Jharkhand University of Technology
Ranchi, 834010

TENTATIVE SYLLABUS

For Diploma Program in
Mechanical Engineering

(Effective from 2025-26)

DEPARTMENT OF MECHANICAL ENGINEERING

(5th – SEMESTER)

PRODUCT DESIGN AND DEVELOPMENT

Course Code- **L:T:P**

I. RATIONALE

Design and development are two key elements necessary to create any product. From start to finish, each phase of the product's lifecycle needs careful coordination between these two disciplines for a successful outcome.Each organization should come with innovative ideas to bring up a new product, to maintain a top position in the market. Product design and development is a complete cycle to launch of new industrial products i.e from conceptualization to product realization.

II. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

CO1 - Apply principles to develop new small industrial products according to customer's requirement for launching.
CO2 - Use aesthetics and ergonomics principles for developing new products
CO3 - Apply DFM principles for development of new product
CO4 - Apply principles of QFD for Quality of new product
CO5 - Use relevant rapid prototyping methods for development of new product along-with IPR process.

III. COURSE CONTENT

Unit	Course Content	Hours
1	**Unit - I Product Development** 1.1 Characteristics of successful product development, Customer need identification 1.2 Definition of product design, principles of good product design, Design by evolution, design by innovation 1.3 Product development process, Phases of process development. flow chart of product development. Tyco product development process 1.4 Concept development- different phases of concept development process, five step concept generation method, Concept classification tree, Concept combination table 1.5 Concept selection- Concept screening, Concept scoring, Seven step method for testing of product concept 1.6 Identification of customer need, Data collection from customer, organize collected data, Establishing relative importance of customer need for designing product with example	

2	**Unit - II Product Architecture** 2.1 Definition of product architecture, Modular and Integral product architecture, its types, Component standardization, Steps for establishing the architecture with example like trailer, Spanners etc 2.2 Ergonomics- definition, necessity of ergonomics in product design. Design consideration for qualitative and quantitative display, Design considerations for controls like knob, levers, handwheel, toggle switch. 2.3 Aesthetics Principles- definition, necessity of aesthetics in product design, consideration of aesthetics in product design, Aspects of Aesthetics in Product Design - form, symmetry, color, continuity, proportion, contrast, impression, surface finish	
3	**Unit - III Industrial Design** 3.1 Importance of industrial design, Industrial design process 3.2 Design for manufacturability (DFM), steps for DFM, design principles for manufacturability , Factors affect on DFM,.Impact of DFM on cost, quality and Time 3.3 Product Life Cycle- definition, importance, stages of Product life cycle, examples for determining product life cycle of Motorcycle, electrical vehicle etc	
4	**Unit - IV Value Engineering** 4.1 Concept, Steps in value engineering, creative thinking, problem identification and value engineering job plan (VEJP). 4.2 Quality Function deployment (QFD) process- need, importance with example, symbols of QFD, voice of customer (VOC),VOC analysis, Quality QFD relationship matrix, roof ranking, Body ranking , importance of QFD 4.3 House of Quality linking customer complaints to technical requirements	
5	**Unit - V Rapid Prototyping and Patent Filing** 5.1 Rapid Prototyping- concepts, principles of rapid prototyping, Types of Rapid Prototyping- Proof of concept prototype, Looks like prototype, Works like prototype 5.2 3-D printer types – Fused deposition Modeling (FDM), Stereolithography (SLA), Selective Laser sintering (SLS), construction and working-. Comparison between different types of 3-D printer 5.3 Planning for prototyping-steps for planning for prototyping, define purpose, establish level of approximation, experimental plan, schedule for procurement, production and testing 5.4 Patents and intellectual property- Importance of patent, patent rights, criteria for patent, process for filing patents.	

IV. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	K.T.Ulrich	Product Design and Development	6th edition, McGrawhill Publication, 2023 ISBN 9780071086950
2	A.K.Chitale, R.C.Gupta	Product Design and Manufacturing	7th edition, PHI publication 2023, ISBN-13-978-9391818722
3	Richard Morris	Fundamentals of Product Design	2nd edition,2023, Bloomsbury Visual Arts Publication, ISBN 13- 978-1350398856
4	M.M.Soreas	Ergonomics in Design	1st edition,2016 CRC Press Publication, ISBN13- 978-0367356903

V. LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://archive.nptel.ac.in/courses/112/107/112107217/	NPTEL lecture on product design steps and analysis
2	https://www.youtube.com/watch?v=mqC4Wn_OK-I	Value engineering
3	https://archive.nptel.ac.in/courses/112/107/112107217/	NPTEL Lecture on Ergonomics for Product Design
4	https://archive.nptel.ac.in/courses/112/107/112107217/	NPTEL Lecture on QFD
5	https://archive.nptel.ac.in/courses/112/107/112107217/	NPTEL Lecture on Functional Analysis Technique
6	https://archive.nptel.ac.in/courses/112/107/112107217/	NPTEL Lecture on Rapid Prototyping
7	https://archive.nptel.ac.in/courses/112/107/112107217/	NPTEL Lecture on Rapid Prototyping Processes
8	https://www.youtube.com/watch?v=dYPW5Rlwn8g	Working of 3 D printer
9	https://archive.nptel.ac.in/courses/112/107/112107217/	NPTEL lecture on product life cycle
10	https://www.youtube.com/watch?v=X1KONQw02H8	Quality of House
11	https://www.youtube.com/watch?v=Lo-AFCv2ggE	Product design and development
12	https://onlinecourses.nptel.ac.in/noc21_me83/preview	NPTEL lecture on product design and development
13	https://www.youtube.com/watch?v=iRMsd-X_e-0	QFD Analysis
14	https://archive.nptel.ac.in/courses/112/107/112107217/	NPTEL Lecture on VEJP
15	https://archive.nptel.ac.in/courses/112/107/112107217/	NPTEL lecture on Value engineering Concepts

ENTREPRENEURSHIP DEVELOPMENT AND STARTUPS

Course Code- **L:T:P-**

Course Description:

This course provides polytechnic students with a foundational understanding of the entrepreneurial mindset, processes, and skills required to identify opportunities, develop innovative solutions, and create sustainable ventures. Throughout the semester, Critical Thinking, Excellent communicator (Good story teller), and Empathetic Leadership skills development for the students, through a blend of theoretical concepts, case studies, and practical exercises, students will learn to think like entrepreneurs, fostering creativity, problem-solving, and a proactive approach to career and economic development. The course emphasizes practical tools and methodologies applicable across various technical and vocational fields. This course will focus towards small Businesses including services and products

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Course Learning Outcomes (CLOs):

Upon successful completion of this course, students will be able to:

1. **Define and explain** core concepts of entrepreneurship, innovation, and small business management.
2. **Identify and evaluate** entrepreneurial opportunities using various ideation and market research techniques.
3. **Develop a basic business model** using tools like the Business Model Canvas.
4. **Understand fundamental aspects** of market analysis, competitive landscape, and target customer identification.
5. **Articulate key considerations** in managing startup finances, legal structures, and intellectual property.
6. **Develop and deliver a compelling pitch** for a new business idea.
7. **Cultivate an entrepreneurial mindset**, including adaptability, resilience, and a willingness to take calculated risks.

Course Content Outline (Weekly Breakdown):

Unit 1: Understanding Entrepreneurship and the Entrepreneurial Mindset (Weeks 1-2)

- **Week 1: What is Entrepreneurship? The Journey Begins.**
    - Definition of entrepreneurship, innovation, and intrapreneurship.
    - Dispelling myths about entrepreneurs.
    - The role of entrepreneurship in economic development and job creation (local and global context).
    - Types of entrepreneurships: lifestyle, scalable, social, tech, side-hustle.
    - Introduction to JUT's entrepreneurial ecosystem and local success stories
    - ***Activity:*** **Ice-breaker: "What problem bothers you the most in your daily life/local community?"**

- **Week 2: The Entrepreneurial Mindset & Traits of Successful Entrepreneurs.**
    - Key entrepreneurial characteristics: passion, resilience, adaptability, creativity, risk-taking (calculated), problem-solving.
    - Growth mindset vs. fixed mindset.
    - Identifying personal strengths and weaknesses as potential entrepreneurs.
    - Importance of networking and mentorship.
    - *Case Study:* Analyze a local polytechnic graduate who started a successful business.
    - ***Activity:*** **Self-assessment quiz: "Are you ready for entrepreneurship?"**

Unit 2: Opportunity Identification & Ideation (Weeks 3-4)

- **Week 3: Finding Your Big Idea: Problem-Solving Approach.**
    - Sources of entrepreneurial opportunities: pain points, market gaps, trends, technological advancements, personal hobbies/skills.
    - Design Thinking principles for problem identification.
    - Techniques for observing and understanding customer needs (empathy mapping).
    - ***Activity:*** **Field observation exercise: Identify 3 problems in a chosen environment (e.g., campus, local market).**
- **Week 4: Ideation & Validation Techniques.**
    - Brainstorming methods: SCAMPER, S- Substitute, C-Combine, A- Adapt, M- Modify, P-Put to another Use, E-Eliminate, R- Reverse/Rearrange (Mind Mapping, Reverse Brainstorming)
    - Concept generation and prototyping
    - Introduction to Minimum Viable Product (MVP) concept.
    - Initial idea validation: informal surveys, interviews with potential customers.
    - ***Activity:*** **Group ideation session for a chosen problem; develop a basic MVP concept.**

Unit 3: Business Model Fundamentals (Weeks 5-6)

- **Week 5: Introduction to the Business Model Canvas (BMC).**
    - Understanding the nine building blocks of the BMC: Customer Segments, Value Propositions, Channels, Customer Relationships, Revenue Streams, Key Resources, Key Activities, Key Partnerships, Cost Structure.
    - How the BMC provides a holistic view of a business.
    - *Activity:* Analyze the BMC of a well-known local or global company.
- **Week 6: Developing Your Value Proposition & Customer Segments.**
    - Deep dive into Value Proposition Design: understanding customer jobs, pains, and gains.
    - Defining your ideal customer segments: demographics, psychographics, behaviors.
    - Niche markets vs. broad markets.
    - ***Activity:*** **Students start populating the Customer Segments and Value Propositions blocks of their own business idea's BMC.**

Unit 4: Market Analysis & Strategy (Weeks 7-8)

- **Week 7: Market Research Essentials.**
    - Importance of market research: primary vs. secondary research.
    - Basic tools for market research: online surveys (e.g., Google Forms), competitor analysis, industry reports.
    - Analyzing market size, trends, and growth potential.

    - ***Activity:*** **Conduct preliminary secondary market research for their chosen industry.**
- **Week 8: Understanding Your Competition & Marketing Basics.**
    - Competitor analysis: identifying direct and indirect competitors, SWOT analysis (Strength, Weakness, Opportunity, Threat).
    - Developing a competitive advantage.
    - Introduction to the Marketing Mix (4 Ps: Product, Price, Place, Promotion) in a startup context.
    - Branding basics for new ventures.
    - *Guest Speaker (Optional):* Local entrepreneur sharing marketing strategies.

Unit 5: Financial, Legal & Operational Foundations (Weeks 9-11)

- **Week 9: Startup Financial Basics.**
    - Understanding startup costs (fixed vs. variable).
    - Revenue models: how businesses make money.
    - Basic concepts of pricing strategies.
    - Sources of funding: bootstrapping, FFF (Friends, Family, Bootstrap), grants, basic loans, angel investors (brief overview).
    - ***Activity:*** **Calculate initial startup costs for their business idea.**
- **Week 10: Legal & Regulatory Aspects for Startups.**
    - Choosing a business structure: Sole Proprietorship, Partnership, LLC (simple overview, focus on local context).
    - Importance of business registration and licensing.
    - Basic understanding of contracts and agreements.
    - Introduction to Intellectual Property (IP): patents, trademarks, copyrights (relevance to polytechnic innovations).
    - *Guest Speaker (Optional):* Small business lawyer or a representative from a local business registration office.
- **Week 11: Operations & Team Building.**
    - Key operational considerations: supply chain, production/service delivery, quality control.
    - Building an effective founding team: complementary skills, roles, and responsibilities.
    - Importance of company culture in a startup.
    - ***Activity:*** **Define key activities and key partners for their BMC.**

Unit 6: Pitching, Growth, and Next Steps (Weeks 12-14)

- **Week 12: Crafting Your Pitch & Storytelling.**
    - Purpose of a pitch deck.
    - Components of a compelling pitch: problem, solution, market, team, business model, ask.
    - Storytelling techniques for engaging an audience.
    - Verbal and non-verbal communication skills.
    - *Activity:* Students draft their initial pitch script.
- **Week 13: Developing Your Business Plan (Lean Approach) & Refining Your Pitch.**
    - Overview of a lean business plan (as opposed to a traditional, lengthy one).
    - Refining the Business Model Canvas into a more comprehensive plan.
    - Peer feedback session on draft pitches.
    - ***Workshop:*** **Pitch practice session.**
- **Week 14: Final Pitch Presentations & Future Directions.**
    - **Final Project:** Students present their business idea pitch (could be 5-7 minutes with Q&A).
    - Discussion on continuous learning, adaptation, and potential next steps for their entrepreneurial journey.

- Resources available for aspiring entrepreneurs at JUT and in the local community.
- *Activity:* Course wrap-up and Q&A.

Assessment Methods:

To ensure a balance between theoretical understanding and practical application, the assessment for this course could include:

- **Participation & Engagement (10-15%):** Active involvement in discussions, group activities, and case study analyses.
- **Module Activities/Quizzes (20-25%):** Short quizzes, completion of assigned BMC sections, market research exercises, ideation assignments.
- **Individual/Group Assignments (30-35%):**
  - **Mid-Term Assignment:** Developed Business Model Canvas for their chosen idea (could be individual or small groups).
  - **Research Report:** A brief report on their market research and competitive analysis.
- **Final Project (30-35%):**
  - **Business Pitch Deck:** A professional-looking presentation outlining their business idea.
  - **Oral Pitch Presentation:** Delivering a concise and compelling pitch to the class (and potentially invited faculty/local entrepreneurs).

Recommended Resources & Tools:

- **Primary Textbook**
- **Online Platforms/Tools: Introduction to Entrepreneurship Dr Prakah Kumar, Raj Jaswa, Ramesh Yadava**
  - Google Workspace (Docs, Sheets, Slides, Forms) for collaboration and surveys. Canva for creating visual aids and pitch decks. URL **https://www.canva.com/**
  - **web.showreelapp.com** Sabeer Bhatia
  - Online market research tools (e.g., Statista, government statistical websites, industry association sites).
  - Whiteboards, sticky notes, and markers for brainstorming sessions.
- **Guest Speakers:** Local entrepreneurs, business development agencies, IP lawyers, startup mentors.

Case Studies: A mix of successful and failed startups, particularly those relevant to polytechnic fields (e.g., tech, engineering, design, trades).

PROFESSIONAL ELECTIVE

Heating Ventilation and Air- Conditioning (HVAC)

Course Code- **L:T:P**

Introduction:

Welcome to the curriculum for the Specialisation Pathway - **Heating, Ventilation and Air conditioning (HVAC)**. This specialisation course is taught in Bootcamp mode. Bootcamps are 12 weeks, intense learning sessions designed to prepare you for the practical world – ready for either industry or becoming an entrepreneur.

Human comfort plays a vital role either in industries or at home or in office or Apartment building. This is made possible through regulation of heat, airflow, ventilation, and air conditioning. Comfortable office climate increases the level of productivity and increases morale amongst the workers and employees. Studies on corporate workplace behaviour and employee motivations suggest that workers are more enticed to keep coming to work if their office is properly cooled and/or heated. Having the proper temperature at work is an added advantage for building a solid team at work.

Controlling the temperature of air inside the designated "Air Conditioned" space along with control of moisture, filtration of air and containment of air borne particles, supply of outside fresh air for control of oxygen and carbon dioxide levels in the air-conditioned space, and finally control of the movement of air or draught, is a very desirable factor. These conditions can be achieved using an HVAC system. The need for hands-on workers to implement and service that high tech HVAC systems is growing and henceforth, is the Specialization pathway - **Heating Ventilation and Air-Conditioning (HVAC)**

You will be assisted through the course, with development-based assessments to enable progressive learning. In this course, you'll learn how to Design and maintain the HVAC systems for domestic and commercial applications that are needed for today's job market.

Leading to the successful completion of this bootcamp, you shall be equipped to either do an **Internship** in an organisation working on HVAC solution or do a **Project** in the related field. After the completion of your Diploma, you shall be ready to take up roles like a MEP engineer, Utilities engineer, Maintenance engineer etc., and also can become Entrepreneur in the related field and more

This course will teach you about Thermal process, Heat transfer, Psychometry, HVAC load estimation, duct and piping design, Selection of the equipment's for HVAC system and more. Details of the curriculum is presented in the sections below

Course outcome: A student should be able to

CO1	**Estimate the Heating and cooling Load and Air Flow for an HVAC application**
CO2	**Select Suitable equipment's for an HVAC application**
CO3	**Design the duct and piping's for an HVAC application using suitable Building information Modelling (BIM) software**
CO4	**Provide innovative HVAC solutions for green buildings**

Detailed Course Content

Week	C O	P O	Days	1st session (9am to 1 pm)	L	T	P	2ND session (1.30pm to 4.30pm)	L	T	P
1	1		1	**Introduction to HVAC** Video Presentation on Application of HVAC system in – Residential buildings, Apartments, Office Space, Hotels, Auditorium, Hospitals, Automobiles, Cold storages**.**			**4**	**Thermal Principles** Concepts of Heat, Sensible Heat, Latent Heat Temperature, Temperature Scale Work, Power, Energy, Enthalpy, Entropy, Specific Heat, Internal energy	3		
	1		2	Perfect Gas – Gas Laws- Charles law, Boyles law, Characteristics Gas Equation Laws of Thermodynamics- Zeroth Law of Thermodynamics, First Law of Thermodynamics, Second Law of Thermodynamics Thermodynamic processes- Explain Work done, change in internal energy, heat supplied or rejected for the following processes using P-V and T-S Diagram: Constant Pressure, Constant Volume, Isothermal	4			Thermodynamic processes- Explain Work done, change in internal energy, heat supplied or rejected for the following processes using P-V and T-S Diagram Adiabatic, Polytropic, Throttling, Free expansion	3		
	1		3	**Psychrometry**: Psychrometric terms- Dry Air, Moist Air, Saturated Air, Degree of Saturation, Dry Bulb Temperature, Wet Bulb Temperature, Humidity, Absolute Humidity, Relative Humidity, Specific Humidity, Humidity Ratio	4			Psychrometric processes – Sensible heating, Sensible Cooling, Humidification and De-Humidification Use Psychrometric chart and measure properties of air Plot Psychrometric processes using Psychometric chart.	1		**2**
	1		4	**Human Comfort-** Factors affecting human comfort, Comfort parameters, IAQ (Indoor air Quality): Causes & Sources of Indoor Air Quality, Indoor Air Pollutants	4			Demonstrate the Concepts of heat transfer – Conduction, Convection, Radiation (Lab**)** Fourier's law of heat transfer- Thermal conductivity- Newton law of cooling - Thermal resistance (Formula's)	1		**2**

				Indoor Air Quality Regulations, ASHRAE Guidelines and Standards							
			5	Developmental Weekly Assessment				Assessment Review and corrective action			3
			6	Industry Class on Use of Psychometric Chart, parameters for Human comfort and ASHRAE standards + Industry Assignment			5				
2	1		1	Tutorial (Peer discussion on Industrial assignment)		4		**Solar Radiation**- Radiation Heat Transfer, Overall Heat Transfer, Heat Capacity, Coefficients for Radiant Heat Transfer	3		
	1		2	SOLAR ANGLES- Basic Solar Angles, Hour Angle and Apparent Solar Time, Angle of Incidence and Solar Intensity (Video Presentation) Solar Radiation for a Clear Sky, Solar Radiation for a Cloudy Sky (Video Presentation) Location, Weather data, Orientation Solar Radiation, U factors (For data Refer ASHRAE Standards)	4			Moisture Migration in Building Materials, Moisture Transfer from the Surface of the Building Envelope, Moisture Transfer in Building Envelopes CONDENSATION IN BUILDINGS- Visible Surface Condensation, Concealed Condensation within the Building Envelope (Video Presentation)	3		
	1		3	THERMAL INSULATION- Basic Materials and Thermal Properties, Moisture Content of Insulation Material, Economic Thickness, Thermal Resistance of Airspaces (Video Presentation)	4			FENESTRATION- Types of Window Glass (Glazing), Optical Properties of Sunlit Glazing (Video Presentation) HEAT ADMITTED THROUGH WINDOWS- Heat Gain for Single Glazing, Heat Gain for Double Glazing (Video Presentation) Selection of Glazing	3		
	1		4	SHADING OF GLASS- Indoor Shading Devices, External Shading Devices, Shading from Adjacent Buildings (Video Presentation)	4			Shading Coefficients, shading coefficients of building envelopes Solar Heat Gain Factors and Total Shortwave Irradiance	3		
			5	Developmental Weekly Assessment				Assessment Review and corrective action			**3**
			6	Industry Class on Thermal Insulation, Fenestration and Shading of Glass + Industry Assignment			**5**				

