic arbitration and conciliation.

Course Outcomes: After completion of course, students would be able to:	
CO1	Understand the key characteristics of Corporate Social Responsibility (CSR), company law and the partnership act
CO2	Comprehend IPR, patent, trademark and copyright law
CO3	Identify techno-legal-commercial linkages in contracts and draft contract clauses related to dispute resolution methods including expert determination, mediation / conciliation, arbitration and litigation
CO4	Acknowledge the significance of consumer, competition law and MSMED Act

Course Contents:	
	Lectures
Total Theory Duration:	**42**
Unit 1	
Corporate Social Responsibility: Introduction to CSR- Concept of Corporate Social Responsibilities- Government Initiatives and CSR- Business Ethics- Corporate Governance **Company Law and The Partnership Act:** Introduction- Procedure for Incorporation of Companies- Indian Partnership Act 1932- Rights and Duties of Partners- Relation of Partners to Third Parties- Dissolution of a Firm.	**10**
Unit 2	
Intellectual Property Rights and Patent Law: Concept and importance of Intellectual Property - Need, Development and Essentials of Patent Law, Procedures for Grant of Patent Application- Drafting of Patent Specifications. **Trademark and Copyright Law:** Introduction to Trademark Law- The Trademark Act 1999- Introduction to Copyright Law- The Norms of International Copyrights- Indian Copyright Act 1957 and Rules.	**12**
Unit 3	
Alternative Dispute Resolution: Methods - pros and cons over litigation. **Amicably resolving the disputes:** Expert determination, mediation / conciliation and relevant laws. The Arbitration and Conciliation Act 1996. History of Law of Arbitration and process of evolution of Act 1996 and amendments till date. Introduction to UNCITRAL 1996 and its	**10**

importance. Arbitration- Important aspects of process of Arbitration leading to Award and subsequent scenario.	
Unit 4	
Consumer Protection and Competition Policy/Act: Introduction and Overview of Competition Act 2002- Important terms and its interpretation- The Consumer Protection Act 1996 **Micro, Small and Medium Enterprises Development Act:** Objectives, Necessity and Significance of MSMED Act 2006.	**10**

Text Books	
1.	William, B., Werther Jr., Chandler, D.; Strategic Corporate Social Responsibility: Stakeholders in a Global Environment, 2nd Edition, Sage Publications, 2011.
2.	Cornish, L., Aplin, Intellectual Property: Patents, Copyrights, Trademarks & Allied Rights, Sweet and Maxwell, 8th Edition, 2013.
3.	Reddy,- G. B., Intellectual Property Rights and The Law (Copyright Law, Patent Law, Designs Law, Trademarks Law, Farmers Rights Law, Biological Diversity Law, Information Technology Law, etc. - Comprehensive Book), 2020.
4.	Singh, A.; Introduction to Law of Partnership Including Limited Liabilility Partnership, 2019.
5.	Markanda, P.C.; Arbitration: Step by step, 2nd Edition, LexisNexis, 2017.

Reference books	
6.	Chakraborty, A.; Law & Practice of Alternative Dispute Resolution in India – A Detailed Analysis, Lexis Nexis, 2016.
7.	Malhotra, O. P., Malhotra, I., The Law and Practice of Arbitration and Conciliation, 3rd Edition, 2014.
8.	Singh, A.; Competition Law, Eastern Book Company, 2012.
9.	Reddy, G. B., Baglekar, A. K.; Consumer Protection Act, Eastern Book Company, 2021.
10.	Taxmann, Micro, Small and Medium Enterprises in India, MSME, Taxmann Publications Private Limited, 2017.

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Quality & Safety Management in Construction					
Course Code	CM-04		**Credits**	3	
Scheme of Instruction Hours/ Week	**L**	**T**	**P**	**Total**	
	3	0	-	42 hrs/sem	
Scheme of Examination TOTAL = 125 marks	**IA**	**TW**	**TH**	**P**	**O**
	25	0	100	-	-

Course Objectives:	
•	To provide a structured management approach to control safety risks in operation
•	To determine the effectiveness and efficiency of each process towards its objectives

Course Outcomes: After completion of course, students would be able to:	
CO1	Understand the tools and techniques for quality management
CO2	Meet the quality requirements
CO3	Execute quality control at the structural site
CO4	Ensure safety measures at construction site

Course Contents:	
	Lectures
Total Theory Duration:	**42**
Unit 1	
Introduction to quality; Importance of quality; Quality transition - quality control and inspection, quality assurance, total quality management; Evolution of quality management.	**10**
Unit 2	
Planning and control of quality during design of structures; Tools and techniques for quality management; Inspection of materials and machinery.	**10**
Unit 3	
Quality assurance in construction; Systems quality management; Quality standards/codes in design and construction; (ISO:9000), Total quality management (TQM) - principles, tools and techniques.	**10**
Unit 4	
Introduction to safety; Safety and health programs in construction industry; Planning for safety provisions; Analysis of construction hazards and accidents; Construction hazards and safety guidelines; Prevention techniques for construction accidents; Site management with regard to safety recommendations, Training for safety awareness and implementation; Construction safety and health manual.	**12**

Text Books	
1	Dale, B. G.; Managing quality,4th Ed., Blackwell Publishing, Oxford, 2003.
2	Reese, D., Eidson, J. V.; Handbook of OSHA construction safety and health, 2nd ed., CRC Press, Bocaaton, 2006.
3	Harris, F., McCaffer, R., Edum-Fotwe, F.; Modern construction management, 6th ed., Blackwell Publishing,Oxford, 2006
Reference books	
4.	Knutson, K., Schexnayder, C. J., Fiori, C. M., Mayo, R.; Construction management fundamentals, 2nd Edition, Mc Graw Hill, New York, 2008.
5.	Holt, S. J. ; Principles of construction safety, Blackwell Publishing, Oxford, 2008.

Infrastructure Planning and Management					
Course Code	CM-05		**Credits**	5	
Scheme of Instruction Hours/ Week	**L**	**T**	**P**	**Total**	
	3	1	2	42 hrs/sem	
Scheme of Examination TOTAL = 175 marks	**IA**	**TW**	**TH**	**P**	**O**
	25	25	100	-	25

Course Objectives:	
•	To understand and explain concepts of infrastructure, private involvement in infrastructure,
•	To understand challenges to successful infrastructure planning and implementation
•	To understand strategies for successful infrastructure project implementation, sustainable development of infrastructure

Course Outcomes: After completion of course, students would be able to:	
CO 1	Understand the basic concepts related to Infrastructure Projects, role of private sector in infrastructure growth
CO 2	Describe the strategies for successful Infrastructure Project implementation.
CO 3	Develop Infrastructure modelling and Life Cycle Analysis Techniques.
CO 4	Practice sustainable infrastructure development

Course Contents:	
	Lectures
Total Theory Duration:	**42**
Unit 1	
Basic Concepts Related To Infrastructure: Introduction to Infrastructure, an overview of the Power Sector, Water Supply and Sanitation Sector, Road, Rail, Air and Port Transportation Sectors, Telecommunications Sector, Urban Infrastructure, Rural Infrastructure in India. Introduction to Special Economic Zones, Organizations and layers in the field of Infrastructure, The Stages of an Infrastructure Project Life cycle.	10
Unit 2	
Private Involvement In Infrastructure: A Historical overview, benefits and problems of Infrastructure Privatization. Challenges in Privatization of Water Supply, Power and road transportation infrastructure in India with case studies. **Challenges To Successful Infrastructure Planning And Implementation:** Mapping and Facing the Risks in Infrastructure Projects, Economic and Demand Risks: The Case study for Political Risks, Socio-Environmental Risks, Cultural Risks in International Infrastructure Projects, Legal and Contractual Issues in Infrastructure.	11
Unit 3	
Strategies For Successful Infrastructure Project Implementation: Planning, Scheduling and control of Infrastructure projects. Risk Management Framework for Infrastructure Projects, Shaping the Planning Phase of Infrastructure Projects to mitigate risks, Designing Sustainable Contracts, Introduction to Fair Process and Negotiation, Negotiating with multiple Stakeholders on Infrastructure Projects	11
Unit 4	
Sustainable Infrastructure Development: Information Technology and Systems for Successful Infrastructure Management, - Innovative Design and Maintenance of Infrastructure Facilities, Infrastructure Modelling and Life Cycle Analysis Techniques, Capacity Building and Improving the Governments Role in Infrastructure Implementation.	10

Lab work (Assignments on):	
1	Work Breakdown structure of a sub-Project
2	Drawing a Network and identifying critical path
3	Preparation of Line of balance chart for Repetitive works in a project
4	Preparation of Time and Resource schedule of a Project using Microsoft Project
5	Case study on Time control methods in Construction Projects.

Text Books	
1.	Neil, G.; Infrastructure Engineering and Management, Wiley, 1988.
2.	Haas, Hudson, Zaniewski, Modern Pavement Management, Krieger, Malabar, 1994.
3.	Hudson, Haas, Uddin, Infrastructure Management: Integrating Design, Construction, Maintenance, Rehabilitation, and Renovation, McGraw Hill, 1997.

Reference books	
4.	Munnell, A., Editor, Is There a Shortfall in Public Capital Investment? Proceedings of a Conference Held in June 1990.
5.	World Development Report 1994: Infrastructure for Development.
6.	Zimmerman, K., Botelho F.; Pavement Management Trends in the United States, 1st European Pavement Management Systems Conference, Budapest, September 2000.

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Engineering Branch: Computer Engineering

Minor/ Honours (Specialization) Subject: Artificial Intelligence and Machine Learning

SCHEME OF INSTRUCTION AND EXAMINATION

Course Code	SEMESTER	Nomenclature of the Course	Scheme of Instruction Hrs/Week			Scheme of Examination						
							Marks					Credits
			L	T	P	Duration (Hrs)	TH	IA	TW*	O	Total	
CEAM-01	IV	Mathematical Foundations for Artificial Intelligence & Machine Learning	3	0	2	3	100	25	0	25	150	4
CEAM-02	V	Introduction to Artificial Intelligence & Machine Learning	3	0	2	3	100	25	0	25	150	4
CEAM-03	VI	Data Science and Analytics	3	0	2	3	100	25	0	25	150	4
CEAM-04	VII	Neural Networks and Deep Learning	3	0	2	3	100	25	0	25	150	4
CEAM-05	VIII	* Elective - Honours/Minor CEAM-051 Applications of Artificial Intelligence	4	0	0	3	100	25	25	0	150	4
					8	**--**	**500**	**125**	**25**	**100**	**750**	**20**

* More Course titles for Elective-Honours/Minor can be included based on Industry requirements.

LEGEND

Abbreviation	Description
L	Lecture
T	Tutorial
P	Practical
O	Oral
TH	Theory
TW	Term Work
IA	Internal Assessment

MATHEMATICAL FOUNDATIONS FOR ARTIFICIAL INTELLIGENCE & MACHINE LEARNING						
Semester	**IV**	**Course Code**		**CEAM-01**	**Credits**	**4**
Scheme of Instruction Hours/ Week		**L**	**T**	**P**	**TOTAL**	
		3	**0**	**2**	**42Hrs/Sem**	
Scheme of Examination TOTAL = 150 marks		**TH**	**IA**	**TW**	**P**	**O**
		100	**25**	**0**	**0**	**25**

Prerequisite:

- The students should have knowledge on basics of Python programming.

Course Objectives:

The subject aims to introduce and equip students with knowledge on:

1	The foundational concepts of Mathematics for Machine Learning like Linear Algebra, Vector Calculus, Probability and Distributions, Analytical geometry, Matrix decompositions and Optimization.
2	The understanding and use of various python constructs required for implementation of the mathematics for machine learning.

Course Outcomes:

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

CO1	Understand the need and importance of various foundational mathematical concepts for Machine Learning.
CO2	Apply the important concepts in Linear Algebra, Analytic Geometry, Matrix Decompositions, Vector Calculus andProbability & Distributions required for different applications in Machine Learning.
CO3	Analyze the need and usage of the basic optimization techniques used in Machine Learning.
CO4	Utilize the various python constructs required for implementing the mathematics for machine learning programmatically.

