CURRICULUM STRUCTURE

V Semester Scheme of Studies - Diploma in Mechanical Engineering [C-20]

Pathway	Course Category / Teaching Department	Course Code	Pathway Title	Hours per Semester			Total contact hrs /Semester	Credits	CIE Marks		SEE-1 Marks (Theory)		SEE-2 Mark (Practical)		Total Marks	Min Marks for Passing (including CIE marks)	Assigned Grade	Grade Point	SGPA and CGPA
				L	T	P			Max	Min	Max	Min	Max	Mi n					
Programme Specialization Pathway																			Both SGPA & CGPA
1	**ES/ME** Specialization pathways in emerging areas Student may select any one of the specializations	**20ME51I**	**Automation and Robotics**	104	52	312	468	24	240	96	60	24	100	40	400	160			
		20ME52I	**Heating, Ventilation and Air Conditioning (HVAC)**	104	52	312	468	24	240	96	60	24	100	40	400	160			
		20ME53I	**Advanced Manufacturing Technologies**	104	52	312	468	24	240	96	60	24	100	40	400	160			
		20ME54I	**- E-Mobility**	104	52	312	468	24	240	96	60	24	100	40	400	160			
Science and Research Pathway				L	T	P	Total	Credit	CIE Marks		SEE Marks								
									Max	Min	Max	Min							
2	BS/SC/ME Specialization pathway in Science and Research **(Student need to take all four papers in this pathway)**	2OSC51T	Paper 1-Applied Mathematics	52	26	0	78	6	50	20	50	20			100	40			
		2OSC52T	Paper 2 – Applied Science	52	0	52	104	6	50	20	50	20			100	40			
		2ORM53T	Paper 3 – Research Methodology	52	0	52	104	6	50	20	50	20			100	40			
		2OTW54P	Paper 4 – Technical Writing	39	13	52	104	6	60	24	40	16			100	40			
			Total	195	39	156	390	24	210	84	190	76			400	160			
Entrepreneurship Pathway																			
3	ES/ME	20ET51I	Entrepreneurship and start up	104	52	312	468	24	240	96	160	64			400	160			

L: - Lecture T: - Tutorial P: - Practical BS- Basic Science: ES-Engineering Science: SC: Science

Note: In 5th Semester student need to select any one of the pathways consisting of 24 credits
Students can continue their higher education irrespective of the Pathway selected

Government of Karnataka
DEPARTMENT OF COLLEGIATE and TECHNICAL EDUCATION

Program	**Mechanical Engineering**	**Semester**	**5**
Course Code	**20ME51I**	**Type of Course**	**L:T:P (104: 52: 312)**
Specialization	**Automation and Robotics**	**Credits**	**24**
CIE Marks	**240**	**SEE Marks**	**160**

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

Pre-requisite

Before the start of this specialisation course, you will have prerequisite knowledge gained in the first two years on the following subjects:

1st year -Engineering Mathematics, Communication Skills, Computer Aided Engineering Graphics, Statistics & Analysis, Basic IT Skills, Fundamentals of Electrical and Electronics Engineering, Project Management skills Engineering Materials and Mechanical Workshop

2nd year-Mechanics of Materials, Machine Tool Technology, Manufacturing Process, Fluid Power Engineering, Product Design and Development, Operations Management, CNC Machines and Elements of Industrial Automation. 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 Cohort Owner

A Course Cohort Owner is a faculty from the core discipline, who is fully responsible for one specialised field of study and the cohort of students who have chosen to study that specialised field of study.

Guidelines for Cohort Owner

1. Each Specialized field of study is restricted to a Cohort of 20 students which could include students from other relevant programs.
2. One faculty from the Core Discipline shall be the Cohort Owner, who for teaching and learning in allied disciplines can work with faculty from other disciplines or industry experts.
3. The course shall be delivered in boot camp mode spanning over 12 weeks of study, weekly developmental assessments and culminating in a mini capstone.
4. The industry session shall be addressed by industry subject experts (in contact mode/online / recorded video mode) in the discipline only.
5. The cohort owner shall be responsible to identify experts from the relevant field and organize industry session as per schedule.
6. Cohort owner shall plan and accompany the cohort for any industrial visits.
7. Cohort owner shall maintain and document industrial assignments, weekly assessments, practices and mini project.
8. The cohort owner shall coordinate with faculties across programs needed for their course to ensure seamless delivery as per time table
9. The cohort owner along with classroom sessions can augment or use supplementally teaching and learning opportunities including good quality online courses available on platforms like Karnataka LMS, Infosys Springboard, NPTEL, Unacademy, SWAYAM, etc.

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

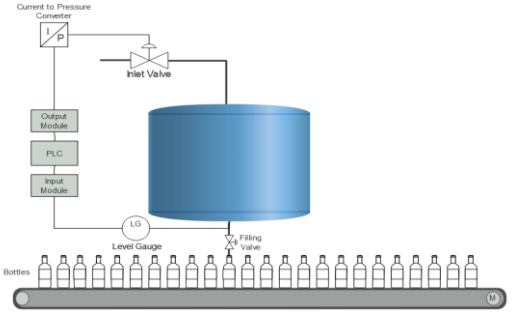
Detailed course plan

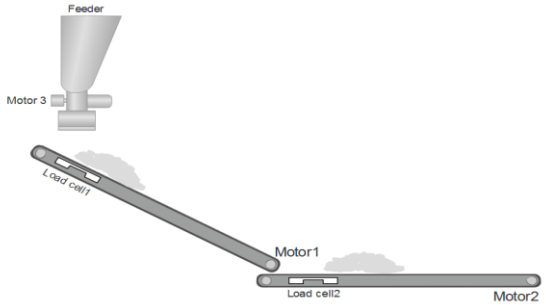
Week	C O	P O	Days	1st session (9am to 1 pm)	L	T	P	2ND session (1.30pm to 4.30pm)	L	T	P
1	1		1	Present an overview on Conventional Production process starting from procurement of raw materials to finished product and delivery to the customer			4	Virtual tour on modern industries such as automobile sector, 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**

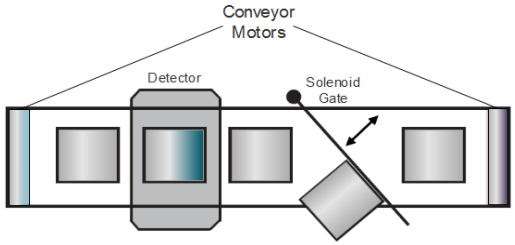
	1,2		3	Recap on Technologies adopted in Automation Demonstrate- • Sensors Technology • Drives and Actuators • Relays and Switches • PLC and Programming • Communication Protocols -	1		3	Modern tools used for Industrial Automation- PAC, SCADA, HMI, DCS, AI, IIOT, etc Importance of IEC, ISO, NEMA, JIC and 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

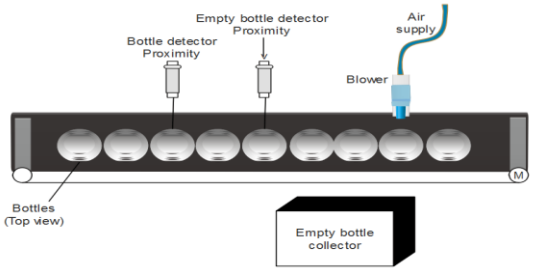
			6	**Industry Class on PLC Programs practiced in Industry + Industry Assignment**			5				
3	2		1	**PEER Discussion on Industry Assignment**		4		Explain and demonstrate how to establish communication network with PLC systems using industry standard communication protocols for data transfer • Serial Communications • 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**

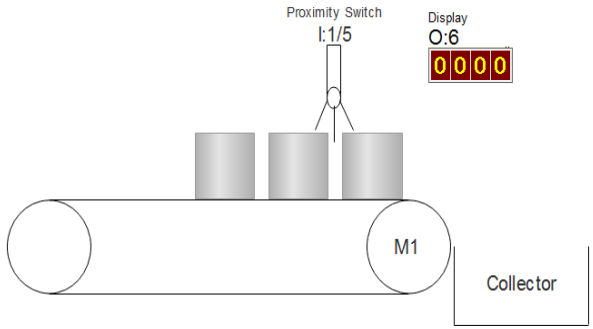
	5		2	Working with HMI software Tool • Configure PLC with HMI • Animation with graphical objects • Animate objects on an HMI screen to monitor motor status • Trend the data of a process parameter using a trend tool. • Create user groups and monitor screens with proper authentication. • Use security features 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**

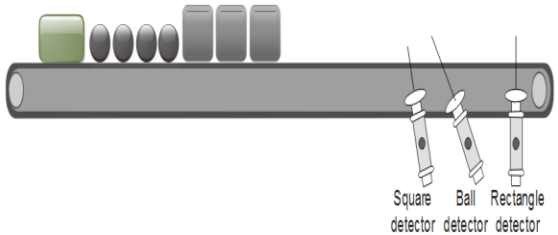
								depends on level of the tank due to its head pressure. To maintain this speed, pressure head of the filling tank has to be maintained at a particular level. Implement this automation in PLC using Ladder Diagram programming language **Diagram:**  **Condition:** To continuously maintain constant Pressure 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			

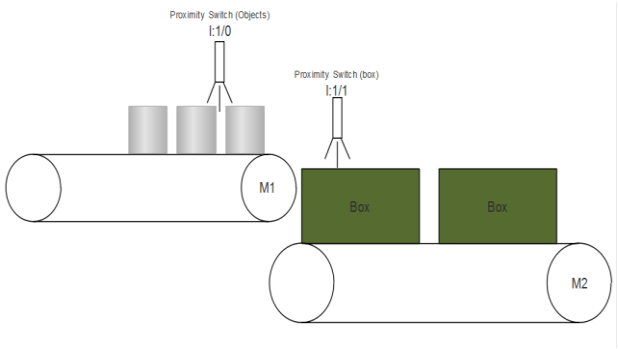
	3		2	**Problem Statement**: A feeder drops material on the conveyor which sends material for further process through one more conveyor. Conveyor must start automatically when material is dropped on it. Implement automation of this in PLC using Ladder Diagram programming language. **Diagram:**  **Condition:** • 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**

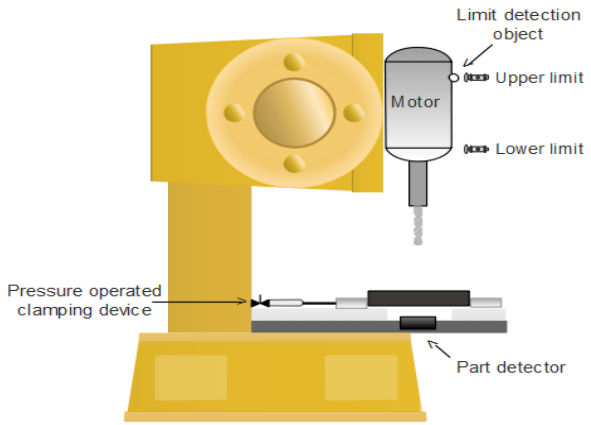
				c) Develop a PLC Ladder Program for the above case, simulate, interface with PLC and execute d) Discuss the Applications of the above Case			
	3		3	**Problem Statement:** Parts are moving on the conveyor from one process line to other with a constant speed. Out of 1000-part, one part is taken out for 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**