Week	C O	P O	Days	1st session (9am to 1 pm)	L	T	P	2ND session (1.30pm to 4.30pm)	L	T	P
3	1		1	Tutorial (Peer discussion on Industrial assignment)		4		**HVAC Load Calculation** Explain – Sensible heat gain, Latent heat gain Calculate sensible heat gain through building structure by conduction Calculate heat gain from solar radiation Calculate Solar (Sensible)heat gain through outside walls and roofs			**3**
	1		2	Explain Sol Air temperature Calculate Solar heat gain through Glass surface Calculate Heat gain through Infiltration Calculate heat gain through Ventilation Calculate heat gain from occupants Calculate Heat gain from Appliances Calculate Heat gain from products	2		**2**	Calculate Heat gain from lighting equipment's Calculate Heat gain from power equipment's Calculate Heat gain through ducts Conversion of Tons of Refrigeration (TR) to British Thermal Units (BTU) Conversion of Tons of Refrigeration (TR) to KW/hr Conversion of British Thermal Units (BTU) to KW/hr	1		**2**
	1		3	Estimate HVAC load for a Single storey building plan using E20 or any similar forms. Calculate Air flow in CFM (Supply air, Return Air, Exhaust Air, Fresh Air)					2		**5**
	1		4	Estimate HVAC load for an office building plan using E20 or any similar forms Calculate Air flow in CFM (Supply air, Return Air, Exhaust Air, Fresh Air)					2		**5**
			5	CIE 1– Written and practice test				Assessment Review and corrective action			3
			6	Industry Class on HVAC load Calculation + Industry Assignment			5				
4	1		1	Tutorial (Peer discussion on Industrial assignment)		4		Estimate HVAC load for a commercial building using E20 or any similar forms Calculate Air flow in CFM (Supply air, Return Air, Exhaust Air, Fresh Air)			3

	1		2	Estimate HVAC load for a commercial building using E20 or any similar forms Calculate Air flow in CFM (Supply air, Return Air, Exhaust Air, Fresh Air)					2		5
	2		3	Choosing an HVAC System - Building design, Location issues, Utilities, Availability and cost, Indoor requirements and loads, Client issues	4			**Air Conditioning systems:** **Introduction to Split Air conditioning system (AC):** Discuss types of Split AC - • Wall mounted split systems • Multi-head Split systems • In-ceiling cassette systems. • Inverter Split AC Demonstrate the Parts and functions of Wall Mounted Split AC Systems Demonstrate the Working of Wall Mounted Split AC Systems	1		2
	2		4	Discuss the specifications of Split AC using Company Catalogue Discuss and Demonstrate Variable Refrigerant flow (VRF)/ Variable Refrigerant volume (VRV) Air Conditioning systems Discuss and Demonstrate Direct Expansion (DX) Air Conditioning systems			4	Demonstrate the installation of Wall Mounted Split Air- Conditioning System			3
			5	Developmental Weekly Assessment				Assessment Review and corrective action			3
			6	Industry Class- Type of Split AC for different Application and Industry Assignment			5				
5	2		1	Tutorial (Peer discussion on Industrial assignment)		4		**Introduction to Centralized Air Conditioning System** Applications of Centralized Air Conditioning System Discuss the Working of Centralized Air Conditioning System **i) Refrigeration Cycle** Explain the working principle of Refrigeration Cycle in a Centralized AC	1		2
	2		2	Explain and demonstrate the components of Refrigeration cycle							

				a) Compressor – Types (Reciprocating, Centrifugal, Screw, Scroll, Hermetic), Specification from catalogue and Selection Criteria b) Condenser - Types, Specification from catalogue and Selection Criteria c) Evaporator - Types, Specification from catalogue and Selection Criteria d) Expansion Valve - Types, Specification from catalogue and Selection Criteria e) Filter drier - Types, Specification from catalogue and Selection Criteria	1		3	Discuss Designation system for Refrigerants Discuss Essential and Desirable Properties of a Refrigerant Discuss the Criteria to Select suitable Refrigerant for the refrigeration cycle Discuss the Effect of Refrigerant on Environment (Env Issues)	3		
	2		3	ii) **Chilled Water cycle** Explain the working principle of Chilled Water cycle in a Centralized AC Explain and demonstrate the components of Chilled Water cycle a) Chillers- Demonstrate the working principle of Chillers, Discuss the types of Chillers-- Air cooled Chillers, Water cooled Chillers, Specification from catalogue and Selection Criteria b) Cooling Tower- Working Principle, Types, Specification from catalogue and Selection Criteria c) Condenser- Working Principle, Types, Specification from catalogue and Selection Criteria d) Water Pump- Working Principle, Types, Specification from catalogue and Selection Criteria	2		2	iii) **Air Distribution System** a) Duct – Types, Material b) Air Handling Unit/ Fan Coil Units - Fan, Grills, Registers, Sealing, Diffuser, Slot Diffusers, Plenum Sealings, Flexible Connectors, Equalizing Grids, Splitter dampers, Control dampers, Anti Smudge rings, Sound and sound controls, Acoustic material (its properties, selection of the same for different HVAC system), filters, VAV Boxes.	1		2
	2		4	iv) **Heating cycle** a) Explain Electric Duct Heater- Types- flange type, round adapter option, Slip in Type- Calculation of Power in the heater	1		3	b) Boiler- Oil or Gas combustion Boiler and Heat exchanger- Furnace heater c) Heat pump	1		2

			5	CIE 2– Written and practice test				Assessment Review and corrective action			3
			6	Industry Class- Centralized Air Conditioning System and Industry Assignment			5				
6	2		1	Tutorial (Peer discussion on Industrial assignment)		4		Designing Centralized AC System **a) Air Distribution System-** • Selection criteria for AHU • Placement/Location of AHU's • Fan – Fan Law, Selection Criteria, Calculation of motor power requirement			**3**
	2		2	Demonstrate • Demonstrate Zone classification- Single Zone and Multi Zone • Shape of the Duct - Circular Rectangular, Square • Duct Materials – Galvanized Iron, Aluminum, Stainless Steel • Thickness of the Duct Sheet • Aspect Ratio (Width to Height)			**4**	• Duct Designing method- Velocity Reduction method, Equal friction Method, Static Regain Method • Pressure in Ducts- Static Pressure, Dynamic or Velocity pressure, Total pressure			**3**
	2		3	Duct classification as per Duct Pressure Design of supply and return duct using ASHRAE standards	1		**3**	• Duct Seal- Class A, Class B, Class C • Distribution System Plans and Symbols- Positive pressure supply, Negative pressure return • Air Terminal Symbol- one way, Two-way, three-way, four -way	3		
	2		4	b) Designing Water Distribution System- • Pipes- Piping materials and its selection • Design of supply and return water pipes • HVAC Piping Insulation • Pumps- Types, Power requirement, Selection using Pump curve			**4**	• Concepts on Kitchen, Toilet, Basement Ventilation • Concept on Staircase and Lift Pressurization • Concept on HVAC for Clean Rooms			**4**

				c) Designing Cooling Coils- • Calculate the Diameter of coil • Calculate Number of Coils							
			5	Developmental Weekly Assessment			•	Assessment Review and corrective action			•
			6	Industry Class on Air and Water distribution System in AC and Industry Assignment			5 •				
Week	**C O**	**P O**	**Days**	**1st session (9am to 1 pm)**	**L**	**T**	**P**	**2ND session (1.30pm to 4.30pm)**	**L**	**T**	**P**
7	3		1	Tutorial (Peer discussion on Industrial assignment)		4		**Working On BIM (Building Information Modelling) software for Designing an HVAC System**. **Exploring the User Interface** • Model- New • Practice to Navigate the ribbon interface. • Practice to Utilize user interface features. • Practice to Use settings and menus • Practice on Import and reuse existing drawings from other formats. • Practice on Manipulating the properties of parameters			**3**
	3		2	HVAC Cooling and Heating Load Analysis- • Creating Spaces • Placing Spaces • Creating a Space Properties Schedule							

				• Modifying Space Properties • Creating Zones • Setting Building Construction Options • Area and Volume Calculations • Color schemes • Performing Heating and Cooling Load Analysis-Load analysis, Weather Data, Outdoor air infiltration, silver spaces • Extracting and interpreting Cooling and Heating Load Report					2		**5**
	3		3	Practice Heating and Cooling Load Analysis for building drawings using BIM					1		**6**
	3		4	Practice Heating and Cooling Load Analysis for building drawings using BIM					1		**6**
			5	CIE 3– Written and practice test				Assessment Review and corrective action			**3**
			6	Industry Class on use of BIM software in a Particular Application + Industry Assignment			5				
8	3		1	Tutorial (Peer discussion on Industrial assignment)		4		Creating Logical Systems • Create and manage air systems • Configure duct connectors. • Select Mechanical Equipment Components-Air Conditioning / Handling Units, VAV Boxes, Heating and Cooling Elements • Select Duct types and perform Duct Routing				**3**
	3		2	Apply/ Practice, the above concepts of logical systems for the given building drawing					1		**6**
	3		3	Create Piping systems • Adjusting Fittings and Extending the Design • Selecting Fittings for Routing Preferences • Choosing Pipe Materials and Sizes • Adjusting the Pipe Sizing Table • Perform Pipe routing • Using Pipe Fitting Controls			3	Apply/Practice the above concepts of piping systems for the given building drawing			**3**

				• Placing Valves • Adding Piping Insulation							
	3		4	Apply/Practice the above concepts of piping systems for the given building drawing				1		**6**
	3		5	Developmental Weekly Assessment			Assessment Review and corrective action			**3**
			6	Industry Class on use of BIM software to design Duct and Piping's for a Particular HVAC Application+ Industry Assignment		**5**				
9	3		1	Tutorial (Peer discussion on Industrial assignment)	4		Design an HVAC system for a Multi storey residential building using BIM software			**3**
	3		2	Design an HVAC system for a Commercial building using BIM software				1		**6**
	3		3	Design an HVAC system for an Auditorium using BIM software				1		**6**
	3		4	Design an HVAC system for a cold storage using BIM software				1		**6**
			5	CIE 4– Written and practice test			Assessment Review and corrective action			**3**
			6	Industry class on Safety and Maintenance of an HVAC system + Industry assignment		**5**				
10	3		1	Tutorial (Peer discussion on Industrial assignment)	4		Building Management System(BMS): • The BMS system and its components • The architecture & different levels of the BMS system • The different common protocols used for BMS system and the most used protocol.	3		
			2	• The different HVAC systems which can be controlled & monitored by the BMS system • Understanding the types of I/O points and their types • Define the cable types which are being used with the BMS system	4		• The BMS riser diagram and how to read it • The different types of documents used with the BMS system submittal	3		
			3	• The different benefits of using BMS system in a building	4		• Understanding the different methods to connect devices in the BMS system	3		

				• The common field devices & sensors used with MEP systems in buildings and how to choose them from the catalogue				• The BMS Schematic diagram and how to read it • Understanding the Graphics of BMS			
			4	Virtual Visit on BMS + Industry Assignment			4	Virtual Visit on BMS			**3**
			5	Developmental Weekly Assessment				Assessment Review and corrective action			**3**
			6	Industry Class on BMS + Industry Assignment			**5**				
Week	**C O**	**P O**	**Days**	**1st session (9am to 1 pm)**	**L**	**T**	**P**	**2ND session (1.30pm to 4.30pm)**	**L**	**T**	**P**
11	2		1	Tutorial (Peer discussion on Industrial assignment)		4		**Interpreting the tender Document:** An organization is setting up a Multi Training Facility building in its campus. The Director invited tenders for Air conditioning work to be carried out for their building. The HVAC tender requirements for this is given in the Annexure at the end of the curriculum • Analyse the tender Requirements and specifications • Make cohort in to sub teams • Sub team as a Vendor, wishes to participate in the tender process • Sub team needs to discuss and prepare a tender Response Document • Conduct Mock tender bids. **Note:** For electrical estimation, use the expertise of electrical faculty. Consult Civil faculty for building drawing issues. Neglect Inspection and Testing data in the document.			**3**
	2		2	An organization is setting up a Multi Training Facility building in its campus. The Director invited tenders for Air conditioning work to be carried out for their building. The HVAC tender requirements for this are given in the Annexure at the end of the curriculum							**7**

				• Analyse the tender Requirements and specifications • Make cohort in to sub teams • Sub team as a Vendor, wishes to participate in the tender process • Sub team needs to discuss and prepare a tender Response • Conduct Mock tender bids. **Note:** For electrical estimation, use the expertise of electrical faculty. Consult Civil faculty for building drawing issues. Neglect Inspection and Testing data in the document.							
	2		3	An organization is setting up a Multi Training Facility building in its campus. The Director invited tenders for Air conditioning work to be carried out for their building. The HVAC tender requirements for this are given in the Annexure at the end of the curriculum • Analyse the tender Requirements and specifications • Make cohort in to sub teams • Sub team as a Vendor, wishes to participate in the tender process • Sub team needs to discuss and prepare a tender Response • Conduct Mock tender bids. **Note:** For electrical estimation, use the expertise of electrical faculty. Consult Civil faculty for building drawing issues. Neglect Inspection and Testing data in the document							**7**
	2		4	An organization is setting up a Multi Training Facility building in its campus. The Director invited tenders for Air conditioning work to be carried out for their building. The HVAC tender requirements for this are given in the Annexure at the end of the curriculum • Analyse the tender Requirements and specifications • Make cohort in to sub teams • Sub team as a Vendor, wishes to participate in the tender process • Sub team needs to discuss and prepare a tender Response • Conduct Mock tender bids. **Note:** For electrical estimation, use the expertise of electrical faculty. Consult Civil faculty for building drawing issues. Neglect Inspection and Testing data in the document Outcome of this Week is: • Must be able to interpret the HVAC Drawings • Understand the Specifications of the equipment. • Select equipment based on Specifications and Requirements along with cost.							**7**
			5	CIE 5– Written and practice test				Assessment Review and corrective action			**3**
			6	Industry Class on Tendering process + Industry assignment			5				

12	4		1	Tutorial (Peer discussion on Industrial assignment)				**Green Buildings and HVAC** • Discuss Green building and its importance in sustainable Planning • Characteristics of green buildings • Demonstrate Life Cycle Assessment	1		**2**
	4		2	LEED (Leadership in Energy and Environmental Design) Certification, Requirements, Benefits Green Building HVAC- Designing for Energy Efficiency: Through Building Simulation (Demo)	2		**2**	Discuss design Measures to reduce Heat Load and increase energy efficiency of the building with techniques like • Solar passive techniques • Building orientation • Proper Shading • Window Wall Ratio • Building Envelope	3		
	4		3	Strategies adopted in the HVAC system to meet green building requirements- • Selection of Chiller • Variable Speed Drives for Pumps • Fans and Compressors • Dedicated Outdoor Air Systems • Supply Air System Control • Demand Control Ventilation • Air to Air Heat Recovery System • Thermal Storage System for Cooling • Gas Fired Chillers Control cooling tower fans by sensing ambient wet bulb temperature	3		**1**	**Case study on environmental benefits through energy savings in HVAC system**	1		2
	4		4	Adding intelligence to HVAC solutions- (Video's) • Occupant-based thermal comfort strategies • Decoupling of ventilation and heating/cooling	2		2	**Case studies to demonstrate energy saving potentials from HVAC in Green Buildings**			**3**

				• Indirect evaporative cooling **A Case Study on Energy Efficient Green Building with New Intelligent Techniques Used in HVAC to Achieve Sustainable Development Goal**							
			5	Developmental Weekly Assessment				Assessment Review and corrective action			**3**

References:

1. ASHRAE HANDBOOK on Heating, Ventilating, and Air-Conditioning APPLICATIONS
2. Air Conditioning A practical introduction by David V. Chadderton
3. Air Conditioning Applications and Design by W. P. Jones
4. Air-Conditioning and Refrigeration by Shan K. Wang and Zalman Lavan
5. Air-Conditioning System Design Manual by Walter Grondzik
6. General Specifications For Heating, Ventilation & Air-Conditioning (HVAC) Works (2017) published by CPWD
7. HANDBOOK OF AIR CONDITIONING AND REFRIGERATION by Shan K. Wang
8. HVAC Equations, Data, and Rules of Thumb by Arthur A. Bell Jr., PE
9. HVAC Systems Testing, Adjusting & Balancing By Sheet Metal And Air Conditioning Contractors' National Association, Inc
10. Fundamentals of HVAC Systems by Robert McDowall, P.
11. A Text Book of Refiguration and Air conditioning by R S Kurmi and J K Gupta
12. A Text Book of Refiguration and Air conditioning by C P Arora
13. BIM handbook: A guide to building information modelling for owners, managers, designers, engineers and contractor
14. Building Information Modelling for Dummies by Stefan Mordue
15. A Practical Guide to Adopting BIM in Construction Projects by Prof Bimal Kumar

Automation and Robotics

Course Code- **L:T:P**

Introduction:

Welcome to the curriculum for the Specialisation Pathway – **Automation and Robotics**. This specialisation course is taught in Bootcamp mode. Bootcamps are 12 weeks, intense learning sessions designed to prepare you for the practical world – ready for either industry or becoming an entrepreneur.

Automation is the process of use of automatic devices and controls in mechanized production line. It is applied to variety of systems in which there is a significant substitution of mechanical, electrical, or computerized action for human effort and intelligence. Automation technology has matured to a point where a number of other technologies have developed from it and have achieved a recognition and status of their own. Robotics is one of these technologies. Robots can work in hazardous conditions, such as poor lighting, toxic chemicals, or tight spaces. They are capable of lifting heavy loads without injury or tiring. Robots increase worker safety by preventing accidents. In addition to these, automated robotics makes production efficient, responsive, flexible and innovative which are key elements of staying competitive. Henceforth, is the Specialization pathway - **Automation and Robotics**

You will be assisted through the course, with development-based assessments to enable progressive learning. In this course, you'll learn how to Automate different activities in various applications and also incorporate Robots for required activities in an automation system.