UNIT -1	
Introduction, Linear Algebra: Systems of Linear Equations, Matrices, Solving Systems of Linear Equations, Vector Spaces, Linear Independence, Basis and Rank, Linear Mappings. **Analytic Geometry:** Norms, Inner Products, Lengths and Distances, Angles and Orthogonality, Orthonormal Basis, Orthogonal Complement, Inner Product of Functions.	12 Hrs
UNIT -2	

Analytic Geometry: Orthogonal Projections, Rotations. **Matrix Decompositions**: Determinant and Trace, Eigenvalues and Eigenvectors, Cholesky Decomposition, Eigen decomposition and Diagonalization, Singular Value Decomposition, Matrix Approximation, Matrix Phylogeny.	10 Hrs
UNIT -3	
Vector Calculus: Differentiation of Univariate Functions, Partial Differentiation and Gradients, Gradients of Vector-Valued Functions, Gradients of Matrices, Useful Identities for Computing Gradients, Backpropagation and Automatic Differentiation, Higher-Order Derivatives, Linearization and Multivariate Taylor Series.	10 Hrs
UNIT -4	
Probability and Distributions: Construction of a Probability Space, Discrete and Continuous Probabilities, Sum Rule, Product Rule, and Bayes' Theorem, Summary Statistics and Independence, Gaussian Distribution, Conjugacy and the Exponential Family, Change of Variables/Inverse Transform **Continuous Optimization:** Optimization Using Gradient Descent, Constrained Optimization and Lagrange Multipliers, Convex Optimization.	10Hrs

TEXTBOOKS	
1	Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong, "Mathematics for Machine Learning", 2020, Cambridge University Press
2	Ian Goodfellow, YoshuaBengio and Aaron Courville, "Deep Learning", 2016, The Mit Press
REFERENCES	
1	Dimitri P. Bertsekas and John N. Tsitsiklis, "Introduction to Probability" 2nd edition (1 June 2008), Athena Scientific
2	David C Lay, "Linear Algebra and Its Applications", 3rd edition, Pearson Education India
3	Jay Dawani, "Hands-On Mathematics for Deep Learning: Build a solid mathematical foundation for training efficient deep neural networks",(June 2020), Packt Publishing Limited

List of Experiments

(Minimum 08 Experiments to be performed from the following list in Python)

Sr. No.	Experiment
1	Program to solve linear equations in one variable.
2	Program to solve linear equations in multiple variables.
3	Program to implement basic operations on Matrices and vectors.
4	Program to find matrix Determinant, Trace, Eigenvalues, Eigenvectors, Singular value decompositions.

5	Program to implement Cholesky Decomposition.
6	Program to implement Taylor series.
7	Program to implement and visualize higher order derivatives.
8	Program to implement conditional probability distribution.
9	Program to implement marginal probability distribution.
10	Program to plot Gaussian distribution.
11	Program to implement gradient descent algorithm.
12	Program to implement convex optimization.

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INTRODUCTION TO ARTIFICIAL INTELLIGENCE & MACHINE LEARNING						
Semester	**V**	**Course Code**		**CEAM-02**	**Credits**	**4**
Scheme of Instruction Hours/ Week		**L**	**T**	**P**	**TOTAL**	
		3	**0**	**2**	**42Hrs/Sem**	
Scheme of Examination TOTAL = 150 marks		**TH**	**IA**	**TW**	**P**	**O**
		100	**25**	**0**	**0**	**25**

Prerequisites:

- Students are expected to be familiar with basics of mathematics.
- Ability to program in Python.

Course Objectives:

The subject aims to introduce and equip students with knowledge on:

1	The course is designed to present an overview of the principles and practices of AI to address real-world problems and to develop a basic understanding of problem solving, knowledge representation, reasoning and learning methods of AI.
2	To introduces the concept of learning from data and develop a strong foundation for understanding important Machine Learning algorithms and their applications.

Course Outcomes:

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

CO1	Understand problem solving through search techniques and classify various types of learning.
CO2	Discuss various knowledge representation methods for AI problems.
CO3	Illustrate and apply learning techniques for real-time problems.
CO4	Formulate solutions to various machine learning tasks.

UNIT -1	
Introduction to Artificial Intelligence: Overview, Turing test, Applications. **Problem Solving by Search:** Importance of search in AI, Defining the Problem, State space search, Problem Solving Approach to Typical AI problems, Problem characteristics, production system characteristics, BFS and DFS. **Predicate Logic:** Representing Knowledge as Rules, Representing simple facts in logic, Computable functions and predicates, Unification and resolution.	12 Hrs
UNIT -2	
Knowledge Representation: Representation and Mapping, Approaches to knowledge Representation. **Weak slot and filter structure:** Semantic nets, partitioned semantic nets, Frames.	10 Hrs

Strong Slot and Filter Structures: Conceptual dependency, Scripts. **Game Playing:** Overview, MiniMax Search Procedure, Adding alpha-beta cut offs, Additional refinements.	
UNIT -3	
Machine Learning: Introduction, Designing a learning System, Issues in machine learning. **Concept Learning**: Introduction, General to specific ordering of hypothesis, Finding a maximally specific hypothesis, Version Spaces, candidate elimination algorithms. **Decision tree Learning**: Introduction, Appropriate problems for decision tree learning, Basic Decision Tree Learning Algorithm, Issues in decision tree learning. **Bayesian Learning**: Introduction, Bayes theorem, Naive Bayes Classifier, K-Nearest neighbor classifier.	10 Hrs
UNIT -4	
Clustering: Introduction, k-Means Clustering, Expectation-Maximization Algorithm, Hierarchical Clustering. **Linear Discrimination**: Introduction, Generalizing the Linear Model, Geometry of the Linear Discriminant, Gradient Descent, Logistic Discrimination. **Reinforcement Learning**: Introduction, Elements of Reinforcement Learning, Model-Based Learning, Temporal Difference Learning.	10Hrs

TEXTBOOKS	
1	Elaine Rich and Kevin Knight, Artificial Intelligence, 2nd edition, McGraw Hill.
2	Tom M Mitchell, Machine Learning, Indian edition, McGraw Hill.
3	Ethem Alpaydin, Introduction to Machine Learning, 2nd Edition,The MIT Press.
REFERENCES	
1	Struart Russell and Peter Norvig, Artificial Intelligence, a Modern Approach, 3rd edition, Prentice Hall.
2	Shaishalev-Shwartz and Shai Ben-David, Understanding Machine Learning (FromTheory to Algorithms), First Edition, Cambridge University Press.

List of Experiments

(Minimum 08 Experiments to be performed from the following list in Python)

Sr. No.	Experiment
1	Implementation of Breadth first search using list or queue.
2	Implementation of depth first search using list or stack.

3	Implementation of 2-gallon and 3-gallon water jug problem based on production rules.
4	Implementation of Tower of Hanoi puzzle using recursion.
5	Implementation of 8-puzzle Problem.
6	Implementation of game tree using min-max algorithm.
7	Implementation of decision tree for a given dataset.
8	Implementation of Naive Bayes Classifier.
9	Implementation of K-nearest neighborhood classifier for the given dataset.
10	Implementation of K-means clustering algorithm.
11	Implementation of Hierarchical clustering algorithm.
12	Implementation of a problem using reinforcement learning.

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DATA SCIENCE & ANALYTICS						
Semester	**VI**	**Course Code**		**CEAM-03**	**Credits**	**4**
Scheme of Instruction Hours/Week		**L**	**T**	**P**	**TOTAL**	
		3	**0**	**2**	**42Hrs/Sem**	
Scheme of Examination TOTAL = 150 marks		**TH**	**IA**	**TW**	**P**	**O**
		100	**25**	**0**	**0**	**25**

Prerequisites:

- Basic knowledge of programming and mathematics involved in data analytics.
- Ability to program using Java and R programming language.

Course Objectives:

The subject aims to introduce and equip students with knowledge on:

1	Introduction to basics of data science and data analytics.
2	Provide a sound understanding of the foundations including fundamental concepts like data collection, segregation, and application of various analytics techniques as well as visualization as per end users requirements.

Course Outcomes:

At the end of course, student will be able to:

CO1	Relate practical use of Data Science concept for solving real life problems along with visualization of end results in required form
CO2	Use various techniques on handling stream data& clustering of data for analytics
CO3	Implement Hadoop framework for providing solutions on decision making process in various domains like e-commerce using data analytics
CO4	Performing data analytic using R programming till visualization.

UNIT -1	
Introduction to Data Science: About data science, Terminologies related to data science, Methods of data repository, Personnel involved in data science, Types of Data, Data science process, Popular Data science toolkits. **Recent Trends in Data Science:** Recent trends in data collection and analysis technique	**11Hrs**

Data Visualization: importance, conventional data visualization technique, Retinal variables, Mapping variables to encodings, Various Big Data Visualization tools, Visualization of Big Data, Pre-attentive attributes, Challenges in Big Data Visualization & Potential solutions.	
UNIT -2	
Mining Data Streams: Stream Data Model and Architecture, Sampling data in a stream, Filtering streams, Counting Distinct Elements in a Stream, **Estimating Moments,** Counting Oneness in a Window, Decaying windows. **Frequent itemset Mining**: Market Baskets model and the A-Priori Algorithm, FP growth Algorithm, Handling Larger Datasets in Main Memory, Limited pass algorithm, computing frequent itemset in a stream. **Clustering**: Introduction to clustering techniques, K-Means, Agglomerative Hierarchical clustering, BFR Algorithm, CURE Algorithm.	**10Hrs**
UNIT -3	
Big Data technology Landscape: **NoSQL,:** Types of NoSQL, Advantages of NoSQL, SQL v/s NoSQL, NewSQL. **Hadoop:** Features of Hadoop, Key advantages of Hadoop, Overview of Hadoop Ecosystem, Hadoop verses SQL. **Big Data Analytics:** RDBMS V/s Hadoop, Distributed Computing challenges, Hadoop Overview, The design of HDFS, HDFS Concept, Name node, Data node, command line interface, Basic File system operations, Hadoop File systems, Anatomy of HDFS File read, Anatomy of HDFS File write, Coherency model, Parallel copying with distcp. Hadoop archives, Limitations. YARN, Managing Resources and Applications with Hadoop YARN, Interacting with Hadoop Eco-system. **Map-Reduce Programming:** Mapper, Reducer, Combiner, Partitioner, Searching, Sorting, Compression. Word Count Example. **HIVE:** Hive architecture, Running Hive, Configuring Hive, Hive Services, Hive data type, File format, Hive Query Language, RCFile implementation, SerDe, UDF.	**10 Hrs**

UNIT -4	
Data Analysis using R Programming: Introduction to applied statistical techniques, Types of statistical data, Types of Big Data analytics, Collecting data for sampling and distribution, Probability, Frequency distribution, Population and parameters, Central tendency or Central Value, Measure of central tendency, Different types of statistical means, **Problems of Estimation:** Population or Sample, Normal distribution curve. **Working with R:** Variables, Vectors and assignments, SQL, Box-Plots, Histograms, Multivariate Graphical Methods, Quartile, Variance, Co-Variance, Co-relation coefficient, Skewness, kurtosis, Probability distribution, Binomial distribution & Normal distribution	**11 Hrs**

TEXTBOOKS	
1	V. K. Jain, "Data Science and Analytics", Edition 1, Khanna Book Publishing Co. (P) Lts
2	Seema Acharya, Subhashini Chellappan, "Big Data Analytics", Second Edition 2019, WILEY Publication
3	Tom White, "Hadoop: The Definitive Guide", First Edition, O'REILLY Publication
4	Jure Leskovec, Anand Rajaraman, Jeffrey David Ullman, "Mining of Massive Datasets", 3rd edition, Cambridge University Press.
REFERENCES	
1	Bill Granks, John Wiley & sons, "Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams With Advanced Analytics", 2007, WILEY Publication

(Minimum 08 Experiments to be performed from the following list)

Sr. No	EXPERIMENT
1	Installation, configuration and running of Hadoop and HDFS
2	Implementation of Word Count Program using Map-Reduce
3	Implementation of Calculator application using R

4	Implementation of Descriptive statistics in R
5	Implementation of Reading and writing different types of datasets
6	Implementation of Visualization in R
7	Implementation and use of data frames in R
8	Performing data Manipulation with dplyr package
9	Performing data Manipulation with data.table package
10	Implementation of MR program that processes a weather dataset
11	Implementation of application that stores big data in Hbase/MongoDB/Pig using R

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NEURAL NETWORKS & DEEP LEARNING						
Semester	**VII**	**Course Code**		**CEAM-04**	**Credits**	**4**
Scheme of Instruction Hours/ Week		**L**	**T**	**P**	**TOTAL**	
		3	**0**	**2**	**42Hrs/Sem**	
Scheme of Examination TOTAL = 150 marks		**TH**	**IA**	**TW**	**P**	**O**
		100	**25**	**0**	**0**	**25**

Prerequisites:

- Students should possess knowledge of basic linear algebra
- Knowledge of programming languages is a must.

Course Objectives:

The subject aims to introduce and equip students with knowledge on:

1	Understanding of concepts of neural network, design of logic functions and implementation of various learning rules using neural network.
2	Knowledge about multilayer neural network, unsupervised learning algorithms and associative memories.
3	An understanding of Deep Neural Networks such as Auto encoders, recurrent neural networks and convolutional neural networks.
4	Knowledge about Deep Neural Networks such as Recurrent and Recursive neural networks.

Course Outcomes:

At the end of course, student will be able to:

CO1	Describe concepts of neural network, design neural network to implement logic functions and solve problems related to various learning rules.
CO2	Explain working of multilayer neural network, its design considerations, implement clustering algorithms and associative memory networks for various applications.
CO3	Implement Deep Neural Network algorithms such as Auto encoders and Convolutional neural networks.
CO4	Design and implement Deep Neural Networks such as Recurrent and Recursive neural networks.

