MRT402	AUTOTRONICS	CATEGORY	L	T	P	CREDIT
			2	1	0	3

Preamble: This course is formulated to understand the fundamentals and control of automobiles using electronic equipments.

Prerequisite: Nil

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

CO 1	Acquire knowledge on various electronic controls, sensors and actuators used in automobiles.
CO 2	Obtain an overview of components, sub-systems, and basics of engine management employed in today's automotive industry.
CO 3	Acquire knowledge on electronic engine management and on-board diagnostics.
CO 4	Apply fundamental knowledge for design of safety systems like airbags, ABS, etc. in automobiles.
CO 5	Comprehend the basic system components and their functions of electric and hybrid vehicles.
CO 6	Acquire a fundamental knowledge on intelligence vehicle systems.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2										
CO 2	3	2										
CO 3	3	2							1			
CO 4	3	2	2						1			
CO 5	3	2	2						1			
CO 6	3	2	2						1			

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 Hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum 2 subdivisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Define engine performance terms: Power, BSFC, Torque and Volumetric Efficiency with relevant formulae and their units.
2. With the aid of sketches explain the construction and working of Mass Air Flow sensors and Throttle position sensors used in vehicles.
3. Explain the different strokes for a four stroke SI engine, with suitable diagrams.

Course Outcome 2 (CO2):

1. With the aid of a control flow diagram, explain EGR control.
2. What do you mean by Ignition in an IC engine? What are the components of an ignition system and explain each of them.
3. Explain Robert Bosh gasoline fuel injection system with the help of a neat sketch.

Course Outcome 3 (CO3):

1. With a block diagram, explain a typical engine control system and list the variables to be measured associated in an engine control configuration.
2. Explain any two conventional methods of engine diagnostics? What are the limitations.
3. What do you mean by Electromagnetic interference?

Course Outcome 4 (CO4):

1. State the need and working of airbags as safety systems.
2. Briefly explain the concept of cruise control.
3. Explain the micro controller-based cruise control, with a suitable block diagram.

Course Outcome 5 (CO5):

1. Explain Hybrid Electric Vehicle (HEV) and its modes of operation
2. Enlist the different architectures of hybrid electric drive train and explain the series hybrid electric drive train
3. Describe in detail all modes of operation for series-parallel hybrid vehicles.

Course Outcome 6 (CO6):

1. Explain the principle of collision avoidance warning system, using a suitable block diagram.
2. Write short notes on:
    (i) Dead lock reckoning navigation
    (ii) Sign post navigation
3. Discuss briefly about computer vision employed in intelligent vehicles.

Model Question Paper
Course Code: MRT 402
Course Name: AUTOTRONICS

Max. Marks: 100 **Duration: 3 Hours**

	PART A **Answer all the questions. Each question carries 3 Marks**	
1.	How can the engine speed be monitored using a non contact type sensor?	
2.	List out the different actuators used in electronic engine management and mention where they are used.	
3.	Differentiate throttle body and multi port fuel injection system.	
4.	Give a list of the various types of sensors used in the MPFI petrol engine.	
5.	Differentiate open loop and closed loop control systems.	
6.	How deceleration leaning of the mixture is achieved in an engine having a closed loop control system?	
7.	Explain the working of the electronic suspension system in an automobile.	
8.	Explain why Antilock Braking System (ABS) is needed. Draw a schematic which depict the configuration of ABS.	
9.	What do you mean by localization? List down the localization techniques employed in intelligent vehicles	
10.	What is Inertial Measurement Unit? List down its elements and their respective functions.	