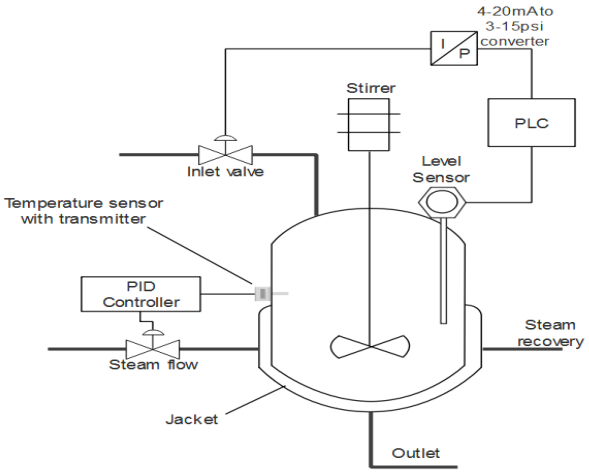
			6	**Industry Class on Automation in Industry + Industry Assignment**			5				
6	3		1	**PEER Discussion on Industry Assignment**		4		**Problem Statement**: Parts are moved on the conveyor. Count the number of parts collected at the end of the conveyor and display it on the display in PLC using Ladder Diagram 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**

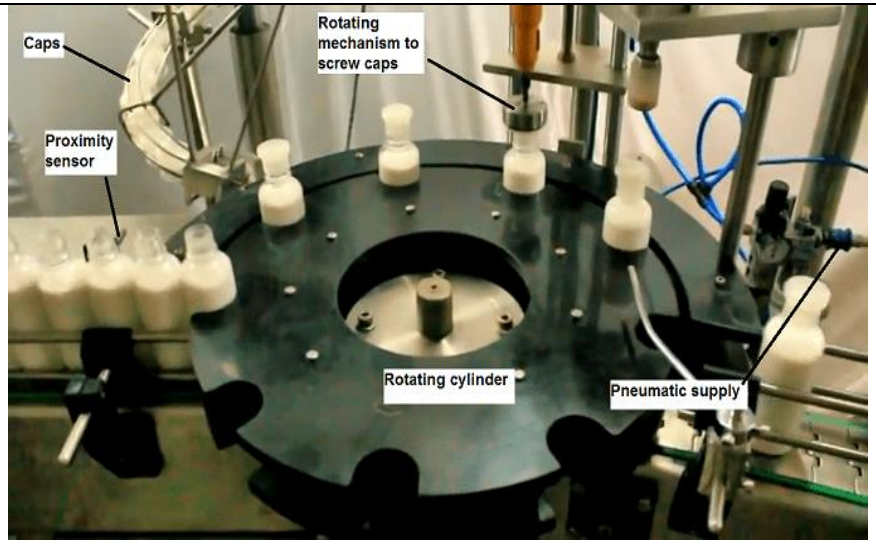
								a) For the above case, Discuss the suitable sensor technology, PLC, Drives, Communication Protocol and Related Hardware components b) Select Hardware components from the Company catalogue and record their specifications in a DATA Sheet c) Develop a PLC Ladder Program for the above case, simulate, interface 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:

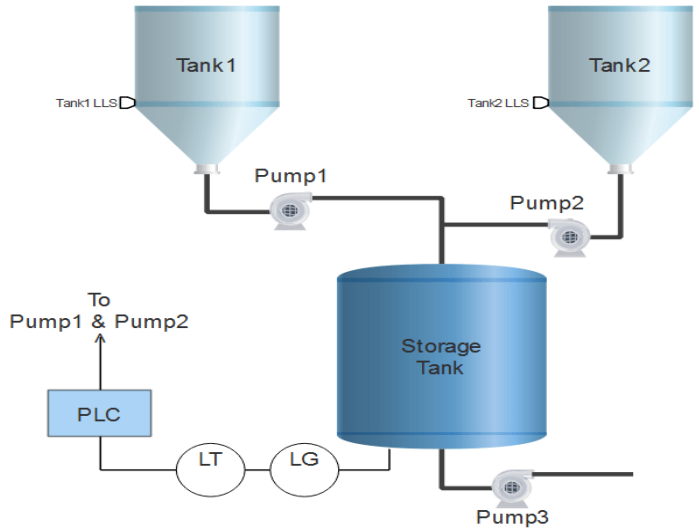
- To sense the bottle, proximity sensor is used.
- Used a timer to stop the cylinder motor for 2secs to screw caps.
- Used one more timer to run the motor for 1sec to rotate the cylinder.
- Bit Shift register is also used to perform this operation.
- Count the number of steps capping machine is placed 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

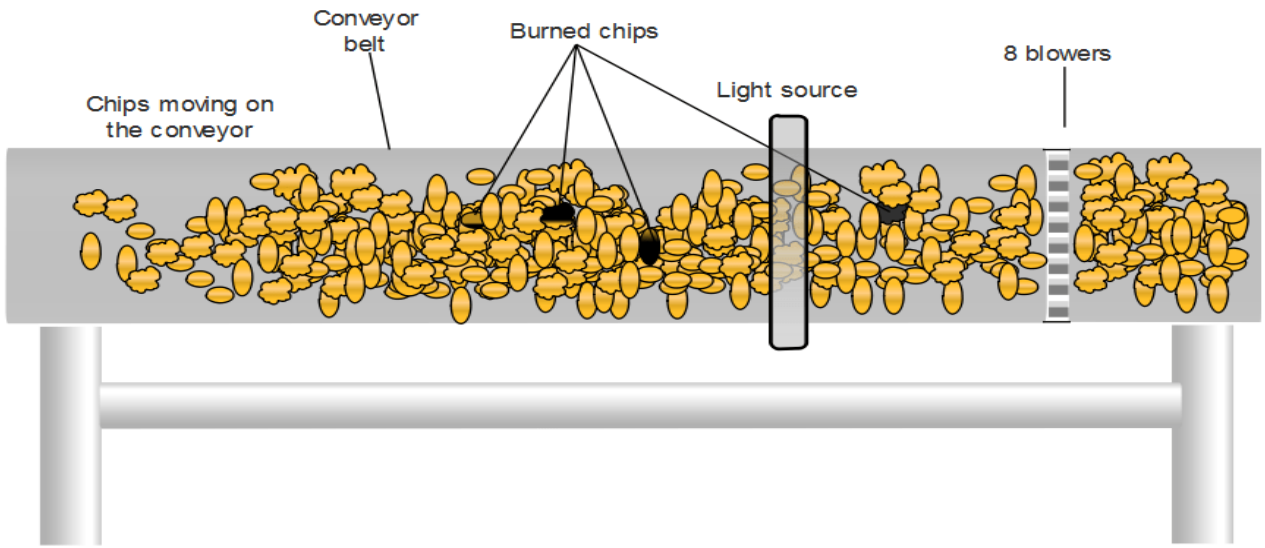
c) Develop a PLC Ladder Program for the above case, simulate, interface with PLC and execute

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:

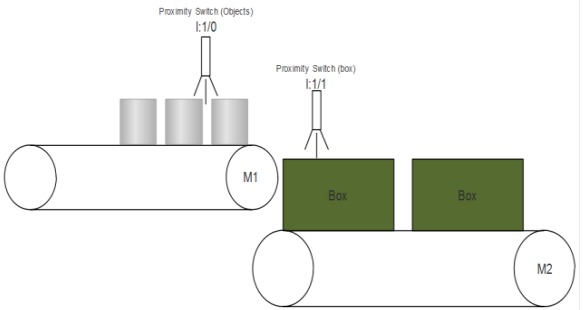


Condition:

- 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**
	5		5	**Developmental Weekly Assessment**				**Assessment Review and corrective action**			**3**
	5		6	**Industry Class on SCADA and IIOT in Automation + Industry Assignment**			5				
13			1	**Internship** **a) Secondary research on various industries and their operations to identify at least 3 companies along with the areas of work interest and develop an internship plan that clearly highlights expectations from the industry during the internship.** **b) Design and develop a cover letter for an internship request to all 3 identified companies and the resume to be submitted to potential companies.** **c) Prepare for an internship interview to highlight your interests, areas of study, career aspirations and**				**Project** **a) Identification of the problem statement (from at least 3 known problems) the students would like to work as part of the project – either as provided by faculty or as identified by the student. Document the impact the project will have from a technical, social and business perspective.** **b) Design and develop the project solution or methodology to be used to solve at least one of the problems identified.**			**40 HRS**

				personnel competence – including the areas of learning you expect to learn during internship	**c) Prepare a project plan that will include a schedule, WBS, Budget and known risks along with strategies to mitigate them to ensure the project achieves the desired outcome.**	

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

CIE and SEE Assessment Methodologies

CIE Assessment	Assessment Mode	Duration In hours	Max Marks
Week 3	CIE 1– Written and practice test	4	30
Week 5	CIE 2– Written and practice test	4	30
Week 7	CIE 3– Written and practice test	4	30
Week 9	CIE 4– Written and practice test	4	30
Week 11	CIE 5– Written and practice test	4	30
	On line Course work (Minimum 10 hours online course with certification from (SWAYAM/NPTEL/Infosys Springboard)		40
	Profile building for Internship / Submission of Synopsys for project work		20
Portfolio evaluation (Based on industrial assignments and weekly developmental assessment) *			30
TOTAL CIE MARKS (A)			**240**
SEE 1 - Theory exam (QP from BTE) Conducted for 100 marks 3 hrs duration reduced to 60 marks		**3**	**60**
SEE 2 – Practical		**3**	**100**
TOTAL SEE MARKS (B)			**160**
TOTAL MARKS (A+B)			**400**

***** The industrial assignment shall be based on peer-to-peer assessment for a total of 10 marks (on a scale of 1 to 10) and in the event of a group assignment the marks awarded will be the same for the entire group, the developmental assessment will be for a total of 20 marks and based on MCQ/case study/demonstration and such other assignment methods

Assessment framework for CIE (1 to 5)

Note: Theory to be conducted for 1 hour and practice for 3 hours, total duration of exam – 4 hours

CIE 2- Model Question Paper

Programme	**Mechanical Engineering**	**Semester**	**V**
Course	**Automation and Robotics**	**Max Marks**	**30**
Course Code	**20ME51I**	**Duration**	**4 hours**
Name of the course coordinator			

Note: Answer one full question from each section.