UNIT 1	
Introduction: Introduction to neural networks, structure of biological neuron, Mc-Culloch Pitts neuron model, Logic network realization by using Mc-Culloch Pitts neuron model, Neuron modelling for artificial neuron systems, Neural learning. **Single layer network:** Concept of linear seperability and non-linear separability. Training rules- Hebbian learning rule, perceptron learning rule, Delta learning rule, Widrow-Hoff learning rule and related problems. **Multilayer network :** Error back propagation algorithm or generalized delta rule.	**12Hrs**
UNIT 2	
Multilayer network Setting of parameter values and design considerations (Initialization of weights, Frequency of weight updates, Choice of learning rate, Momentum, Generalizability, Network size, Sample size, Non-numeric inputs), performance evaluation. **Unsupervised learning**: Clustering, simple competitive learning algorithm, LVQ algorithm, , SOM, Adaptive Resonance Theory. **Associative memories:** Hopfield networks, Brain-state-in-a-box network, and problems.	**10 Hrs**
UNIT 3	
Deep Neural Networks: Introduction & Necessity of deep neural networks (DNN), Auto encoder and its types. **Convolutional Networks:** The Convolution Operation - Variants of the Basic Convolution Function, Structured Outputs, Data Types, Efficient Convolution Algorithms, Random or Unsupervised Features - LeNet, AlexNet.	**10 Hrs**
UNIT 4	
Recurrent Neural Networks: Recurrent Neural Networks: Bidirectional RNNs - Deep Recurrent Networks **Recursive Neural Networks:** The Long Short-Term Memory and Other Gated RNNs. **Deep Generative Models:** Deep Belief networks, Boltzmann Machines, Deep Boltzmann Machine, Generative Adversial Networks.	**10 Hrs**

TEXTBOOKS	
1	Kishan Mehrotra, Chilukuri Mohan, Sanjay Ranka, Elements of artificial neural network, Edition-Second, Penram Publications.
2	J. Zurada; Introduction to Artificial neural network, Edition-Second, Jaico Publications
3	Ian Goodfellow, Yoshua Bengio, Aaron Courville; Deep Learning, Edition-Second, MIT Press
REFERENCES	
1	Satish Kumar, Neural networks: a classroom approach, Edition-Second,Tata McGraw-Hill
2	B. Yegnanarayana, Artificial Neural Netwoeks, Edition-Second, Prentice Hall
3	S. Haykin, Neural Network and Learning Machines,Edition-Second, Prentice Hall

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(Minimum 08 Experiments to be performed from the following list)

Sr. No	Experiment
1	Study of different libraries for ANN and DNN
2	Design of logic gates using neural network
3	Implementation of Perceptron learning rule
4	Implementation of Delta learning rule
5	Implementation of classifier using EBPA
6	Implementation of clustering using SCL
7	Design of associative memory using Hopfield network
8	Implementation of Autoencoders-1
9	Implementation of Autoencoders-2
10	Implementation of Convolutional Neural Networks
11	Implementation of Recurrent Neural Networks
12	Implementation of Recursive Neural Network

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CEAM-05 ELECTIVE - HONOURS/MINOR *						
APPLICATIONS OF ARTIFICAL INTELLIGENCE						
Semester	**VIII**	**Course Code**		**CEAM-051**	**Credits**	**4**
Scheme of Instruction Hours/ Week		**L**	**T**	**P**	**TOTAL**	
		4	**0**	**0**	**56Hrs/Sem**	
Scheme of Examination TOTAL = 150 marks		**TH**	**IA**	**TW**	**P**	**O**
		100	**25**	**# 25**	**0**	**0**

* More Course titles for Elective-Honours/Minor can be included based on Industry requirements.

 # Term Work (**TW**) marks are to be awarded through continuous evaluation. One or more evaluation technique/techniques such as assignments, case studies, Seminars can be included to award term work marks.

Prerequisite:

- Linear algebra, Linear calculus, Probability, Statistics, Data Structures, Image Processing, Artificial Intelligence and Neural Networks.

Course Objectives:

The subject aims to introduce and equip students with knowledge on:

1	The course introduces the fundamental concepts and techniques of natural language processing (NLP).
2	The course aims to provide students with knowledge about applications of AI in recognition, feature tracking and motion estimation.

Course Outcomes:

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

CO1	Justify the need of Natural Language Processing & various approaches to text pre-processing.
CO2	Identify the approaches to syntax and semantics in NLP.
CO3	Understand the recognition, feature tracking and motion estimation.
CO4	Compare various motion estimation techniques.

UNIT -1	
Introduction to Natural Language Understanding The Study of Language, Applications of Natural Language understanding, Evaluating Language Understanding Systems, The Different Levels of Language Analysis, Representations and Understanding, The Organization of Natural Language Understanding Systems. **Linguistic Background & Grammars and Parsing** An Outline of English Syntax Words- The Elements of Simple Noun Phrases, Verb Phrases and Simple Sentences, Noun Phrases Revisited, Adjective Phrases, Adverbial Phrases, Grammars and Sentence Structure, What Makes a Good Grammar, A Top-Down Parser, A Bottom-Up Chart Parser, Top-Down Chart Parsing, Finite State Models and Morphological Processing, Grammars and Logic Programming. **Features and Augmented Grammars** Feature Systems and Augmented Grammars, Some Basic Feature Systems for English, Morphological Analysis and the Lexicon, A Simple Grammar Using Features, Parsing with Features, Augmented Transition Networks, Definite Clause Grammars, Generalized Feature Systems and Unification Grammars.	**14 Hrs**
UNIT -2	
Semantic Interpretation and Ambiguity Resolution Semantics and Logical Form, Word Senses and Ambiguity, The Basic Logical Form Language, Encoding Ambiguity in Logical Form, Verbs and States in Logical Form. **Linking Syntax and Semantics** Semantic Interpretation and Compositionality, A Simple Grammar and Lexicon with Semantic Interpretation, Prepositional Phrases and Verb Phrases, Lexicalized Semantic Interpretation and Semantic roles, Handling Simple Questions, Semantic Interpretation Using Feature Unification. **News Headline Summarization** Approach, Environment setup, Understanding the data, Text Preprocessing, Model building, T5 Pretrained Model, Evaluation Metrics for Summarization. **Text Generation: Next Word Prediction** Problem statement, Approach: Understanding Language Modelling, Implementation: Model 1, Model 2, Model 3, GPT-2 (Advanced Pretrained Model)	**14 Hrs**
UNIT -3	

Recognition Instance Recognition, Image Classification, Object Detection, Semantic Segmentation, Video Understanding. **Feature Detection and Matching** Points and Patches: Feature Tracking, Application, Edges and Contours, Contour Tracking, Lines and Vanishing points.	**14 Hrs**
UNIT-4	
Motion Estimation Translational Alignment, Parametric Motion, Optical Flow, Layered Motion. **Structure from Motion and SLAM** Geometric Intrinsic Calibration, Pose Estimation, Two-Frame Structure from Motion, Multi-Frame Structure from Motion.	**14 Hrs**

TEXTBOOKS

1	James Allen, Natural Language Understanding, 2nd Edition, Pearson.
2	Akshay Kulkarni, Adarsha Shivananda, Anoosh Kulkarni, Natural Language Processing Projects Build Next-Generation NLP Applications Using AI Techniques 1st ed. Edition,, Apress.
3	Richard Szeliski, Computer Vision: Algorithms and Applications, 2nd Edition, Springer.

REFERENCES

1	Steven Bird, Ewan Klein, Edward Lopper, Natural Language Processing with Python,1st Edition,O'reilly.
2	Daniel Jurafsky and James H. Martin,Speech and Language Processing, 2nd Edition, Pearson Education.
3	Robert B. Fisher et al, Dictionary of Computer Vision and Image Processing, 2nd Edition, John Wiley and Sons Ltd.
4	Richard Hartley and Andrew Zisserman, Multiple View Geometry in Computer Vision, Cambridge University Press.

Engineering Branch: Electrical & Electronics Engineering

Minor/ Honours (Specialization) Subject: Electric Vehicle

Scheme of Instruction

Course Code	Semester	Name of the Course	Hrs/Week			Scheme of Examination					Credit
			L	T	P	Th Duration (Hrs)	Marks				
							Th	S	Oral	Total	
EEM401	**IV**	Introduction To Electric Vehicle	4	0	0	3	100	25	25	**150**	**4**
EEM501	**V**	Battery Management system	4	0	0	3	100	25	25	**150**	**4**
EEM601	**VI**	Electrical Vehicle Drives & Control	3	0	2	3	100	25	25	**150**	**4**
EEM701	**VII**	Mechanical & Thermal Design of Battery Pack In Electric Vehicle.	3	0	2	3	100	25	25	**150**	**4**
EEM801	**VIII**	Economic Aspect and Electric Vehicle Integration To Smart Grid	4	0	0	3	100	25	25	**150**	**4**
		TOTAL	**18**	**0**	**4**	**--**	**500**	**125**	**125**	**750**	**20**

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INTRODUCTION TO ELECTRIC VEHICLE					
Course Code	**EEM401**		**Credit**	**4**	
Scheme of Instruction Hours/Week	**L**	**T**	**P**	**TOTAL**	
	4	**0**	**0**	**56 hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**Oral**	**Total**
	25	**0**	**100**	**25**	**150**

Course Objectives:

The objective of this course is that on its completion, the students will be able to

1) Course will be useful for students to get insight in to the basics of Electric Vehicles.

2) Assess and explain different aspects of Electric vehicles.

3) Do assessment of the various electric drive trains and storage systems

Course Outcomes:

The student will be able to:

CO1	Understand the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals.
CO2	Demonstrate the different configurations of electric vehicles.
CO3	Analyse the vehicle dynamics and battery technology used for electric vehicles.
CO4	Summarize the various electric drives suitable for electric vehicles.

UNIT-1	
Electro-mobility and environment : History of electric power vehicle, energy sources for propulsion and emissions, carbon emissions for conventional and electric power train, Social and environmental importance of electric vehicles, Impact of electric vehicles on power system, Overview and comparison of Conventional IC engine vehicle, battery electric vehicle, Hybrid electric vehicle and Fuel cell electric vehicle. Types of Hybrid electric vehicle systems.	**14hrs**
UNIT-2	
Vehicle dynamics: vehicle load forces, basic power, energy and speed relationships, aerodynamic drag, rolling resistance, vehicle range at constant speed, vehicle acceleration, regenerative braking, drive cycle.	**14hrs**

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UNIT-3	
Batteries : Introduction to batteries, battery types and battery packs, Lead acid battery, Nickel metal hydride battery, Lithium ion battery, units of battery energy storage, capacity rate, battery parameters and comparison, cell voltage, specific energy, cycle life specific power, self discharge, Lifetime and sizing considerations, battery charging.	**14hrs**
UNIT-4	
Introduction to traction machines : Propulsion machine overview, DC machines, AC machines, Comparison of traction machines, machine specifications, four quadrant operation, rated parameters, rated torque, rated and base speeds, rated power, peak operation, starting torque, characteristic curves of a machine, constant-torque mode, constant-power mode.	**14hrs**

TEXT BOOKS	
1.	Iqbal Hussein,"Electric and Hybrid Vehicles: Design Fundamentals", CRC press
2.	James Larminie, John Lowry, "Electric Vehicle Technology Explained", Wiley Press
3.	John G Hayes, G Abas Goodarzi, "Electric Power train", Wiley International Press
REFERENCE BOOKS	
1.	Lino Guzella, Antonio Sciarretta, "Vehicle Propulsion Systems :- Introduction to Modelling and Optimization", Wiley press
2.	Mehrdad Ehsani,Yimi Gao, Sebastian E.Gay, Ali Emadi, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design", CRC press

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Battery Management System					
Course Code	EEM501		Credits	4	
Scheme of Instruction Hours/ Week	L	T	P	TOTAL	
	4	0	0	56 hrs/sem	
Scheme of Examination	IA	TW	TM	Oral	Total
	25	0	100	25	150

Course Objectives:

The objective of this course is to introduce learner

1) To batteries, its parameters, modelling and charging requirements.
2) The Course will help learner to develop battery management systems for EV.

Course Outcomes:

The student will be able to:

CO1	Understand the role of battery management system
CO2	Identify the requirements of Battery Management System
CO3	Analyze battery charging / discharging process
CO4	Design of parameters of battery and battery pack and develop the model of battery pack

UNIT-1	
Introduction: Introduction to Battery Management System, Cells & Batteries, Nominal voltage and capacity, C rate, Energy and power, Cells connected in series, Cells connected in parallel, Electrochemical and lithium-ion cells, Rechargeable cell, Charging and Discharging Process, Overcharge and Undercharge, Modes of Charging.	**14 hrs**
UNIT-2	
Battery Management System Requirement: Introduction and BMS functionality, Battery pack topology, BMS Functionality, Voltage Sensing, Temperature Sensing, Current Sensing, High-voltage contactor control, Isolation sensing, Thermal control, Protection, Communication Interface, Range estimation, State-ofcharge estimation, Cell total energy and cell total power,	**12hrs**
UNIT-3	
Battery State of Charge and State of Health Estimation, Cell Balancing: Battery state of charge estimation (SOC), voltage-based methods to estimate SOC, Model-based state estimation, Battery Health Estimation, Lithium-ion aging, Negative electrode, Positive electrode, Cell Balancing, Causes of imbalance, Circuits for balancing	**16 hrs**

UNIT-4	
Modelling and Simulation: Equivalent-circuit models (ECMs), Physics-based models (PBMs), Empirical modelling approach, Simulating battery packs. **Design of BMS:** Design principles of BMS, Effect of distance, load, and force on battery life in BMS, energy balancing with multi-battery system.	**14 hrs**

TEXT BOOKS	
1	Bergveld, H.J., Kruijt, W.S., Notten, P.H.L "Battery Management Systems -Design by Modelling" Philips Research Book Series 2002
2	Davide Andrea," Battery Management Systems for Large Lithium-ion Battery Packs" Artech House, 2010
REFERENCE BOOKS	
1	Plett, Gregory L. Battery management systems, Volume I& II: Battery modeling. Artech House, 2015
2	Pop, Valer, et al. Battery management systems: Accurate state-of-charge indication for battery-powered applications. Vol. 9. Springer Science & Business Media, 2008

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Electrical Vehicle Drives and Control					
Course Code	**EEM601**		**Credits**	**4**	
Scheme of Instruction Hours/Week	**L**	**T**	**P**	**TOTAL**	
	3	**0**	**2**	**42 hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**Oral**	**Total**
	25	**0**	**100**	**25**	**150**

Course Objectives:

The objective of this course is that on its completion, the students will be

1) Able to assess and explain Various aspects of traction motors and their controllers suitable for electric vehicles.