	PART B **Answer any one full question from each module. Each question carries 14 Marks**	
	Module 1	
11.	(a) Explain the working of mass flow sensor with relevant diagram. (b) What is hall effect? Explain a position sensor using the principle of hall effect. Compare it with the magnetic reluctance position sensor.	7 7
12.	(a) With the aid of a neat sketch, explain the construction and theory of operation of a typical oxygen sensor used in a vehicle. (b) Explain the working of magnetic reluctance position sensor with relevant diagram.	7 7
	Module 2	
13.	(a) Explain EGR actuator control with a relevant diagram. (b) Explain the working of Fuel Injector and pulse mode fuel control signal with relevant diagrams and waveforms.	6 8
14.	(a) Write about the different types of triggering devices in a contact less ignition system. (b) Explain Spark Plug configuration, spark pulse generation and Ignition Timing with relevant diagrams.	7 7
	Module 3	
15.	(a) Explain on-board and off-board diagnostics in automobiles. (b) What are the CAN protocol layers? What are the four different frames? Write the message format.	7 7
16.	(a) What are the various digital modules in the control unit? Draw a block diagram depicting those modules. (b) With the aid of a block diagram, explain the working of a microcomputer on board a vehicle.	7 7
	Module 4	

17.	(a) Explain adaptive cruise control system with a neat sketch. (b) Draw the typical torque vs speed envelope curves of drive train motors and show the continuous intermittent and peak overload ratings.	7 7
18.	(a) Explain Antilock Braking System (ABS) with relevant diagrams. (b) Explain Accelerometer based Air bag system with relevant diagrams.	7 7
	Module 5	
19.	(a) Explain collision avoidance radar warning system with relevant diagrams. (b) Explain a low tire-pressure warning system with relevant diagrams.	8 6
20.	(a) Explain how an expert system can be used in automobile electronics. (b) Explain the software architecture of intelligent vehicles with a block diagram.	6 8

Syllabus

Module 1

Automotive fundamentals: The engine, components, drive train, starting & charging systems operation, ignition system, suspension systems, brakes, steering system.

Sensors and actuators for power train and chassis systems: Introduction, working principle, throttle position, Manifold absolute pressure (MAP), oxygen concentration sensor, lambda sensor, mass air flow, engine coolant temperature, engine oil pressure, vehicle speed, crankshaft position, detonation, emission, exhaust gas oxygen, lighting, central locking, electric windows, climatic control, driver information, parking, etc., hardware implementation example of simple automotive systems using sensors, controller, actuators etc.

Module 2

SI Engine Management: Feedback carburetor system, throttle body injection and multi point fuel injection system, injection system controls, advantage of electronic ignition systems, three way catalytic converter, conversion efficiency versus lambda, layout and working of SI engine management systems like Bosch Monojetronic, L-Jetronic and LH-Jetronic, group and sequential injection techniques. Working of the fuel system components. Advantages of electronic ignition systems, types of solid state ignition systems and their principle of operation, contactless electronic ignition system, electronic spark timing control.

CI Engine Management: Fuel injection system, parameters affecting combustion, noise and emissions in CI engines. Pilot, main, advanced, post injection and retarded post injection, electronically controlled unit injection system, fuel injection, types, layout of the Common Rail Fuel Injection system, working of components like fuel injector, fuel pump, rail pressure limiter, flow limiter, EGR valve control in electronically controlled systems.

Module 3

Digital engine control system: Open loop and closed loop control system, PID control, lookup tables, engine cooling and warm up control, acceleration, deceleration and idle speed control, integrated engine control system, exhaust emission control engineering, electronic dash board instruments, on-board diagnostics, security and warning systems, parameters to be controlled in SI and CI engines, introduction to modern control strategies like fuzzy logic and adaptive control, future automotive electronic systems, electromagnetic interference and suppression, electromagnetic compatibility.

Module 4

Safety and comfort : Antilock Braking System (ABS), Electronic Stability Control (ESC), Roll Stability Control (RSC), ASBRS, EPS, traction control system, electric seats, mirrors and sun roofs, central locking and electric windows, adaptive cruise control, electric power steering, electronic clutch, electronic suspension system, airbags.

Electric vehicles and hybrid vehicles: Introduction, electric vehicle development, system layout, basic system components, fuel cell, electric vehicle, hybrid vehicle: series hybrid vehicle, parallel hybrid vehicle, CNG-electric hybrid vehicle.