Leading to the successful completion of this bootcamp, you shall be equipped to either do an **Internship** in an organisation working on **Automation and Robotics** or take up a **Project** in the related field. After the completion of your Diploma, you shall be ready to take up roles like Automation Engineer, Floor shop Manager, Production In-charge and also can become Entrepreneur in the related field and more.
This course will teach you about Designing an Automation system with or without Robots, Selection of the equipment's for an Automation and Robotics System, integrate SCADA and IoT in Automation system and more. Details of the curriculum is presented in the sections below

Course Outcomes: At the end of the Course, the student will be able to:

CO-01	Identify the possibilities of automation in a production system
CO-02	Select the Hardware components required for Automation and establish communication network by using industry standard protocol
CO-03	Develop, simulate, interface and Execute an Automation system for a given Application
CO-04	Develop, simulate, interface and Execute Robot Program for a specified process in an Automation system
CO- 05	Integrate HMI, SCADA and IIOT in an automation system

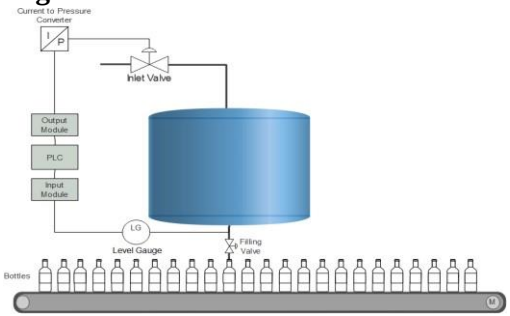
Detailed Course Content

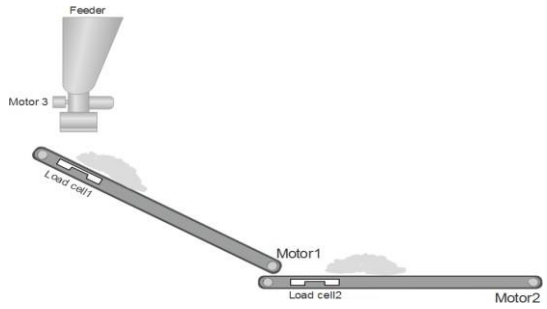
Week	C O	P O	Days	1st session (9am to 1 pm)	L	T	P	2ND session (1.30pm to 4.30pm)	L	T	P
1	1		1	Present an overview on Conventional Production process starting from procurement of raw materials to finished product and delivery to the customer			4	Virtual tour on modern industries such as automobile sector, aviation sector, Fast Moving Consumer Goods (FMCG) sector etc. Discuss Hierarchy of Industrial Automation, Industrial Automation pyramid. Present an Overview on the Levels of Automation- • Device level • Machine Level • Cell Level • Plant Level • Enterprise Level	1		**2**
	1		2	• Understand Design Thinking as a problem-solving process. • Impact of design thinking on design, manufacturing and delivery • Describe the principles of Design Thinking • Discuss the feasibility of the operations that can be Automated in a Production system • Identify the operations that cannot be Automated in a Production system and requires human intervention	2		2	Importance of Industrial automation in the Indian manufacturing industry Challenges and Limitations of industrial automations Present an Overview of Industry 4.0 and Challenges in implementation of Industry 4.0 in India	1		**2**

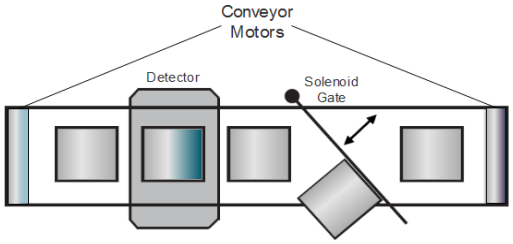
	1,2		3	Recap on Technologies adopted in Automation Demonstrate- • Sensors Technology • Drives and Actuators • Relays and Switches • PLC and Programming • Communication Protocols -	1		3	Modern tools used for Industrial Automation- PAC, SCADA, HMI, DCS, AI, IIOT, etc Importance of IEC, ISO, NEMA, JIC and other standards used in automation.	2		1
	1,3		4	Programmable Automation Controllers (PACs)-Role of PACs in modern industries. Discuss Proportional Integral Derivative (PID)- Proportional Response, Integral Response, Derivative Response, Demonstrate Applications of PAC and PID	2		**2**	Programming with IEC 61131-3 Languages • Ladder Diagrams • Structural Text language • Sequential function Chart • Functional Block diagram • Instruction List	1		**2**
			5	**Developmental Weekly Assessment**				**Assessment Review and corrective action**			**3**
			6	**Industry Class on Sensors and Actuators + Industry Assignment**			5				
2	3		1	**PEER Discussion on Industry Assignment**		4		Recap and Practice PLC Ladder Diagram for Logic Gates, Timers, Counters	1		**2**
	3		2	Explain and Practice PLC Ladder Diagram for Compare, Jump and Subroutines	**1**		**3**	Explain and Practice PLC Ladder Diagram for Math Instructions and Shift Registers	1		**2**
	3		3	Explain and Practice PLC Program using Functional Block Diagram	**1**		**3**	Explain and Practice PLC Program using Functional Block Diagram	1		**2**
	3		4	Explain and Practice PLC Program using Structural Text language	**1**		**3**	Explain and Practice PLC Program using Structural Text language	1		**2**
			5	**Developmental Weekly Assessment**				**Assessment Review and corrective action**			3

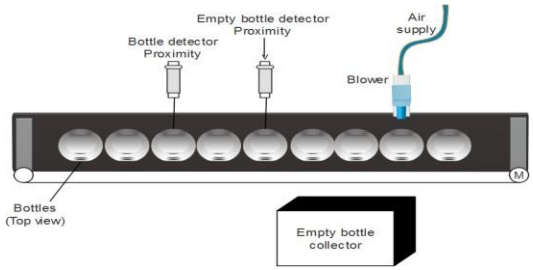
			6	**Industry Class on PLC Programs practiced in Industry + Industry Assignment**			5				
3	2		1	**PEER Discussion on Industry Assignment**		4		Explain and demonstrate how to establish communication network with PLC systems using industry standard communication protocols for data transfer • Serial Communications • ASCII Functions • Parallel Communications	1		**2**
	2		2	Explain and demonstrate different types of networking architecture Explain OSI model of networking Networking hardware	2		**2**	Demonstrate TCP/IP Protocol Introduction to IP Address, Subnet Mask, Networking Devices, Network topology	2		**2**
	2		3	Demonstrate Industrial Automation Communication Protocols - RS232-422-485 standards	2		**2**	Demonstrate the Network standards, Modbus, CAN bus, ControlNet, Ethernet, Profibus, FIP I/O, Static and Dynamic Routing principle	2		**2**
	2		4	Demonstrate HART, DH-485 and Foundation fieldbus etc. Concepts of Wireless Networking	2		**2**	Latest trends in PLC communication protocols. Fundamental Parts and Characteristics of PLC communication Protocol Demonstrate Peer to Peer (PLC to PLC) & PLC to PC Communication protocols	1		**2**
			5	**CIE 1– Written and practice test**				**Assessment Review and corrective action**			3
			6	**Industry Class on Communication Protocol practiced in industry + Industry Assignment**			5				
4	5		1	**PEER Discussion on Industry Assignment**		4		• HMI (Human Machine Interface) - Types- Selection- Specifications PLC with colour Touch screen Human Machine Interface (HMI): • Colour Touch Screen HMI panels and specifications, various industry interfaces on HMI panels, features of HMI panels	1		**2**

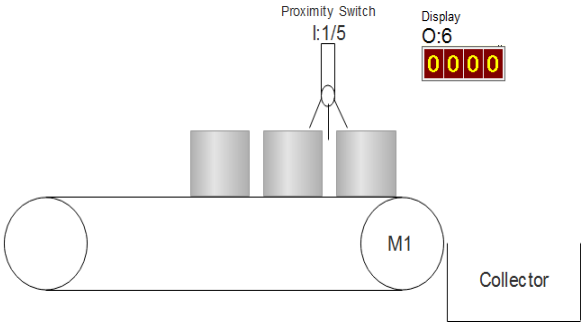
	5		2	Working with HMI software Tool • Configure PLC with HMI • Animation with graphical objects • Animate objects on an HMI screen to monitor motor status • Trend the data of a process parameter using a trend tool. • Create user groups and monitor screens with proper authentication. • Use security features to do tag logging and command execution	2		**2**	• Practice HMI programming involving alarms, trends and bar graphs	1		**2**
	5		3	• Practice control of a Motor through HMI						2		**5**
	5		4	Supervisory data control and acquisition system (SCADA) • Concepts of SCADA systems • SCADA hardware i. Field level instrumentation and control devices ii. RTU- Remote terminal unit iii. Communication systems iv. Master control station v. Data processing computer systems vi. Creating and Editing tax vii. Creating Graphs and bar charts, Alarm configuration, Trends (Real time and Historical), Report generation • SCADA Protocols • Application of SCADA	4			Practice control of a Motor through SCADA software	1		**2**
			5	**Developmental Weekly Assessment**				**Assessment Review and corrective action**			**3**
			6	**Industry Class on HMI and SCADA + Industry Assignment**			5				
5	3		1	**PEER Discussion on Industry Assignment**		4		**Problem Statement**: Bottle filling has a constant speed of filling 20 bottles per minute. This speed	1		**2**

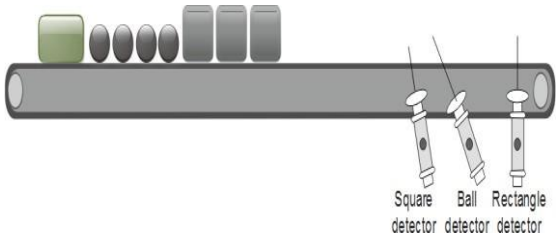
								depends on level of the tank due to its head pressure. To maintain this speed, pressure head of the filling tank has to be maintained at a particular level. Implement this automation in PLC using Ladder Diagram programming language **Diagram:**  **Condition:** To continuously maintain constant Pressure in the tank i) For the above case, Discuss the suitable sensor technology, PLC, Drives, Communication Protocol and Related Hardware components ii) Select Hardware components from the Company catalogue and record their specifications in a DATA Sheet iii) Develop a PLC Ladder Program for the above case, simulate, interface with PLC and execute iv) Discuss the Applications of the above Case			

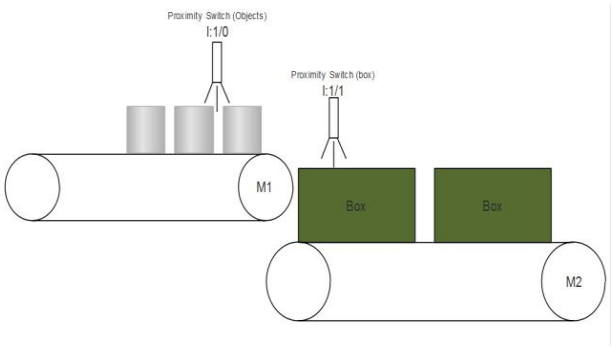
	3		2	**Problem Statement**: A feeder drops material on the conveyor which sends material for further process through one more conveyor. Conveyor must start automatically when material is dropped on it. Implement automation of this in PLC using Ladder Diagram programming language. **Diagram:**  **Condition:** • Feeder has a motor mounted to feed material on conveyor belts. • Load cells are installed at the bottom of conveyor belts to detect if material is present on the conveyor belt. • When material falls on conveyor belt 1, motor 1 should start, and when material in present on conveyor belt 2, motor 2 remain On. • Switches can also be used sometimes to detect material's presence. But for more reliable operation, Load cells can be used as shown in the diagram above a) For the above case, Discuss the suitable sensor technology, PLC, Drives, Communication Protocol and Related Hardware components b) Select Hardware components from the Company catalogue and record their specifications in a DATA Sheet	2		**5**

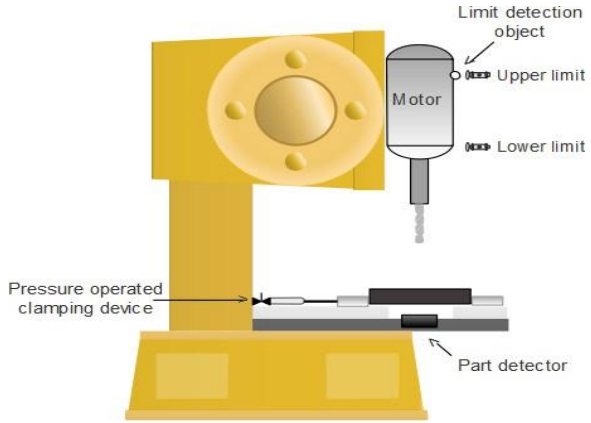
				c) Develop a PLC Ladder Program for the above case, simulate, interface with PLC and execute d) Discuss the Applications of the above Case			
	3		3	**Problem Statement:** Parts are moving on the conveyor from one process line to other with a constant speed. Out of 1000-part, one part is taken out for quality check. Implement automation of this in PLC using Ladder Diagram programming language. **Diagram:**  **Condition:** • To detect the parts, detector such as proximity switch, optical sensors or any other sensor is used. • Connect output of this detector to Input Module of PLC which sets and resets image memory according to parts' detection. • Give this detection, as an input to Up Counter which is incremented with each part's detection. • Set counter preset value to 1000. • Operate Solenoid for a few seconds until the part is diverted for quality check. a) For the above case, Discuss the suitable sensor technology, PLC, Drives, Communication Protocol and Related Hardware components b) Select Hardware components from the Company catalogue and record their specifications in a DATA Sheet c) Develop a PLC Ladder Program for the above case, simulate, interface with PLC and execute d) Discuss the Applications of the above Case	2		**5**

	3		4	**Problem Statement:** After filling process, bottles are moved on the conveyor belt for packing process. Detect if any empty bottle is left on the conveyor and remove it from the conveyor. Implement automation of this in PLC using Ladder Diagram programming language. **Diagram:**  **Condition:** • Proximity sensors are used to detect bottles. • One proximity is calibrated such that it detects all the bottles passing on the conveyor. And other proximity is used such that it detects only empty bottle. • Use Bit Shift Register to shift a bit which is set when an empty bottle is detected. • Use a Pneumatic Cylinder or blower to throw an empty bottle out of the conveyor a) For the above case, Discuss the suitable sensor technology, PLC, Drives, Communication Protocol and Related Hardware components b) Select Hardware components from the Company catalogue and record their specifications in a DATA Sheet c) Develop a PLC Ladder Program for the above case, simulate, interface with PLC and execute d) Discuss the Applications of the above Case							2		**5**
			5	**CIE 2– Written and practice test**				**Assessment Review and corrective action**				**3**

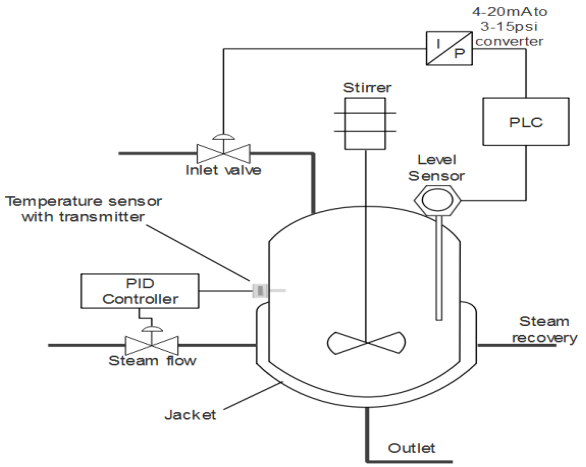
			6	**Industry Class on Automation in Industry + Industry Assignment**			5				
6	3		1	**PEER Discussion on Industry Assignment**		4		**Problem Statement**: Parts are moved on the conveyor. Count the number of parts collected at the end of the conveyor and display it on the display in PLC using Ladder Diagram programming language. **Diagram:**  **Condition:** • Mount Proximity Switch to detect the parts. • Use output of proximity to counter as an input to increment data. • Convert this number into appropriate numerical and show number of parts collected. • Use Inductive or Capacitive Proximity switches are Depending on Metal or Non-Metal • Mount this sensor according to the size of parts present on the conveyor and width of conveyor so that this sensor can detect parts easily. • CUP is used to increment the number of parts collected.	1		**2**

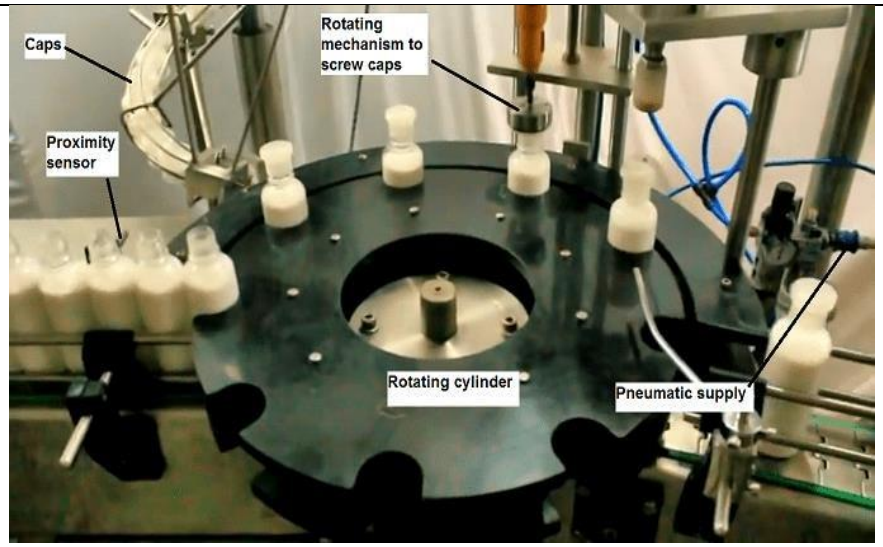
								a) For the above case, Discuss the suitable sensor technology, PLC, Drives, Communication Protocol and Related Hardware components b) Select Hardware components from the Company catalogue and record their specifications in a DATA Sheet c) Develop a PLC Ladder Program for the above case, simulate, interface with PLC and execute d) Discuss the Applications of the above Case			
	3		2	**Problem Statement**: Different objects are moving on a conveyor belt. Let's say, circular balls, square blocks and rectangular blocks. All three types of objects are collected in the same sized box. As these types are different in size and shapes as well, number of objects to be placed are different for each type. Set counter value according to different sized objects' detection. Implement automation of this in PLC using Ladder Diagram programming language. **Diagram:**  **Condition:** • Use three different proximity switches to detect all three different objects.							2		**5**

				• Mount these switches such that switches detect assigned object only. For example, mount Square detector proximity such that it neither detects Rectangular blocks nor Balls. • Load counter values in registers for different objects. And load this value as soon as a particular type of object is detected. a) For the above case, Discuss the suitable sensor technology, PLC, Drives, Communication Protocol and Related Hardware components b) Select Hardware components from the Company catalogue and record their specifications in a DATA Sheet c) Develop a PLC Ladder Program for the above case, simulate, interface with PLC and execute d) Discuss the Applications of the above Case			
	3		3	**Problem Statement**: Objects are moving on a conveyor belt 1. When an empty box is detected, conveyor belt starts and 5pcs are packed in a box. When box is filled, it is carried to the storage area via conveyor belt 2. Implement automation of this process in PLC using Ladder Diagram programming language. **Diagram:**  **Condition:**	2		**5**

				• Use proximity switches to detect moving objects on the conveyor belt 1 and to detect an empty box on conveyor belt 2. • Use counter to count number of objects to be packed. • Use timer such that when 5pcs are detected, conveyor runs for a while and stops when 5th object is finally collected in the box. Assume time by calculating conveyor belt speed. • When number of parts to be packed are detected timer is activated. When timer is over, it stops the conveyor until next empty box is detected. • Assuming time taken by the last 5th object is 2secs to be collected. a) For the above case, Discuss the suitable sensor technology, PLC, Drives, Communication Protocol and Related Hardware components b) Select Hardware components from the Company catalogue and record their specifications in a DATA Sheet c) Develop a PLC Ladder Program for the above case, simulate, interface with PLC and execute d) Discuss the Applications of the above Case			
	3		4	**Problem Statement:** Whenever a part is placed on the drilling table, pneumatic clamper clamps the part and drilling process is done. On completing the drilling process, the clamper releases the part by releasing pressure. When another part is detected, the process is repeated. Implement this in PLC using Ladder Diagram programming language **Diagram:**  **Condition:**	2		**5**

				• Set lower and upper limit of a motor to stop and start the drilling process. This is done for precise drilling and to obtain uniformity. • Pressure operated clamping device is used to hold the objects firmly. This is operated by air supply which is provided when an object is detected. • Limit detection object is placed on the motor to detect upper and lower limit by the switches. a) For the above case, Discuss the suitable sensor technology, PLC, Drives, Communication Protocol and Related Hardware components b) Select Hardware components from the Company catalogue and record their specifications in a DATA Sheet c) Develop a PLC Ladder Program for the above case, simulate, interface with PLC and execute d) Discuss the Applications of the above Case in other machines						
			5	**Developmental Weekly Assessment**				**Assessment Review and corrective action**			3
			6	**Industry Class on Trends in Automation + Industry Assignment**			5				
	3		1	**PEER Discussion on Industry Assignment**		4		**Problem Statement:** Implement automation to control Continuous Stirred Tank Reactor of a chemical plant in PLC using Ladder Diagram programming language **Diagram:**	1		**2**

7								 **Condition:** • Three parameters are controlled in this reactor. Temperature, Flow and Level of the tank • Use PID Controller For the Above case, Develop a PLC program			
	3		2	**Problem Statement:** Water bottles are moved on a conveyor for capping. Screw caps are screwed to close the opening end of the bottle using rotating mechanism. Implement this in PLC using Ladder Diagram programming language **Diagram:**					2		**5**



Condition:

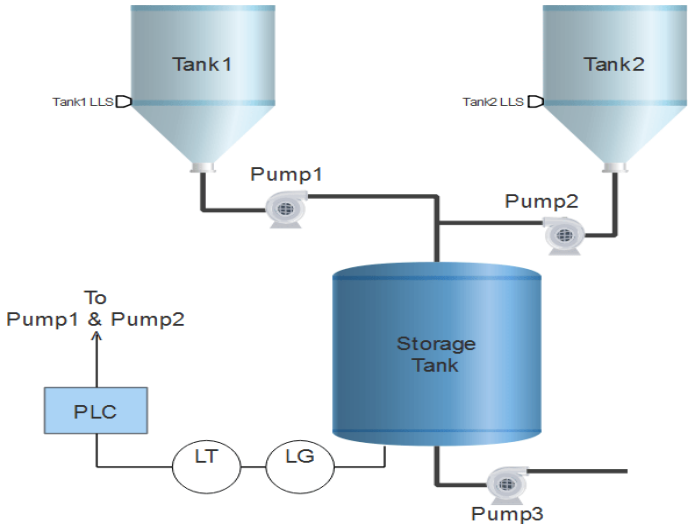
- To sense the bottle, proximity sensor is used.
- Used a timer to stop the cylinder motor for 2secs to screw caps.
- Used one more timer to run the motor for 1sec to rotate the cylinder.
- Bit Shift register is also used to perform this operation.
- Count the number of steps capping machine is placed from the sensor and set bit position to operate capping machine accordingly.
- In this example as you can see, bottle is 7 steps away from the proximity switch, so if Bit register B3:0 is used, then capping machine should be operated when B3:0/0 is shifted to B3:0/6.
- Two inputs are given to this Capping machine, electric supply to run motor and pneumatic supply to push machine down cap ram.

a) For the above case, Discuss the suitable sensor technology, PLC, Drives, Communication Protocol and Related Hardware components

b) Select Hardware components from the Company catalogue and record their specifications in a DATA Sheet

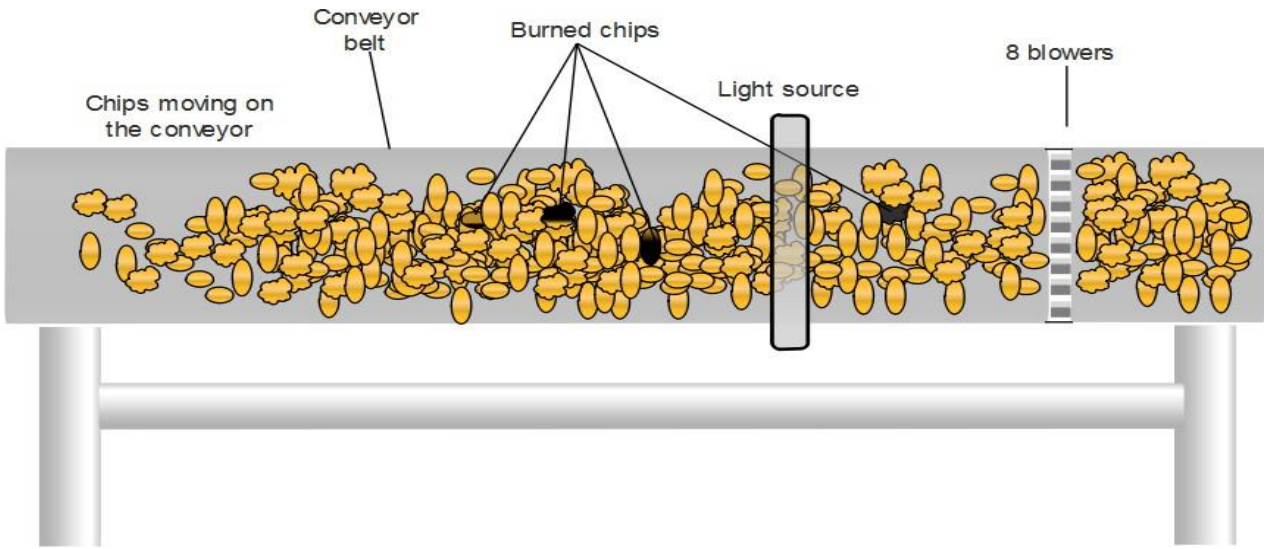
c) Develop a PLC Ladder Program for the above case, simulate, interface with PLC and execute

d) Discuss the Applications of the above case

	3		3	**Problem Statement:** Two tanks have same products filled. Draining from these depends on the requirement from the storage tank. Implement automation in this Drainage tank using with PLC using Ladder Diagram programming language **Diagram:**  **Condition:** • Level gauge is used to measure level of the storage tank continuously • Level gauge is connected with Level Transmitter which converts corresponding level output in 4-20mA equivalent. • Analog I/O Modules are chosen to deal with Analog signals. • Pumps are used to drain material from both the tanks at the same time. • Two low level switches are used to detect low level of tanks 1 and 2 which turns Pumps OFF when low level is reached. • Height of storage tank is 5meters that is 500cm and the level which is to be maintained is 470cm. a) For the above case, Discuss the suitable sensor technology, PLC, Drives, Communication Protocol and Related Hardware components b) Select Hardware components from the Company catalogue and record their specifications in a DATA Sheet c) Develop a PLC Ladder Program for the above case, simulate, interface with PLC and execute	2		**5**

				d) Discuss the Applications of the above Case			
	3		4	**Problem Statement:** Potato chips are made and ready to be packed. But before that, it goes through a conveyor in which final quality check is done, burnt chips are detected and removed from the process line. Implement this in PLC using Ladder Diagram programming language	2		**5**

Diagram:

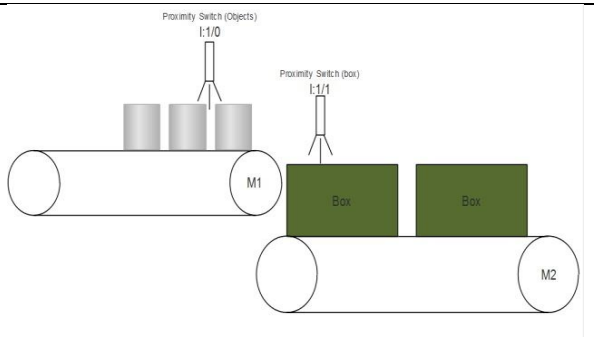


Condition:

- To detect burned chips, light source and sensors are used.
- Light source is used so light detectors such as Light Dependent Resistors are used to detect the burned chips.
- Blowers are used to throw burned chips away from the conveyor when detected.
- There are total number of 8 blowers. Number of blowers to be used depends on the width of a conveyor belt.
- Time measurement of an event to take place can be used here to measure what time burned chips take to reach from light source to blowers when detected.
- Set this time as pre-set of a timer to operate particular blower.
- There are 8 blowers, so 8 light detecting circuits must be used in order to operate all blowers.
- Let us assume we are using Light Dependent Resistor. To use this resistor, threshold has to be set that is darkest color to be passed as a good quality product. If chips are darker than the desired level, light source detects it and activates corresponding circuit.
- So, output of this circuit is normally high and to activate blower, normally low logic has to be set while programming or we can even invert output from LDR circuit.

				Develop a PLC Ladder Program for the above case							
			5	**CIE 3– Written and practice test**				**Assessment Review and corrective action**			**3**
			6	**Industry Class on Automation in process industry + Industry Assignment**			5				
8	4		1	**PEER Discussion on Industry Assignment**		4		Concepts of Industrial Robots, Applications of Robotics, Types of robots, Configurations of robots – Articulated Robot, Polar configuration, SCARA, Cartesian Co-ordinate Robot, Delta Robot, Key Components of Robot.	3		
	4		2	Demonstrate Wrist configuration, Work Volume Degree of Freedom- Forward and Back, Up and Down, Left and Right, Pitch, Yaw, Roll, Joint Notation & Type of joints in robot- Linear Joint (L Joint), Orthogonal Joint (O Joint), Rotational Joint (R Joint), Twisting Joint (T Joint), Revolving Joint (V Joint)	2		**2**	End Effectors- Grippers, Tools, Types of grippers, Factors to be considered for Selecting a Gripper, Robotic Drives- Electric Drive, Pneumatic Drive, Hydraulic Drive	3		
	4		3	Demonstrate Robot Control systems- • Point- to Point control Systems • Continuous Path Control • Intelligent control • Controller Components • System Control	1		**3**	Present a Robotic Coordinate system using a robot • Joint co-ordinate system • Rectangular co-ordinate system • User or object coordinate system • Tool coordinate system. Steps to define user co-ordinate system. • Defining X, Y, Z co-ordinate system • Verifying co-ordinate system by multiple motion movements.	1		**2**
	4		4	Jogging Practice on robot with different coordinate systems					2		**5**
			5	**Developmental Weekly Assessment**				**Assessment Review and corrective action**			3
			6	**Industry Class on interfacing of Robots with peripheral devices + Industry Assignment**			5				
9	4		1	**PEER Discussion on Industry Assignment**				Introduction about Simulation software. Creating new model in Simulation Software.	1		**2**

								Importing different types of robots Identify the position variation in robots Perform Robot axis movements			
	4		2	Practice simple robot program using simulation software					2		**5**
	4		3	Practice simple robot program using simulation software					2		**5**
	4		4	Practice simple robot program using simulation software					2		**5**
			5	**CIE 4– Written and practice test**				**Assessment Review and corrective action**			**3**
			6	**Industry Class on Robot Programming + Industry Assignment**			5				
10	4		1	**PEER Discussion on Industry Assignment**		4		Develop a simple welding Robot program and simulate using suitable software.	1		**2**
	4		2	Develop a simple welding Robot program and simulate using suitable software					2		**5**
	4		3	Interface the above welding program with a Physical Robot Consider all required parameters and Tools and Execute the same. Perform Quality check					2		**5**
	4		4	Interface the above welding program with a Physical Robot Consider all required parameters and Tools and Execute the same.					**2**		**5**
			5	**Developmental Weekly Assessment**				**Assessment Review and corrective action**			**3**
			6	**Industry Class on Robots in Welding + Industry Assignment**			5				
11	4		1	**PEER Discussion on Industry Assignment**		4		**Problem Statement**: Objects are moving on a conveyor belt 1. When an empty box is detected, conveyor belt starts and 5pcs are packed in a box. When box is filled, it is carried to the storage area via conveyor belt 2. Integrate a robot with the system to pick the filled box from conveyor belt 2 and place it on a fork lift truck	1		**2**

								 **Develop and execute an Automated system for the above condition**			
	4		2	**Develop and execute the above Automated system**					2		**5**
	4		3	**Develop and execute the above Automated system**					2		**5**
			4	**Develop and execute the above Automated system**					2		**5**
			5	**CIE 5– Written and practice test**				**Assessment Review and corrective action**			**3**
			6	**Industry Class on Robot for PICK and PLACE + Industry Assignment**			5				
12	5		1	**PEER Discussion on Industry Assignment**		4		• Concepts of IIOT- How it works • How IIoT is Improving Operational Effectiveness Transforming Legacy Systems, Greater Energy Efficiency, Data Analytics Get Smarter, Cobots Bring Connected Support to Human workers, Digital Twins are Gaining Traction Among Enterprises	1		**2**
	5		2	• Convergence of Operation Technology and Information Technology • Technologies which bring Convergence of OT and IT ➢ No code Application ➢ Digital Twins ➢ Augmented Reality ➢ Edge computing	4			BENEFITS OF IIOT • Improving Inventory Management • Simplified process control • Cloud-Based Inventory Systems • Gain Supply Chain Visibility • Improves Product Design & Quality Controls			**3**

								• Real-Time Insights Provide Greater Business Agility • Location Tracking Offers Surprising Cost Savings • Reduced Downtime and Repair Costs via Predictive Maintenance, Safety and Compliance			
	5		3	• Risks and Challenges Associated with IIOT • Security considerations for IIOT ➢ Cybersecurity challenge ➢ Potential Human Impact ➢ Murky Regulatory Guidance ➢ Data Management ➢ Interoperability challenges ➢ Cyber hacking ➢ IP Leakage ➢ Production Sabotage	4			• Concept of Artificial Intelligence (AI) • Bringing the power of AI to the IOT ➢ Edge computing ➢ Collaborative robots (COBOTS) ➢ Digital twins ➢ Autonomous Delivery robots • Selecting right IIOT platform and Partner	3		
	5		4	• **Case study -** IIoT with other emerging technologies			4	• **Case study -** IIoT with other emerging technologies			**3**

References:

1 Programmable logic Controllers by W. BOLTON

2 Digital electronics By FLYOD

3 Exploring PLC with applications By PRADEEP KUMAR SRIVATSAVA

4 Automation, Production systems and Computer integrated Manufacturing By MIKELL GROOVER

5 Sensors Hand book-SABRIE SOLOMAN-MC-GRAW HILL publications

6 Hand book of Modern Sensors, Physics, Designs and Applications- JACOB FRADEN-Springer Publications

7 Electric Motors and Drives BY AUSTIN HUGHES and BILL DRURY

8 Automating Manufacturing Systems with PLC by Hugh Jack

9 Thomas Braunl, Embedded Robotics: Mobile Robot Design and Application with Embedded Systems, 2nd ed., Springer, 2006.

10 John M. Holland, Designing Autonomous Mobil Robots: Inside the Mind of an Intelligent Machine, Newnes, 2003.

11 Springer Handbook of Automation by Shimon Y. N

12 Industrial Robotics technology, programming and Application by Mikelle P Groover

13 SCADA: Supervisory Control and Data Acquisition, Fourth Edition by A_Boyer

14 PLCs & SCADA - Theory and Practice First Edition, Kindle Edition by Rajesh Mehra and Vikrant Vij

15 The Internet of things by Samuel Greengard

16 Getting Started with Internet of Things by Cuno Pfister

Advanced Manufacturing Technologies

Course Code- **L:T:P**

Introduction:

Welcome to the curriculum for the Specialisation Pathway – **ADVANCED MANUFACTURING Technologies.** This specialisation course is taught in Bootcamp mode. Bootcamps are 12 weeks, intense learning sessions designed to prepare you for the practical world – ready for either industry or becoming an entrepreneur. You will be assisted through the course, with development-based assessments to enable progressive learning.

Conventional manufacturing processes, have their inherent drawbacks which cannot be eliminated. In other words, due to their technological constraints, it is not always feasible to produce various components in terms of geometry, dimension, and strength, etc. CNC machining can have difficulties in machining complex shapes due to tool accessibility. High temperature and tool wear are other considerations while machining hard materials.

Advancement in manufacturing processes has drawn preeminent interest from researchers and industry. This makes the process of manufacturing more productive and highly efficient. Advancement of technology has been done by several approaches to combine different manufacturing processes with similar objectives of increasing material removal rate, improving surface integrity, reducing tool wear, reducing production time, and extending application areas. A combination of different processes opens new opportunities and applications for manufacturing various components that are not able to be produced economically by processes on their own.

In this course, you'll learn how to Select a suitable materials and Processes in Advanced manufacturing in accordance with the present Manufacturing Scenario.

Leading to the successful completion of this bootcamp, you shall be equipped to either do an **Internship** in an organisation working on Advanced Manufacturing solution or do a **Project** in the related field. After the completion of your Diploma, you shall be ready to take up Production Supervisor, Engineer, Production Manager and also can become Entrepreneur in the related field and more

This course will teach you about Advanced materials, Advanced Processes, Advanced Manufacturing, Advanced Inspection and Diagnostics. Details of the curriculum is presented in the section below

Course Outcomes: At the end of the Course, the student will be able to:

CO-01	Select suitable Non- Conventional Machining process with Process parameter and machine the component as per the given drawing.
CO-02	Prepare a given component by using 3D Printing manufacturing process.
CO-03	Check the components for Functionality and conformance to defined standards using Measuring instruments.
CO-04	Integrate Automation and IIOT in Advanced Manufacturing

Detailed Course Content

Week	C O	P O	Days	1st session (9am to 1 pm)	L	T	P	2ND session (1.30pm to 4.30pm)	L	T	P
1	1		1	Present an overview on Conventional manufacturing process starting from procurement of raw materials to finished product and delivery to the customer			4	Present a Video on components manufactured in Modern manufacturing Industries Virtual tour on modern industries such as automobile sector, aviation sector, Fast Moving Consumer Goods (FMCG) sector etc Present an Overview on Need, Classification and Features of Advanced manufacturing technologies with respect to • Materials • Manufacturing Processes • Automation • Inspection and Quality • Information Technology	2		1
	1		2	• Discuss the Advancement in material technology leading to advancement in Manufacturing Process • Discuss the Properties and Characteristic features of Composite materials, Steel Alloys, Aluminum alloys, Polymers, Glass, Ceramics, Super Alloys	4			• Discuss and record the Application of these materials in making components used in Aircraft, Cutting tools, high temperature applications, Automobiles etc.,	2		**1**
	1		3	• Discuss the Need and significance of non-Conventional machining process • Discuss classification of non-Conventional machining process • Explain the Principle, Construction and Working of Ultrasonic Machining Process (USM) using Videos	2		2	• Explain Tool materials and their Properties, Tool wear Rate, Abrasive material and Slurry, Work materials used in USM • Discuss the Characteristics of USM • Calculate Metal removal Rate	2		1

				• Explain different Transducers used in USM and Present them using Videos • Discuss the criteria considered for selecting the right type of transducer for the given application • Explain the Process Parameters involved in USM				• Present a Video on the Applications of USM			
	1		4	Prepare a job using USM (ON Campus/ OFF Campus) • Study the component drawing • Select the process Parameter • Perform the process • Check for dimensional accuracies					3		**4**
			5	Developmental Weekly Assessment				Assessment Review and corrective action			3
			6	Industry Class - Use Cases on USM + Industry Assignment			5				
2	1		1	Tutorial (Peer discussion on Industrial assignment)		4		• Explain Principle, Construction and Working of Electro Chemical Machining (ECM) using videos • Discuss the Types of Electrolytes and its selection for different materials	2		1
	1		2	• Discuss types of Tool material, their properties and selection • Discuss the factors governing surface finish in ECM • Discuss the Characteristics of ECM	2		2	• Calculate Metal Removal rate • Present a Videos on the Application of ECM			**3**
	1		3	• Explain Principle, Construction and Working of Chemical Machining (CM) using videos • Types of Chemical machining- Milling, Blanking, Engraving	4			• Steps involved in Chemical machining- Clean, Mask, Scribe, Etch, Demask • Commonly used Etchants- • Applications of Chemical Machining	2		1
	1		4	Prepare a job using ECM (ON Campus/ OFF Campus) • Study the component drawing			**4**	Prepare a job by Chemical Machining (ON Campus/ OFF Campus) • Study the component drawing			**4**

				• Select the process Parameter • Perform the process • Check for dimensional accuracies				• Select the process Parameter • Perform Clean, Mask, Scribe, Etch, Demask • Check for dimensional accuracies			
			5	Developmental Weekly Assessment				Assessment Review and corrective action			3
			6	Industry Class - Use Cases on ECM + Industry Assignment			**5**				
3	1		1	Tutorial (Peer discussion on Industrial assignment)		4		• Explain the Principle, Construction and Working of Electrical Discharge Machining (EDM) using videos • Discuss types and functions of Dielectric Fluid	1		2
	1		2	• Discuss types of Tool material, their properties and selection • Calculate Metal Removing Rate- Factors affecting MRR	2		2	• Explain the Process Parameters involved in EDM • Discuss the Characteristics of EDM	3		
	1		3	• Discuss and Present a Video on spark Generating circuit/Process used in EDM • Applications of EDM	1		3	• Explain the Principle, Construction and Working of Wire cut electro-Discharge Machining (WCEDM) using videos • Discuss the Features of WCEDM	1		2
	1		4	Prepare a job using – EDM (ON Campus/ OFF Campus) • Study the component drawing • Select the process Parameter • Perform the process • Check for dimensional accuracies			4	Prepare a job using – WCEDM (ON Campus/ OFF Campus) • Study the component drawing • Select the process Parameter • Perform the process • Check for dimensional accuracies			3
			5	CIE 1– Written and practice test				Assessment Review and corrective action			3
			6	Industry Class - Use cases on EDM/WCEDM+ Industry Assignment			**5**				
Week	**C O**	**P O**	**Days**	**1st session (9am to 1 pm)**	**L**	**T**	**P**	**2ND session (1.30pm to 4.30pm)**	**L**	**T**	**P**

4	1		1	Tutorial (Peer discussion on Industrial assignment)		4		• Explain the Principle, Construction and Working of Electron Beam Machining (EBM) using videos			3
	1		2	• Explain the Process Parameters that influence Beam intensity • Explain the Process Parameters that influence Metal Removal Rate	3			• Discuss the Characteristics of EBM • Calculate Metal Removal Rate • Present a Video on the Applications of EBM	2		1
	1		3	• Explain the Principle, Construction and Working of Laser Beam Machining (LBM) using videos • Discuss different Laser materials used in LBM	1		3	• Discuss the Characteristics of LBM • Calculate Metal Removal Rate • Present a Video on the Applications of LBM			3
	1		4	Prepare a job using EBM (ON Campus/ OFF Campus) • Study the component drawing • Select the process Parameter • Perform the process • Check for dimensional accuracies			4	Prepare a job using LBM (ON Campus/ OFF Campus) • Study the component drawing • Select the process Parameter • Perform the process • Check for dimensional accuracies			4
			5	Developmental Weekly Assessment				Assessment Review and corrective action			3
			6	Industry Class - use cases on EBM, LBM, PAM + Industry Assignment			**5**				
5	2		1	Tutorial (Peer discussion on Industrial assignment)		4		• Explain the General Overview on Additive Manufacturing (AM) • Present a Video on the evolution of AM, Need, Benefits • Present a Video on components made using AM	1		2
	2		2	Additive Manufacturing Technologies (AM)– Explain and Demonstrate the Additive Manufacturing Techniques- Liquid Based Additive Manufacturing 1.1 Melting 1.1.1 Fusion Deposit Modelling 1.2 Polymerization	2		2	3.0 Powder based Additive Manufacturing 3.1 Melting 3.1.1 Selective Laser Sintering 3.1.2 Electron Beam Sintering 3.1.3 Laser Engineered Net Shaping 3.2 Binding 3.2.1 3 – Dimensional Printing	1		2