Qn.No	**Question**	**CL L3/L4**	**CO**	**PO**	**Marks**
	Section-1 (Theory) – 10 marks				
1.a)	The cutting area is an important section in the float glass production line, which includes many productions control equipment, such as longitudinal cutting, transverse cutting, conveying roller table, etc. The main control part of the whole system is PLC, and the monitoring will be undertaken by HMI. Is it required to use both HMI and PLC, As opposed to just a PLC in this Production line? Justify your statement.	L4	5		03
b)	In any manufacturing plant, motor plays a vital role. Controlling the speed of the motor according to the prerequisite is a requirement in any plant. If any problem occurs in a process which cannot be tackled by the operator, then error should be checked by the programmer. It is not compulsory that programmers should be present at the place to solve the issue. Henceforth, how do you Remotely control the speed of the Motor using HMI.	L3	5		07
2.a)	In a manufacturing plant, 3 different machines are to be controlled from a single location with real time information. Specific production data are to be gathered from ERP system. Similarly, equipment data and sensor information are also required for cloud-based analytics resulting in predictive maintenance. Discuss the hardware and Protocols of SCADA and suggest suitable solution to the case with justification	L4	5		04

b)	An oil industry is constantly having issues on Oil leakage. Constant monitoring was required to detect this issue and resolve to prevent accidents. Henceforth, the company decided to introduce Alarms. Device a method to detect Gas Leakage and to strike an Alarm on detection using HMI alarm.	L3	5		06
Section-2 (Practical) - 20 marks					
3)	One open tank is installed in the water plant in which liquid level is to be controlled. Develop a PLC Ladder Program for the following condition: a) When Level High is detected, outlet flow is allowed and inlet flow is blocked b) When Level Low is detected, Outlet flow is blocked and inlet flow is allowed until high level is achieved Also, Simulate the above case. Suggest PLC and protocols for the above case	L4	3		20
4)	In a Process industry, filled bottles are moved on the conveyor belt for packaging process. Device a PLC Ladder Diagram program to a) Pick one bottle after every 500 bottles for inspection. Simulate, interface with PLC and execute the above case.	L4	3		20

Note : Theory questions shall be aligned to practical questions

Scheme of Evaluation for Practical question- Section 2

Sl. No	**Description**	**Marks: 20**
1	Analyze the given Problem Statement	02
2	Selecting suitable sensor technology, PLC, Drives for the above case,	05
3	Develop and simulate PLC Ladder Program for the above case	05
4	Suggest/Interface with PLC and execute using suitable communication protocols	05
5	Execution of the same program for different boundary conditions	03
	Total	**20**

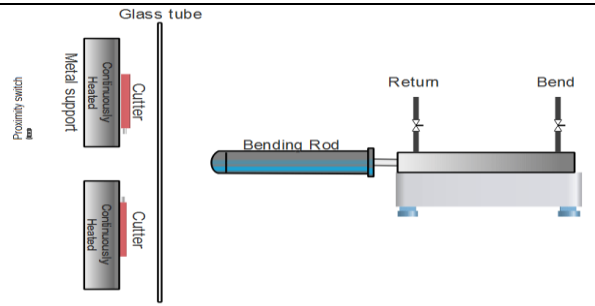
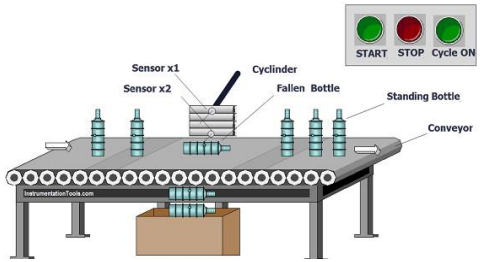
Assessment framework for SEE 1 (Theory)

Programme	**:**	**Mechanical Engineering**	**Semester: V**
Course	**:**	**Automation and Robotics**	**Max Marks: 100 Marks**
Course Code	**:**	**20ME51I**	**Duration: 3 Hrs**

Instruction to the Candidate: Answer one full question from each section.

Q.No	Question	CL (L3/L4)	CO	Marks
	Section-1			
1.a)	When a product is manufactured, there is always a start line and a finish line. The start line is where the raw materials enter the factory, and the finish line is where the final product is complete and ready to be shipped. A process turns the raw materials into the final finished product between the start and finish lines. This process can happen either manually or automatically. How does the automation affect the manufacturing? Can Automation be introduced at all levels? Justify your statement with examples	L4	1	10
b)	Virtually all industrial devices and processes are governed by standards to various degrees. Why are these standards important? Discuss standards established by IEC and ISO and their applications	L3		10
2.a)	Over many years, Sainsbury company was operating with the same supply chain and the IT system. These systems were outdated. Since they were created long before. So, the new firms in the market had started to overtake Sainsbury in terms of the market share since they had the recent technologies in supply chain. Hence, Sainsbury company decided to go for Automation. Provide an overview to Sainsbury company about various technologies and tools that are available for Automation. Suggest the best technology and tool that the company can adopt with justification	L4		10
b)	The modern and globalized world cannot exist without standards which are supporting cooperation, trade, health, safety, and economic growth etc. In fact, standards exist in almost all aspects of modern life. Highlight the importance of Automation Standards? List some Automation standards used and the role played by them?	L3		10
	Section-2			

3.a)	An industrial control network is a system of interconnected equipment used to monitor and control physical equipment in industrial environments. Interconnection is achieved by adopting suitable automation protocols. Compare the protocols used in Automation based on their Application, Strengths and limitations.	L4	2	10
b)	Sensors can be found in almost everything we use on a day-to-day basis. According to the National Science Foundation, "incorporating new sensor technologies, manufacturers can bring new capabilities to their products while improving performance and efficiency. Discuss the sensor technologies used in automation with examples and application.	L3		10
4.a)	The development of newer technologies such as cloud computing, internet of things and cyber-physical systems has brought a new revolution to the manufacturing industry. Communication among devices is one of the key goals of Industry 4.0. One way of achieving this is by using PLC communication protocols. Discuss the features of these PLC communication protocols and their usage in the existing systems with a comparative analysis?	L4		10
b)	A local food and beverage company was working with Horizon Solutions on automation to upgrade projects for one of their key manufacturing facilities. One of the machines looked at upgrading was connected to a conveyor on the packing line. This machine merged three conveyor lines. Also, before packing, one among the lot had to pushed for inspection which is performed by actuators. Discuss different actuators available with their strength and limitations. Suggest a suitable actuator for the above case with justification.	L3		10
Section- 3				
5.a)	A beverage industry has to fill its bottle with beverages at a constant speed of filling 30 bottles per minute. This speed 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 head. Suggest a) A Suitable sensor technology, PLC, Drives, Communication Protocol b) A PLC Ladder Program for the above case	L3	3	10
b)	Heated glass tubes are passing in a process line having a particular length which are to be bent. To manufacture fluorescent bulbs, these tubes are to be bent in U-Shape as shown in the diagram. Analyse the diagram and automate this process using Ladder Diagram programming language.	L4		10

				
6.a)	Heating of the liquid in the tank is to be performed. To heat this liquid, steam flow is controlled. If the temperature is detected less than the set point, increase the steam flow and vice-versa. Select a Suitable sensor technology, PLC, Drives, Communication Protocol Implement automation of this process in PLC using Ladder Diagram programming language.	L3		10
b)	 Analyse the above diagram. Automate the above process in PLC using Ladder Diagram Programming language	L4		10
	Section-4			
7.a)	Picking and placing parts or assemblies is often a simple, repetitive, and monotonous task in most industrial manufacturing processes. Especially when it comes to moving large, small, or hard-to-handle parts, automating this function on the factory line with high-speed pick and place robots can provide many benefits to manufacturers. To utilise these benefits, the company has asked programmers to device a Pick and place robot program which will not only provide solution to their problem but also is cost effective. Write a program for the above case assuming the required criteria.	L4	4	10
b)	Inertia Switch company got the full benefits of automation by using effective Grippers in Robots. Discuss different Robot Grippers and Highlight the criteria considered in selection of right type of Robot grippers.	L3		10
8.a)	Pick and place robots used for inspection applications are equipped with advanced vision systems to pick up objects, detect variation and remove defective parts or items by placing them in a designated location. Device a Pick and place robot program for the above case. Assume the required criteria.	L4		10
b)	Develop a program to command a PUMA robot to unload a cylindrical part of 10 mm diameter from machine 1 positioned at point P1 and load the part on machine 2 positioned at P2. The speed of robot	L3		10

	motion is 40 in/s. However, because of safety precautions, the speed is reduced to 10 in/s while moving to a machine for an unloading or loading operation.			
Section-5				
9.a)	One of the key requirements for effective predictive maintenance is a vast quantity of historical and real-time data of machine operations. In the industry 3.0 era, when computers began running traditionally manual operations, this required regular collection and recording of operational data. This was a cumbersome task for the maintenance team. Does the convergence of OT and IT emerge as a solution to this problem? Justify. What is this convergence called? What are the risks and security challenges faced by this convergence?	L3	5	10
b)	Jeff Thornton, product manager at Red Lion Controls pointed five key facets of HMI technology that are changing the common perceptions of HMI. One among them is the protocol. Compare the HMI protocols available and suggest the best one with justification.	L4		10
10.a)	HMI Panel software uses virtual components called Objects. Meters and Graphs are part of these objects. These help in producing simple, human machine interfaces. Using HMI, how is the level of liquid in a container indicated in the form of Bar graphs.	L3		10
b)	With the fourth industrial revolution, Industry 4.0, the Internet of Things has become the hot topic for numerous latest technological development efforts. Although they are merely a subset of modern technologies that are used to improve business processes still, they have their benefits and hence is spreading its wings over the enterprise. Does the introduction of IIOT improve the operational effectiveness? Justify considering all parameters.	L4		10

Scheme of Evaluation for SEE 2

Sl. No	**Description**	**Marks: 100**
Problem statement	Condition: A company is involved in supplying mineral water. They need to continuously meet the customer demand. Hence, have decide to Automate their entire unit. Following conditions were provided by the company a) Bottles are to be filled at a constant speed of 30bottles per min to meet the Demand. b) The bottles are to capped and lifted from the conveyor belt and shifted to the packaging process. c) 200 bottles are to be packed in one carton during packaging. d) The cartons are to be labelled with the company's Tag. Device a fully Automated system with Robots which will satisfy the company's requirement.	
1	Analyze the given Problem Statement	10
2	Selecting suitable sensor technology for the above case,	10

3	Selecting suitable PLC for the above case	10
4	Selecting suitable Drives for the above case,	10
5	Develop and simulate PLC Ladder Program for the above case	20
6	Interface with PLC and execute using suitable communication protocols	30
7	Execution of the same program for different boundary conditions	10
Total		**100**

Heating Ventilation and Air-Conditioning (HVAC)

Government of Karnataka
DEPARTMENT OF COLLEGIATE and TECHNICAL EDUCATION

Program	**Mechanical Engineering**	**Semester**	**5**
Course Code	**20ME52I**	**Type of Course**	**L:T:P (104:52:312)**
Specialization	**Heating Ventilation and Air-Conditioning (HVAC)**	**Credits**	**24**
CIE Marks	**240**	**SEE Marks**	**160**

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

Pre-requisite

Before the start of this specialisation course, you will have prerequisite knowledge gained in the first two years on the following subjects:

1st year -Engineering Mathematics, Communication Skills, Computer Aided Engineering Graphics, Statistics & Analysis, Basic IT Skills, Fundamentals of Electrical and Electronics Engineering, Project Management skills Engineering Materials and Mechanical Workshop

2nd year-Mechanics of Materials, Machine Tool Technology, Manufacturing Process, Fluid Power Engineering, Product Design and Development, Operations Management, CNC Machines and Elements of Industrial Automation

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 Cohort Owner
A Course Cohort Owner is a faculty from the core discipline, who is fully responsible for one specialised field of study and the cohort of students who have chosen to study that specialised field of study.