Module 5

Vehicle Intelligence: Introduction, basic structure, vision based autonomous road vehicles, architecture for dynamic vision system, features, applications, application of mobile robot vision to a vehicle information system, object detection, collision warning and avoidance system, low tire pressure warning system.

Text Books

1. Tom Denton, Automobile electrical and electronic systems, BH Publications, 3rd Ed., 2004.
2. Young, Griffitns, Automobile Electrical & Electronic Equipments, Butterworths.
3. Najamuz Zaman, Automotive Electronics Design Fundamental, 1st Ed., Springer, 2015.
4. Hillier's, Fundamentals of Motor Vehicle Technology on Chassis and Body Electronics, 5th Ed., Nelson Thrones, 2007.
5. William B. Ribbens, Understanding Automotive Electronics, 6th Ed., Elsevier, Newnes, 2002.
6. A.P. Young, L. Griffiths, Automotive Electrical Equipment, ELBS & New Press, 1999.

Reference Books

1. Ronald K. Jurgen, Sensors and Transducers, SAE 2003
2. Jack Erjavec, Robert Scharff, Automotive Technology, Delmar publications Inc 1992
3. Ronald K. Jurgen, Electric and Hybrid-electric vehicles, SAE 2002
4. Ichiro Masaki, Vision-based Vehicle Guidance, Springer Verlag, Newyork 1992
5. Jay Webster, Class room manual for automotive service and system, Delmer, 1995.
6. Ronald K. Jurgen, Automotive Electronics Handbook, McGraw Hill Publishing Co.
7. Al Santini, Automotive Electricity and Electronics, Delmar Publishers, NY
8. Bechfold, Understanding Automotive Electronics, SAE 1998
9. R. Hodkinson, J. Fenton, Light Weight Electric/Hybrid Vehicle Design, Read Educational and Professional Publications Ltd. 2001.
10. Bosch, Automotive Electrics and Automotive Electronics System and components, Networking and Hybrid drive, 5th Ed., Springer, 2014.
11. W.H. Crouse, Automobile Electrical Equipment, McGraw-Hill, 3rd edition, 1986.
12. A. W. Judge, Modern Electrical Equipment of Automobiles, Chapman & Hall, 1992.
13. Kholi. P.L. Automotive Electrical Equipment, Tata McGraw-Hill, 1975.
14. Robert Bosch Automotive Hand Book, SAE, 5th Ed., 2000.
15. Ganesan.V. Internal Combustion Engines, Tata McGraw-Hill, 2003.
16. Diesel Engine Management- Robert Bosch, SAE Publications, 3rd Ed., 2004
17. Gasoline Engine Management by Robert Bosch, SAE Publications, 2nd Ed., 2004
18. E. Chowanietz, Automobile Electronics, SAE.
19. V.A.W.Hilliers, Fundamentals of Automotive Electronics, Hatchin, London
20. J. R. Tomwather, C. Hunter, Automotive Computer & Control System, Prentice Inc.
21. R. N. Brandy, Automotive Computers & Digital Instrumentation, Prentice Hall
23. J. Hartly, The Fundamentals of Electrical Systems, Longman Scientific & Technical