2) Able to do assessment of the various electric drive trains and control systems that can be used in Electric vehicles.

3) To get insight in to the fundamentals of deciding about the selection and suitability of particular motor and controller for the EV.

Course Outcomes:

The student will be able to:

CO1	To understand about technical aspects of different motors and controller.
CO2	To learn motor drive assembly and components of controller.
CO3	To analyze the Electric Propulsion System characteristics
CO4	To perform a case study analysis of application of motors and control systems for in EV.

UNIT-1	
Electric Machines in HEVs: Types of Motors, Selection and sizing of Motor, RPM and Torque calculation of different motors, torque speed characteristics. Fundaments of BLDC motor drive, Induction Motor Drives, Permanent Magnet DC Motor Drives, Switched Reluctance Motors, Permanent Magnet Synchronous motor drive, Design and Sizing of Traction Motors.	**10 hrs**

UNIT 2	
Electric Vehicle Drives Configurations of Electric Vehicles, Performance of Electric Vehicles, Traction Motor Characteristics, Tractive Effort and Transmission Requirement, Vehicle Performance, Tractive Effort in Normal Driving, Energy Consumption. **Concept of Hybrid Electric Drive Trains** Concept of Hybrid Electric Drive Trains, Architectures of Hybrid Electric Drive Trains, Series Hybrid Electric Drive Trains, Parallel Hybrid Electric Drive Trains, Torque-Coupling and Speed-Coupling Parallel Hybrid Electric Drive Train.	**10hrs**
UNIT-3	
Control aspects of DC Electric Drive DC Motor Drive, Principle of Operation and Performance, Combined Armature Voltage and Field Control, Chopper Control of DC Motors, Multi quadrant Control of Chopper-Fed DC Motor Drives, Single phase and three phases fully controlled and half controlled DC drives. Basic Principles of control aspects BLDC Motor Drives, PMSM drives and of SRM (synchronous reluctance motor) based drive	**10 hrs**
UNIT -4	
Control aspects of AC Electric Drive Induction Motor Drives, Basic Operation, Steady-State Performance, Stator voltage variation by three phase controllers, Speed control using chopper, resistance in the rotor circuit, slip power recovery scheme. Pulse width modulated inverter fed and current source inverter fed induction motor drive. Volts/Hertz Control.	**12 hrs**

TEXT BOOKS	
1.	IqbalHussein, "Electric and Hybrid Vehicles: Design Fundamentals", CRC press
2.	M. Ehsani, 'Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design", CRC Press,2005
3.	G. Lechner and H. Naunheimer, "Automotive Transmissions: Fundamentals, Selection, Design and Application", G. Lechner and H. Naunheimer, Springer, 1999, Third edition
4.	C. C. Chan and K.T. Chau, "Modern Electric VehicleTechnology", Oxford SciencePublication,2001, Volume II
REFERENCE BOOKS	
1.	C.G. Hochgraf, M.J. Ryan, and H.L. Wiegman, "Engine control strategy for a series hybrid electric vehicle incorporating load leveling and computer controlled energy management", Warrendale, PA, 2002, 2nd ed. Edition
2.	Seth Leitman Bob Brant, "Build your own electric vehicle", Mc Graw hill Second edition

List of Experiments

1. To analyse and determine the selection and sizing of motors for Electric Vehicles.
2. To determine the performance characteristics of dc motors.
3. To perform speed control of a separately excited dc motor using a chopper.
4. To perform speed control of the dc motor using closed loop and open loop control.
5. To perform speed control of a single-phase induction motor using different methods.
6. To perform the speed control of a slip ring Induction motor using different methods.
7. To determine the performance characteristics of a 3 phase squirrel cage induction motor.
8. To understand the principles of control aspects and determine the performance characteristics of BLDC motor drives / simulation.
9. To understand the principles of control aspects and determine the performance characteristics of Switched Reluctance motor drives / simulation.
10. To understand the operation of permanent magnet Synchronous motor drive / simulation.
11. To study the modelling of an Electric Vehicle using MATLAB and Simulink.
12. To construct a series hybrid electric vehicle using the Simulink Model.

Mechanical and Thermal Design of Battery Pack in Electric Vehicle.					
Course Code	**EEM701**		**Credits**	**4**	
Scheme of Instruction Hours/Week	**L**	**T**	**P**	**TOTAL**	
	3	**0**	**2**	**42hrs/sem**	
Scheme of Examination	**IA**	**T W**	**TH**	**Oral**	**Total**
	25	**0**	**100**	**25**	**150**

Course Objectives:

The objective of this course is that on its completion, the students will be able

1) To assess and explain different aspects of design of Battery pack in Electric vehicles.

2) To do assessment of the various mechanical design aspects and thermal design aspects of Batteries in Electric vehicles.

3) To get insight in to the design of Battery pack in Electric Vehicles.

Course Outcomes:

The student will be able to:

CO1	Understand the electrical, mechanical and thermal design specifications of batteries in EV
CO2	Demonstrate the concept of the electrical, mechanical and thermal design of batteries in EV
CO3	Analyse the electrical, mechanical and thermal design of batteries in EV
CO4	Perform the electrical, mechanical and thermal design of batteries in EV

UNIT-1	
Fundamentals of battery pack deign: Battery pack development process, Stages of Battery pack development, Major components of battery pack **Electrical Design**: design considerations, conductor material selection, Design criteria, busbar sizing, Short circuit, mechanical considerations, conductor insulation, Contact resistance, Voltage drop and its significance, Current Equalization in parallel path, Testing and standards	**10hrs**
UNIT-2	
Mechanical Design of Battery pack: Building battery pack, Forces acting on battery pack, Stress-Strain Theory. Base Plate dimension calculations, Material Selection Criteria, Ashby Methodology, Battery Swelling. End Plate Support, Thermal Runaway, Test standards. Simulating Vibration tests, Vibration Analysis.	**10hrs**
UNIT3	
Thermal Design of Battery pack-I: Required functions of Thermal Design, Battery Pack Temperature Considerations, Heat Generation in battery pack, Heat Load Determination, Energy Flow in first principles. Modes of battery thermal management, Active thermal management, Forced Air Convection, Liquid cooling of battery pack, Immersion Cooling, Peltier cooling,	**12hrs**

UNIT-4	
Thermal Design of battery pack-II: Heat Sink Natural Convection, Heat Pipe Cooling, Thermal Interface Material, Phase Change Material, Selection of Thermal management method, Materials and Design, Matreials for Battery Pack, Thermal Insulations, Monitoring thermals of battery pack, Temperature sensors types.	**10hrs**

TEXT BOOKS	
1.	Iqbal Hussein, "Electric and Hybrid Vehicles: Design Fundamentals", CRC press
2.	James Larminie, John Lowry, "Electric Vehicle Technology Explained", Wiley press
3.	John G Hayes, G Abas Goodarzi, "Electric Power train", Wiley Press
REFERENCE BOOKS	
1.	Lino Guzella, Antonio Sciarretta, "Vehicle Propulsion Systems :- Introduction to Modelling and Optimization", Wiley press
2.	Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design", CRC press

List of Experiments

1. To Determine voltage current Characteristics for Series, Parallel, & Series-Parallel connection of Batteries.
2. To Determine the C-rating, Ampere Hour Capacity, Specific Gravity, SOC, DOD of Battery.
3. To study & analyze the characteristics of various types of batteries for Hybrid electric vehicle
4. Design of end plate and side plates of a battery pack
5. Design of providing isolation against vibration for a battery pack.
6. Simulations of various vibration tests
7. Modal Analysis of a battery pack
8. Case study of Directional Thermal Properties
9. Study for Simulation of Cells
10. Case study of Bus bar ohmic Heat generation Simulation
11. Case Study of MOSFET Thermal Management in BMS, Module thermal management
12. Design of bus bars for Battery pack
13. Study of Bus bar welding methods and protection used in Batteries.

Economic Aspects and Electric Vehicle Integration to Smart Grid					
Course Code	**EEM801**		**Credits**	**4**	
Scheme of Instruction Hours/Week	**L**	**T**	**P**	**TOTAL**	
	4	**0**	**0**	**56 hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TH**	**Oral**	**Total**
	25	**0**	**100**	**25**	**150**

Course Objectives:

The objective of this course is that on its completion, the students will be able

1) To assess and explain various economic and integration aspects of Electric vehicles with grid.

2) To do assessment of the selection of charging that can be used in Electric vehicles. Course will be useful for students

3) To get insight in to the fundamentals of deciding about the selection and suitability of V_2G, G_2V and V_2V modes.

Course Outcomes:

The student will be able to:

CO1	To understand the economic aspects of EV and integration of EV to power network
CO2	To demonstrate/illustrate the economic aspects of EV and integration of EV to power network
CO3	To analyze the economic aspects of EV and integration of EV to power network
CO4	To perform various case studies on the economic aspects of EV and integration of EV to power network

UNIT-1	
Economics of Electric Vehicle: Upfront Cost, Operating cost, Maintenance cost of Electric Vehicle. Grid supply side incentives, electric vehicle purchased incentives, Impact of electricity prices on charging and discharging pattern, charging infrastructure incentives, economic efficiency, Life cycle costing of electric vehicle, Annualized life cycle costing, Computation of electricity cost of charging of hybrid electric vehicle	**14hrs**
UNIT-2	
Charging Infrastructures and Protocols Introduction to EV chargers, slow and fast chargers, Battery swapping, standardization and onboard chargers, Bulk chargers, swap stations, Location of Chargers, AC Chargers, Fast DC Chargers,Communication with batteries, Communication with Server, Charging Status, Data Capturing Monitoring EV Subsystems, Life Cycle Predictions.Distributed Architecture, Standalone Model, Centralized Architecture, Hub and Spoke Model, International Swap Standards,	**14hrs**

Comparisons between Swap standards, LS - VBCC Protocol, India Open Standard, Tools used for Analytics.	
UNIT-3	
Grid Integration of Electric vehicle Concept of Grid to vehicle, vehicle to grid and vehicle to vehicle, Benefits of G2V, V2G,and V2V to vehicle owners and utilities, Infrastructure needed for grid integration of vehicle, vehicle to grid power flow regulation codes, potential hurdles of EV integration, case studies.	**14 hrs**
UNIT -4	
Effect of Electric vehicle on Power system network Impact of Electric vehicle integration on Power system network. Impact on Grid voltage level, power demand and active power loss, power quality. Planning of power system for grid integrated Electric vehicles. Practical problems to the utility relevant to largescale Electric vehicle integration	**14hrs**

TEXT BOOKS	
1.	Andrés Ovalle, Ahmad Hably, Seddik Bacha, Grid Optimal Integration of Electric Vehicles: Examples with Matlab Implementation, Springer 1st edition .
2	Qiuwei Wu, Grid Integration of Electric Vehicles in Open Electricity Markets , Wiley; 1st edition
REFERENCE BOOKS	
1.	Junwei Lu , Jahangir Hossain, Vehicle-to-Grid: Linking electric vehicles to the smart grid, IET publication.
2	Nand Kishor, Jesus Fraile Ardunay, ICT for Electric Vehicle Integration with the Smart Grid , IET, UK Publication.