Guidelines for Cohort Owner

1. Each Specialized field of study is restricted to a Cohort of 20 students which could include students from other relevant programs.
2. One faculty from the Core Discipline shall be the Cohort Owner, who for teaching and learning in allied disciplines can work with faculty from other disciplines or industry experts.
3. The course shall be delivered in boot camp mode spanning over 12 weeks of study, weekly developmental assessments and culminating in a mini capstone.
4. The industry session shall be addressed by industry subject experts (in contact mode/online / recorded video mode) in the discipline only.
5. The cohort owner shall be responsible to identify experts from the relevant field and organize industry session as per schedule.
6. Cohort owner shall plan and accompany the cohort for any industrial visits.
7. Cohort owner shall maintain and document industrial assignments, weekly assessments, practices and mini project.
8. The cohort owner shall coordinate with faculties across programs needed for their course to ensure seamless delivery as per time table
9. The cohort owner along with classroom sessions can augment or use supplementally teaching and learning opportunities including good quality online courses available on platforms like Karnataka LMS, Infosys Springboard, NPTEL, Unacademy, SWAYAM, etc.

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 plan

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**
			6	Industry Class on Sustainable HVAC solutions + Industry asignment			**5**				
13			1	**Internship** **1. Secondary research on various industries and their operations to identify at least 3 companies along with the areas of work interest and develop an internship plan that clearly highlights expectations from the industry during the internship.** **2. Design and develop a cover letter for an internship request to all 3 identified companies and the resume to be submitted to potential companies.** **3. Prepare for an internship interview to highlight your interests, areas of study, career aspirations and personnel competence – including the areas of learning you expect to learn during internship.**				**Project (Internship/Project Total = 40Hrs)** **1. Identification of the problem statement (from at least 3 known problems) the students would like to work as part of the project – either as provided by faculty or as identified by the student. Document the impact the project will have from a technical, social and business perspective.** **2. Design and develop the project solution or methodology to be used to solve at least one of the problems identified.** **3. Prepare a project plan that will include a schedule, WBS, Budget and known risks along with strategies to mitigate them to ensure the project achieves the desired outcome.**			

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

CIE and SEE Assessment Methodologies

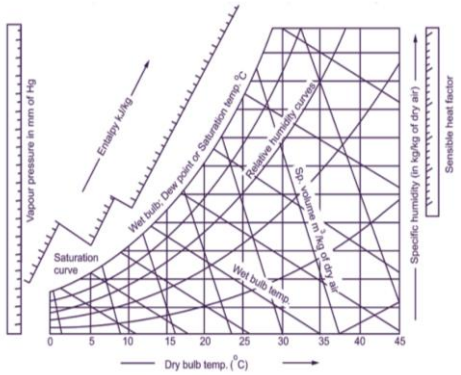
CIE Assessment	**Assessment Mode**	**Duration** In hours	**Max Marks**
Week 3	CIE 1– Written and practice test	4	30
Week 5	CIE 2– Written and practice test	4	30
Week 7	CIE 3– Written and practice test	4	30
Week 9	CIE 4– Written and practice test	4	30
Week 11	CIE 5– Written and practice test	4	30
	On line Course work (Minimum 10 hours online course with certification from (SWAYAM/NPTEL/Infosys Springboard)		40
	Profile building for Internship / Submission of Synopsys for project work		20
Portfolio evaluation (Based on industrial assignments and weekly developmental assessment) *			30
TOTAL CIE MARKS (A)			**240**
SEE 1 - Theory exam (QP from BTE) Conducted for 100 marks 3 hrs duration reduced to 60 marks		**3**	**60**
SEE 2 – Practical		**3**	**100**
TOTAL SEE MARKS (B)			**160**
TOTAL MARKS (A+B)			**400**

***** The industrial assignment shall be based on peer-to-peer assessment for a total of 10 marks (on a scale of 1 to 10) and in the event of a group assignment the marks awarded will be the same for the entire group, the developmental assessment will be for a total of 20 marks and based on MCQ/case study/demonstration and such other assignment methods

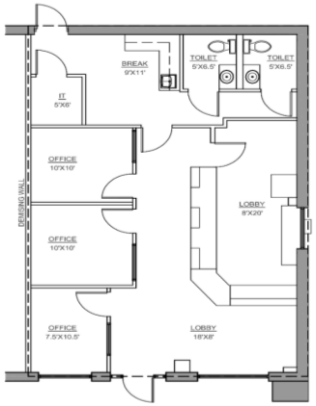
Assessment framework for CIE (1 to 5)

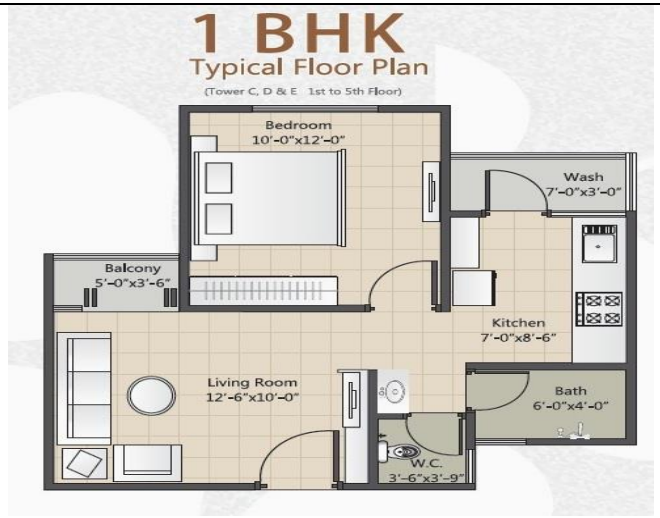
Note: Theory to be conducted for 1 hour and practice for 3 hours, total duration of exam – 4 hours

CIE 1 - Model Question Paper

Programme	**Mechanical Engineering**		**Semester**	**V**	
Course	**Heating, Ventilation and Air-Conditioning (HVAC)**		**Max Marks**	**30**	
Course Code	**20ME52I**		**Duration**	**4 hours**	
Name of the course coordinator					
Note: Answer one full question from each section.					
Qn.No	**Question**	**CL L3/L4**	**CO**	**PO**	**Marks**
Section-1 (Theory) – 10 marks					
1.a)	What does these lines represent on a Psychometric chart i) Vertical and uniform space lines ii) Curved line iii) Non-Uniformly spaced inclined straight lines iv) Non-Uniformly spaced horizontal lines v) Uniformly spaced inclined straight lines vi) Shading a portion of the psychrometric chart 	L3	1		03
b)	Rajasthan has a unique weather, though the deserts of Rajasthan have shrunk drastically still the Ganganagar district of Rajasthan has similar weather: 1. Sand storms, which brings a lot of heat and dust. 2. Strong Sunlight, which causes extreme day temperature. 3. Colder nights, vast difference in the day and night temperature. 4. Lots of insects and flies.	L4	1		07

	Analyse different Glazing methods and suggest a suitable solution to the above problem				
2.a)	Indicate the following Psychometric processes on a Psychometric chart i) Sensible heating ii) Sensible cooling iii) Humidification and dehumidification	L4	1		03
b)	Energy efficiency of buildings is attracting significant attention from the research community as the world is moving towards sustainable buildings design. Shading influences the solar energy on a window and the conveyed energy within the room through the window. Discuss shading phenomenon and its effect in heat load calculations?	L3	1		07
Section-2 (Practical) - 20 marks					
3)	Estimate HVAC load for a building plan given using E20 or any similar forms Also, Calculate Air flow in CFM. The conditions are as follows Inside conditions: 25°C dry bulb, 50 percent RH, Wi = 0.00992 kg water/kg air Outside conditions: 43°C dry bulb, 24°C wet bulb, Wo = 0.0105 kg water/kg air U-value for wall: 1.75 W/m^2 K U-value for roof: 1.33 W/m^2 K U-value for floor: 1.3 W/m^2K Effective Temp. Difference (ETD) for wall: 22°C Effective Temp. Difference (ETD) for roof: 26°C U-value for glass: 2.9 W/m^2 K Solar Heat Gain (SHG) of glass: 275 W/m^2 Internal Shading Coefficient (SC) of glass: 0.8 Occupancy: 6 (100 W sensible heat/person) (50 W latent heat/person) Lighting load: 50 W/m^2 of floor area Appliance load: 650 W (Sensible) + 310W(latent) Infiltration: 0.4 Air Changes per Hour Barometric pressure: 101 kPa Note: hfg of water = 2501 kJ/kg.	L4	1		20

					
4)	Estimate HVAC load for a building plan given using E20 or any similar forms Also, Calculate Air flow in CFM. The conditions are as follows Outside conditions 43 C dry bulb, 24 °C wet bulb, density of dry air 1,095 kg/m3 U-value for wall 1.78 W/m² K U-value for floor 12 W/m² K U-value for glass 3.12 W/m² K Cooling load temperature difference (CLTD) for wall 25° C Cooling load temperature difference (CLTD) for roof 30 °C Solar Heat Gain (SHGFmax) of glass 300 W/m2 Internal Shading Coefficient (SC) of glass 0.86 Cooling load factor (CLF) 1.0 Occupancy 4 people (90 W sensible heat/person) (40 W latent heat person) Lighting load 33 W/m2 of floor area Appliance load 600 W (Sensible) 300 W (latent) Infiltration rate 8.2125 x 109k/Hr Barometric pressure 101 kPa Specific heat of moist air (Cpm) 1.0216 kJ/kgK Specific enthalpy of vaporization 2501 kJ/kg	L4			20

Note : Theory questions shall be aligned to practical questions

Scheme of Evaluation for Practical question- Section 2

Sl. No	**Description**	**Marks: 20**
1	Analyze the given Problem Statement	03
2	Calculate Heat Load for the given drawing using E20 or other forms	10
3	Tabulate the result and provide inference	03
4	Suggest one way to reduce the heating load with justification	04
	Total	**20**

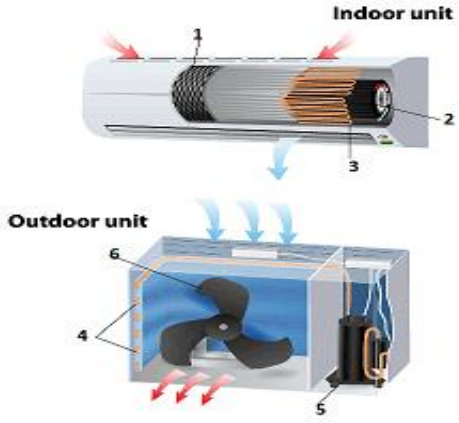
Assessment framework for SEE 1 (Theory)

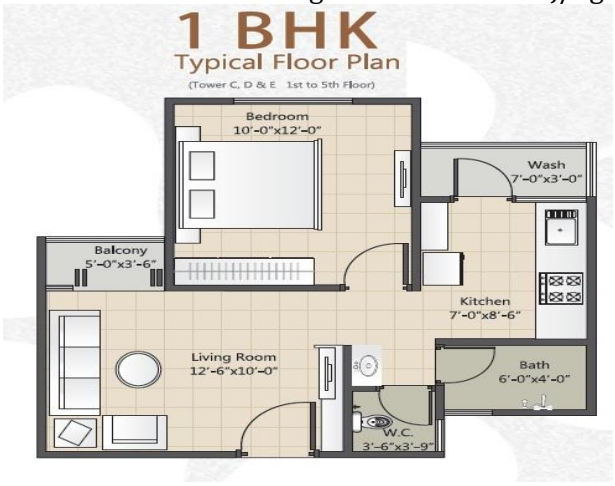
Programme	**:**	**Mechanical Engineering**	**Semester: V**
Course	**:**	**Heating, Ventilation and Air-Conditioning (HVAC)**	**Max Marks: 100 Marks**
Course Code	**:**	**20ME52I**	**Duration: 3 Hrs**

Instruction to the Candidate: Answer one full question from each section.