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
	Module 1	
1.1	Automotive fundamentals: The engine, components, drive train, starting & charging systems operation, ignition system, suspension systems, brakes, steering system	2
	Sensors and actuators for power train and chassis systems: Introduction, working principle, throttle position	1
1.2	Manifold absolute pressure (MAP), oxygen concentration sensor, lambda sensor, mass air flow, engine coolant temperature, engine oil pressure, vehicle speed, crankshaft position	2
1.3	detonation, emission, exhaust gas oxygen, lighting, central locking, electric windows, climatic control, driver information, parking, etc.	1
1.4	Hardware implementation example of simple automotive systems using sensors, controller, actuators etc.	1
	Module 2	
2.1	SI Engine Management: Feedback carburetor system, throttle body injection and multi point fuel injection system, injection system controls, advantage of electronic ignition systems, three way catalytic converter, conversion efficiency versus lambda	2
2.2	Layout and working of SI engine management systems like Bosch Monojetronic, L-Jetronic and LH-Jetronic. Group and sequential injection techniques. Working of the fuel system components. Advantages of electronic ignition systems. Types of solid state ignition systems and their principle of operation, Contactless electronic ignition system, Electronic spark timing control	2
2.3	CI Engine Management: Fuel injection system, parameters affecting combustion, noise and emissions in CI engines. Pilot, main, advanced, post injection and retarded post injection. Electronically controlled Unit Injection system, fuel injection, types, layout of the Common Rail Fuel Injection system	2
2.4	Working of components like fuel injector, fuel pump, rail pressure limiter, flow limiter, EGR valve control in electronically controlled systems	1
	Module 3	
3.1	Digital engine control system: Open loop and closed loop control system, PID control, Look up tables, engine cooling and warm up control, acceleration, deceleration and idle speed control	2
3.2	integrated engine control system, exhaust emission control engineering, electronic dash board instruments, on-board diagnostics, security and warning systems	2
3.3	Parameters to be controlled in SI and CI engines, introduction to modern control strategies like Fuzzy logic and adaptive control, future automotive electronic systems	2
3.4	Electromagnetic interference and suppression, electromagnetic compatibility	1
	Module 4	
4.1	Safety and comfort: Antilock Braking System (ABS), Electronic Stability Control (ESC)	2
4.2	Roll Stability Control (RSC), ASBRS, EPS, traction control system	2
4.3	electric seats, mirrors and sun roofs, central locking and electric windows, adaptive cruise control, electric power steering, electronic clutch, electronic suspension system, airbags	2
4.4	Electric vehicles and hybrid vehicles: Introduction, electric vehicle development, system layout, basic system components, fuel cell, electric vehicle	2
4.5	Hybrid vehicle: series hybrid vehicle, parallel hybrid vehicle, CNG-electric hybrid vehicle	1
	Module 5	

5.1	Vehicle Intelligence: Introduction, basic structure, vision based autonomous road vehicles	2
5.2	architecture for dynamic vision system, features, applications	2
5.3	application of mobile robot vision to a vehicle information system	2
5.4	object detection, collision warning and avoidance system, low tire pressure warning system.	1

MRT 414	IoT AND APPLICATIONS	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble:

To expose the students to the field of IoT and its applications.

Course Outcomes:

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

CO 1	Explain the basic concepts of IoT and IoT networking.
CO 2	Perceive ideas on the different connectivity technologies and Wireless Sensor Networks.
CO 3	Discuss on UAV Networks & M2M Communication, Software defined networking.
CO 4	Explain the basic concepts of cloud computing and fog computing.
CO 5	Apply the basics of IoT for different applications like Smart Homes and Industrial IoT.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3											2
CO 2	3											2
CO 3	3											2
CO 4	3											2
CO 5	3											2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	20	20	30
Understand	30	30	70
Apply			
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance	: 10 marks
Continuous Assessment Test (2 numbers)	: 25 marks
Assignment/Quiz/Course Project	: 15 marks

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum 2 subdivisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Define IoT.
2. Enlist any three characteristics of IoT and explain.

Course Outcome 2 (CO2):

1. Discuss on Plasma HART and Wireless HART.
2. Explain the challenges in WSN.

Course Outcome 3 (CO3):

1. Discuss on different UAV components.
2. Define Software Defined WSN.

Course Outcome 4 (CO4):

1. Explain public cloud.
2. List out the advantages of Fog.

Course Outcome 5 (CO5):

1. Use course project to evaluate the CO.

Model Question paper

Course Code: MRT 414

Course Name: IoT AND APPLICATIONS

Max. Marks: 100 **Duration: 3 Hours**

PART A

Answer all Questions. Each question carries 3 Marks

1. Discuss the applications of IoT.
2. Define multihoming.
3. Explain the working of RFID.
4. Compare Stationary WSN and Mobile WSN.
5. Explain the difference between FANET and the existing Ad hoc Networks.
6. What is Open Flow protocol? Explain.
7. Discuss on Community cloud.
8. Explain the challenges in Fog.
9. Discuss on smart home implementation.
10. Explain the benefits of IoT.