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Engineering Branch: Electronics and Telecommunication Engineering/ Electronics and Communication Engineering

Minor/ Honours (Specialization) Subject: Internet of Things

Scheme of Instruction and Examination

Course Code	Semester	Nomenclature of the Course	Scheme of Instruction Hrs/Week			Scheme of Examination						
			L	T	P	Duration (Hrs)	Marks					Credits
							Th	IA	TW*	P	Total	
IOT-01	IV	Introduction To Internet Of Things	4	0	0	3	100	25	25	--	150	4
IOT-02	V	Introduction to Security of Cyber-Physical Systems	3	0	2	3	100	25	--	25	150	4
IOT-03	VI	Ubiquitous Sensing, Computing And Communication	3	0	2	3	100	25	--	25	150	4
IOT-04	VII	Embedded Systems For IoT	4	0	0	3	100	25	25	--	150	4
IOT-05	VIII	IOT with Arduino, ESP and Raspberry Pi	3	0	2	3	100	25	--	25	150	4
		TOTAL	17	0	6		500	125	50	75	750	20

L-Lecture T-Tutorial P-Practical Th-Theory TW-Term Work IA-Internal Assessment

*Term work marks to be awarded through continuous evaluation (Assignments/Mini Project etc)

INTRODUCTION TO INTERNET OF THINGS					
Course Code	**IoT-01**		**Credits**	**4**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**4**	**0**	**0**	**56 hrs/sem**	
Scheme of Examination	**IA**	**TW**	**TM**	**P**	**O**
TOTAL = 150 marks	**25**	**25**	**100**	**0**	**0**

Course Objective:

The objectives of this course for a learner are:

1. To understand the basic components of an IoT system.
2. To understand the technologies and current standards relating to each of the IOT layers.
3. To understand the importance of interoperability in IoT, and the concepts of Cloud computing and Fog computing via examples.
4. To appreciate and understand the appropriate use of various IoT technologies through real-life case studies and examples.

Course Outcomes:

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

CO1	Explain the basic components of an IOT system.
CO2	Demonstrate familiarity with communication protocols, technology and standards relating to each layer in IoT systems.
CO3	Explain the concepts of Cloud Computing and Fog Computing and their relevance to IoT.
CO4	Demonstrate an understanding of tools and IoT technologies that would be suited for building and deploying IoT-based solutions in various application domains through examples and case studies.

UNIT 1	**(14 hrs)**
Emergence of IoT : Introduction, Evolution of IoT, Enabling IoT and the Complex Interdependence of Technologies, IoT Networking Components. **IoT Sensing and Actuation** : Sensors, Sensing Types, Actuators, Actuator Types, Actuator Characteristics.	
UNIT 2	**(14 hrs)**

IOT Processing Topologies and Types: Data Format, Importance of Processing in IoT, Processing Topologies, Processing Offloading.
IOT Connectivity Technologies: Introduction to connectivity technologies and standards, IEEE 802.15.4, Zigbee, RFID, NFC, LORA, Wi-Fi, Bluetooth.
IoT Communication Technologies: Introduction to communication technologies, Infrastructure Protocols and Discovery Protocols, Introduction to Data Protocols - MQTT, CoAP, REST and Web Sockets.

UNIT 3	**(14 hrs)**

IOT Interoperability: Introduction, Standards, Frameworks.
Cloud Computing: Introduction, Virtualisation, Cloud Models, Cloud Implementation, Senor-cloud: Sensors-as-a-service.
Fog Computing and its application: Introduction, View of a fog computing architecture, Fog Computing in IOT, Selected applications of FOG Computing.

UNIT 4	**(14 hrs)**

IOT Case studies and future trends:
Agricultural IoT- Components of an agricultural IoT, Advantages of IoT in agriculture, Case Studies - In-situ assessment of leaf area index using IoT-based agricultural system Smart irrigation management system.
Vehicular IoT- Introduction, Components of vehicular IoT, Advantages of vehicular IoT, Crime assistance in a smart IoT transportation system.
Healthcare IoT- Introduction, Components of healthcare IoT, Advantages and risks of healthcare IoT.
Case Studies - AmbuSens system.
Evolution of New IoT Paradigms, Challenges Associated with IoT, Emerging Pillars of IoT.

TEXTBOOKS

1	**Sudip Misra, Anandarup Mukherjee, Arijit Roy, Introduction to IoT, Cambridge University Press, 2020**

REFERENCES

1	Nitesh Dhanjani, Abusing the Internet of Things, Shroff Publisher/O'Reilly Publisher, 2015.
2	RMD Sundaram, Shriram K. Vasudevan, Abhishek S. Nagarajan, Internet of Things, John Wiley and Sons, 2019
3	Cuno Pfister, Getting Started with the Internet of Things, Shroff Publisher, 2011
4	Francis daCosta, Rethinking the Internet of Things: A Scalable Approach to Connecting Everything, Apress Publications, 1st Edition, 2014.
5	Massimo Banzi, Michael Shiloh, Getting Started with the Arduino, Maker Media Publishers/ O'Reilly, 3rd edition, 2015.
6	https://onlinecourses.nptel.ac.in/noc22_cs96/preview
7	https://www.coursera.org/specializations/internet-of-things

INTRODUCTION TO SECURITY OF CYBER-PHYSICAL SYSTEMS					
Course Code	**IoT-02**		**Credits**	**4**	
Scheme of Instruction Hours/ Week	**L**	**T**	**P**	**TOTAL**	
	3	**0**	**2**	**42 hrs/sem**	
Scheme of Examination TOTAL = 150 marks	**IA**	**TW**	**TM**	**P**	**O**
	25	**0**	**100**	**25**	**0**

Course Objective:

The course aims to provide the student with:

1. An understanding of the basics of Cyber-Physical Systems and how they differ from conventional computer networks
2. An understanding of the main aspects of network security, namely Security, Confidentiality and Authenticity
3. Knowledge of various types of security issues and their mitigation strategies in Cyber-Physical Systems.
4. Knowledge of different cryptography techniques available and various security attacks.
5. An ability to explore security and privacy in Internet of Things
6. An insight of Software Defined Networks and security of SDN.

Course Outcomes:

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

CO1	Explain the basics of Cyber-Physical System and various types of security issues in CPS.
CO2	Apply various cryptography techniques available for network security
CO3	Analyze security and privacy in Internet of Things
CO4	Explain Software Defined Networks and security of SDN

UNIT -1	
Introduction: Cyber-Physical System, Key Features of CPS, Application Domains of CPS, CPS Platform components: CPS HW platforms, Processors, Sensors and Actuators, CPS Network - Wireless, CAN, Automotive Ethernet. Security of Cyber-Physical Systems: Introduction to CPS Securities, Basic Techniques in CPS Securities, Cyber Security Requirements, Attack Model and Countermeasures, Advanced Techniques in CPS Securities.	10 hrs
UNIT -2	
Applied Cryptography & Intrusion Detection, Architecture of Applied Cryptography, Block Ciphers, Stream Ciphers, Private Key and Public Key Cryptography, One Way Hash Function and Integrity, Encryption Algorithms and Confidentiality, Digital Signature and Authentication (DH, RSA, 2 class), Intrusion Detection.	11 hrs
UNIT -3	
Securing the Internet of Things: Security Requirements in IoT Architecture, IoT Data Security Challenges, Security Threats and Vulnerabilities at IoT End-Node, Authentication/Authorization for Smart Devices, Transport Encryption-TLS, SSL and HTTPS. Secure Cloud/Web Interface, Physical Layer Security.	11 hrs
UNIT -4	
Software-Defined Networks, Introduction of Software-Defined Networks, Security for Software-Defined Networks, Privacy Leakages for Software-Defined Networks.	10 hrs

TEXTBOOKS	
1	Li Da Xu, Shancang Li, Securing the Internet of Things, Syngress, 2017.
2	Mohammad Amjad, Cryptography and Network Security, John Wiley & Sons, 2015
3	B. Forouzan , Cryptography and Network Security, McGraw-Hill, 2007
4	Raj Rajkumar, Dionisio de Niz and Mark Klein, Cyber-Physical Systems, Addison-Wesley, 2016
5	Chuck Black and Paul Goransson, Software Defined Networks: A Comprehensive Approach, Morgan Kaufmann, 2014.

6	Thomas Nadeau and Ken Gray, SDN – Software Defined Networks, O'Reilly; 1st edition, 2013

REFERENCE BOOKS/RESEARCH PAPERS	
1	Atul Kahate, Cryptography & Network Security , McGraw Hill Education; 3rd edition,, 2017
2	Rajeev Alur, Principles of Cyber-Physical Systems, MIT Press, 2015.
3	D.R. Stinson, Cryptography - Theory and practice, CRC Press, 2005.
4	A.J. Menezes, P.C. van Oorschot and S.A. Vanstone, Applied Cryptography, CRC Press, 5th Print, 2001
5	Stallings, Cryptography and Network Security, Pearson Education, 2017
6	B Schneir, Applied Cryptography, Wiley, 1995
7	C. Kaufman, R. Perlman, Network Security, Prentice Hall, 2002
8	Nina Godbole, Cyber Security, John Wiley & Sons, 2011
9	Alasdair Gilchrist, IoT Security Issues, Walter de Gruyter GmbH & Co KG, 2017
10	Sean Smith, The Internet of Risky Things, Shroff Publisher/O'Reilly Publisher, 2017
11	Yaacoub, Jean-Paul A et al. "Cyber-physical systems security: Limitations, issues and future trends." Microprocessors and microsystems, vol. 77 (2020): 103201. doi: 10.1016/j.micpro.2020.103201

Online Resources:
https://www.coursera.org/lecture/iot-connectivity-security/introduction-to-cps-security-and-privacy-skRaa
https://nptel.ac.in/courses/106105162/

LIST OF LABORATORY EXPERIMENTS

Implementation of following mechanism in C/C++/Java/Python.

SN	Experiment
1	Write a program to implement Caesar Cipher.
2	Write a program to implement Monoalphabetic Cipher.
3	Write a program to implement Polyalphabetic Cipher.
4	Write a program to implement Hill Cipher.
5	Write a program to implement Rail Fence Technique.
6	Write a program to implement S-DES.
7	Write a program to implement DES.
8	Write a program to implement AES-128.
9	Write a program to implement Diffie Hellman Key exchange.
10	Socket Programming using Python

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UBIQUITOUS SENSING, COMPUTING AND COMMUNICATION					
Course Code	**IoT-03**		**Credits**	**4**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**3**	**0**	**2**	**42 hrs/Sem**	
Scheme of Examination	**IA**	**TW**	**TM**	**P**	**O**
TOTAL = 150 marks	**25**	**0**	**100**	**25**	**0**

Course Objectives:

1 An understanding of Ubiquitous Sensing System and its applications
2 An ability to select a particular sensor for the desired application.
3 An understanding of the architectural design for Ubiquitous Computing Systems.
4 An understanding of various Ubiquitous Communication networks.
5 An understanding of security related issues in Ubiquitous Communication networks.

Course Outcomes: After completion of the course, students will be able to:

CO1	Analyze a sensing system, conditioning circuits and list various applications of Ubiquitous sensing.
CO2	Justify the selection & estimation of an energy source and sensors for energy harvesting & Sensor integration respectively.
CO3	Discuss various Ubiquitous Computing techniques and its applications.
CO4	Describe the communication & security related issues in Ubiquitous networks.

UNIT 1	**(11 hrs)**
Introduction to Ubiquitous Sensing System: Overview, Sensing System, Conditioning System, Analog-to-digital Signal Conversion, Processor, Example: A Wireless Electrocardiogram. **Applications:** Civil Infrastructure Monitoring-Water Pipelines, Medical Diagnosis and Monitoring - Sleep Apnea and Medical Journaling, Water-quality Monitoring. **Conditioning Circuits:** Voltage and Current Sources, Transfer Function, Impedance Matching, Filters, Amplification, Closed-loop Amplifiers, Difference Amplifier.	

Concepts of Sensing (Introduction only): Electrical, Ultrasonic, Optical, Magnetic & Medical.	
UNIT 2	**(11 hrs)**
Energy Harvesting: Factors Affecting the Choice of an Energy Source, Architecture of an energy-harvesting system, Prototype - Microsolar Panel. **Sensor Selection and Integration:** Sensor Selection Parameters, Example: Temperature Sensor Selection, Sensor Integration Issues. **Estimation:** Sensor Error as a Random Variable, Zero-offset Error, Conversion Error, Accumulation of Error.	
UNIT 3	**(10 hrs)**
Ubiquitous Computing: Basics and Vision, Illustrative Ubiquitous Computing Applications, Modeling the Key Ubiquitous Computing Properties, Ubiquitous System Environment Interaction, Architectural Design for UbiCom Systems, Comparison of smart device, smart environment and smart interaction. **Ubiquitous Computing Applications in the Virtual, Human and Physical World:** Human–Computer Interaction, Human-to-Human Interaction, Human-Physical World-Computer Interaction.	
UNIT 4	**(10 hrs)**
Ubiquitous Communication: Introduction, Audio Networks, Data Networks, Wireless Data Networks, Universal and Transparent Audio, Video and Alphanumeric Data Network Access, Ubiquitous Networks. **Security:** Introduction, Security Protocols, Encryption, Security in Bluetooth, Authentication	

TEXTBOOKS	
1	Waltenegus Dargie, Principles and Applications of Ubiquitous Sensing, A John Wiley and Sons, Ltd, Publication, 1st Edition, 2017.
2	Stefan Poslad, Ubiquitous Computing: Smart Devices, Environments and Interactions, A John Wiley and Sons, Ltd Publication, 1st Edition, 2009.
3	A. Genco and S. Sorce, Pervasive Systems and Ubiquitous Computing, WIT Press, 1st Edition, 2010.

REFERENCES	
1	Athanasios Vasilakos, Witold Pedrycz, Ambient Intelligence, Wireless Networking, and Ubiquitous Computing, Artech House, 1st Edition, 2006.