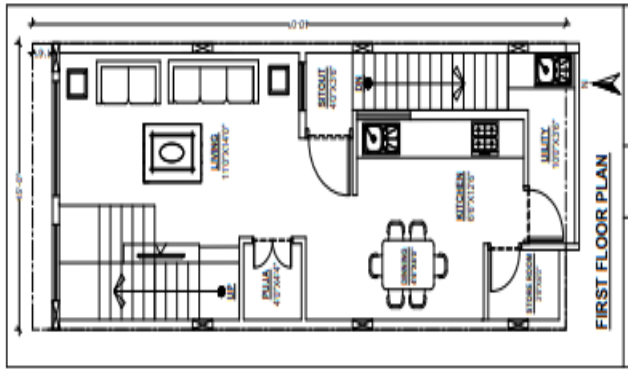
Q.No	Question	CL (L3/L4)	CO	Marks
	Section-1			
1.a)	According to statistics, major percentage of the overall business operating cost is spent on staff cost including medical benefit paid for employee. Therefore, promoting health and wellbeing at work not only contributes to employees' active engagement and improved productivity, but also leads to remarkable savings in operating cost for employers. For these reasons, an acceptable indoor environmental quality plays a key role. What comfort parameters need to be considered for maintaining indoor air quality? Discuss.	L4	1	08
b)	An air-conditioned room that stands on a well-ventilated basement measures 3 m wide, 4 m high and 8 m deep. The two 8 m walls contain a double-glazed glass window of size 1.2 m by 1.3 m, mounted flush with the wall with no external shading. There are no heat gains through the other walls other than the ones with windows. Calculate the total latent heat and the total heat from the walls only using E20 or other forms Inside conditions: 25°C dry bulb, 50 percent RH, Wi = 0.00992 kg water/kg air Outside conditions: 43°C dry bulb, 24°C wet bulb, Wo = 0.0105 kg water/kg air U-value for wall: 1.75 W/m^2 K U-value for roof: 1.33 W/m^2 K U-value for floor: 1.3 W/m^2K Effective Temp. Difference (ETD) for wall: 22°C Effective Temp. Difference (ETD) for roof: 26°C U-value for glass: 2.9 W/m^2 K Solar Heat Gain (SHG) of glass: 275 W/m^2 Internal Shading Coefficient (SC) of glass: 0.8 Occupancy: 3 (100 W sensible heat/person) (50 W latent heat/person)	L3		12

	Lighting load: 30 W/m^2 of floor area Appliance load: 550 W (Sensible) + 280 W(latent) Infiltration: 0.4 Air Changes per Hour Barometric pressure: 101 kPa Note: hfg of water = 2501 kJ/kg.			
2.a)	Building energy efficiency is an important matter for energy policy at the regional, national and international levels. Several technological techniques and designs for high performance are based on central concepts such as space conditioning, ventilation, daylighting, and solar heat gain control. Does the techniques of Glazing and Shading affect energy efficiency? Justify	L4		08
b)	An air-conditioned room that stands on a well-ventilated basement measures 3 m wide, 3 m high and 6 m deep One of the two 3 m walls faces west and contains a double-glazed glass window of size 1.5 m by 1.5 m, mounted flush with the wall with no external shading. There are no heat gains through the walls other than the one facing east. From the following information Inside conditions 25 °C dry bulb, 50% relative humidity Outside conditions 43 C dry bulb, 24 °C wet bulb, density of dry air 1,095 kg/m3 U-value for wall 1.78 W/m^2 K U-value for floor 12 W/m^2 K U-value for glass 3.12 W/m^2 K Cooling load temperature difference (CLTD) for wall 25° C Cooling load temperature difference (CLTD) for roof 30 °C Solar Heat Gain (SHGFmax) of glass 300 W/m2 Internal Shading Coefficient (SC) of glass 0.86 Cooling load factor (CLF) 1.0 Occupancy 4 people (90 W sensible heat/person) (40 W latent heat person) Lighting load 33 W/m2 of floor area Appliance load 600 W (Sensible) 300 W (latent) Infiltration rate 8.2125 x 109k/Hr Barometric pressure 101 kPa Specific heat of moist air (Cpm) 1.0216 kJ/kgK Specific enthalpy of vaporization 2501 kJ/kg Since the room stands on a well-ventilated basement, assume the conditions in the basement to be the same as that of the outside. Also, since the floor is not exposed to solar radiation assume the Cooling load temperature difference for the floor as the temperature difference between the outdoor and indoor. Calculate the sensible, latent and total heat gains using E20 or other forms	L3		12
Section-2				

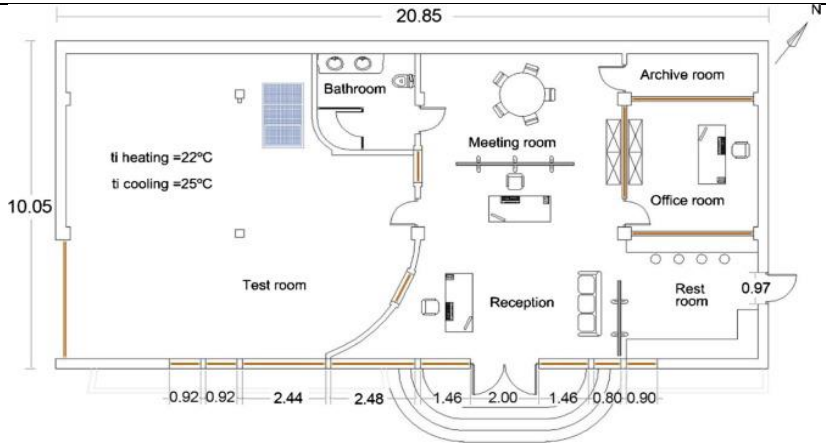
3.a)	 Fig (a)	A Split Airconditioning system is shown in Fig (a). Identify the components indicated by numbers. What are the functions of these components? How is Air conditioned happening in this system?	L3	2	08
b)	Homeowners were looking for more comfort than they were getting from window air conditioners in the summer, and they were tired of having to install and store the heavy, bulky units every year. They needed ductless HVAC system to solve their problem. Compare different ductless air-conditioning systems available and suggest a suitable one for this case with justification:		L4		12
4.a)	HVAC systems are provided with Cooling towers and Condensers. What is the role played by these components? How do they work in an Air-Conditioning system?		L3		08
b)	You have been approached by Walthamstow Academy as they have recognised the need for an integrated air conditioning solution for their flagship school. The requirement was to provide the most efficient method of cooling mixed-use rooms including offices, classrooms, laboratories and IT Suites over three floors and a 12,000 square feet footprint. Compare different Air-Conditioners and suggest a suitable one to solve their problem with justification:		L4		12
Section- 3					
5.	Heating and Cooling Load is required to be analysed for the building drawing shown in Fig (a)for the following conditions Inside conditions: 25°C dry bulb, 50 percent RH, Wi = 0.00992 kg water/kg air Outside conditions: 43°C dry bulb, 24°C wet bulb, Wo = 0.0105 kg water/kg air U-value for wall: 1.75 W/m^2 K U-value for roof: 1.33 W/m^2 K U-value for floor: 1.3 W/m^2K Effective Temp. Difference (ETD) for wall: 22°C		L4	1	20

	Effective Temp. Difference (ETD) for roof: 26°C U-value for glass: 2.9 W/m² K Solar Heat Gain (SHG) of glass: 275 W/m^2 Internal Shading Coefficient (SC) of glass: 0.8 Occupancy: 6 (100 W sensible heat/person) (50 W latent heat/person) Lighting load: 50 W/m^2 of floor area Appliance load: 650 W (Sensible) + 310W(latent) Infiltration: 0.4 Air Changes per Hour Barometric pressure: 101 kPa Note: hfg of water = 2501 kJ/kg.  Fig(a)			
6	Three thousand lug boxes of apples are stored at 35° F in a storage cooler 50 ft x 40 ft x 10 ft. The apples enter the cooler at a temperature of 90° F and at the rate of 200 lugs per day each day for the 15 day harvesting period. The walls including floor and ceiling are constructed of 1 in. boards on both sides of 2x4 studs and are insulated with $3\frac{5}{8}$ in. of rock wool. All of the walls are shaded and the ambient temperature is 85° F. The average weight of apples per lug box is 59 lb. The lug boxes have an average weight of 4.5 lb and a specific heat value of0.60 Btu/lb/° F. Determine the average hourly cooling load based on 16 hr operating time for the equipment.	L4		20
	Section-4			
7.a)	The green building is an eco-friendly segment, since it depends on the essential principles - "REDUCE, REUSE and RECYCLE. Does sustainable planning help in adopting these principles? Justify with illustrations.	L3	4	10

b)	Green Building movement has been driving the HVAC community for now about a decade to look at innovative solutions for reducing the energy cost and better IEQ (Indoor Environment Quality). The ventilation and air conditioning system which is a key component in green building design is on the verge of a paradigm shift. This shift is providing designers opportunities to explore energy efficient designs. The new initiatives such as intelligent HVAC systems are aimed at improving health, comfort and productivity. Discuss with comparison various intelligent HVAC methods that are available and suggest suitable that can be adopted to reduce the energy consumption. Illustrate with examples.	L4		10
8.a)	LEED (Leadership in energy and Environmental Design) is the most widely used green building rating system in the world. LEED certification is a globally recognized symbol of sustainability achievement and leadership. What requirement should the building satisfy to obtain LEED certificate? How does this certificate help HVAC in green buildings?	L3		10
b)	In a study conducted by Howarth, it was found that energy consumption (EC) in Saudi Arabia is very different in summer and winter. Taking into account 60 GW for summer and 23 GW for winter, it is clear that owing to using AC throughout the country, the summer electricity consumption is 2.6 times that of winter. Adopt suitable techniques to reduce heat load and improve the energy efficiency of the building by comparing the various techniques and hence provide solutions to this problem.	L4		10
Section-5				
9.a)	A two-story house; with the living room, kitchen, and hallway located on the ground floor, while 3 bedrooms, and a smaller living room are located upstairs. The upper portion of the house is mostly occupied during the night only. It makes sense then to establish zones in such a situation. Suggest suitable zoning for the above case to provide solution by comparing the zoning methods adopted in HVAC systems.	L4	2	10
b)	Piping's play a critical role in HVAC systems. While designing Piping system, losses in pipes are to be considered. Discuss various losses in pipe and methods to overcome these losses?	L3		10
10.a)	Ductwork is an essential part of the HVAC system. There are so many ducts material options in the market, and each serves a different purpose. The option you choose may be decided based on needs such as insulation, noise reduction, moisture and condensation, and build-up. Discuss different Duct materials for HAVC system and their application.	L3		10

b)		Analyse the given drawing and select suitable Air distribution system and justify.	L4		10