				1.2.1 Stereolithography 1.2.2 Poly jet 2.0 Solid Based Additive Manufacturing 2.1 Laminated object manufacturing				3.2.2 Pro Metal (Binder Jetting)			
	2		3	Discuss the Bio-Medical, Aviation, Automobile Application of Additive Manufacturing			4	**Materials used in additive manufacturing-** Discuss the Properties and Applications of Additive manufacturing materials- • Ceramics • Plastics: Acrylonitrile Butadiene Styrene (ABS), Polylactide (PLA), Polyethylene Terephthalate (PET), Polycarbonate (PC) • Polymers	2		1
	2		4	Discuss the Properties and Applications of Additive manufacturing materials- • Metals and alloys- Cobalt based Alloys, Aluminum based Alloys, Nickel based Alloys, Stainless steel, Titanium alloys	3			Discuss the Properties and Applications of Additive manufacturing materials- • Composites- Polymer base, Metal based, Ceramic based • Smart materials- Shape memory Polymer and Alloys	3		
			5	CIE 2– Written and practice test				Assessment Review and corrective action			3
			6	Industry Class - Use case on Additive manufacturing techniques + Industry Assignment			**5**				
6	2		1	Tutorial (Peer discussion on Industrial assignment)		4		Binding Mechanisms/Techniques- 1) Discuss on Chemical induced Binding • Reactive binding • Polymerization	1		2
	2		2	2) Discuss on Secondary phase assisted binding • Adhesive Additives • Evaporation and Hydration Binding • Liquid Phase Sintering: In-Process, Post Process infiltration	1		2	3) Liquid Fusion • Low Viscous flow • Melting: Partial Melting, Full Melting 4) Solid State Sintering	1		2

	2		3	**Explain Generic AM Process** 1. 3D CAD Modelling 2. STL File Conversion 3. File transfer to machine 4. Machine Set up 5. Part building 6. Part Removing 7. Post- Process			3	• Introduction to 3 - D Printing • Discuss and demonstrate the working principle and Construction of 3-D Printing Machine • Interface CAD Software with Machine • 3-D Scanning and transferring the file to 3-D Printing machine			3
	2		4	Develop an AM Process required to produce the given Component on a 3-D Printing machine • Prepare a Solid model and convert to STL File • Select a suitable material for the given model • Perform Machine setting and upload STL file • Feed the Raw material • Develop the Model and check for accuracies					2		5
			5	Developmental Weekly Assessment				Assessment Review and corrective action			3
			6	Industry Class - Use case on prototype models prepared on 3-D Printing +Industry Assignment			5				
7	2		1	Tutorial (Peer discussion on Industrial assignment)		4		Develop an AM Process required to produce the given Component on a 3-D Printing machine • Prepare a Solid model and convert to STL File • Select a suitable material for the given model • Perform Machine setting and upload STL file • Feed the Raw material • Develop the Model and check for accuracies	3		
	2		2	Develop an AM Process required to produce the given Component on a 3-D Printing machine					2		5

				• Prepare a Solid model and convert to STL File • Select a suitable material for the given model • Perform Machine setting and upload STL file • Feed the Raw material • Develop the Model and check for accuracies							
	2		3	Develop an AM Process required to produce the given Component on a 3-D Printing machine • Prepare a Solid model and convert to STL File • Select a suitable material for the given model • Perform Machine setting and upload STL file • Feed the Raw material • Develop the Model and check for accuracies					2		5
	2		4	Develop an AM Process required to produce the given Component on a 3-D Printing machine • Prepare a Solid model and convert to STL File • Select a suitable material for the given model • Perform Machine setting and upload STL file • Feed the Raw material • Develop the Model and check for accuracies					2		5
			5	CIE 3– Written and practice test				Assessment Review and corrective action			3
			6	Industry Class on Reverse engineering and Modelling + Industry Assignment			5				
Week	**C O**	**P O**	**Days**	**1st session (9am to 1 pm)**	**L**	**T**	**P**	**2ND session (1.30pm to 4.30pm)**	**L**	**T**	**P**
8	2		1	Tutorial (Peer discussion on Industrial assignment)		4		Develop an AM Process required to produce the given Component on a 3-D Printing machine • Prepare a Solid model and convert to STL File • Select a suitable material for the given model • Perform Machine setting and upload STL file	3		

								• Feed the Raw material • Develop the Model and check for accuracies				
	2		2	Develop an AM Process required to produce the given Component on a 3-D Printing machine • Prepare a Solid model and convert to STL File • Select a suitable material for the given model • Perform Machine setting and upload STL file • Feed the Raw material • Develop the Model and check for accuracies					2		5
	2		3	Develop an AM Process required to produce the given Component on a 3-D Printing machine • Prepare a Solid model and convert to STL File • Select a suitable material for the given model • Perform Machine setting and upload STL file • Feed the Raw material • Develop the Model and check for accuracies					2		5
	2		4	Develop an AM Process required to produce the given Component on a 3-D Printing machine • Prepare a Solid model and convert to STL File • Select a suitable material for the given model • Perform Machine setting and upload STL file • Feed the Raw material • Develop the Model and check for accuracies					2		5
			5	Developmental Weekly Assessment				Assessment Review and corrective action				3
			6	Industry Class -Use case on AM + Industry Assignment			5					
9	3		1	Tutorial (Peer discussion on Industrial assignment)		4		Discuss Latest Technologies used in Inspection and Quality control	3			

	3		2	Perform measurement with desired accuracy to check the components for Functionality and conformance to defined standards using different instruments like Vernier caliper, Vernier height gauge, Micrometer, Depth Gauge, Bevel Protractor, Sine bar, Dial Indicator					2		5
	3		3	Perform measurement with desired accuracy to check the components for Functionality and conformance to defined standards using different instruments like Vernier caliper, Vernier height gauge, Micrometer, Depth Gauge, Bevel Protractor, Sine bar, Dial Indicator					2		5
	3		4	Demonstrate the construction and working Principle of Profile Projector Check the Dimensional Accuracies of the Models using Profile Projector					4		3
			5	CIE 4– Written and practice test				Assessment Review and corrective action			3
			6	Industry Class on used cases on Inspection and Quality control + Industry Assignment			5				
10	3		1	Tutorial (Peer discussion on Industrial assignment)		4		Demonstrate the construction and working Principle of Co-Ordinate Measuring Machines (CMM) using videos.	3		
	3		2	Check the Dimensional Accuracies of the Models using CMM for different Components (ON Campus/ OFF Campus)					2		5
	3		3	Check the Dimensional Accuracies of the Models using CMM for different Components (ON Campus/ OFF Campus)					2		5
	3		4	Discuss and Demonstrate different Non- Destructive testing Methods (ON Campus/ OFF Campus) • Radiography Testing • Ultrasonic Testing • Magnetic Particle Testing			4	Discuss and Demonstrate different Non- Destructive testing Methods (ON Campus/ OFF Campus) • Penetrant Testing • Visual Testing • Electromagnetic testing	1		2
			5	Developmental Weekly Assessment				Assessment Review and corrective action			3
			6	Industry Class on Non-Destructive testing + Industry Assignment			5				

Week	**C O**	**P O**	**Days**	**1st session (9am to 1 pm)**	**L**	**T**	**P**	**2ND session (1.30pm to 4.30pm)**	**L**	**T**	**P**
11	4		1	Tutorial (Peer discussion on Industrial assignment)		4		Discuss the Role of Automation in Advanced Manufacturing Process Present an Overview on the Levels of Automation-	3		

								• Device level • Machine Level • Cell Level • Plant Level • Enterprise Level Role of CAM (Computer Aided Manufacturing) in Advanced Manufacturing Role of CAPP (Computer Aided Process Planning) in Advanced Manufacturing			
	4		2	Material handling in Advanced Manufacturing: a) Automated Guided Vehicle (AGV)- • Overview on AGV • Working Principle • Applications of AGV's • Types of AGV • AGV Navigation			4	b) Automated storage and Retrieval System (AS/RS) • Overview on AS/RS • Working Principle • Types of AS/RS • Application of AS/RS	1		2
	4		3	Robots in Advanced Manufacturing • Concepts of Industrial Robots • Impacts of Robots in Manufacturing • Application of Robots Types of Robots • Articulated Robots • SCARA Robots • Cartesian Robots • Delta Robots	1		3	Demonstration - Future of Robots in Manufacturing • Lights-Out Manufacturing • Internet of Things Capability • Transformations in Cybersecurity • Collaborative Industrial Robots- Cobots	1		2
	4		4	Visit an Industry which is adopting Automation and Robotic control in Manufacturing					2		5
			5	CIE 5– Written and practice test				Assessment Review and corrective action				3
			6	Industry Class on Robots in Manufacturing + Industry Assignment			5					

12	4		1	Tutorial (Peer discussion on Industrial assignment)		4		**Overview and Video Presentation on** • Industry 4.0 Technologies • Benefits of Industry 4.0 in Manufacturing	3		
	4		2	• Convergence of IT (Information Technology) and OT (Operation Technology) • Technologies which bring Convergence of OT and IT ➢ No code Application ➢ Digital Twins ➢ Augmented Reality ➢ Edge computing	1		3	• Concepts of IIOT (Industry Internet of Things)- How it Works • IIOT – Analytics and Data Management			**3**
	4		3	Demonstrate Adoption of IIOT Technology • Predictive maintenance. • Remote Production Control. • Asset tracking. • Logistics management.	1		3	Demonstrate IIOT for • Sustainability Assessment of Manufacturing Industry • Lean Production System • Smart Factories	1		**2**
	4		4	Visit a Manufacturing Firm which is adopting IIOT					2		**5**
			5	Developmental Weekly Assessment				Assessment Review and corrective action			**3**
			6	Industry Class on Industry IIOT+ Industry Assignment			5				

References:

1. Andreas Gebhardt “Understanding Additive Manufacturing: Rapid Prototyping, Rapid Manufacturing” Hanser Gardner Publication
2. Kamrani A.K. and Nasr E.A., “Rapid Prototyping: Theory and practice”, Springer
3. Liou L.W. and Liou F.W., “Rapid Prototyping and Engineering applications: A tool box for prototype development”, CRC Press
4. Tom Page “Design for Additive Manufacturing” LAP Lambert Academic Publishing
5. Chua C.K., Leong K.F., and Lim C.S., “Rapid prototyping: Principles and applications”, Third edition, World Scientific Publishers
6. Ian Gibson, David W. Rosen, Brent Stucker “Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing” Springer
7. Rapid Prototyping: Laser-based and Other Technologies, Patri K. Venuvinod and Weiyin Ma, Springer, 2004.
8. Electron Beam welding, Schultz H., Woodhead Publishing, 1994
9. Principles of Plasma Discharge and Materials Processing, Lieberman M.A. and Lichtenberg A. J., Wiley Interscience, 1994.
10. Additive Manufacturing of Metals: The Technology, Materials, Design and Production, Li Yang · Keng Hsu · Brian Baughman Donald Godfrey · Francisco Medina Mamballykalathil Menon · Soeren Wiener, Springer, 2017.
11. Laser Additive Manufacturing of High-Performance Materials, Dongdong Gu, Springer, 2015
12. An Introduction to MEMS, Published in 2002 by PRIME Faraday Partnership
13. Unconventional Machining Process by Dr N Senthil Kumar, ARS Publications
14. Unconventional Machining Processes by Dr S Senthil, Suchithra Publications
15. Benedict. G.F. “Nontraditional Manufacturing Processes”, Marcel Dekker Inc., New York, 1987.
16. Mc Geough, “Advanced Methods of Machining”, Chapman and Hall, London, 1998.
17. Paul De Garmo, J.T.Black, and Ronald.A.Kohser, “Material and Processes in Manufacturing” Prentice Hall of India Pvt. Ltd., 8thEdition, New Delhi , 2001.
18. IIoT A Complete Guide - 2021 Edition by Gerardus Blokdyk
19. A Practical Guide for IoT Solution Architects By Dr Mehmet Yildiz
20. The Second Machine Age: Work, Progress and Prosperity in a Time of Brilliant Technologies by Erik Brynjolfsson and Andrew McAfee.

Power Plant Engineering

Course Code: L:T:P

I. RATIONALE

The economic growth of a nation essentially results in growth in the power sector and electric power is the main resource. Various power plants are playing a vital role in the generation of electricity. Most of the power plants are using mechanical engineering equipment and components. Hence, this course will provide the basic knowledge of the components, operation, and maintenance of power plants to the students and also acquaint them with the latest technological advances taking place in the sector. Therefore, this course is designed to cater the requirements of energy efficient devices of power plant.

II. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

CO1 - Choose appropriate fuel for power plant in given situation.
CO2 - Apply relevant knowledge & skills to maintain modern steam power plant efficiently and safely.
CO3 - Use knowledge and skills related to Gas Power Plant and Waste Heat Recovery properly in given situation.
CO4 - Use suitable strategies to run nuclear power plants safely.
CO5 - Calculate economic parameters of various power plants.

III. COURSE CONTENT

Unit	COURSE CONTENT	Hours
1	**Unit - I Fundamental of Power plant** 1.1 Present Indian & Global scenario of demand and supply of conventional power plant with respect to available resources. 1.2 Over view of Power generating plants- Govt. and Private corporations in India with including power generating capacity. 1.3 Site selection criteria for steam power plant. 1.4 IBR (Indian Boiler Regulation) Norms for steam power plant. 1.5 CPCB (Central Pollution Control Board) and MPCB (Maharashtra Pollution Control Board) Norms for Power Plants. 1.6 Introduction to power plants: their importance and classification. 1.7 Types of fuels used in conventional power plant and their properties (Calorific value, Flash point & Fire point) & Relative Cost per kWh (Power Plant Production Cost on the basis of fuel used).	
2	**Unit - II Modern Steam Power Plant** 2.1 Schematic diagram of modern steam power plant. 2.2 Construction, working and functions of super heater, air preheater, economizer, feed pump, electrostatic precipitator, steam traps and its types. 2.3 Fuel handling system- Coal handling layout, Pulverization of coal – Ball Mill 2.4 Ash Handling System- Types of ash (Bottom Ash & Fly Ash) , Layout, Components used & their functions. Commercial use of fly ash. 2.5 Feed Water Treatment- Objective of feed water treatment, Parameters of feed water. (Total Hardness, pH, Total Dissolved Solid (TDS)) 2.6 Fluidized Bed Combustion Boiler (FBC): Types, Construction and Working, Advantages and Disadvantages. Concept of steam temperature control and boiler feed water control (Three Element Control only).	

3	**Unit - III Gas Power Plant and Waste Heat Recovery** 3.1 Introduction to Gas Turbine Power Plant, Concept of Brayton cycle. (No Numerical) 3.2 Arrangement of open and close cycle with constant pressure gas turbine power plant. 3.3 Components of gas turbine power plant and its function. 3.4 Methods to improve the thermal efficiency of a simple open cycle constant pressure gas turbine power plant (No derivation). Advantage & Disadvantages over other power plant.(No Numerical) 3.5 Waste heat recovery in thermal power plants, its need, opportunities, present practices. 3.6 Cogeneration, its need, opportunities, Application of cogeneration in sugar industry, Introduction to bagasse fired boiler. 3.7 Trigeneration, its need, opportunities, presents practices.	
4	**Unit - IV Nuclear Power Plant** 4.1 Introduction to nuclear power plant - Site selection Criteria - Nuclear fuel - Layout 4.2 Nuclear reactor - Construction and Working of - Pressurized Water Reactor (PWR) - Boiling Water Reactor (BWR) 4.3 Nuclear Waste and Disposal. 4.4 Present Nuclear power scenario in India 4.5 Introductions to regulating agencies and regulations, Atomic Energy Regulatory Board (AERB), International Atomic Energy Agency (IAEA), it's a regulation method.	
5	**Unit - V Recent Trends And Economic Analysis of Power Plants** 5.1 Introduction to captive power plant, Definition, Benefits. 5.2 National Mission for Enhanced Energy Efficiency (NMEEE) in power plants- Perform, Achieve and Trade (PAT), Market Transformation for Energy Efficiency (MTEE), Market Transformation for Energy Efficiency (MTEE), Framework for Energy Efficient Economic Development (FEEED). 5.3 Estimation of the production cost of electrical energy. (Simple numerical) 5.4 Estimation of various performance parameters. (Simple numerical)	

IV. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	R.K. Rajput	A Text Book of Power Plant Engineering.	Laxmi Publications, New Delhi 2016,ISBN-13 978-8131802557
2	Arora and Domkundwar	Power Plant Engineering	Dhanpat Rai & CO (P) LTD 2022, ISBN-13 978-8177001952
3	P. K. Nag	Power Plant Engineering	McGraw Hill 2017, ISBN-13 978-9339204044
4	G. R. Nagpal	Power Plant Engineering	Khanna publishers 2002, ISBN-13 978-8174091550
5	Dr. P. C. Sharma	Power Plant Engineering.	S. K. Kataria 2013, ISBN-13 978-9350143841
6	M.M. EL-Wakil	Power Plant Technology	McGraw Hill 2084 ISBN-13 978-0070192881
7	Bernhardt G A Sarotzki, William A Vopat	Power Station Engineering and Economy	Tata Mc Graw Hill 2001, ISBN-13 978-0070995734
8	P.K.Das & A.K.Das	An Introduction to Thermal Power Plant Engineering and Operation : For Power Plant Professionals	Notion Press; 1st edition 2018, ISBN-13 978-1643248622

9	A K Raja, Amit Prakash Srivastava and Manish Dwivedi	Power Plant Engineering	New age international Publishers 2020, ISBN-13 978-9380386782
10	Gupta Manoj Kumar	Power Plant Engineering	PHI Learning Publication 2012, ISBN-13 978-8120346123

V. LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://static.investindia.gov.in/s3fs-public/2023-04/Energy StatisticsIndia2023.pdf	Present Indian Energy scenario
2	https://beeindia.gov.in/en/nmeee-0	Bureau of Energgy Efficiency (BEE)
3	http://www.indiaenvironmentportal.org.in/files/NMEEE.pdf	Recent Trends
4	https://www.youtube.com/watch?v=IdPTuwKEfmA	Thermal Power Plant
5	https://www.youtube.com/watch?v=zcWkEKNvqCA	Gas Power Plant
6	https://www.youtube.com/watch?v=vggzl9OngaM	Nuclear Power Plant
7	https://www.youtube.com/watch?v=NgCb4Er9mew	Nuclear Power Plant
8	https://www.youtube.com/watch?v=ell3ExEpzd8	Waste Heat Recovery
9	https://www.youtube.com/watch?v=1kMT7BJ0d-8	Cogeneration Power Plant
10	https://www.youtube.com/watch?v=w4MnNfUsBPU	Thermodynamics Steam Trap
11	https://www.youtube.com/watch?v=5ZjQhh-7Dkc	Thermodynamics Steam Trap
12	https://www.youtube.com/watch?v=FV9pmX86j8o	Float Steam Trap
13	https://www.youtube.com/watch?v=AcyFY3iAdlw	Electrostatic Precipitator
14	https://www.youtube.com/watch?v=is5wdVgPOkI	Feed Water Treatment

-E-Mobility-

Course Code- **L:T:P**

Introduction:

Welcome to the curriculum for the Specialization Pathway - **E-Mobility**. This specialization course is taught in Bootcamp mode. Bootcamps are 12 weeks, intense learning sessions designed to prepare you for the practical world – ready for either industry or becoming an entrepreneur. You will be assisted through the course, with development-based assessments to enable progressive learning.

The automotive industry is already expanding and growing faster than before. With these advancements in place, it is evident that EV is creating ripples, redefining transportation in a new way. While these developments are fascinating, the evolving nature of the sector makes it complex with each passing day, and hence, a complete understanding of the system and in-depth exposure is necessary.