2	John Krumm, Ubiquitous Computing Fundamentals, CRC Press, Taylor and Francis Group, LLC, 1st Edition, 2010.

List of Experiments:

(At least 10 experiments should be conducted from the following list of experiments.)

SN	Experiment
1	To implement Signal Conditioning for an Electrical sensor & test it.
2	To implement Signal Conditioning for an Ultrasonic sensor & test it.
3	To implement Signal Conditioning for a Magnetic sensor & test it.
4	To implement Signal Conditioning for a Medical sensor & test it.
5	To set up a smart environment for smart interaction using ubiquitous computing.
6	To analyze Inertial Sensor Noise using software like MATLAB/Octave/ Simulink.
7	To Setup a Wireless Network using a Wireless Access Point on Cisco packet tracer/ NS2.
8	To configure the Radius Server on Cisco Packet Tracer/ NS-2
9	To establish communication between two systems running on the same network.
10	To establish communication between two systems running on different networks.
11	To implement security features in layer two devices.
12	To analyze a given biomedical signal and measure its parameters.
13	To connect Arduino to Cayenne IOT Platform to monitor a particular task.
14	Case study on application of Ubiquitous Sensing, computing & communication System
15	To set up an access point for remote connections related to IoT.
16	To establish communication in a network using bluetooth.

EMBEDDED SYSTEMS FOR IOT					
Course Code	**IoT-04**		**Credits**	**4**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**4**	**0**	**0**	**56 hrs/Sem**	
Scheme of Examination	**IA**	**TW**	**TM**	**P**	**O**
TOTAL = 150 marks	**25**	**25**	**100**	**0**	**0**

Course Objectives:

1 An understanding of architecture of embedded systems
2 An understanding of different design platforms used for an embedded system for IoT applications
3 An understanding of web and cloud based IoT applications
4 Knowledge about the IoT enabled technology

Course Outcomes: After completion of the course, students will be able to

CO1	Understand the embedded system concepts and architecture of embedded systems.
CO2	Understand the different hardware/software co-design techniques for microcontroller-based embedded systems, apply techniques in IoT applications.
CO3	Appreciate the different design platforms used for an embedded system for IoT applications.
CO4	Understand web/cloud based IoT applications.

UNIT 1	**(14 hrs)**
Embedded IoT Platform Design Methodology: Purpose and requirement specification, Process specification, Domain Model Specification, Information Model Specification, Service Specification, IoT level specification, Functional view Specification, Operational view specification, Device and Component integration.	
UNIT 2	**(14 hrs)**

Design of Embedded Systems: Common Sensors, Actuators.

Inputs and Outputs: Digital Inputs and Outputs, Digital Inputs, Digital Outputs, BusIn, BusOut, and BusInOut, Analog Inputs and Outputs, Analog Inputs, Analog Outputs Pulse Width Modulation (PWM), Accelerometer and Magnetometer, SD Card, Local File System (LPC1768).

UNIT 3	**(14 hrs)**

IoT Enabling Technologies: Communications, RFID and NFC (Near-Field Communication), Bluetooth Low Energy (BLE), LiFi, 6LowPAN, ZigBee, Z-Wave, LoRa, Protocols, HTTP, WebSocket, MQTT, CoAP, XMPP, Node-RED, Platforms, IBM Watson IoT—Bluemix, Eclipse IoT, AWS IoT, Microsoft Azure IoT Suite, Google Cloud IoT, ThingWorx, GE Predix, Xively, macchina.io, Carriots.

UNIT 4	**(14 hrs)**

Four Pillars of IOT: M2M, RFID, WSN, SCADA

The DNA of IOT: Introduction to DCM: Device, Connect and Manage.

Platform Middleware for Web of Things, Web of Things versus Internet of Things, The Internet of things and Cloud Computing

TEXTBOOKS	
1	Arshdeep Bahga, Vijay Madisetti, Internet of Things- A Hands-on Approach Published by Universities Press 2015
2	Adrian McEwen and Hakim Cassimally, Designing the Internet of Things, Wiley, 2014
3	Perry Xiao, Designing Embedded Systems and the Internet of Things (IoT) with the ARM Mbed, Wiley, 2018
4	Honbo Zhou, The Internet of things in the cloud-A Middleware Perspective, CRC Press, Taylor & Francis, 2013

REFERENCES	
1	RMD Sundaram Shriram K Vasudevan, Abhishek S Nagarajan, Internet of Things, John Wiley and Sons, 2nd edition, 2019
2	Klaus Elk, Embedded Software for the IoT, DeG Press, 3rd edition, 2018
3	Online resource: Introduction to the Internet of Things and Embedded Systems, https://www.coursera.org/learn/iot

IOT with Arduino, ESP and Raspberry Pi					
Course Code	**IoT-05**		**Credits**	**4**	
Scheme of Instruction	**L**	**T**	**P**	**TOTAL**	
Hours/ Week	**3**	**0**	**2**	**42 hrs/Sem**	
Scheme of Examination	**IA**	**TW**	**TM**	**P**	**O**
TOTAL = 150 marks	**25**	**0**	**100**	**25**	**0**

Course Objectives:

1. Ability to understand Arduino Uno, NODE MCU 8266 and Raspberry PI architecture
2. Ability to interface Input Output devices to Arduino Uno, NODE MCU 8266 and Raspberry PI
3. An understanding of programming the Arduino Uno, NODE MCU 8266 and Raspberry PI
4. Ability to apply commonly used IOT protocols such as REST API, MQTT through IOT based demonstration

Course Outcomes:

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

CO1	Explain the concepts related to IoT, sensors, actuators, Rpi, arduino and ESP826612E
CO2	Explain the concept of interfacing of different input, output devices.
CO3	Develop a code to implement the IOT applications using arduino, ESP82612E, Rpi
CO4	Design web/cloud based IoT applications

UNIT -1	
Introduction to Internet of things: Characteristics of IoT, Design Principles of IoT, IoT Architecture and Protocols, Sensors: Characteristics, Sensing Types Scalar sensing, Multimedia sensing, Hybrid sensing, Virtual sensing, Sensing Considerations. Actuators: Definition, Actuator types, Hydraulic actuators Pneumatic actuators, Electric actuators, Thermal or magnetic actuators, Mechanical actuators, Soft actuators Actuator Characteristic. IoT Versus Related Technologies, IoT Devices, IoT boards. Introduction to Arduino Uno, ESP 8266-12E Node MCU, and Raspberry Pi 3, general pin description.	10hrs
UNIT -2	

Arduino Uno – getting started with the Uno boards--- Blink program, Connecting Uno board to the sensors (Analog and Digital) and reading values. Study of various types of interrupts on Arduino Uno board and programs to handle/implement the interrupts. Interfacing of Arduino Uno with DC motor, Stepper, and Servo Motor. Case Study: Interfacing of Temperature/Humidity sensor with uno, Sending Temperature/Humidity values to the Internet via GSM module. Features of ATmega series.	11hrs
UNIT -3	
ESP 8266-12E Node MCU – getting started with the ESP board, installing micropython on the ESP8266 board, connecting sensors to the ESP board, Connecting ESP board to WiFi, Interfacing ESP with the Cloud (REST API-GET, POST). interrupts, comparison of ESP 32 board with the ESP 8266 board. Case Study: Switching light on /off remotely using MQTT. Case Study: Voice-based Home Automation for switching lights on/off (Android phone – Google Assistant (Assistant <-> IFTTT).	11 hrs
UNIT -4	
Introduction to Raspberry Pi, Raspberry Pi component, terminal Commands, Setting up Headless Raspberry pi, Interfacing: Interfacing of Led with Raspberry Pi, Reading the digital input, Reading an edge triggered input, Interfacing of Relay with Raspberry Pi, Interfacing of DC motor with Raspberry Pi, Face recognition using Raspberry Pi, Communicate Rpi with cloud server using HTTP and MQTT.	10 hrs

TEXTBOOKS

1	Singh, R., Gehlot, A., Gupta, L.R., Singh, B., & Swain, M. Internet of Things with Raspberry Pi and Arduino, 1st edition, CRC Press, 2019.
2	John Soldatos, 360-degree View of Iot Technologies, Artech House, 2020
3	Sudip Misra Anandarup, Introduction to IOT by Mukherjee Arijit Roy, Cambridge university Press, 2021
4	Schwartz Marco, Internet of Things with ESP8266, Packet Publishing Ltd, 2016

REFERENCES

1	Brian W. Evans, Arduino Programming notebook, Second Edition, Creative Commons, 2008
2	Alan G. Smith, Introduction to Ardunio, A piece of cake!, CreateSpace Publisher, 2011
3	Rao, M. Internet of Things with Raspberry Pi 3: Leverage the power of Raspberry Pi 3 and JavaScript to build exciting IoT projects, Packt Publishing Ltd, 2018
4	Richardson, M., & Wallace, S. Getting started with raspberry PI, O'Reilly Publisher Media, Inc. 2012
5	Baichtal, John, Arduino for beginners: essential skills every maker needs, Pearson Education, 2013

List of Experiments:

(At least 10 experiments should be conducted from the following list of experiments.)

NOTE: IoT application-based experiments should be conducted

SN	Experiment
1	Arduino Uno interfacing with I/O pins
2	Arduino Uno interfacing with Analog and digital Sensors
3	Arduino Uno interfacing with motors
4	A GSM based Remote Temperature and Humidity Monitor
5	Switching light on /off remotely using MQTT with ESP8266
6	Voice-based Home Automation for switching lights on/off using Google assistant with ESP8266
7	Data-logging DHT-11 sensor using ESP8266
8	Installation of OS onto Raspberry Pi
9	Raspberry pi interface with Analog and digital Sensors,
10	Interfacing of motors and relay to Raspberry Pi
11	Interfacing DHT11 sensor with Raspberry Pi, print temperature and humidity.
12	Get input from DHT11 sensor and upload on cloud using Raspberry Pi
13	Get input from ultrasonic sensor and upload on cloud using Raspberry pi
14	Interfacing Camera with Pi for image processing

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Engineering Branch: Information Technology

Minor/ Honours (Specialization) Subject: Advanced Web Development

Definition of Credit

1 Hour of Lecture (L) / Week	**1 Credit**
1 Hour of Tutorial (T)/ Week	**1 Credit**
2 Hours of Practical (P) /Week	**1 Credit**

The Minor degree programme is divided into four courses:

1. Web Development 101 - Getting started with JavaScript
2. Web Development 201 - Server-side programming with Node.js
3. Web Development 301 - Front-end development with React & TypeScript
4. Web Development 401 - Getting ready for production

These four courses add up to 20 Credits. Students may choose to replace WD 401 with an internship as well.

Minor Degree in Advanced Web Development

Course Structure						
S.No	**Course Code**	**Title**	**L**	**T**	**P**	**Credits**
1	WD101	**Web Development 101** Getting started with JavaScript	0	1	0	1
2	WD201	**Web Development 201** Server-side Programming with Node.js	0	6	0	6

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3	WD301	**Web Development 301** Front-end development withReact & TypeScript	0	6	0	6
4	WD401	**Web Development 401** Getting ready for production	0	0	10-14	7
TOTAL			**0**	**13**	**10-14**	**20**

Head-start to industry for students

A student of any branch, who has completed second semester, is eligible for this advanced minor degree programme. The institutes, their affiliating university may plan the implementation details along with Pupilfirst.

Colleges may plan the implementation details together with AICTE LITE faculty coordinators.

Detailed Syllabus

Course Code	:	Web Development 101
Course Title	:	Getting Started with JavaScript
Number of Credits	:	1 (L: 0; T: 1; P: 0)
Course Category	:	Web Development (WD)

Course Objective:

This course is meant for students who do not have prior programming experience, or havea light background, and are looking to build a robust foundation for computational thinking.

1.The students will learn to deconstruct what software applications do, and reason about the essence ofcomputation as transformation of data from one shape to another.

2. Practically, the students will be able to set up a development environment, be introduced to HTML & CSS, and learn to program in a functional subset of JavaScript.

3. They will also be able to create and deploy a simple and basic website to the internet.

Course Outcomes:

1. Set up a development environment and create and style basic web pages.
2. Transform data with JavaScript.
3. Work with the HTML Forms and Validations.

4. Understand Web Storage for saving and retrieving data.

Prerequisites:

Course Contents:

Module 1: Welcome to the course

This module introduces students to the World Wide Web. Students are also guided through setting up a development environment on their computer. Students are taught to set up Visual Studio Code as their editor and to use Prettier and ESLint extensions for code formatting and code quality respectively.

Module 2: Let's create our own websites!

In this module students learn how to develop a simple website using HTML. They experiment with some useful HTML tags, learn how to look inside websites. The students deploy the website they develop and share it over the Internet.

Module 3: Basic Introduction to HTML and CSS

This module gives some basic introduction of HTML and CSS. Students learn how to put together a web page that contains HTML, CSS, and JavaScript.

Module 4: Style Matters

This module teaches students how to style web pages using CSS. Students also learn how touse Tailwind CSS to add custom styling to their webpages.

Module 5: Working with JavaScript data types

In this module students are introduced to different data types - Number, Boolean and String. They carry out various operations on these data types to understand the difference between them and also can decide the suitability of a data type given a task or operation.