Scheme of Evaluation for SEE 2

Sl. No	Description		Marks
Problem statement		**Design an HVAC system for the given office space using suitable BIM software** **Note:** Necessary Psychometric, building data and location must be provided by the examiner	**100**
1	Heating and cooling load calculation using E20 forms or any other forms		20

2	Apply logical systems for the given office space drawing	30
3	Apply piping systems for the given office space drawing	30
4	Innovating methods to reduce the Heating and cooling Load	20
Total		**100**

Advanced Manufacturing Technologies

Government of Karnataka
DEPARTMENT OF COLLEGIATE and TECHNICAL EDUCATION

Program	**Mechanical Engineering**	**Semester**	**5**
Course Code	**20ME53I**	**Type of Course**	**L: T:P (104:52:312)**
Specialization	**Advanced Manufacturing Technologies**	**Credits**	**24**
CIE Marks	**240**	**SEE Marks**	**160**

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

Pre-requisite

Before the start of this specialisation course, you will have prerequisite knowledge gained in the first two years on the following subjects:

1st year -Engineering Mathematics, Communication Skills, Computer Aided Engineering Graphics, Statistics & Analysis, Basic IT Skills, Fundamentals of Electrical and Electronics Engineering, Project Management skills Engineering Materials and Mechanical Workshop

2nd year-Mechanics of Materials, Machine Tool Technology, Manufacturing Process, Fluid Power Engineering, Product Design and Development, Operations Management, CNC Machines and Elements of Industrial Automation

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.

Instruction to course coordinator

1. Each Pathway is restricted to a Cohort of 20 students which could include students from other relevant programs.
2. Single faculty shall be the Cohort Owner.
3. This course shall be delivered in boot camp mode
4. The industry session shall be addressed by (in contact mode/online / recorded video mode) industry experts only.
5. The cohort owner shall identify experts from the relevant field and organize industry session as per schedule.
6. Cohort owner shall plan and accompany the cohort for industrial visits.
7. Cohort owner shall maintain and document the industrial assignments and weekly assessments, practices and mini project.
8. The cohort owner shall coordinate with faculties across programs needed for their course to ensure seamless delivery as per time table
9. The cohort owner along with classroom, can augment or use for supplementally teaching, on line courses available although reliable and good quality online platforms like Karnataka LMS, Infosys Springboard, NPTEL, Unacademic, SWAYAM, etc.
10. Cohort owner shall guide the cohort for the execution of mini project

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 plan

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				
13			**Internship** **1 Secondary research on various industries and their operations to identify at least 3 companies along with the areas of work interest and develop an internship plan that clearly highlights expectations from the industry during the internship.** **2 Design and develop a cover letter for an internship request to all 3 identified companies and the resume to be submitted to potential companies.** **3 Prepare for an internship interview to highlight your interests, areas of study, career aspirations**				**Project** **Internship/Project Total = 40Hrs** **1 Identification of the problem statement (from at least 3 known problems) the students would like to work as part of the project – either as provided by faculty or as identified by the student. Document the impact the project will have from a technical, social and business perspective.** **2 Design and develop the project solution or methodology to be used to**			**40Hrs**

			and personnel competence – including the areas of learning you expect to learn during internship.	**solve at least one of the problems identified.** **3 Prepare a project plan that will include a schedule, WBS Budget and known risks along with strategies to mitigate them to ensure the project achieves the desired outcome.**	

Note: Saturday session from 9 AM -2 PM

References:

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2. Kamrani A.K. and Nasr E.A., “Rapid Prototyping: Theory and practice”, Springer
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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
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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.

CIE and SEE Assessment Methodologies

CIE Assessment	Assessment Mode	Duration In hours	Max Marks
Week 3	CIE 1– Written and practice test	4	30
Week 5	CIE 2– Written and practice test	4	30
Week 7	CIE 3– Written and practice test	4	30
Week 9	CIE 4– Written and practice test	4	30
Week 11	CIE 5– Written and practice test	4	30
	On line Course work (Minimum 10 hours online course with certification from (SWAYAM/NPTEL/Infosys Springboard)		40
	Profile building for Internship / Submission of Synopsys for project work		20
Portfolio evaluation (Based on industrial assignments and weekly developmental assessment) *			30
TOTAL CIE MARKS (A)			**240**
SEE 1 - Theory exam (QP from BTE) Conducted for 100 marks 3 hrs duration reduced to 60 marks		**3**	**60**
SEE 2 – Practical		**3**	**100**
TOTAL SEE MARKS (B)			**160**
TOTAL MARKS (A+B)			**400**

***** The industrial assignment shall be based on peer-to-peer assessment for a total of 10 marks (on a scale of 1 to 10) and in the event of a group assignment the marks awarded will be the same for the entire group, the developmental assessment will be for a total of 20 marks and based on MCQ/case study/demonstration and such other assignment methods

Assessment framework for CIE (1 to 5)
CIE 1- Model Question Paper

Note: Theory to be conducted for 1 hour and practice for 3 hours, total duration of exam – 4 hours

Programme	**Mechanical Engineering**	**Semester**	**V**
Course	**Advanced Manufacturing Technologies**	**Max Marks**	**30**
Course Code	**20ME53I**	**Duration**	**4 hours**
Name of the course coordinator			

Note: Answer one full question from each section.

Qn.No	Question	CL L3/L4	CO	PO	Marks
	Section-1 (Theory) – 10 marks				
1.a)	The materials used in the manufacturing of aircraft have changed significantly from the construction of the first aircraft. With its objective of flying using air support while, resisting gravitational forces, the materials used for the construction of aircraft must have some specific characteristics. Which are the advanced materials used in aircraft and what specific characteristics are present in these materials?	L3	01		05
b)	For the following application, identify one or more non-traditional machining processes that might be used, and present arguments to support your selection. Assume that either the part geometry or the work material (or both) prevents the use of conventional machining. • An engraved aluminium printing plate is to be used in an offset printing press to make 275 x 350 mm (11 x 14 in) posters of Independence Day. The engraving is as follows:" 75 Years of India's Independence"	L4			05
2.a)	Superalloys are used in the most important temperature-limited applications. Specifically, they are usually used for turbine blades. Why are Superalloys important and also, Special?	L3			05

b)	A metal removal rate of 0.01 in3 /min is achieved in a certain EDM operation on a pure iron work part. What metal removal rate would be achieved on nickel in this EDM operation if the same discharge current were used? The melting temperatures of iron and nickel are 2802°F and 2651°F, respectively.	L4			05
Section-2 (Practical) - 20 marks					
3)	Prepare a job using – EDM • Study the component drawing • Select the process Parameter • Perform the process • Check for dimensional accuracies	L4	01		20
4)	Prepare a job by Chemical Machining • Study the component drawing • Select the process Parameter • Perform Clean, Mask, Scribe, Etch, Demask • Check for dimensional accuracies	L4			20

Note : Theory questions shall be aligned to practical questions

Scheme of Evaluation for Practical question- Section 2

Sl. No	**Description**	**Marks: 20**
1	Analyze the given drawing and select the process parameter	07
2	Prepare the component by machining	07
3	Check for Dimensional accuracies	04
4	Suggest any innovating changes that can be incorporated	02
	Total	**20**

Assessment framework for SEE 1 (Theory)

Programme	**: Mechanical Engineering**	**Semester**	**: V**
Course	**: Advanced Manufacturing Technologies**	**Max Marks**	**: 100**
Course Code	**: 20ME53I**	**Duration**	**: 3 Hrs**

Instruction to the Candidate: Answer one full question from each section.

Q.No	Question	CL (L3/L4)	CO	Marks
	Section-1			
1.a)	Back in the days, aircraft were constructed using wood and fabrics. But aircraft that are made up of wood and fabric were subject to rapid deterioration and high maintenance. Thus, the search for better materials began. Now, aluminium, steel, titanium and composite materials are preferred in the construction of aerospace structures. Why such materials are used in Aerospace structures? Where else do you find the application of these materials?	L4	01	10
b)	For the following application, identify one or more non-traditional machining processes that might be used, and present arguments to support your selection. Assume that either the part geometry or the work material (or both) prevents the use of conventional machining. The application is a through-hole in the shape of the letter L in a 12.5 mm (0.5 in) thick plate of glass. The size of the ‘‘L’’ is 25 x15 mm (1.0x 0.6 in) and the width of the hole is 3 mm (1/8 in).	L4		10
2.a)	A furniture company that makes chairs and sofas must cut large quantities of fabrics. Many of these fabrics are strong and wear-resistant, which make them difficult to cut. What non-traditional process(es) would you recommend to the company for this application? Justify your answer by indicating the characteristics of the process that make it attractive.	L4		10

b)	An electric discharge machining operation is being performed on two work materials: tungsten and zinc. Determine the amount of metal removed in the operation after 1 hour at a discharge amperage = 20 amps for each of these metals. Express the answer in in^3 /hr. The melting temperatures of tungsten and zinc are 6170°F and 420°F, respectively.	L4		10
Section-2				
3.a)	Uniform Wares explores the advantages of additive manufacturing (AM) technology, pushing the boundaries of design in an industry traditionally centred around heritage. What benefits exist in additive manufacturing? Differentiate the technologies available in Additive manufacturing and list their applications?	L3	02	10
b)	In additive manufacturing, the material properties are being established alongside the geometry of the part. There are different classes of materials used in additive manufacturing. Differentiate these different materials used in Additive manufacturing with respect to their Properties and Applications?	L4		10
4.a)	The Airbus Helicopters cabin ventilation distributor was originally made by using composite of 7 separate parts. The objective was to minimize the final delivery time by dramatically reducing manufacturing time through 3D printing, using sintering technology, also ensuring lower manufacturing costs. Illustrate how this Process can be achieved?	L3		10
b)	Selective laser sintering (SLS) and 3D printing (3DP) are two powerful and versatile AM techniques which are applicable to powder-based material systems. Differentiate and suggest the best technique among the two. Present arguments to support your selection	L4		10
Section- 3				
5.a)	Additive Manufacturing (AM) components are known to have various internal defects, such as balling, porosity, internal cracks and thermal/internal stress, which can significantly affect the quality, mechanical properties and safety of final parts. Therefore, inspection methods are important for reducing manufactured defects and improving the surface quality and mechanical properties of AM components. Discuss different inspection methods adopted in AM with their merits and demerits?	L3	03	10
b)	AM-produced parts are being used by NASA in mission-critical situations and in the aviation and power industries where safety and reliability are of prime importance. These parts are tested using Non-Destructive testing methods. Suggest the best Non-Destructive testing method used in this case. Present arguments to support your selection	L4		10
6.a)	3D printing is finally crossing that threshold from prototype to production. However, there are still a few challenges that hold AM back such as quality measures and quality control. These	L3		10