Leading to the successful completion of this bootcamp, you shall be equipped to either do an internship in an organisation working on E Mobility or do a capstone project in the related field. After the completion of your Diploma, you shall be ready to take up roles like a design or maintenance assistant and can rise up to the level of a design or maintenance engineer, also can become Entrepreneur in the related field and more

This course will teach you to manage electric vehicle complexity, optimize vehicle performance, and more by using Model-based Systems and better understand the intricate EV architecture.

Details of the curriculum is presented in the sections below.

Course Outcomes:

After completing the course, the students will be able to:

CO-01	Demonstrate the components, architecture and technologies in electric vehicles
CO-02	Analyze the vehicle dynamics, Transmission system, suspension systems; braking system and steering systems in electric vehicles
CO-03	Analyze the use of different power electronics converters and electrical machines in electric vehicles.
CO-04	Analyze the use of different energy storage systems, charging system, their control techniques, and energy management technology for electric vehicles
CO- 05	Demonstrate the electrical systems, communication protocols and Maintenance in Electric vehicles
CO-06	Model the Electric vehicle and analyze its performance using a simulation software

Detailed Course Content

Week	C O	P O	Days	1st session (9am to 1 pm)	L	T	P	2ND session (1.30pm to 4.30pm)	L	T	P
1	1		1	**Introduction** • Principles and Trends of e-Mobility • e-Mobility Business Model • Impact of mobility on existing sectors • e-mobility for personal vehicles • e-mobility in public transportation • e- mobility in goods transport • Environmental impact of e-Mobility	4			• Overview on Conventional Vehicles-Components, Working Principle • Overview of EV such as Tesla, Hyundai, TATA, KIA, MG, Mahindra motors etc • Technology and Market Scenario in Indian and global perspective • Merits and demerits of Electric vehicles	3		
	2		2	**Vehicle Dynamics** • Fundamentals of Vehicle Dynamics • Vehicle resistance, Types: Rolling Resistance, gradient resistance, Aerodynamic drag • Tire- Ground Adhesion	4			• Calculating the Rolling Resistance • Calculating the gradient resistance • Calculate the Aerodynamic drag • Calculating the Acceleration Force • Calculate the maximum speed of the vehicle • Calculate the Maximum Tractive Effort and Powertrain Tractive Effort • Find the Total Tractive Force • Calculate the Torque Required on the Drive Wheel	1		**2**
	2		3	• Calculating the Rolling Resistance • Calculating the gradient resistance • Calculate the Aerodynamic drag • Calculating the Acceleration Force • Calculate the maximum speed of the vehicle • Calculate the Maximum Tractive Effort and Powertrain Tractive Effort • Calculate the Torque Required on the Drive Wheel							7

	2		4	**Suspension system** • Explain and demonstrate the working principle and components of Double Wishbone suspension • Explain and demonstrate the working principle and components of Trailing twist axle suspension • Explain and demonstrate the working principle and components of Macpherson Srut suspension • Explain and demonstrate the working principle and components of electronic adjustable-rate shock absorbers	2		2	**Transmission system** Explain and Demonstrate the Working principle and components of Power transmission system used in EV **Chassis System** • Explain and demonstrate the different Chassis systems in EV	1		2
			5	Weekly developmental Assessment				Assessment Review and corrective action			**3**
			6	Industry Class on vehicle dynamics + Industry Assignment			**5**				
2	2		1	Tutorial (Peer discussion on Industrial assignment)		4		**Tires and Wheels** • Designation of tires • Explain JATMA, ETRTO standards, • Tire selection considerations for EV • Compare Diagonal vs Radial tires • Compare Tubed vs Tubeless tires	3		
	2		2	**Steering Systems** • Explain the importance of steering geometry (Caster, Camber, Kingpin inclination, Toe-in, Toe- out) • Explain and demonstrate the working principle and	2		2	**Braking System** • Explain and demonstrate the working principle and components of disc and drum brakes. • Explain and demonstrate the working principle and components of hydraulic brakes	2		**1**

				components of electronic power assisted steering				• Calculate Braking Performance and Distribution braking Force			
	2		3	• Explain and demonstrate the working principle and components of Electric brakes • Explain and demonstrate the working principle and components of Electro hydraulic braking (EHB) • Explain and demonstrate the working principle and components of Electronic Parking Brake (EPB)	2		**2**	• Explain and demonstrate the working principle and components ABS brake system • Explain and Demonstrate Wheel speed sensors, ABS with Electronic Brake force Distribution (EBD) control unit • Explain and Demonstrate Electronic Stability Control (ESC) • Explain and Demonstration on warning & safety device	2		**1**
	1		4	**Architecture of EV** • Explain and Demonstrate the Architecture, working principle, Major component, performance parameter, merits and demerits of all Electric Battery Electric Vehicles (BEV)	2		**2**	• Explain and Demonstrate the Architecture, working principle, Major component, performance parameter, merits and demerits of Hybrid-Electric Vehicles (HEV)	2		**1**
			5	Weekly developmental Assessment				Assessment Review and corrective action			**3**
			6	Industry Class on Steering geometry, transmission system and ABS + Industry Assignment			**5**				

Week	**C O**	**P O**	**Days**	**1st session (9am to 1 pm)**	**L**	**T**	**P**	**2ND session (1.30pm to 4.30pm)**	**L**	**T**	**P**
3	1		1	Tutorial (Peer discussion on Industrial assignment)		4		• Explain and Demonstrate the Architecture, working principle, Major component, performance parameter, merits and demerits of Plug-in hybrid vehicles (PHEV)	1		2

	1		2	• Explain and Demonstrate the Architecture, working principle, Major component, performance parameter, merits and demerits of Fuel cell electric vehicles (FCEV)	2		**2**	• Compare the features of BEV, HEV, PHEV, FCEV type of vehicles • Discuss on current adoption status of BEV, HEV, PHEV, FCEV type vehicles	3		
	3		3	**Electric Machines and Drives** • Explain and demonstrate the working principles and components of DC Motor and Brushless DC motors (BLDC)	2		**2**	• Explain and demonstrate the working principles and components of Induction motors	1		**2**
	3		4	• Explain and demonstrate the Working principle and components of Permanent magnet synchronous motor (PMSM)	2		**2**	• Explain and demonstrate the Working principle and components of Switched Reluctance Motor (SRM)	1		2
			5	CIE 1– Written and practice test				Assessment Review and corrective action			3
			6	Industry Class on architecture of EV + Industry Assignment			**5**				
4	3		1	Tutorial (Peer discussion on Industrial assignment)		4		• Calculate speed and Torque of motor • Calculate Power consumption of EV • Selection and sizing of Motor			**4**
	3		2	• Calculate speed and Torque of motor • Calculate Power consumption of EV • Selection and sizing of Motor							**7**
	3		3	• Discuss the merits and demerits of DC motors, BLDC motors, Induction motors, PMSM motors and SRM motors • Discuss the type of Electric drives used in EV such as Tesla, Hyundai, TATA, KIA, MG, Mahindra motors	4			• Explain the Principle of Regenerative Braking • Explain the Regenerative Brake cooperative control operation. Riding Modes -Sport and Comfort, Driver Behaviour, Economy mode	3		

				etc with their specifications from company catalogue							
	3		4	**Control Unit and Control Strategies** • Explain and Demonstrate DC-DC Converters • Explain and Demonstrate DC-AC Converters • Explain and Demonstrate AC-DC Converters • Explain Switch Controller • Explain Solid-State Controller • Explain Electronic Controllers	4			• Explain and Demonstrate AC Controllers • Explain and Demonstrate DC Motor Controller- The Lesson of the Jones Switch • Explain Off-the-Shelf Curtis PWM DC Motor Controller			**3**
			5	Weekly developmental Assessment				Assessment Review and corrective action			**3**
			6	Industry Class on electric drives and their control strategies + Industry Assignment			5				**3**
5	3		1	Tutorial (Peer discussion on Industrial assignment)		4		• Explain Zilla Controller • Explain ZAPI Control Strategies • Explain Max. SOC-of-PPS Control Strategy (SOC- State of Charge; PPS-Peak power source)	3		
	3,6		2	Modelling of Electric machines and controllers by using simulation software							7
	3,6		3	Modelling of Electric machines and controllers by using simulation software							**7**
	3,6		4	Modelling of Electric machines and controllers by using simulation software							**7**
			5	CIE 2– Written and practice test				Assessment Review and corrective action			3
			6	Industry Class on modelling of electric drives and controllers + Industry Assignment			**5**				
6	4		1	Tutorial (Peer discussion on Industrial assignment)		4		**Energy Storage Solutions (ESS)** • Explain Battery capacity, Discharge Rate, State of Charge (SOC), State of Health (SOH), State of Energy (SoE) State of Power (SOP), state of discharge (SOD) Depth of discharge (DOD), C -Rate	2		**1**

								• Explain Thermodynamic Voltage, Specific Energy, Specific Power, Energy Efficiency			
	4		2	Classification of Batteries ➢ Primary ➢ Secondary • Li –ion • Na- ion • Mg –ion • K-ion Geometry of Batteries ➢ Coin Cell ➢ Cylindrical Cell ➢ Stack Cell ➢ Pouch Cell Chemistry behind Batteries Battery Materials- Anode, Cathode, Electrolyte, Separator Explain the working principle, of Lead Acid and Lithium-ion (Li-ion) batteries used in electric vehicle	4			• Future developments in Batteries- Na- ion, Mg –ion K-ion, Li air • Discuss Corrosion of Battery Terminals • Discuss Lithium-Ion Batteries Aging Effects • Discuss on Selection and sizing of cells and Handling of Cells • Explain working principle of Ultra capacitors and its features	3		
	4		3	• Explain Cell Charging and Discharging cycles and Discharging Curves • Ragone plot for Batteries • Calculations on Battery charging and discharging • Explain the Temperature impact on cell, Internal resistance • Study the Lifecycle of batteries • Discuss Battery Fabrication Process	4			**Battery Module and Pack Development** • Demonstrate the Battery Pack Module Construction, Configurations, Types and Energy Concepts • Demonstrate the Voltage, Current and Temperature Measurement • Discuss the Battery pack selection criteria	1		2
	4		4	**Battery Management System (BMS)** • Discuss the Need of BMS	4			**EV Thermal Management** • Explain Cooling of Battery Pack, Motor and Inverter	3		

				• Explain L9963 battery management device • Explain the Voltage, Current and Temperature Monitoring, • Demonstrate various sensors installed on BMS • Explain Battery management design considerations (Service life, efficiency, safety, operational parameters) • Discuss Cell Balancing - Types, Active, Passive, SoC Determination, SoC Algorithms				• Explain Active and Passive Cooling • Explain Fluid Based Cooling, Ethylene Glycol, • Explain Forced Air Cooling, Cabin Air Based Cooling			
			5	Weekly developmental Assessment				Assessment Review and corrective action			3
			6	Industry Class on Battery technology and BMS + Industry Assignment			**5**				
Week	**C O**	**P O**	**Days**	**1st session (9am to 1 pm)**	**L**	**T**	**P**	**2ND session (1.30pm to 4.30pm)**	**L**	**T**	**P**
7	4,6		1	Tutorial (Peer discussion on Industrial assignment)		4		• Modeling of Electric vehicle batteries and battery pack by using simulation software			3
	4,6		2	• Modeling of Electric vehicle batteries and battery pack by using simulation software							7
	4,6		3	• Modeling of Electric vehicle batteries and battery pack by using simulation software							7
	4,6		4	• Modeling of Electric vehicle batteries and battery pack by using simulation software							7
			5	CIE 3– Written and practice test				Assessment Review and corrective action			3
			6	Industry Class on modeling of EV batteries + Industry Assignment			5				

8	4		1	Tutorial (Peer discussion on Industrial assignment)		4		**Electric Vehicles charging station** • Explain and Demonstrate the Electric Vehicle charging Technology and Charging Equipment's • Draw Basic charging Block Diagram of Charger • Differentiate Slow charger, fast charger and Rapid charger • Explain Slow charger design rating • Explain Fast charger design rating	2		1
	4		2	• Demonstrate AC charging and DC charging methods • Demonstrate Inboard and off board charging methods and specification • Demonstrate Modes of charger-Mode -2, Mode-3 and Mode-4 • Perform EVSE (Electric Vehicle supply Equipment) associated charge time Calculation.			4	**Selection and sizing of fast and slow Charger** • Demonstrate AC Pile Charger • Demonstrate DC Pile Charger • Demonstrate EVSE Power Module selection and technical specification			3
	4		3	• Demonstrate Specification of open charge point protocol (OCCP 1.6/2.0) • Demonstrate Bharat DC001 & AC001 Charger specification • Demonstrate Communication Interface between charger and CMS (central management system)			4	**Selection and sizing of Common types of connectors and applications** • Demonstrate Selection of AC charger type-1, type -2 and type -3 • Demonstrate Communication between charging station and EV			3
	4		4	• Demonstrate Selection of DC charger connector GB/T, CHAdeMO, CCS-1 and CSS-2 • Demonstrate Communication methodology of DC fast chargers			4	• Demonstrate IS/ IEC/ARAI/ standard of Charging topology, Communication and connectors (IEC 61851-1, IEC 61851-24,62196-2)			3

				• Sizing of Charger connector cable							
			5	Weekly developmental Assessment				Assessment Review and corrective action			3
			6	Industry Class on EV chargers and charging stations + Industry Assignment			5				
9	5		1	Tutorial (Peer discussion on Industrial assignment)				**Trace and Test all Electrical & Electronic components & circuits** • Demonstrate the EV electrical architecture, power supply systems by using service manual			3
	5		2	• Identify the electrical and electronics components in a vehicle • Explain and Demonstrate the Wiring Harness Design, Harness Topology.	2		2	• Hands on removing and fitting basic electrical and electronic components			3
	5		3	**Trace the wiring circuit of lighting system in an EV** • Explain and Demonstrate Headlight & dimmer circuits, Park & taillight circuits, Brake light circuits, turn signal circuit, Cornering lights, Fog lights circuit, interior lights courtesy, reading and instrument panel lights, Smart lighting, Reverse lights circuits	2		2	**HVAC** • Explain and demonstrate the working principle and components of HVAC in EV • Climate Control System in EV			3
	5		4	**Vehicle and Occupants Safety** • Explain and demonstrate the types of safety systems and their functions and applications. - Seat Belt, Child Restraint System (CRS), Air Bag - Supplemental Restraint System (SRS), Cruise Control, Central Lock System			4	**Instrument Cluster** • Explain and demonstrate the electronic instrumentation cluster for battery status, distance to empty, battery temperature, gear position indicator, tire air pressures, cabin temperature, vehicle speed, trip information,			3

				(CTL), Parking electronic System (PTS), power windows, Smart key				Warning and indicator lights, display messages, GPS, fault diagnosis etc			
			5	CIE 4– Written and practice test				Assessment Review and corrective action			3
			6	Industry Class on electronic vehicle management system + Industry Assignment			5				
10	5		1	Tutorial (Peer discussion on Industrial assignment)				**Communication protocols** • Explain and Demonstrate the Application of Automotive bus system-CAN (Control Area Network)	3		
	5		2	• Explain and Demonstrate the Application of Automotive bus system- LIN (Local Interconnect Network)	4			• Explain and Demonstrate the Application of Automotive bus system- FlexRay™ and MOST (Media Oriented Systems Transport).	3		
	5		3	**Vehicle Telematics** • Explain Integrated communications, Global positioning satellites, Triangulation/ trilateration, Telematics	4			• Explain Integrated communications, Global positioning satellites, Triangulation/ trilateration, Telematics	3		
	5		4	**Advancement in EV technology** • Explain the Advanced Driver Assist vehicle system architecture (ADAS) • Explain the ADAS system components- LIDAR, AI cameras, collision detection, object detection, Adaptive Cruise Control,	4			• Intelligent Speed Adaptation, Driver Monitoring System, Drowsy Driver Warning, Driver Fatigue Warning, Blind Spot Detection, Lane Keeping Assist, Lane Departure Warning, etc	3		

			5	Weekly developmental Assessment				Assessment Review and corrective action			3
			6	Industry Class on EV communication protocol + Industry Assignment			5				
Week	**C O**	**P O**	**Days**	**1st session (9am to 1 pm)**	**L**	**T**	**P**	**2ND session (1.30pm to 4.30pm)**	**L**	**T**	**P**
11	6		1	Tutorial (Peer discussion on Industrial assignment)		4		Model the Electric vehicle by using simulation software and analyze the EV performance parameters such as speed, Torque, Top speed reached, distance travelled, SOC, regenerative braking effort, current, voltage for different drive cycles, electric drives & power rating, and also analyze the impact of vehicle dynamics like rolling resistance, air drag, frontal area, weight of the body etc on EV performance			3
	6		2	Model the Electric vehicle by using simulation software and analyze the EV performance parameters such as speed, Torque, Top speed reached, distance traveled, SOC, regenerative braking effort, current, voltage for different drive cycles, electric drives & power rating, and also analyze the impact of vehicle dynamics like rolling resistance, air drag, frontal area, weight of the body etc on EV performance							7
	6		3	Model the Electric vehicle by using simulation software and analyze the EV performance parameters such as speed, Torque, Top speed reached, distance traveled, SOC, regenerative braking effort, current, voltage for different drive cycles, electric drives & power rating, and also analyze the impact of vehicle dynamics like rolling resistance, air drag, frontal area, weight of the body etc on EV performance							7
	6		4	Model the Electric vehicle by using simulation software and analyze the EV performance parameters such as speed, Torque, Top speed reached, distance travelled, SOC, regenerative braking effort, current, voltage for different drive cycles, electric drives & power rating, and also analyze the impact of vehicle dynamics like rolling resistance, air drag, frontal area, weight of the body etc on EV performance							7
			5	CIE 5– Written and practice test				Assessment Review and corrective action			3
			6	Industry Class on modeling of EV + Industry Assignment			5				
12	5		1	Tutorial (Peer discussion on Industrial assignment)				Precaution to be taken care while handling the electric vehicle. • Things to know while handling EVs	2		1

								• Importance of Practicing Battery Safety for Electric Vehicles			
	5		2	Safety of e- vehicle batteries- • Electric system safety - Protection against electric shocks, Protection against direct contact, Protection against indirect contact • Functional system safety - System activation warning, Power on procedure, driving backwards: Prevention of fierce reverse braking, Emergency disconnect device, Fail-safe operation- Power surge prevention, Fail-safe operation - Frame faults, Fail-safe operation - Electromagnetic compatibility, The auxiliary network, • Battery charging safety- electrical aspect, mechanical aspect, chemical aspect, explosion hazard	2		2	Maintenance in EV • First-line maintenance: by the user • Second-line maintenance: in the Authorised service centre. • Maintenance for safe operation	1		2
	5		3	Visit an EV authorized service station and observe the following • Observe the Safety Precaution practices followed while handling EV's • Study the job card and case history of the vehicles • Study the owner's instruction manual for periodic maintenance • Interact with the Service execute while Vehicle Inspection form is recorded • Observe the use of Diagnostics software • Observe the Periodic maintenance and repair performed on EV's							7
	5		4	Visit an EV authorized service station and observe the following • Observe the Safety Precaution practices followed while handling EV's • Study the job card and case history of the vehicles • Study the owner's instruction manual for periodic maintenance • Interact with the Service execute while Vehicle Inspection form is recorded							7

				• Observe the use of Diagnostics software • Observe the Periodic maintenance and repair performed on EV's							
			5	Weekly developmental Assessment				Assessment Review and corrective action			3

References:

1. Iqbal Husain, Electric and Hybrid Vehicles –Design Fundamentals, CRC Press
2. Mehrdad Ehsani, Yimin Gao, Sebastian E.Gsay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Celll vehicles-Fundamentals - Theory and Design", CRC Press
3. Energy Storage by Robert A. Huggins, Springer Publication
4. Handbook of Energy Audit, Albert Thumann P.E. CEM, William J. Younger CEM, The Fairmont Press Inc., 7th Edition.
5. Energy storage (A new approach) by Ralph Zito Wiley Publication
6. Energy Management Handbook, Wayne C. Turner, The Fairmont Press Inc., 5th Edition,Georgia
7. Energy Storage Systems, Alfred Rufer, CRC Press
8. Chang Liang Xia,"Permanent Magnet Brushless Dc Motor Drives and Controls" Wiley 2012.
9. Bimal K Bose, " Modern Power Electronics and AC Drives", Pearson Education, Second Edition, 2003
10. Miller. T. J. E., "Brushless Permanent Magnet and Reluctance Motor Drives", Clarendon Press, Oxford, 1989
11. Kenjo. T and Nagamori. S, "Permanent Magnet and Brushless DC Motors", Clarendon Press, Oxford, 1989.
12. Robert .L.Boylsted,and Louis Nashelsky, "Electronic Devices and Circuit Theory", Pearson Education,9th edition,2009
13. David A Bell, "Fundamentals of Electronic Devices and Circuits", Oxford University Press, 2009.
14. Albert D Halfride & William D Cooper, "Modern Electronic instrumentation and Measurement techniques", Prentice Hall of India Pvt Ltd., 2007.
15. Rajendra Prasad, "Electrical Measurements & Measuring instruments", C Publishers, 4th Edition, 2004

OPEN ELECTIVE

ARTIFICIAL INTELLIGENCE & MACHINE LEARNING

Course Code- L:T:P

Introduction:

Welcome to the curriculum for the Artificial Intelligence and Machine Learning (AI&ML) Specialisation. This specialisation course is taught in Bootcamp mode. Bootcamps are 12 weeks, intense learning sessions designed to prepare you for the practical world – ready for either industry or becoming an entrepreneur. You will be assisted through the course, with development-based assessments to enable progressive learning. In this course, you'll learn how to produce a computer-assisted solution when data is too complex for humans to find answers as they combine both data science and machine learning skills that are needed for today's job market.
Some common examples include; Amazon Alexa - converting spoken audio into language; Google Image Search – uses image recognition to return specific search results; Samsung Smart Fridges – uses data and machine learning to produce intuitions about your behavior. Leading to the successful completion of this bootcamp, you shall be equipped to either do an internship at an organization working in AI or do a project in AI. After the completion of your Diploma, you shall be ready to take up roles like Machine Learning Engineer, Data Scientist, Data Analyst, and more.
This course will teach you Fundamentals of AI, Python and Python libraries, data visualization, machine learning models, maths like linear algebra, data interpretation, deep learning, Version control system, cloud deployment and more. Details of the curriculum is presented in the sections below.