PART B

Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. With a neat sketch, explain the Functional components of IoT and implementation of IoT.
12. Discuss on IoT identification and data protocols.

Module 2

13. Discuss on (a) ZigBee (b) NFC.
14. Explain the applications of WSN with suitable examples.

Module 3

15. Discuss M2M communication in detail.
16. Explain the architecture and controller Placement of SDN.

Module 4

17. With a neat sketch explain the different Cloud computing service models.
18. Explain the architecture and working of Fog.

Module 5

19. Discuss in detail on Home Area Networks (HANs).
20. With suitable examples explain the applications of IIoT.

Syllabus

IoT AND APPLICATIONS

Module 1 (7 Hours)

Introduction to Internet of Things

Introduction- Characteristics of IoT- Applications of IoT- IoT categories- IoT Enablers and Connectivity Layers - Baseline Technologies-Sensors-Characteristics of a Sensor-Classification of Sensors-Actuators-Types of Actuators-IoT components and implementation-Service Oriented Architecture-IoT Interdependencies-Challenges for IoT.

IoT Networking

Connectivity Terminologies, Gateway Prefix Allotment-Impact of Mobility on Addressing-Multihoming-Deviations from Regular Web-IoT Identifications and Data Protocols.

Module 2 (7 Hours)

Connectivity Technologies

Introduction-IEEE 802.15.4-ZigBee-6LoWPAN-RFID-HART and wireless HART-NFC- Bluetooth- Z-wave-ISA 100.11A.

Wireless Sensor Networks

Introduction-Components of a sensor Node-Modes of Detection-Challenges in WSN-Sensor Web-Cooperation-Behaviour of Nodes in WSN-Information Theoretic Self-Management of WSN-Social Sensing in WSN-Applications of WSN-Wireless Multimedia Sensor Networks-Wireless Nano sensor Networks-Under Water Acoustic Sensor Networks- WSN Coverage-Optimal Geographical Density Control (OGDC) Algorithm-Stationary WSN-Mobile WSN.

Module 3 (7 Hours)

UAV Networks & M2M Communication

Introduction-UAV Components- UAV Networks- Features- Challenges- Topology- FANET-Features-Difference between FANET and the Existing Ad hoc Networks, FANET Design Considerations-FANET communication-Gateway Selection in FANETS-M2M Communication- M2M Applications-

Types of Node in M2M-M2M Ecosystem-M2M Service platform- Interoperability-Need for Interoperability-Types of Interoperability.

Software Defined Networking

Introduction, Limitations of Current Network-Origin of SDN-SDN Architecture-Rule Placement-OpenFlow Protocol-Controller Placement-Security in SDN-Integrating SDN in IoT-Software defined WSN-SDN for Mobile Networking-Rule Placement at Access Devices.

Module 4 (7 Hours)

Cloud Computing

Introduction-Architecture-Characteristics-Deployment Models-Public Cloud-Private Cloud-Hybrid Cloud-Community Cloud-Multi Cloud-Distributed Cloud-Inter Cloud-Big Data Cloud-HPC Cloud-Service Models-Service Management-Cloud Security.

Fog Computing

Introduction-Why Fog Computing-Requirements of IoT-Architecture of Fog-Working of Fog-Advantages of Fog-Applications of Fog-Challenges in Fog.

Module 5 (7 Hours)

IoT Applications-Smart Homes

Introduction-Origin of Smart Home-Examples of Smart Home Technologies-Smart Home Implementation-Home Area Networks-HAN Elements-HAN Standards-HAN Architectures-HAN Initiatives-Smart Home Benefits and Issues.