	are essential for repeatability, consistency, scalability, and overall confidence in the process. Discuss different Quality control methods adopted in AM with their merits and demerits?			
b)	NDT methods are used for inspecting Manufactured parts. Why is Non-Destructive Testing (NDT) Important? What Tests are Available? What criterions are considered in selection of these NDT methods?	L4		10
Section-4				
7.a)	Automation in manufacturing is the process of using production management software or robotic tools to operate a factory when making a physical product. Discuss the various levels of Automation in Advanced Manufacturing.	L4	04	10
b)	Driverless vehicles and navigation systems are improving day after day and are contributing to boost the AGV (Automated guided Vehicle) Market worldwide. Illustrate the working principle of AGV.	L3		10
8.a)	Automated Storage and Retrieval Systems (ASRS or AS/RS) are used in applications where high volumes of inventory move in-and-out of manufacturing or distribution operations. Illustrate how an automated storage and retrieval systems work?	L3		10
b)	Modern organizations engage with two worlds. There is the traditional physical world composed of machines, electromechanical devices, and manufacturing systems. Then, there is the more recent digital world using servers, storage, networking and other devices used to run applications and process data. Does convergence of these two-world beneficial in Advanced manufacturing? Justify your argument with Illustration.	L4		10
Section-5				
9.a)	Laser Beam machining (LBM) is a well-established machining option for manufacturing geometrically complex or hard material parts that are extremely difficult-to-machine by conventional machining processes. Discuss the process parameters required in LBM process? Suggest a suitable process parameter that need to be considered for this case and justify.	L4	01	10
b)	Illustrate the Working of Electron Beam Machining process	L3		10
10.a)	Ultrasonic machining offers a solution to the expanding need for machining brittle materials such as single crystals, glasses and polycrystalline ceramics, and for increasing complex operations to provide intricate shapes and workpiece profiles. Illustrate the working of USM	L3		10
b)	Electrical discharge machining (EDM) is a well-established machining option for manufacturing geometrically complex or hard material parts that are extremely difficult-to-machine by conventional machining processes. Discuss the process parameters required in an EDM process? Suggest a suitable process parameter that need to be considered for this case and justify	L4		10

Scheme of Evaluation for SEE 2

Sl. No	Description	Marks
Problem statement	Prepare a job using – 3D Printing • Study the component drawing • Select the process Parameter • Perform the process • Check for dimensional accuracies	**100**
1	Prepare a Solid model and convert to STL File	30
2	Select a suitable material for the given model, Perform Machine setting and upload the STL file	20
3	Feed the Raw material and Develop the Model	40
4	Perform measurement with desired accuracy to check the components for Functionality and conformance to defined standards using different instruments.	10
Total		**100**

E-Mobility

Government of Karnataka
DEPARTMENT OF COLLEGIATE and TECHNICAL EDUCATION

Program	**Mechanical Engineering**	**Semester**	**5**
Course Code	**20ME54I**	**Type of Course**	**L: T:P (104:52:312)**
Specialization	**E-Mobility**	**Credits**	**24**
CIE Marks	**240**	**SEE Marks**	**160**

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.

Pre-requisite

Before the start of this specialization course, you will have prerequisite knowledge gained in the first two years on the following subjects:
1st year -Engineering Mathematics, Communication Skills, Computer Aided Engineering Graphics, Statistics & Analysis, Basic IT Skills, Fundamentals of Electrical and Electronics Engineering, Project Management skills Engineering Materials and Mechanical Workshop
2nd year-Mechanics of Materials, Machine Tool Technology, Manufacturing Process, Fluid Power Engineering, Product Design and Development, Operations Management, CNC Machines and Elements of Industrial Automation, in this year of study, you shall be applying your previous years learning along with specialized field of study into projects and real-world applications.

Instruction to course coordinator

1. Each Pathway is restricted to a Cohort of 20 students which could include students from other relevant programs.
2. Single faculty shall be the Cohort Owner.
3. This course shall be delivered in boot camp mode
4. The industry session shall be addressed by (in contact mode/online / recorded video mode) industry experts only.
5. The cohort owner shall identify experts from the relevant field and organize industry session as per schedule.
6. Cohort owner shall plan and accompany the cohort for industrial visits.
7. Cohort owner shall maintain and document the industrial assignments and weekly assessments, practices and mini project.
8. The cohort owner shall coordinate with faculties across programs needed for their course to ensure seamless delivery as per time table
9. The cohort owner along with classroom, can augment or use for supplementally teaching, on line courses available although reliable and good quality online platforms like Karnataka LMS, Infosys Springboard, NPTEL, Unacademic, SWAYAM, etc.
10. Cohort owner shall guide the cohort for the execution of mini project

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 plan

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
			6	Industry Class on modeling of EV + Industry Assignment			5				
13			1	**Internship** **a) Secondary research on various industries and their operations to identify at least 3 companies along with the areas of work interest and develop an internship plan that clearly highlights expectations from the industry during the internship.** **b) Design and develop a cover letter for an internship request to all 3 identified companies and the resume to be submitted to potential companies.** **c) Prepare for an internship interview to highlight your interests, areas of study, career aspirations and personnel competence – including the areas of learning you expect to learn during internship.**				**Project** **Internship/Project Total = 40Hrs** **a) Identification of the problem statement (from at least 3 known problems) the students would like to work as part of the project – either as provided by faculty or as identified by the student. Document the impact the project will have from a technical, social and business perspective.** **b) Design and develop the project solution or methodology to be used to solve at least one of the problems identified.** **c) Prepare a project plan that will include a schedule, WBS, Budget and known risks along with strategies to mitigate them to ensure the project achieves the desired outcome.**		

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7. Energy Storage Systems, Alfred Rufer, CRC Press
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13. David A Bell, "Fundamentals of Electronic Devices and Circuits", Oxford University Press, 2009.
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CIE and SEE Assessment Methodologies

CIE Assessment	Assessment Mode	Duration In hours	Max Marks
Week 3	CIE 1– Written and practice test	4	30
Week 5	CIE 2– Written and practice test	4	30
Week 7	CIE 3– Written and practice test	4	30
Week 9	CIE 4– Written and practice test	4	30
Week 11	CIE 5– Written and practice test	4	30
	On line Course work (Minimum 10 hours online course with certification from (SWAYAM/NPTEL/Infosys Springboard)		40
	Submission of Profile building for Internship / Synopsys for project work		20
Portfolio evaluation (Based on industrial assignments and weekly developmental assessment) *			30
TOTAL CIE MARKS (A)			**240**
SEE 1 - Theory exam (QP from BTE) Conducted for 100 marks 3 hrs duration reduced to 60 marks		**3**	**60**
SEE 2 – Practical		**3**	**100**
TOTAL SEE MARKS (B)			**160**
TOTAL MARKS (A+B)			**400**

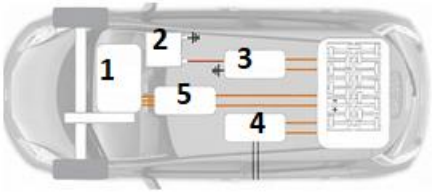
***** The industrial assignment shall be based on peer-to-peer assessment for a total of 10 marks (on a scale of 1 to 10) and in the event of a group assignment the marks awarded will be the same for the entire group, the developmental assessment will be for a total of 20 marks and based on MCQ/case study/demonstration and such other assignment methods

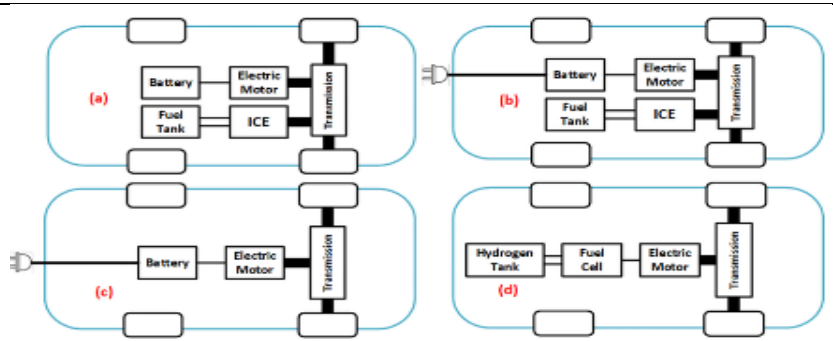
Assessment framework for CIE (1 to 5)
CIE 1 - Model question paper

Note: Theory to be conducted for 1 hour and practice for 3 hours, total duration of exam – 4 hours

Programme	**Mechanical Engineering**	**Semester**	**V**
Course	**E- Mobility**	**Max Marks**	**30**
Course Code	**20ME54I**	**Duration**	**4 hours**
Name of the course coordinator			

Note: Answer one full question from each section.