Module 6 - Working with JavaScript data structures

This module teaches students how to iterate with arrays using *forEach* method and generate an HTML list from an array. Students perform various transformations on an arrayusing the map method and are introduced to filtering of arrays.

Students are also introduced to objects in JavaScript. They learn how to create objects, add and access properties of objects and perform various operations on them.

Module 7 - Functions - code we can call multiple times

This module teaches students how to use functions to modularize the codebase. Students learn how to return values from a function and also how to treat functions as values, by passing them as arguments.

Module 8 - Create a form with validations

In this module, students learn about HTML form element and form data. They learn how to create a user form, add validations, store and retrieve data. Students develop and deploy their personal website that includes the form they have built with additional validations and display the data submitted by users on the website.

Text/Reference Books (if any):

This course does not require students to use physical textbooks. Instead, original course material (videos, text and images) has been prepared for students to go through and is open-sourced under Creative Commons Attribution-ShareAlike 4.0 International License

This course material may include some third-party content with a compatible license, and external links for additional reading on the Internet. Students are also taught how to search for information on their own.

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Course Code	:	Web Development 201
Course Title	:	Server-side programming with Node.js
Number of Credits	:	6 (L: 0; T: 6; P: 0)
Course Category	:	Web Development (WD)

Course Objective:

1. The objective of this course is to teach students how to build web applications using the Express.js framework, with focus on industry-practices like functional programming, object-oriented design, programming style guides, security, and version control.

Course Outcomes:

1. Model real-world systems using object-oriented design
2. Build web applications using Express.js.
3. Write HTML & CSS to create elegant web pages
4. Build database applications using Sequelize.

Course Content:

Module 1 - Introduction to Node.js

In this module students are introduced to Node.js - they learn how to install it and write programs on it and use Node.js REPL. Students also start using GitHub and learn how to collaborate on code with others using the git tool.

Module 2 - Working with NPM

This module is an introduction to Node.js package manager for students where they startwriting custom NPM modules. They also explore and use built-in modules of Node.js

Module 3 - Node.js deep dive

In this module students start building their first application and learn how to use closure toemulate private methods.

Module 4 - Testing

In this module students are introduced to testing. They start writing tests for their application, learn how to use Jest to run the tests and pre-commit hooks to run the testsautomatically before each commit.

Module 5 - Databases and Sequelize

In this module students get to learn about databases and set up a PostgreSQL database.

They learn how to connect to a database from a Node.js application and then work on the database by creating Sequelize models to manipulate data.

Module 6 - Backend Web development with Express.js

In this module, students develop their first application and connect it to the PostgreSQL database on their machine, and begin learning the basics of the CRUD pattern by buildingsome additional features to the application that they're working on.

Module 7 - Add User Interface for To-do Application

This module teaches students how to create interfaces for their application. They also practice converting a given visual design into working HTML and CSS.

Module 8 - EJS Templating

This module teaches touches upon the basics of the MVC pattern, instructing student how to render dynamic data inside their HTML pages using EJS templates. This module also letsthe student practice how to deploy their work to a remote server.

Module 9 - HTML forms to save and accept user inputs

This module teaches students how to accept user input on their application via form

element in HTML. Students also explore more of the CRUD pattern, moving onto creation of resources using forms, deletion of existing resources, and learn about Cross Site Request Forgery (CSRF) and how authenticity tokens can be used to prevent such attacks. Students are also

introduced to APIs.

Module 10 - User Authentication and final wrap-up

In this module students dig deeper into Sequelize association, migration and validation. They build a functional user sign-up page, learn about password storage and play aroundwith browser cookies, sessions, user authentication, and related best practices. They alsolearn to display one-off flash messages.

Text/Reference Books (if any):

This course does not require students to use physical textbooks. Instead, original course material (videos, text and images) has been prepared for students to go through and is open-sourced under Creative Commons Attribution-ShareAlike 4.0 International License © Freshworks Inc. & Pupilfirst Pvt. Ltd.

This course material may include some third-party content with a compatible license, and external links for additional reading on the Internet. Students are also taught how to searchfor information on their own.

Course Code	:	Web Development 301
Course Title	:	Front-end development with React & TypeScript
Number of Credits	:	6 (L: 0; T: 6; P: 0)
Course Category	:	Web Development (WD)

Course objective

The course aims at training students on the following fronts:

1. Understand the basic architecture of front end applications and create web applications using React TypeScript front-end stack.

2. Interaction between a client-side application and server-side app via an API.
3. Industry practices for state management and usage of static types.
4. Best practices with regard to the development of a modern client-side application.
5. Learn to build TypeScript projects from scratch to scale.

Course outcome

By the end of the course the students will:

1. Understand the fundamentals of TypeScript and React
2. Create Single Page Web Applications (SPA) using React, Typescript and Tailwind CSS.
3. Have a solid understanding of static types, and know how to port untyped JavaScript to TypeScript.
4. Learn typed state management that is inline with a backend data model.

Course outline

Module 1: React fundamentals

This module introduces students to development using TypeScript by setting up a development environment, introducing them to the TypeScript programming language and the React framework, and demonstrates some of the basic concepts that underpin the use of React for building dynamic reactive user interfaces.

Module 2: State management

This module introduces students to the *Hooks* feature of React, on the usage of callback functions and how to use them to build dynamic components that maintain an internal state. This module also demonstrates state management by building a form and accepting user input.

Module 3: A deeper dive into React Hooks

This module discusses the common pitfalls of state management, introduces in-browser persistent storage, demonstrates additional standard hooks and the creation and use of custom hooks.

Module 4: Client-side routing

This module covers the concept of client-side routing as a separate behaviour from server-side route management. It demonstrates the various aspects of client-side routing such as the use of path parameters, query parameters, programmatic navigation and the operation of links and URLs that are handled client-side.

Module 5: Types in depth and Variants

This module takes a deeper dive into TypeScript's type system, demonstrating concepts such as function types, custom-defined types, generics, and union types. It also instructs the student why the "any" type should be avoided in practice, and finishes up with a demonstration of TypeScript's type inference behaviour.

Module 6: Modelling and managing complex states

This module teaches students how to manage complex states using the state reducer pattern, and then demonstrates the pattern by implementing it using React's useReducer hook.

Module 7: APIs and state modelling

Through this module, students are introduced to using APIs to interface their client-side code with the server-side, how to model types to allow this interaction to take place, how to maintain a session with the backend, and how to work with pageable APIs.

Module 8: Best practices and npm packages

This module covers the best practices of front-end development, including the importance of accessibility and WAI-ARIA standards, and use of third-party packages from the NodeJS ecosystem.

Module 9: Production React Apps

This final module focuses on production-specific optimizations of a React application, best practices for its build & deployment process, and the configuration of a progressive web app.

Text/Reference Books (if any):
This course does not require students to use physical textbooks. Instead, original course material (videos, text and images) has been prepared for students to go through and is open-sourced under Creative Commons Attribution-ShareAlike 4.0 International License.

This course material may include some third-party content with a compatible license, and external links for additional reading on the Internet. Students are also taught how to search for information on their own.

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Course Code	:	Web Development 401
Course Title	:	Getting ready for production
Number of Credits	:	7 (L: 0; T: 0; P: 14)
Course Category	:	Web Development (WD)

Course objective

1. The objective is to allow the student to learn more about production-ready deployments.

Course outcome

By the end of the course the students will:

1. Be able to bundle a codebase with non-trivial JS dependencies and code.
2. Understand why testing is important, what TDD is, and be able to write both unit and integration tests for Rails applications that use JS in the front-end.
3. Be aware of container-based deployments, be able to build a Docker image for their web application and then deploy that image to a web server
4. Set up error-logging for their web application to capture runtime errors - both in the back-end and in the front-end.

Course outline

Module 1: Workflow using pull-requests

This module acts as an advanced guide to the usage of git in development teams, where thenorm is to develop on branches, perform peer-reviews, and to re-work based on reviews before merging. Since this cycle is most often performed using online tooling that uses pullrequests to achieve this workflow, students are taught how to open a pull request, make changes, submit work for review and then update code based on review.

Module 2: JS Bundling - integration of JS into non-JS backends

This module covers the history of why "bundling" as a process exists for the JS ecosystem,the most common bundling tools, and the general methodology. This module also covers the new "import maps" feature that allows for similar capability without the use of a bundling tool.

Module 3: Compile to JS languages - options & approaches

This module covers the reason why languages that compile to JS exist, the different purposes that they serve, and demonstrate a few of the most popular options and the differences between each.

Module 4: Testing

This module covers the importance of testing, the different approaches to testing such asunit testing, integration testing, and hybrid testing. It should also cover popular librariesthat are used to help with testing, and also common pitfalls in the practice of testing andhow to avoid them.

Module 5: CI/CD - Continuous integration & delivery

This module teaches students about modern development processes that enable teams torelease changes quickly and often, by leading them through the process of setting up an automated system that detects changes to code to run tests and then linking that to the deployment of code that passes its test suite to a remote server.

Module 6: Application environments

This module teaches students about the different environments in which an application is expected to run. This module explains the differences between the environments that a student has already operated in - development, testing & production, and also introducesthe concept of a staging environment which acts as a gateway to the production environment.

Module 7: Containerization

This module covers the field of containerization - where complex applications are packagedto run in isolated spaces called containers. The approach for covering this topic involves theuse of the popular Docker (OCI) standard, teaching students how to build a Docker image for their web application, and how to deploy this image to different targets.

Module 8: Internationalisation and localisation

This module covers i18n, teaching students the basics of setting up their web applications to support users who prefer or require a language different from the default language of theapp, and/or live in a timezone that is different from the default. This module also covers L10n, teaching students how to use the i18n framework to customise their web applicationfor another locale.

Module 9: Error logging & debugging

This module covers the practice of logging and notification of runtime errors that occur ona deployed application. This module also covers the process that is followed to detect the source of a bug, and how testing can be used to ensure a fix and to prevent recurrences.

Text/Reference Books (if any):

This course does not require students to use physical textbooks. Instead, original course material (videos, text and images) has been prepared for students to go through and is open-sourced under Creative Commons Attribution-ShareAlike 4.0 International License.

This course material may include some third-party content with a compatible license, and external links for additional reading on the Internet. Students are also taught how to searchfor information on their own.

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Engineering Branch: Information Technology

Minor/ Honours (Specialization) Subject: Data Science

Course Code Nomenclature:

- MDS denotes Minor/Honours degree in "Data Science".
- 01, 02, 03, 04, 05 are course in order they have to be taken, if taken in different semesters.

SCHEME OF INSTRUCTIONs AND EXAMINATION

Course Code	Semester	Nomenclature of the Course	Scheme of Instruction Hrs/Week			Scheme of Examination						
			L	T	P	Duration (Hrs)	Marks					Credits
							Th	IA	TW	O	Total	
MDS01	IV	Introduction to Data Science	3		2	3	100	25	--	25	150	4
MDS 02	V	Basics of AI and ML	3	--	2	3	100	25	--	25	150	4
MDS03	VI	Computational Data analytics	3	--	2	3	100	25	--	25	150	4
MDS04	VII	Statistics for Data Science	4	--	--	3	100	25	25	--	150	4
MDS05	VIII	Analysing, Visualizing and Applying Data Science	4	--	--	3	100	25	25	--	150	4
		TOTAL	17	--	6		500	125	50	75	750	20

LEGEND

Abbreviation	Description
L	Lecture
T	Tutorial
P	Practical
O	Oral
Th	Theory
TW	Term Work
IA	Internal Assessment

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Detailed Syllabus

Course Code	**:**	**MDS 01**
Course Title	**:**	**Introduction to Data Science**
Number of Credits	**:**	**4 (L:3; T:0; P:2)**

Course Objectives:

1. Building the fundamentals of data science.
2. Imparting design thinking capability to build big-data
3. Developing design skills of models for big data problems
4. Gaining practical experience in programming tools for data sciences
5. Empowering students with tools and techniques used in data science

Course Outcome's (CO): At the end of the course the student should be able to:

1. Understand and Apply data visualisation in big-data analytics
2. Utilise EDA, inference and regression techniques
3. Utilize Matrix decomposition techniques to perform data analysis
4. Apply data pre-processing techniques and basic Machine Learning Algorithms

Course Contents:

[Total Theory Duration: 42 Lectures]

Unit 1: [Duration: 10 Lectures]

Introduction to Data Science, Different Sectors using Data science, Purpose and Components of Python in Data Science, Data Analytics Process, Knowledge Check, Exploratory Data Analysis (EDA), EDA Quantitative technique, EDA- Graphical Technique, Data Analytics Conclusion and Predictions.

Unit 2: [Duration: 11 Lectures]

Feature Generation and Feature Selection (Extracting Meaning from Data) – Motivating application: user (customer) retention- Feature Generation (brainstorming, role ofdomain expertise, and place for imagination)- Feature Selection algorithms.

Unit 3: [Duration: 11 Lectures]

Data Visualization- Basic principles, ideas and tools for data visualization, Examples of inspiring (industry) projects, creating one's own visualization of a complex dataset, Dashboard development tools.