Industrial IoT

Introduction-IIoT Requirements-Design Considerations-Applications of IIoT-Manufacturing Industry-Health Care Service Industry-Transportation and Logistics-Mining-Firefighting-Smart Dust-Drones-Futuristic Farming-Aerospace-Energy Networks-Benefits of IIoT-Challenges of IIoT.

Text Books

1. Jeeva Jose, “Internet of Things”, Khanna Book Publishing Co.(P) Ltd, 1/e.
2. RMD Sundaram Shriram K Vasudevan, & Abhishek S Nagarajan, “Internet of Things”, Wiley.

Reference Books

1. Hanes David , Salgueiro Gonzalo , Grossetete Patrick , Barton Rob , Henry Jerome, “IoT Fundamentals: Networking Technologies, Protocols and Use Cases for the Internet of Things”, Pearson, 1/e.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Introduction to Internet of Things**	
1.1	Introduction- Characteristics of IoT- Applications of IoT- IoT categories- IoT Enablers and Connectivity Layers	1 Hour
1.2	Baseline technologies-Sensors-Characteristics of a Sensor-Classification of Sensors-Actuators-Types of Actuators-IoT components and implementation-Service Oriented Architecture-IoT Interdependencies-Challenges for IoT.	3 Hours
	IoT Networking	
1.3	Connectivity Terminologies, Gateway Prefix Allotment-Impact of Mobility on Addressing-Multihoming-Deviations from Regular Web-IoT Identifications and Data Protocols	3 Hours
2	**Connectivity Technologies**	
2.1	Introduction-IEEE 802.15.4-ZigBee-6LoWPAN-RFID-HART and wireless HART-NFC-Bluetooth-Z-wave-ISA 100.11A	2 Hours
	Wireless Sensor Networks	
2.2	Introduction-Components of a sensor Node-Modes of Detection-Challenges in WSN-Sensor Web-Cooperation-Behaviour of Nodes in WSN-Information Theoretic Self-Management of WSN-Social Sensing in WSN-Applications of WSN	2 Hours
2.3	Wireless Multimedia Sensor Networks-Wireless Nano sensor Networks-Under Water Acoustic Sensor Networks-WSN Coverage-Optimal Geographical Density Control (OGDC) Algorithm-Stationary WSN-Mobile WSN	3 Hours
3	**UAV Networks & M2M Communication**	
3.1	Introduction-UAV Components-UAV Networks-Features-Challenges-Topology-FANET-Features-Difference between FANET and the Existing Ad hoc Networks, FANET Design Considerations	2 Hours
3.2	FANET communication-Gateway Selection in FANETS-M2M Communication-M2M Applications-Types of Node in M2M-M2M Ecosystem-M2M Service platform- Interoperability- Need for Interoperability-Types of Interoperability	2 Hours
	Software Defined Networking	
3.3	Introduction, Limitations of Current Network-Origin of SDN-SDN Architecture	1 Hour

3.4	Rule Placement- OpenFlow Protocol-Controller Placement-Security in SDN-Integrating SDN in IoT-Software defined WSN-SDN for Mobile Networking-Rule Placement at Access Devices	2 Hours
4	**Cloud Computing**	
4.1	Introduction-Arhitecture-Characteristics-Deployment Models-Public Cloud-Private Cloud-Hybrid Cloud-Community Cloud	2 Hours
4.2	Multi Cloud-Distributed Cloud-Inter Cloud-Big Data Cloud-HPC Cloud-Service Models-Service Management-Cloud Security	2 Hours
	Fog Computing	
4.3	Introduction-Why Fog Computing-Requirements of IoT-	1 Hour
4.4	Architecture of Fog-Working of Fog-Advantages of Fog-Applications of Fog-Challenges in Fog	2 Hours
5	**IoT Applications-Smart Homes**	
5.1	Introduction-Origin of Smart Home-Examples of Smart Home Technologies	1 Hour
5.2	Smart Home Implementation-Home Area Networks-HAN Elements-HAN Standards-HAN Architectures-HAN Initiatives-Smart Home Benefits and Issues	2 Hours
	Industrial IoT-Introduction	
5.3	IIoT Requirements-Design Considerations-Applications of IIoT-Manufacturing Industry-Health Care Service Industry	2 Hours
5.4	Transportation and Logistics-Mining-Firefighting-Smart Dust-Drones-Futuristic Farming-Aerospace-Energy Networks- Benefits of IIoT-Challenges of IIoT	2 Hours