Pre-requisite

Before the start of this specialisation course, you would have completed the following courses;

In the 1st year of study, you would have studied Engineering Mathematics, Communication Skills, Computer Aided Engineering Graphics, Statistics & Analysis, Basic IT Skills, Fundamentals of Computer, Fundamentals of Electrical and Electronics Engineering, Project Management skills and Multimedia & Animation.

In the 2nd year of study, you would have studied Python Programming, Computer Hardware, Maintenance and Administration, Computer Networks, Database System Concepts and PL/SQL, Data Structures with Python, Operating System and Administration, Object oriented programming and Design with Java, Software Engineering principles and practices.

In this year of study, you shall be applying your previous years learning along with specialised field of study into projects and real-world applications.

Course outcome: A student should be able to

CO1	**Explain the concept of AI, its applications, constituents and challenges of ethics in AI.**

CO2	**Analyze and visualize any given dataset**
CO3	**Evaluate, optimize, build and test an AI model for a given requirement**
CO4	**Perform comparative analysis of methods or algorithms for a given requirement**
CO5	**Select the appropriate tools, production environment and deploy the model.**

Detailed Course Content

Week	CO	PO	Days	1st session (9am to 1 pm)	L	T	P	2ND session (1.30pm to 4.30pm)	L	T	P
1	1	1	1	1. AI based movie (Screening)			4	- AI influence in companies viz, Amazon, Microsoft, Google, IBM - Latest developments in AI domain - Google's DeepMind AI Just Taught Itself To Walk - YouTube - Introducing Amazon Go and the world's most advanced shopping technology - YouTube - IBM Watson - Understanding the evolution of AI and HMI (human machine interface) - Discussion on how AI will Impact of daily life, work life, work force, jobs, products and services – T	2		1
	1	1	2	Fundamentals of AI - What is artificial intelligence? - How AI works - Purpose of AI - Types of Artificial Intelligence - Goals of AI - Applications of AI	3		1	- Significance of data in AI - AI Software Development life cycle - Compare traditional software development with AI Software Development - Example – Game rules (Chess) Explore and prepare a report on all popular AI cloud services (ML & DL) offered by vendors - T	2		1

				- Ethics in AI Examples of AI in real world - T							
	5	4,5	3	Why Do We Need a Version Control System? Fundamentals of Git Git installation and setup basic local Git operations ▪ creating a repository, ▪ cloning a repository, ▪ making and recording changes ▪ staging and committing changes, ▪ viewing the history of all the changes ▪ undoing changes	1		3	Git Branching and merging Basic ▪ Creating and switching to new branches ▪ Switching between branches ▪ Merging local branches together			3
	5	4,5	4	GitHub - Basics of distributed git - Account creation and configuration - Create and push to repositories - versioning - Collaboration - Migration	1		3	Create repository – named mini project-1 Push the same to GitHub TOC - Git Essentials: Become a Git and GitHub Ninja | Infosys Springboard (onwingspan.com)			3
			5	**Developmental Assessment**				Assessment Review and corrective action			3
	1	**1,5**	6	Real industry experience of AI	2		3	Weekly Assignment(1PM-2PM)			
2	1	1	1	Peer Review		4		**Machine Learning**	2		1

								- Fundamentals - Machine learning types - Machine learning workflow - Machine learning applications - Challenges in ML - Building a model – steps involved - Pipelines ▪ Data engineering ▪ Machine learning ▪ Deployment - What is Data Science? - How Data Science works? - Data Science uses Group discussion - Examples of ML in everyday life / Use of Machine Learning in Daily Life Machine Leaning Terminologies - T TOC - Machine Learning Fundamentals | Infosys Springboard (onwingspan.com) Prediction – continuous value			
	1,5	1,4	2	Introduction to Cloud Computing - Essentials of Cloud Computing - Cloud Deployment Models - Cloud Service Models	2		2	Introduction to Containers Cloud Native application development Explore AI (ML and DL) services across public cloud platforms	1		2

				- Serverless Services - Major Cloud service Providers - Virtualization Explore the cloud service providers and services offered by them - T				Note : teacher has to choose a public cloud platform to perform the fallowing activities - Getting to know cloud platform - Creating an account			
	1,5	**4,5**	3	- Walking through the administrative console and Cloud SDK - Explore Virtual machines (PaaS, Iaas and SaaS) and storage options - Deploy a simple application on the cloud - AI Platform overview	1		3	Essentials of cloud billing SLA TOC - Essentials of Cloud Computing | Infosys Springboard (onwingspan.com) Tutorial - Automatically Create Machine Learning Models - Amazon Web Services Tutorial - Automatically Create Machine Learning Models - Amazon Web Services	1		2
	1	1,3 4	4	Big Data - What is Big Data? - Vs of Big Data - Sources of data - Role of Big Data in AI&ML Python Packages for Machine Learning and Deep Learning - Scientifics computing libraries - Visualization Libraries - Algorithmic libraries Environment setup: install required packages	1		3	Python recap Database connectivity	1		2

				Explore above listed packages							
			5	**Developmental Assessment**				Assessment Review and corrective action			3
	1,5	**2,3 ,4**	6	Build applications using AI cloud services	2		3	Weekly Assignment			
3	**1,5**	**2,3 ,4**	1	Peer review		4		Explore NumPy Module - Array Aggregation Functions - Vectorized Operations - Use Map, Filter, Reduce and Lambda Functions with NumPy - TOC - Pandas and NumPy Tips, Tricks, and Techniques | Infosys Springboard (onwingspan.com)			3
	1,5	**2,3 ,4**	2	Explore Pandas modules - Aggregation and Grouping - Time Series Operations - Pivot and melt function - Use Map, Filter, Reduce and Lambda Functions with Pandas dataframes - TOC - Unpacking NumPy and Pandas | Infosys Springboard (onwingspan.com)	1		3	Contd.			3
	2,5	**2,3 ,4**	3	**Data visualization with python** - Visualization fundamentals - Why visualization	2		2	- Visualizing Amounts - Visualizing distributions			3

				- Coordinate Systems and Axes - Directory of Visualizations Amounts, Distributions, Proportions, x-y Relationships, Uncertainty Basics of python visualization with Matplotlib - Understand the anatomy of a figure - Plot creation - Plotting routines - Basic plot customizations - Saving plots				- Visualizing proportions - Visualizing associations - Visualizing time series **Consider a dataset and infer the relations with the help of different plots.**			
	2,5	2,3, 4	4	- Visualizing trends - Visualizing uncertainty - Visualizing categorical data - visualize proportions - visualize data on multi-plot grid - Composite views for informative summaries of data	1		3	Basics of python visualization with Seaborn The Course Overview - Viewer Page | Infosys Springboard (onwingspan.com)			3
			5	**CIE 1 – Written and Practice Test**				Assessment Review and corrective action			3
	1	4	6	How to create project plan and product backlog for AI project Create Git Repository for following Regression Project - ML / deep learning	2		3	Weekly Assignment			

				Classification Project – ML / deep learning Clustering project – ML / deep learning Natural Language Processing – ML / deep learning							
4	2	**2,3,4**	1	**Peer review** **Mini Project Activity (2)** - **Regression** - **Classification** **(Individual/ Team of 2)** - Define Problem statement (solution to be presented at the semester end) - Create project plan and product backlog - Create git repository for the project - Work progress should be monitored weekly		4		**Data engineering pipeline** **Data Collection** - Population and sample - Types of data ▪ Data type (type 1 (cross sectional, time series), type 2 (univariate, multivariate)) ▪ Variable types (categorical, ordinal, ratio, interval) - Data Collection Key terminologies in Statistics – T **<u>Mini Project Activity</u>** - Data collection for the stated problem	2		1
	2	1,3	2	**Probability** - **Basic concepts** - Conditional and Joint probability - Bayes' Theorem Probability Distributions - Discrete	2		2	**Exploratory data analysis** - overview - EDA goals and benefits **Univariate data analysis** - Characterizing data with descriptive statistics - Univariate distribution plots	1		2

				- Continuous - Central Limit Theorem Infosys Springboard (onwingspan.com) TOC - Probability Distribution using Python | Infosys Springboard (onwingspan.com) **Use relevant python packages to compute Central tendency for the parameters Dispersion for the parameters** **data distribution** **Visualize above computation with various techniques**				- Univariate comparison plots - Univariate composition plots **Mini Project Activity** Data Exploration and analysis for the stated problem			
	2	**2,3 ,4**	3	**Univariate analysis tests** Hypothesis testing Error, Test statistic, type, interpreting test statistics. Understanding p-value	1		3	**Multivariate analysis** Finding relationship in data - Covariance - Correlation	1		2
	2	**2,3 ,4**	4	- Multivariate distribution plot Multivariate comparison plot Multivariate relationship plot Multivariate composition plot			4	**Linear algebra using python** - Scalars - Vectors - Matrices - Tensors Gradients	1		2

				- TOC - Exploratory Data Analysis with Pandas and Python 3.x | Infosys Springboard (onwingspan.com) **Mini Project Activity – Status review** (Data Exploration and analysis for the stated problem)				- **E**igen values and eigen vectors - Norms and Eigen decomposition **Use relevant python packages to perform operations over vectors and matrices.** TOC - Basics of Linear Algebra using Python | Infosys Springboard (onwingspan.com) Interactive Scenario: Introduction to Vector Algebra Using Python (oreilly.com)			
			5	**Developmental Assessment**				Assessment Review and corrective action			3
	2	**2,3 ,4**	6	Statistics and Linear algebra	2		3	Weekly assignment			
5	2,5	**2,3 ,4**	1	Peer review **Mini Project Activity – Status review**		4		**Data Preprocessing** Importance of data preprocessing **Data cleaning** - Assess Data quality - Data anomalies - Detect missing values with pandas dataframe functions: .info() and .isna() - Diagnose type of missing values with visual and statistical methods (eg. chi-squared test of independence) Approaches to deal with missing values ▪ Keep the missing value as is	1		2

								▪ Remove data objects with missing values ▪ Remove the attributes with missing values ▪ Estimate and impute missing values			
	2,5	**2,3 ,4**	2	Practice: Dealing with missing values with different approaches Outliers Detecting outliers ▪ univariate outlier detection ▪ bivariate outlier detection ▪ Time series outlier detection	1		3	Dealing with outliers - Do nothing - Replace with the upper cap or lower cap - Perform a log transformation - Remove data objects with outliers Practice: Dealing with outliers with different approaches TOC - Data Preprocessing | Infosys Springboard (onwingspan.com) TOC - Data Cleaning and Transformation | Infosys Springboard (onwingspan.com)			3
	2,5	**2,3 ,4**	3	Data Integration - Overview - data integration challenges - Approaches - Adding attributes - Adding data objects Practice: data integration	1		3	Data reduction - Distinction between data reduction and data redundancy - Objectives - Methods o numerosity data reduction o dimensionality data reduction	1		2

								Practice: Data reduction with numerosity data reduction method			
	2,5	**2,3 ,4**	4	Data transformation Need for data transformation. - **Normalization** - Standardization Data transformation with - binary coding - ranking transformation - discretization	1		3	Data transformation with - ranking transformation - discretization			3
			5	**CIE 2 – Written and Practice Test**				Assessment Review and corrective action			3
	2,5	**2,3 ,4**	6	**Feature engineering**	2		3	Weekly Assignment			
6	**2,3 ,5**	**2,3 ,4**	1	Peer review **Mini Project Activity – Status review**	4			**Data Splitting** Importance of data splitting - Training set - Validation set - Testing set Underfitting and overfitting Practice : split training and testing data sets in Python using train_test_split() of sci-kit learn. Explore the options of train_test_split()	1		2

	2,3 ,5	**2,3 ,4**	2	**Machine Learning pipeline: Model training** - Supervised Learning: Regression - What is Regression? - Types of regression - Regularization in ML - Real-Life Applications - T - Linear regression Overview Types - simple linear regression - Multiple linear regression - Polynomial linear regression Applications of Linear Regression - T	2		2	Understanding Simple linear regression - Regression equation - Assumptions - Gradient descent - Setting up the regression problem Practice: student score based on study hours Problem statement: • Create a model to analyses the relation between CIE and SEE result • Create a model to analyze the relation between crop yield and rain fall rate Build linear regression model using - Stats model - Scikit learn	1		2
	2,3 ,5	**2,3 ,4**	3	**Model Evaluation & testing** Evaluate regression model: Evaluation Metric - Coefficient of Determination or R-Squared (R2) - Root Mean Squared Error (RSME) - Optimize regression model - Gradient descent	2		2	Cross-validation Why do we need Cross-Validation? Techniques - Hold out method - Leave One Out Cross-Validation - K-Fold Cross-Validation	1		2

	2,3,5	**2,3,4**	4	Multiple Linear Regression - Overview - Assumptions - Normal Equation - Applications Identification and collection of regression dataset - T Perform data exploration, preprocessing and splitting on datasets like - Boston housing price from sci-kit learn datasets - Cricket match result - past data - Performance of a cricket player - past data - Crop yield - past data	2		2	Implementation in python - Build regression model - Evaluate the model - To minimize the cost function			3
			5	**Developmental Assessment**				Assessment Review and corrective action			3
	2,3,5	**2,3,4**	6	**Optimization and performance matrices for regression**	2		3	Weekly Assignment			
7	**2,3,5**	**2,3,4**	1	Peer Review **Mini Project Activity – Status review**		4		Explore other regression algorithms - T Rebuild the model with other regression algorithms such as - Random Forest Regressor - Support Vector Regression - Lasso regression			3

								Evaluate and compare the performance of each.			
	2,3 ,5	**2,3 ,4**	2	Supervised learning – classification What is classification? Types: - Binary classification - Multi-Label Classification - Multi-Class Classification - Imbalanced Classification Classification models Applications - T Practice: Iris dataset from sci-kit learn Perform data exploration, preprocessing and splitting	2		2	Decision trees - What is decision tree? - Understanding Entropy, information gain - How to stop overfitting - Pruning DecisionTreeClassifier - How it works? - Understanding the parameters - Applications	3		
	2,3 ,5	**2,3 ,4**	3	Build decision tree-based model in python for like Breast Cancer Wisconsin (diagnostic) dataset from sci-kit learn Or any classification dataset from UCI , Kaggle			4	Evaluation Metrics for Classification - confusion matrix, - Accuracy - Precision and Recall - Specificity - F1-score - AUC-ROC ▪ How to compute ▪ How does it work	1		2

								▪ When to use			
	2,3,5	**2,3,4**	4	Evaluation Metrics for Classification- contd. Evaluation of decision tree model with different metrics			4	Hyper parameter tuning for DecisionTreeClassifier			3
			5	**CIE 3 – Written and Practice Test**				Assessment Review and corrective action			3
	2,3,5	**2,3,4**	6	Hyper parameter tuning for classification	2		3	Weekly Assignment			
8	**2,3,5**	**2,3,4**	1	Peer review **Mini Project Activity – Status review**		4		Logistic regression - Overview - Types - How does logistic regression work? - Assumptions - Understanding sigmoid function - Applications Practice: build Logistic regression model in python	1		2
	2,3,5	**2,3,4**	2	build Logistic regression model in python Evaluation and optimization of the model	2		2	Support Vector Machine - Introduction to SVM - How does it work? - Applications Practice: Build a SVM Model in python for Fish dataset from Kaggle	2		1
	2,3,5	**2,3,4**	3	Build a SVM Model in python			4	**Ensemble Learning**			3

				How to optimize SVM?				Introduction Basic Ensemble Techniques - Max Voting - Averaging - Weighted Average Advanced Ensemble Techniques - Stacking - Blending - Bagging - Boosting Explore and list the Ensemble Algorithms - T Random Forest - Introduction - How does it work? - Hyper parameters - Applications			
	2,3 ,5	**2,3 ,4**	4	Build Random Forest-based model in python for Breast Cancer Wisconsin (diagnostic) dataset from sci-kit learn Or dataset from UCI , Kaggle			4	Evaluation and optimization			3
			5	**Development Assessment**				Assessment Review and corrective action			3
	2,3 ,5	**2,3 ,4**	6	Comparison of classification algorithms with real world scenario	2		3	Weekly Assignment			

9	3	2,3	1	Peer review **Mini Project Activity – Status review**		4		Unsupervised learning – - What is unsupervised learning? - Common approaches - Challenges - Clustering Types Applications of unsupervised learning - T K-means – Working of K-means How to Choose the Right Number of Clusters?	2		1
	2,3 ,5	**2,3 ,4**	2	**Implementation in python** Evaluation Metrics - Inertia - Dunn Index Evaluate the model using mentioned metrics	1		3	**Contd.**			3
	2,3 ,5	**2,3 ,4**	3	Dimensionality Reduction - Importance of Dimension Reduction in machine learning Common methods to perform Dimension Reduction - T Dimensionality Reduction using PCA in python	2		2	Dimensionality Reduction using PCA in python			3
	5	4,5	4	MLOps - Overview	2		2	- Monitoring - Deployment			3

				- Why MLOps? - ML pipeline - Versioning - Model registry				- Model monitoring			
			5	**CIE 4 – Written and Practice Test**				Assessment Review and corrective action			3
	4	2,3	6	Compare various clustering techniques	2		3	Weekly Assignment			
10	1	3,4	1	Peer review **<u>Mini Project Activity (2)</u>** - Regression - Rebuild with deep learning model - Classification - Rebuild with deep learning model - Analyze the performance of ML and DL **(Individual/ Team of 2)** - Define Problem statement (solution to be presented in the 13th week CIE – 6) - Create project plan and product backlog - Create git repository for the project Work progress should be monitored weekly		4		**Deep learning** - Limitations of Machine Learning - What is deep learning? - Deep learning models - Deep Learning Applications - Deep learning frameworks Group discussion – T Future -Impact deep learning will likely to have on a variety of industries in the next few years. Environment setup - Local - Cloud <u>TOC - Deep Learning with TensorFlow | Infosys Springboard (onwingspan.com)</u>	2		1
	2,3	3,4	2	Introduction to Neural Networks ▪ Understanding	2		2	Introduction to TensorFlow - What is TensorFlow?	1		2

				- Biological Neurons - Artificial neuron /Perceptron - Working of perceptron ▪ Neural network - Architecture - Working of NN - Forward propagation - Back propagation ▪ Activation function - Sigmoid - Tanh - ReLU - LeakyReLU ▪ Cost function - How to measure loss? - How to reduce Loss? - Gradient Descent Get data, and explore Eg. Stroke Prediction Dataset | Kaggle or dataset from any other source Prepare data: Dealing with - missing values - Categorical values				- Why TensorFlow? - TensorFlow ecosystem - TensorFlow architecture - Program Elements in TensorFlow Keras - What is Keras? - Keras APIs – three programming models - Sequential Model - Functional API and - Model Subclassing - Keras layers - Custom Keras Layers TOC - Deep Learning with TensorFlow | Infosys Springboard (onwingspan.com) TOC - TensorFlow for Beginners | Infosys Springboard (onwingspan.com)			