Unit 4: [Duration: 10 Lectures]

Applications of Data Science, Data Science and Ethical Issues- Discussions on privacy, security, ethics- A look back at Data Science- Next-generation data scientists,- Getting informed consent - The Five Cs – Diversity – Inclusion – Future Trends.

Text Books:

1. Davy Cielen, Arno D. B. Meysman, Mohamed Ali, Introducing Data Science, Manning Publications Co., 1st edition, 2016.

2. Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, An Introduction to Statistical Learning: with Applications in R, Springer, 1st edition, 2013.
3. Bart Baesens, Analytics in a Big Data World: The Essential Guide to Data Science and its Applications, Wiley,2014
4. D J Patil, Hilary Mason, Mike Loukides, Ethics and Data Science, O' Reilly, 1st edition, 2018.

Reference Books:

1. Business Analytics: The Science of Data - Driven Decision Making, U Dinesh Kumar, John Wiley & Sons, 2nd Edition November 2021
2. Introducing Data Science: Big Data, Machine Learning, and More, Using Python Tools, Davy Cielen, John Wiley & Sons, 2nd Edition January 2016
3. Joel Grus, Data Science from Scratch, Shroff Publisher/O'Reilly Publisher Media, 2nd Edition April 2019
4. Annalyn Ng, Kenneth Soo, Numsense! Data Science for the Layman, Shroff Publisher, 2nd Edition 2017
5. Cathy O'Neil and Rachel Schutt. Doing Data Science, Straight Talk from The Frontline. O'Reilly Publisher,1st Edition October 2013
6. Jure Leskovek, Anand Rajaraman and Jeffrey Ullman. Mining of Massive Datasets. v2.1, Cambridge University Press, 2nd Edition, January 2016
7. Jake VanderPlas, Python Data Science Handbook, Shroff Publisher/O'Reilly Publisher Media, 2nd Edition, December 2022
8. Philipp Janert, Data Analysis with Open Source Tools, Shroff Publisher/O'Reilly Publisher Media, 1st Edition 2010

Lab Work:

1) Tools used for data visualization.
2) Case study on Implementing Exploratory Data Analysis.
3) Implementing Data Analytic for prediction.(Any one Application)
4) Implementing Visualization for any complex dataset.
5) Implementing the components of python in data science.
6) Implementing Feature Selection algorithms.
7) Implementing the different application of data science.
8) Case study on different feature generation in Data Science.
9) Case study on Data Analytic process.
10) Case study on security and ethical issues in data science.

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Course Code	**:**	**MDS 02**
Course Title	**:**	**Basics of AI and Machine Learning**
Number of Credits	**:**	**4 (L:3; T:0; P:2)**

Course Objectives:

1. Become familiar with basic principles of AI & ML toward problem solving, inference, perception, knowledge representation, and learning.
2. To introduce the concept of learning patterns from data and develop a strong theoretical foundation for understanding state of the art Machine Learning algorithms.
3. Apply the algorithms to a real problem, optimize the models learned and report on the expected accuracy that can be achieved by applying the models
4. Explore the current scope, potential, limitations, and implications of intelligent systems.

Course Outcome's:

After completion of course, students would be able to:

1. Understand basic concepts of classification, clustering and regression.
2. Apply machine learning solutions to classification, regression and clustering problems.
3. Evaluate and interpret the results of the different ML techniques.
4. Design and implement various machine learning algorithms to solve real world applications.

Course Contents:

[Total Theory Duration: 42 Lectures]

Unit 1: [Duration: 11 Lectures]

Defining Artificial Intelligence, Defining AI techniques, Using Predicate Logic and Representing Knowledge as Rules, Representing simple facts in logic, Computable functions and predicates, Procedural vs. Declarative knowledge, Logic Programming, Mathematical foundations: Matrix Theory and Statistics for Machine Learning.

Unit 2: [Duration: 11 Lectures]

Idea of Machines learning from data, Classification of problem –Regression and Classification, Supervised and Unsupervised learning.

Unit 3: [Duration: 10 Lectures]

Linear Regression: Model representation for single variable, Single variable Cost Function, Gradient Decent for Linear Regression, Gradient Decent in practice.

Unit 4: [Duration: 10 Lectures]

Logistic Regression: Classification, Hypothesis Representation, Decision Boundary, Cost function, Advanced Optimization, Multi-classification (One vs. All), Problem of Over fitting.

Text Books:

1. Saroj Kaushik, Artificial Intelligence, Cengage Learning, 1st Edition 2011.
2. Anindita Das Bhattacharjee, "Practical Workbook Artificial Intelligence and Soft Computing for beginners, Shroff Publisher-X team Publisher, September 2018
3. Tom Mitchell, Machine Learning, McGraw Hill, 2017.
4. T. Hastie, R. Tibshirani, J. Friedman. The Elements of Statistical Learning, 2e, 2011.

Reference Books:

1. Yuxi (Hayden) Liu, "Python Machine Learning by Example", Packet Publishing Limited, 2017.
2. Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer, 2011.

Lab Work:

1. Implement logical facts and rules in Python.
2. Implement Computable functions and predicates in Python
3. Implement linear regression approach for predicting a response using a single feature.
4. Implement Multiple linear regression for predicting response using multiple feature
5. Implement Logistic regression approach for supervised learning
6. Implement support vector machine method for supervised learning
7. Implement gradient decent approach.
8. Implementation of clustering algorithms.
9. Implementation of Decision tree using Python
10. Implementation of Multi class classification method using Python

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Course Code	**:**	**MDS 03**
Course Title	**:**	**Computational Data Analytics**
Number of Credits	**:**	**4 (L:3; T:0; P:2)**

Course Objectives:

1. To learn how to think about your study system and research question of interest in a systematic way in order to design an efficient sampling and experimental research program.
2. To understand how to analyze collected data to derive the most information possible about your research questions.

Course Outcomes:

1. Understand how data is collected, managed and stored for data science.
2. Apply knowledge to determine when to use which type of Machine learning model.
3. Analyse various Machine learning models
4. Implement various ML algorithms on data models.

Course Contents:
[Total Theory Duration: 42 Lectures]

Unit1: [Duration: 11 Lectures]
Starting with R and data: Starting with R, Working with data from files, Working with relational databases, Exploring data: Using summary statistics to spot problems, Spotting problems using graphics and visualization

Unit 2: [Duration: 11 Lectures]
Managing data: Cleaning data, Data transformations, Sampling for modelling and validation; Data engineering and data shaping: Data selection, Basic data transforms, Aggregating transforms, Multitable data transforms, Reshaping transforms; Choosing and evaluating models: Mapping problems to machine learning tasks, Evaluating models.

Unit 3: [Duration: 10 Lectures]
Linear and Logistic Regression: Using linear regression, using logistic regression, Regularization, Unsupervised methods: Cluster analysis, Association rules

Unit 4: [Duration: 10 Lectures]
Exploring advanced methods: Tree-based methods, Using GAMs to learn non-monotone relationships, solving inseparable problems using support vector machines

Text Books:

1. Practical Data Science with R, Nina Zumel, John Wiley & Sons,1st Edition April 2014
2. N. C. Das, Experimental Designs in Data Science with Least Resources, Shroff Publisher Publisher, 2nd Edition October 2019

Reference Books:

1. Hadley Wickham, Garret Grolemund, R for Data Science, Shroff Publisher/O'Reilly Publisher, 2nd Edition December 2016
2. Benjamin M. Bolker. Ecological Models and Data in R. Princeton University Press,1st Edition 2008. ISBN 978-0-691-12522-0.
3. John Fox and Sanford Weisberg. An R Companion to Applied Regression. Sage Publications, Thousand Oaks, CA, USA, second edition, 2011. ISBN 978-1-4129-7514-8.

Lab Work:

The following programs should be implemented in R:

1. To implement basic R programs
2. To implement matrices and vectors in R
3. To visualize a given dataset in R
4. To perform data cleaning on a given dataset
5. To perform data transformations
6. To perform linear regression on a suitable dataset
7. To perform logistic regression on a suitable dataset
8. To implement any clustering method on a suitable dataset
9. To implement any association method on a suitable dataset
10. To implement any tree-based method on a suitable dataset
11. To implement GAM on actual data
12. To classify data using support vector machines

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Course Code	**:**	**MDS 04**
Course Title	**:**	**Statistics for Data Science**
Number of Credits	**:**	**4 (L: 4; T: 0; P: 0)**

Course Objective:

1. To introduce the basic principles of statistical methods
2. To acquaint the learner with procedures used for data analysis
3. To gather, review, analyse and draw conclusions from data
4. To apply quantified mathematical models to appropriate variables.

Course Outcomes: After completion of course, students would be able to:

1. Execute statistical analyses with professional statistical software.
2. Explain the Descriptive statistics concepts
3. Perform clustering of data and its analysis.
4. Perform regression analysis.

Course Contents:
[Total Theory Duration: 56 Lectures]

Unit 1: [Duration: 13 Lectures]
Understanding basic data cleaning

1. Common Data Issues
2. Contextual Data Issues
3. Data Cleaning Techniques

Detect and diagnose common data issues such as missing values, special values, outliers, inconsistencies, and localization. Address advanced statistical situations, such as transformation, deductive correction, and deterministic imputation.

Unit 2: [Duration:15 Lectures]
Partitioning based Clustering

1. K-Means Clustering
2. K-Medoids Clustering

Soft Computing based Clustering

1. Fuzzy C Means Clustering

Hierarchical Clustering

1. Agglomerative Clustering – AGNES
2. Divisive Hierarchical Clustering – Bisecting K Means Clustering

Genetic Algorithms based Clustering,

Density based Clustering,

1. DBSCAN
2. OPTICS
3. DENCLUE

Discriminant analysis, Factor analysis, Regression analysis, Logistic analysis, Preparing the developer for data mining rather than data querying, Using R for dimensional reduction, frequent patterns, and sequence mining

Unit 3: [Duration: 13 Lectures]
Data analysis, Statistical analysis, Summarization, Establishing the nature of data, Successful statistical analysis, R and statistical analysis. Introduction to Statistical regression: Linear, Logistic and Polynomial Regression

Unit 4: [Duration: 15 Lectures]

1. Stepwise Regression
2. Ridge Regression
3. Lasso Regression

Methods for identification of opportunities for using regression (in data projects)

1. Summarizing data (building a data profile)
2. Exposing and exploring relationships between variables in the data
3. Testing the significance of differences (between variables or groups within data)

R and statistical regression

Text Books:

1. Statistics for Data Scienceby James D. Miller, Publisher(s): Packt Publishing, ISBN: 9781788290678,2nd Edition year -November 2017
2. Practical Statistics for Data Scientistsby Peter Bruce, Andrew Bruce, Publisher(s): O'Reilly Media, Inc.ISBN: 9781491952962, 2nd Edition year – May 2020

Reference Books :

1. The Art of Statistics: Learning from Data by David Spiegelhalter, Pelican Books, 2nd Edition March 2019

2. Think Stats: Exploratory Data Analysis by Allen Downey, Second Edition,O'Reilly Publisher Publication, 1st Edition November 2014

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Course Code	**:**	**MDS 05**
Course Title	**:**	**Analysing, Visualizing and Applying Data science**
Number of Credits	**:**	**4 (L: 4; T: 0; P: 0)**

Course Objective:

1. To learn how to use python for data science
2. To understand all the tools and libraries of python for data science
3. To apply python and python packages for data science.

Course Outcomes: After completion of course, students would:

1. Work with the most widely used Python packages; including NumPy, Pandas,
2. Work with the Scikit-learn machine learning tool
3. Apply NumPy, Pandas, Scikit-learn to Data Analysis and Data Visualization projects.
4. Implement statistics with Python and its packages

Course Contents:

[Total Theory Duration: 56 Lectures]

Unit 1: [Duration: 13Lectures]

Data Analysis libraries:

1. Pandas
2. Data Frames
3. Numpy multi-dimentional arrays
4. SciPy libraries

SciPy libraries to work with a various dataset, Pandas an open-source library and use it to load, manipulate, analyse, and visualize various datasets.

Unit 2: [Duration:15 Lectures]

Scikit-learn machine learning algorithms to build smart models and make predictions, various parameters that can be used to compare various parameters.

1. Dimensionality Reduction
2. Decision Trees
3. Clustering (unsupervised)
4. Stochastic Gradient Descent
5. Neural network models (supervised)
6. Multiclass and multilabel algorithms

Unit 3: [Duration: 13 Lectures]

Descriptive Statistics, Basic of Grouping, ANOVA, Correlation, Polynomial Regression and Pipelines, R-squared and MSE for In-Sample Evaluation, Prediction and Decision Making.

Unit 4: [Duration: 15 Lectures]
Grid Search, Model Refinement Binning (Binning Numerical Variables &Binning Categorical Features). Indicator variables. Introduction to Hadoop and Map Reduce.

Text Books:

1. Data Visualization with Python and JavaScript, Kyran Dale, Shroff Publisher/O'Reilly Publisher Publication,2nd Edition year- 2016
2. Data Science Using Python and R by Chantal D. Larose and Daniel T. Larose, Wiley Publication, 2nd Edition year March 2019

Reference Books :

1. Python for Data Science and Visualization -Beginners to Pro, Udemy, 2020

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