Qn.No	Question	CL L3/L4	CO	PO	Marks
	Section-1 (Theory) – 10 marks				
1.a)	The Architecture of an Electric Vehicle is as shown in the Diagram. Identify the different components? 	L3	01		02
b)	Electric vehicle is now becoming a need of the current era, to meet the environmental target of zero emission. EV's must be sustainable for society and that will be achieved by the Electric vehicle architecture. Vehicle architecture needs to be flexible so that they can adopt drivetrain electrification. Illustrate how the Architecture of battery electric vehicle is different from Conventional Vehicle?	L4	01		08
2.a)	Identify the types of Electric Vehicles shown in (a), (b), (c), (d).	L3	01		03

					
b)	Development and evolution of the electric vehicles have undergone a great growth, especially in the last 5 years. Technological developments are providing enhanced solutions for EV. What are the technological developments that have surfaced in EV's? Discuss with Illustration	L4	01		07
Section-2 (Practice) - 20 marks					
3)	Demonstrate the Working principle and components of BLDC motor used in EV	L4	03		20
4)	Demonstrate the working principles and components of Induction motor used in EV	L4	03		20

Note : Theory questions shall be aligned to practical questions

Scheme of Evaluation for Practical question- Section 2

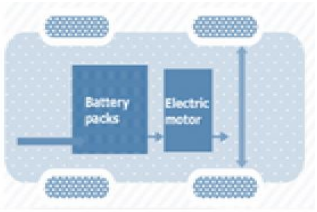
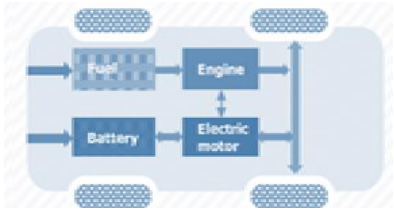
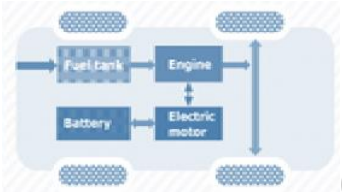
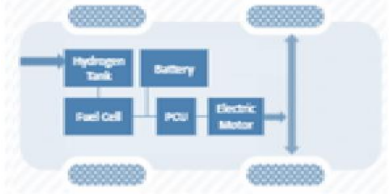
Sl. No	**Description**	**Marks: 20**
1	Identify the components of BLDC motor/Induction motor	05
2	Functions of each component	05
3	Working of the BLDC motor /Induction Motor	07
4	Suggest any innovating changes that can be incorporated	03

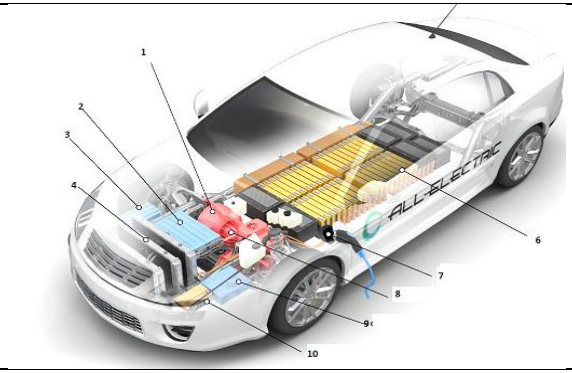
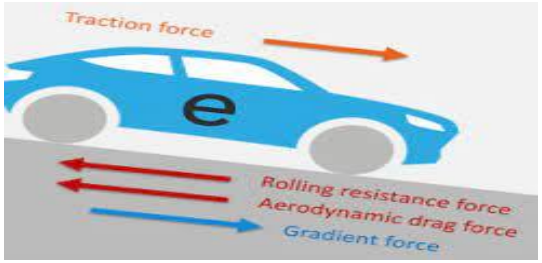
		Total	**20**

Assessment framework for SEE 1 (Theory)

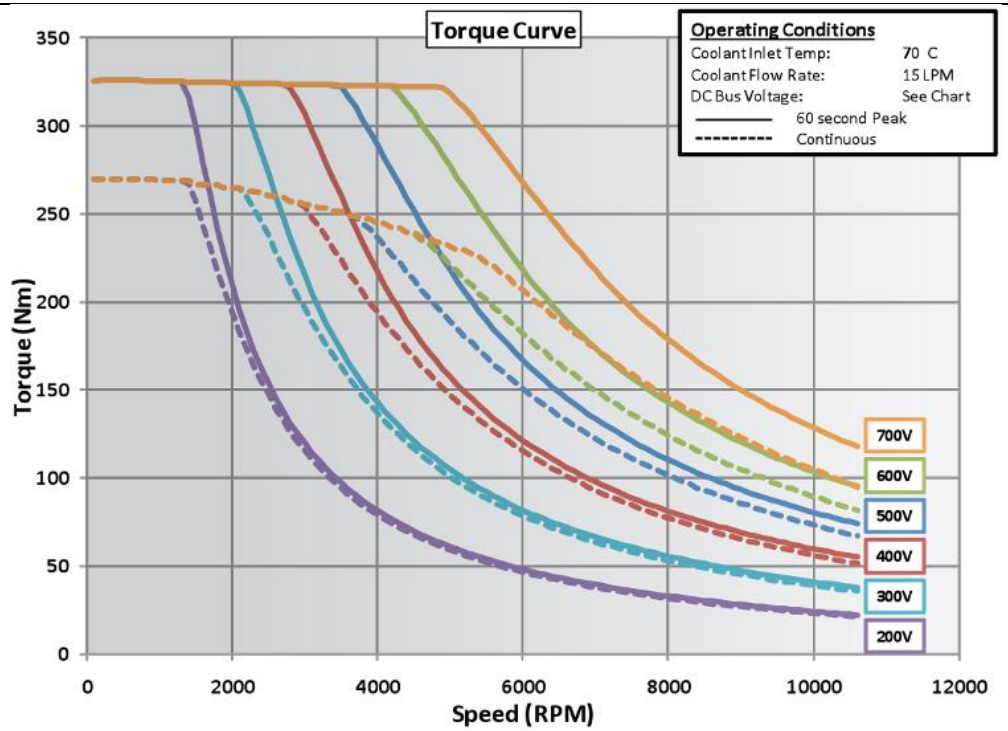
Programme	**:**	**Mechanical Engineering**	**Semester**	**:**	**V**
Course	**:**	**E- Mobility**	**Max Marks**	**:**	**100**
Course Code	**:**	**20ME54I**	**Duration**	**:**	**3 Hrs**

Instruction to the Candidate: Answer one full question from each section.

Q.No	Question	CL (L3/L4)	CO	Marks
	Section-1			
1.a)	 (a)  (c)  (b)  (e) The above sketches represent different types of Electric vehicles. Identify them and prepare a comparison statement on different types of EV's. Suggest the best EV which will provide Zero emission.	L3	1	10

b)	It is debatable whether hydrogen EVs will dethrone battery-electric vehicles as the cars of the future, but it is an interesting technology with wide-ranging potential. In what way is the architecture of fuel cell electric vehicle (FCEV) different from Battery Electric vehicle.? Illustrate the working of FCEV.	L4		
2.a)	 Identify the different components of an electric car: What is the role played by these components in EV?	L3		10
b)	According to a report by the European Union, the transport sector is responsible for nearly 28% of the total carbon dioxide (CO2) emissions, while the road transport is accountable for over 70% of the transport sector emissions. Therefore, the authorities of most developed countries are encouraging the use of Electric Vehicles (EVs). Do you think electric vehicles will provide solution to this problem? How do these electric vehicles work when compare to conventional vehicles	L4		10
	Section-2			
3.a)	Analyse the diagram shown. How are these forces determined? What are the effects of these forces on Vehicle movement? How does power and torque overcome these resistances? 	L3	2	10

b)	When selecting drive wheel motors for e- vehicles, several factors must be considered to determine the maximum torque required. The following example presents vehicle design criteria: ▪ Gross vehicle weight (GVW): 35 lb ▪ Weight on each drive wheel (WW): 10 lb ▪ Radius of wheel/tire (Rw): 4 in ▪ Desired top speed (Vmax): 1.5 ft/sec ▪ Desired acceleration time (ta): 1 sec ▪ Maximum incline angle (α): 2 degrees ▪ Worst working surface: concrete (good) Choose the motors capable of producing enough torque to propel the above example vehicle, by considering the total tractive effort (TTE) requirement for the vehicle	L4		10
4.a)	How Power gets transmitted from Motor to wheels in Electric vehicles? Illustrate the working of the transmission system used electric vehicles.	L3		10
b)	The main objective of a vehicle suspension system is to reduce the discomfort sensed by passengers which arises from road roughness and to increase the ride handling associated with the pitching and rolling movements. Different suspension systems are available. Compare these suspension systems provided in EV's? Which transmission system do you think is more effective and why?	L4		10
Section- 3				
5.a)	A company is interested in converting the Internal Combustion Engine Vehicle to EV? They are in a dilemma of selecting a right type of electric motor. Compare different electric motors used in EV. From your comparison, Suggest a best Electric motor with justification	L4	3	10
b)	Conventional vehicle is propelled by a combustion engine that can only be fuelled by gasoline. This technology is well-established, and reliable, but consumes large amounts of gasoline—which can be costly in many ways. Also, releases large amount of exhaust gases. Which component in electric vehicle helps in overcoming this problem? Analyse the working of this component in electric cars?	L4		10

6.a)	 The Torque and Speed characteristics of an electric motor is shown in the figure, interpret the graph and analyse how it is suitable for e -vehicles	L4		10
b)	The motor control solution consists of the communication, diagnostics, and features like regenerative breaking and power management capabilities. Analyse how the motor controller in EV controls the electric motors such as BLDC, induction motors, PMSM and Reluctance motors as per the requirements of a drive cycle.	L4		10
	Section-4			
7.a)	The lithium-ion battery has established itself as the technology of reference in the world of electric cars. Compare the working principle of this battery with a lead acid battery with respect to material used for anode, cathode, electrolyte, and separator	L4	4	10
b)	"Lithium-ion batteries are preferred in EV due to their high energy per unit mass compared to other batteries. They also have the advantages of a high power-to-weight ratio, energy	L4		10

	efficiency, high-temperature performance, and low self-discharge. Present an argument to support this statement			
8.a)	The performance of an EV mainly depends on the health of a battery. Presently researchers are focusing on safety and enhanced performance of the battery. But one of the major issues is the corrosion of the battery terminals. What may be the reason for this? How can battery terminal corrosion be prevented?	L4		10
b)	Battery management systems (BMS) is used in electric vehicle to monitor health of the batteries which makes the operation more economical. Battery management system keeps the battery safe, reliable and increases the senility without entering damaging state. Analyse how BMS will maintain the state of the battery, voltage, current, ambient temperature in safe range	L4		10
Section-5				
9.a)	Assuming you are executing the project of installing the e vehicle charging stations in a metro city having considerable e vehicle density. Discuss the fundamentals you need to consider before installing EV charging stations?	L3	5	10
b)	Draw Basic charging Block Diagram of Charger and discuss the salient features of Slow charger, fast charger, and Rapid charger	L3		10
10.a)	In the old days, automotive systems were concentrated on a few nodes. Now, they're continuously evolving. 45 to 70 or 80 subsystems can exist in a car carrying out multiple functionalities. Communication between all these subsystems (for example ADAs, or telematics units) is essential for the overall implementation of the vehicle's features. Right from vehicle start-up till the driver leaves the car, all the subsystems continuously transmit their status to, as well as receive data from, other subsystems necessary to perform a task. In view of the above developments in EV technology, discuss the most widely used communication protocols in EV	L3		10
b)	Charge point operators and e-mobility service providers are facing challenges expanding internationally especially in dealing with different protocols, regulations, and multi-currencies, and integrating roaming capabilities into their networks. Provide an overview on EV Charging Industry Protocols so that right protocols are selected and adopted?	L3		10

Scheme of Evaluation for SEE 2

Sl. No	Description	Marks
Problem statement	Model an Electric vehicle by using simulation software and analyze the EV performance parameters such as a) Speed, Torque, Top speed reached, distance travelled b) Current, voltage for different drive cycles c) Vehicle dynamics like rolling resistance, air drag, frontal area, weight of the body etc on EV performance	**100**
1	Modelling an EV on Simulation software	40
2	Analyze EV performance parameters and write inference	25
3	Analyze Impact of vehicle dynamics on EV performance and write inference	25
4	Innovative changes in the Model	10
Total		**100**

Annexure

HVAC Tender Document- Sample