				- Labeled encoding - One hot coding Prepare data : Feature scaling with StandardScalar() or other method Dropping unnecessary features Data splitting Dealing with imbalanced dataset							

	3	2,3, 4	3	- Why do we have to flatten the input data?
				- Understand Keras Dense Layer
				  - Overview
				  - Parameters
				  - Operation
				- Building Shallow Neural Network with Keras Dense Layer
				- Building Deep Neural Network with Keras Dense Layers
				- Create a complete end to end neural network model using Keras Sequential Model and Keras Layer API
				Eg.
				MNIST dataset (classify handwritten numerals) or fashion-MNIST dataset or dataset from other source
					1		3	Keras optimizers
								Keras Metrics
								Keras Losses
								Create a complete end to end neural network – Contd.
								TOC - Learning TensorFlow 2.0 | Infosys Springboard (onwingspan.com)
									1		2

	3	3,4	4	Keras - Callbacks - Commonly used callbacks Monitor neural network performance with TensorBoard - TensorBoard Basics - TensorBoard Setup Understand Model Behavior During Training Reduce overfitting with Dropout Layer	1		3	How to save trained model Local deployment with TensorFlow ModelServer			3
			5	**Development Assessment**				Assessment Review and corrective action			3
	2,3	3,4	6	Building deep learning model with TensorFlow and Keras for use cases	2		3	Weekly Assignment			
11	1,5	2,3, 4	1	Peer Review **Mini Project Activity – Status review**		4		Natural Language Processing Understanding natural language processing NLP approaches – rule based, statistical NLP use cases How to use dictionary? Commonly used NLP tools & libraries Setup environment (spaCy or similar nlp package)	2		1
	2,3	2,3, 4	2	Text processing tasks (Processing Words)	1			Spell Correction	1		2

				Document Assembler Annotation Tokenization - Sentence tokenization - Word tokenization - Visualize frequency distribution of words - Visualize with word cloud Stop word - Dropping stop words - Dropping punctuations			3	Normalization - Stemming - Lemmatization			
	2,3	3	3	Parts of speech tagging Named Entity Recognition	1		3	Vectorizer N-Gram	1		2
	2,3	2.3, 4	4	TF-IDF Build a pipeline for text processing	1		3	Contd.			3
			5	**CIE 5 – Written and Practice Test**				Assessment Review and corrective action			3
	3	2,3	6	NLP – text summarization	2		3	Weekly Assignment			
12	1	2,3, 4	1	Peer review Mini Project Activity – Status review				NLP use case – Sentiment Analysis (SA) What is sentiment analysis? Why is SA important? Business applications for SA How does sentiment analysis work? Transformers	1		2

								Conduct Sentiment analysis to classify movie reviews with - spaCy - TensorFlow and keras			
	1,2, 3,4,	2,3, 4,6	2	NLP use case – Sentiment Analysis (SA) Contd.			4	Ethics in AI - Importance of AI ethics - Ethical challenges of AI - AI code of ethics Group Discussion: Discussion on the Ethics of AI Ethics of AI: Safeguarding Humanity | Professional Education (mit.edu)	1		2
	5	2,3, 4	3	Containers Why containers? What is a docker? How docker works? Components of docker - Docker container - Docker client - Docker daemon - Docker image - Docker registry Install docker on desktop and start the docker tool.	2		2	Publish the container in Registry			3

				TOC - Containers & Images | Infosys Springboard (onwingspan.com) Docker file Docker image Commands to create docker file. Build docker image with docker file create docker container from docker image Run the docker container TOC - Deploying and Running Docker Containers | Infosys Springboard (onwingspan.com) TOC - Docker, Dockerfile, and Docker-Compose (2020 Ready!) | Infosys Springboard (onwingspan.com)							
	5	3,4	4	Deployment strategies	1		3	Contd.			3
			5	**Development Assessment**				Assessment Review and corrective action			3
	1,3	5	6	Using cloud service for MLOps	2		3	Weekly Assignment			

References

Sl. No	Description
1	Hands-On Artificial Intelligence for Beginners By Patrick D. Smith
2	Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 2nd Edition, By Aurélien Géron
3	Machine Learning with Python for everyone, Mark E Fenner
4	Hands on Data processing in Python , Joy Jafari
5	Deep Learning with TensorFlow2 and Keras , Antonio Gulli, Amita Kapoor,Sujith Pal
6	Cloud Computing, Concepts, Technology and Architecture by Thomas Erl
7	Khan Academy
8	Fundamentals of Data Visualization, Claus O. Wilke
9	Pro Git ,Scott Chacon, Ben Straub
10	Mathematics for Machine Learning, A. Aldo Faisal, Cheng Soon Ong, and Marc Peter Deisenroth
11	Machine Learning, Pipelines, Deployment and MLOps Tutorial | DataCamp
12	MLOps Python Tutorial for Beginners -Get Started with MLOps (projectpro.io)

Cloud Computing and Cyber Security

Under Preparation…….

Internet of Things (IoT)

Pre-requisites-

Knowledge of basic programming skills in python, networking concepts and basic electronic components

Course Outcomes-

Upon completion of the course, the student shall be able to

CO1	**Familiarize with Internet of Things Physical and Logical Design and Levels.**
CO2	**Understand IoT System Management with NETCONF-YANG**
CO3	**Understand Internet of Things, its hardware & software components and applications.**
CO4	**Interpret IoT Application Development**
CO5	**Discuss Security, Privacy and Governance in IoT**
CO6	**Explain IIoT and Case studies for IoT Design**

Course Contents

UNIT - 1: Introduction to Internet of Things

8 Periods

IoT – Definition, characteristics, Physical design of IoT, Things in IoT, IoT Protocols, Logical Design of IoT, IoT functional blocks, IoT communication Models, IoT communication API's IoT enabling Technologies – Wireless sensor networks, Cloud Computing, Big Data Analytics, Communication protocols, embedded systems. IoT Levels and Deployment templates – IoT Level-1, IoT Level-2, IoT Level-3, IoT Level-4, IoT Level-5, IoT Level-6, Popular IoT platforms, Domain specific IoTs

UNIT - 2: M2M, IoT System Management with NETCONF-YANG

6 Periods

M2M, Difference between IoT and M2M, SDN and NFV for IoT, Need for IoT Systems Management, Simple Network Management Protocol, Network Operator requirements, NETCONF, YANG, IoT Systems Management with NETCONG-YANG

UNIT - 3: Elements of IoT

8 Periods

Overview of IoT components-basic building blocks of IoT, Hardware Components- IoT Devices: Raspberry PI, Arduino; Sensors, Actuators, Smart objects and RFID, Software Components-Python Packages of interest for IoT, Networking Protocols

UNIT – 4: IoT Application Development

6 Periods

IoT Design Methodology, Linux on Raspberry PI, Raspberry PI interfaces, Programming Raspberry PI with Python, Data storage on cloud/local server

UNIT - 5: IoT Privacy, Security and Governance

6 Periods

Overview of Governance, Security and Privacy issues, Security, Privacy and Trust in IoT, IoT security life cycle, use of Blockchain in IoT security

UNIT - 6: IIoT and Case Studies on IoT Design

6 Periods

Industrial Internet of Things (IIoT), Differentiate IoT and IIoT, Case Studies- Home Automation, Urban Cities, Environment, Agriculture, Health Care, Transportation.

Reference Books

1. Internet of Things - A Hands-on Approach, Arshdeep Bahga and Vijay Madisetti, Universities Press, 2015, ISBN: 9788173719547
2. Getting Started with Raspberry Pi, Matt Richardson & Shawn Wallace, O'Reilly (SPD), 2014, ISBN: 9789350239759
3. Dr. SRN Reddy, RachitThukral and Manasi Mishra, “Introduction to Internet of Things: A practical Approach”, ETI Labs
4. Raj Kamal, “Internet of Things: Architecture and Design”, McGraw Hill

Suggested E-learning referencess

1. https://internetofthingsagenda.techtarget.com/
2. https://dzone.com/iot-developer-tutorials-tools-news-reviews
3. https://blog.bosch-si.com/
4. https://www.hackster.io/
5. https://www.libelium.com/
6. https://www.ibm.com/blogs/internet-of-things/
7. https://azure.microsoft.com/en-us/blog/topics/internet-of-things/
8. https://blog.arduino.cc/
9. https://www.raspberrypi.org/blog/
10. www.lemalabs.com/iot

BLOCK CHAIN TECHNOLOGY

OBJECTIVES:

- To understand the concepts of block chain technology
- To understand the consensus and hyper ledger fabric in block chain technology.

OUTCOMES:

- State the basic concepts of block chain
- Paraphrase the list of consensus and Demonstrate and Interpret working of Hyper ledger Fabric
- Implement SDK composer tool and explain the Digital identity for government

UNIT - I

History: Digital Money to Distributed Ledgers -Design Primitives: Protocols, Security, Consensus, Permissions, Privacy- : Block chain Architecture and Design-Basic crypto primitives: Hash, Signature- Hash chain to Block chain-Basic consensus mechanisms.

UNIT - II

Requirements for the consensus protocols-Proof of Work (PoW)-Scalability aspects of Block chain consensus protocols**:** Permissioned Block chains-Design goals-Consensus protocols for Permissioned Block chains.

UNIT - III

Decomposing the consensus process-Hyper ledger fabric components-Chain code Design and Implementation: Hyper ledger Fabric II:-Beyond Chain code: fabric SDK and Front End-Hyper ledger composer tool.

UNIT - IV

Block chain in Financial Software and Systems (FSS): -Settlements, -KYC, -Capital markets-Insurance- Block chain in trade/supply chain: Provenance of goods, visibility, trade/supply chain finance, invoice management/discounting.

UNIT - V

Block chain for Government: Digital identity, land records and other kinds of record keeping between government entities, public distribution system / social welfare systems: Block chain Cryptography: Privacy and Security on Block chain.

TEXT BOOKS:

1. Mark Gates, "*Block chain: Ultimate guide to understanding block chain, bit coin, crypto currencies, smart contracts and the future of money*", Wise Fox Publishing and Mark Gates 2017.
2. Salman Baset, Luc Desrosiers, Nitin Gaur, Petr Novotny, Anthony O'Dowd, Venkatraman Ramakrishna, "*Hands-On Block chain with Hyper ledger: Building decentralized applications with Hyperledger Fabric and Composer*", 2018.
3. Bahga, Vijay Madisetti, "*Block chain Applications: A Hands-On Approach*", Arshdeep Bahga, Vijay Madisetti publishers 2017.

REFERENCE BOOKS:

1. Andreas Antonopoulos, "*Mastering Bitcoin: Unlocking Digital Crypto currencies*", O'Reilly Media, Inc. 2014.
2. Melanie Swa, "*Block chain* ",O'Reilly Media 2014.

WEB REFERENCES:

- NPTEL & MOOC courses titled blockchain technology
- blockgeeks.comguide/what-is-block-chain-technology
- https://nptel.ac.in/courses/106105184/

DRONE TECHNOLOGY & ROBOTICS

COURSE OBJECTIVES

The course should enable the students to:

1. Learn concepts of Drone and Drone Technology
2. Impart knowledge of AI and Drone technology for various domains applications
3. To make the students to understand the basic concepts of UAV drone systems.
4. To introduce the stability and control of an aircraft

COURSE OUTCOMES

1. Design, build and program simple autonomous robots.
2. Implement standard signal processing and control algorithms.
3. Ability to design UAV drone system
4. To understand working of different types of engines and its area of applications
5. To understand static and dynamic stability dynamic instability and control concepts

UNIT-I- Robotics, Sensors and Signal processing Robotics:

Robotics and AI, Embedded Systems, Agent-Task-Environment model, Embodied Systems, Synthetic approaches to science Sensors and signal processing Common sensors and their properties, 1D signal processing, Vision

UNIT-II- AI and the Internet of Things:

AI and the Internet of Things: Real World Use-Cases: Automated vacuum cleaners, like that of the iRobot Roomba, Smart thermostat solutions, like that of Nest Labs

UNIT-III- Introduction to Drones:

Introduction to Drones: Introduction to Unmanned Aircraft Systems, History of UAV drones, classification of drones, System Composition, applications

UNIT-IV- Design of UAV Drone Systems:

Design of UAV Drone Systems: Introduction to Design and Selection of the System, Aerodynamics and Airframe Configurations, Characteristics of Aircraft Types, Design Standards and Regulatory Aspects-India Specific, Design for Stealth.

UNIT-V- Avionics Hardware of Drones:

Avionics Hardware of Drones: Autopilot, AGL-pressure sensors servos-accelerometer –gyros-actuators-power supply-processor, integration, installation, configuration.

TEXT BOOKS

1. Reg Austin "Unmanned Aircraft Systems UAV design, development and deployment", Wiley, 2010.
2. Robert C. Nelson, Flight Stability and Automatic Control, McGraw-Hill, Inc., 1998.

REFERENCE BOOKS

1. The Art of Robotics: An introduction to engineering, F Martin, Addison-Wesley, forthcoming

DATA ANALYTICS

I. RATIONALE

Data Analytics uses statistical and computational methods to analyze data, aiding informed decision-making. Excel dashboards effectively present vital data at a glance, enhancing user interactivity. A Data Analyst collects, cleans, and visualizes Datasets to solve problems.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

Perform Data Analytics in various business domains for improved decision making

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

CO1 - Elaborate the fundamental concepts of Data Analytics.
CO2 - Apply appropriate statistical techniques to analyze and interpret complex Datasets.
CO3 - Analyze numerical data by creating pivot table.
CO4 - Represent data in terms of various types of charts.
CO5 - Visualize the data using a Python library.

IV. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Course Content	Hours
1	**Unit - I Introduction to Data Analytics** 1.1 Data Analytics: An Overview, Importance of Data Analytics 1.2 Types of Data Analytics: Descriptive Analysis, Diagnostic Analysis, Predictive Analysis, Prescriptive Analysis, Visual Analytics 1.3 Life cycle of Data Analytics, Quality and Quantity of data, Measurement 1.4 Data Types, Measure of central tendency, Measures of dispersion 1.5 Sampling Funnel, Central Limit Theorem, Confidence Interval, Sampling Variation	
2	**Unit - II Statistical Analysis** 2.1 Graphical techniques, box plot, skewness and kurtosis, Descriptive Stats 2.2 Correlation and Regression, Data Cleaning 2.3 Imputation Techniques 2.4 Anova and Chi Square 2.5 Scatter Diagram 2.6 Estimation and Hypothesis Testing 2.7 Sampling Distributions, Counting 2.8 Probability,Probability Distributions	
3	**Unit - III Data Analytics with Excel** 3.1 Excel Dashboard: Tables and Data Grids, Dynamic Filters and Controls, Trend Analysis and Forecasting 3.2 Pivot Tables: Creating a Pivot Table Specifying Pivot Table Data 3.3 Changing a Pivot Tables, Calculation Filtering and Sorting a Pivot Table 3.4 Creating a Pivot Chart, Grouping Items 3.5 Updating a Pivot Table, formatting a Pivot Table using Slicers	

4	**Unit - IV Data Visualization** 4.1 Creating a Simple Chart, Charting Non-Adjacent Cells 4.2 Creating a Chart Using the Chart Wizard, Modifying Charts, Moving an Embedded Chart, Sizing an Embedded Chart 4.3 Changing the Chart Type, Changing the Way Data is Displayed, Moving the Legend 4.4 Formatting Charts, Adding Chart Items, Formatting All Text, Formatting and Aligning Numbers, Formatting the Plot Area, Formatting Data Markers 4.5 Pie Charts, Creating a Pie Chart Moving the Pie Chart to its Own Sheet Adding Data Labels, Exploding 1.6 a Slice of a Pie Chart	
5	**Unit - V Data Visualization using Python** 5.1 Overview of Matplotlib and its role in data visualization, Installing and setting up Matplotlib in Python 5.2 Basic plotting with Matplotlib, Line plot, Scatter plots, Bar charts, Histograms, adding titles, labels, and legends to plots 5.3 Changing figure size and aspect ratio, Customizing axes (limits, ticks, and labels) 5.4 Exporting and Saving Visualizations: Saving plots in different formats (PNG, PDF, SVG), Adjusting the resolution and quality of saved plots, creating interactive visualizations using Matplotlib widgets	

SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	**Jinjer Simon**	**Excel Data Analysis: Your visual blueprint for analyzing data, charts, and PivotTables**	**Wiley Publication Edition: 3rd ISBN: 978- 0-470-59160-4**
2	**A. J. Smalley**	**Data Analysis with Excel**	**SAGE Publications Edition: 1st, 2007 ISBN 10: 0070139903 / ISBN 13: 9780070139909**
3	**Fabio Nelli**	**Python Data Analytics: With Pandas, NumPy, and Matplotlib**	**Apress pubication ISBN-13 :978-1484239124 ISBN-13978-1484247372**
4	**Jake VanderPlas**	**Python Data Science Handbook**	**Shroff/O'Reilly Publication ISBN-10-9355422555 ISBN-13-978-9355422552**
5	**Business Analytics with MindTap**	**Jeffrey D. Camm | James J Cochran | Michael J. Fry | Jeffrey W. Ohlmann**	**Cengage Learning India Pvt. Ltd. Publication Edition:4th ISBN: 9789360533533**

V. LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://spreadsheetpoint.com/excel/dashboard-in-excel/	Advance Excel
2	https://www.javatpoint.com/how-to-create-a-dashboard-in-exce l	Excel Dashboard
3	https://www.simplilearn.com/tutorials/excel-tutorial/data-an alysis-excel	Data Visualization
4	https://www.freecodecamp.org/news/introduction-to-data-vizua lization-using-matplotlib/	Matplotlib in Python
5	https://archive.nptel.ac.in/courses/106/107/106107220/	Introduction to data analytics

METROLOGY LAB

Course Code- **L:T:P**

Prerequisites:

Basic knowledge of Metrology& pneumatics systems

Course Outcomes:

On successful completion of the course, the students will be able to

CO1	Measure the angle of the machined surface using a sine bar with slip gauges
CO2	Measure the geometrical dimensions of a given thread and spur gear and alignment of a given surface
CO3	Measure the surface roughness and linear displacement

List Of Experiments:

S.No.	Description
1	Introduction to Metrology
2	Measure the angle of the machined surface using a sine bar with slip gauges
3	To measure the screw thread parameters of a given specimen and given spur gear teeth using Tool Maker's Microscope and Gear tooth vernier
4	Check the alignment using Autocollimator
5	Measurement of displacement using LVDT
6	Measurement of surface roughness using Talysurf tester

Reference Books:

1. Engineering Metrology – R. K. Jain
2. Engineering precision metrology – R. C. Gupta
3. A Handbook of Industrial Metrology – ASME
4. Measurement System (Application and Design) – Ernest O Doebelin

REFRIGERATION AND AIR CONDITIONING LAB

Course Code- **L:T:P**

Prerequisites:

Basic knowledge of Thermodynamics and Refrigeration & Air conditioning

Course Outcomes:

CO	**On Successful completion of the course, the student will be able to**
1	Summarize working of refrigeration and air conditioning system tools and perform basic operations on softcopper tube
2	Identify and acquire knowledge to handle different components of Refrigeration and Air Conditioning systems.
3	Classify refrigerants and justify their application.
4	Evaluate Coefficient of Performance (COP) of Refrigeration and Air conditioning system with given data and validate the result by using p-hchart.
5	Determine Coefficient of Performance (COP) of Refrigeration and Air conditioning systems
6	Illustrate working of air cooler, water cooler, domestic refrigerator, split air Conditioner and window air conditioner and sketch the flow diagram.

Course Outcomes:

CO1	Evaluate Refrigeration and Air conditioning system tools and basic operations on soft copper tube
CO2	Identify and acquire knowledge on working of different parts of Refrigeration and Air conditioning systems.
CO3	Develop knowledge on refrigerants.
CO4	Measure Coefficient of Performance(COP) of Refrigeration and Air conditioning system withgiven data and use p-h chart.
CO5	Determine Coefficient of Performance(COP) of Refrigeration and Air conditioning systems systems.
CO6	Distinguish working of air cooler, water cooler, domestic refrigerator, split air conditioner and window air conditioner.

Course Content

S.No.	Course Content
1.	R&AC Tools, Basic Operations on soft Coppertube
2.	Vapour Compression cycle testrig
3.	Water cooler
4.	Air conditioning test rig
5.	Domestic refrigerator
6.	Window air conditioner
7.	Split air conditioner
8.	Air cooler