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MRT424	COMMUNICATION ENGINEERING	PEC	2	1	0	3

Preamble: Nil

Prerequisite: Nil

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

CO 1	Summarize analog modulation techniques, and the need for modulation
CO 2	Explain analog and digital pulse modulation schemes.
CO 3	Summarize various multiple access techniques
CO 4	Explain the working of cellular communication and radar.
CO 5	Explain the working of optical communication systems.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	1	1								
CO 2	3	3		1			1					
CO 3	3	3	3	1								
CO 4	3		2	1	2	2						
CO 5	3	2		2								

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
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Mark distribution

Total Marks	CIE	ESE	ESE Duration
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Continuous Internal Evaluation Pattern:

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End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each full question carries 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the necessity for modulating a signal.

2. Compare AM and FM.

Course Outcome 2 (CO2)

1. Compare PAM, PWM and PPM.
2. Explain the working of a PCM system.

Course Outcome 3(CO3):

1. Compare various multiple access techniques.

2. Explain the multiple access techniques used for wired networks.

Course Outcome 4 (CO4):

1. Explain various handoff techniques used in mobile communication.

2. With the help of the block diagram explain the working of pulsed radar.

Course Outcome 5 (CO5):

1. Explain the principle behind the transmission of optical signal through the fibre. Mention the losses associated with optical fibres.

2. Explain various optical sources used for communication.

Syllabus

Module 1

Analog Modulation: Need for modulation**,** AM and FM fundamentals. AM – Frequency spectrum – vector representation – power relations – generation of AM – DSB, DSB/SC, SSB, VSB. FM – frequency spectrum – power relations

Module 2

Digital Communication: Sampling process-pulse modulation Techniques- PAM, PWM and PPM, Principles of digital communication & advantages – PCM encoder and decoder, Applications of data communication.

Module 3

Satellite Communication: Introduction to satellite communication, Multiple access (MA) techniques- FDMA, TDMA, CDMA, SDMA - applications in satellite communication, Applications of MA techniques in wired communication, satellite earth station.

Module 4

Cellular communication: Basic concepts, frequency reuse, interference cell splitting, sectoring, cell system layout, cell processing, hand off.

Radar systems-Radar and navigation: principle of radar and radar equation, block schematics of pulsed radar, radar application

Bluetooth, Zigbee, Wi-Fi, Wi-Max

Module 5

Optical communication: Introduction to fiber optics, principle, V-Number concept, Attenuation- absorption –scattering losses-bending losses, types of fibers, sources-LED, LASER detectors –PIN, avalanche, applications of optical communication.

Text Books

1. Kennedy G., Electronic Communication Systems, McGraw-Hill, New York, 2008.
2. 2. Roody and Coolen, Electronic Communication, Prentice Hall of India LTD., New Delhi, 2007.

Reference Books

1. William Scheweber, Electronic Communication Systems, Prentice Hall of India LTD, New Delhi, 2004.
2. Wayne Tomasi, Electronic Communication Systems, Prentice Hall of India LTD, New Delhi, 2004.
3. Frank R. Dungan, Electronic Communication Systems, 3/e, Vikas Publishing House, 2002.
4. Simon Haykins, Communication Systems, John Wiley, USA, 2006.
5. Bruce Carlson. Communication Systems, Tata McGraw Hill, New Delhi, 2001
6. Taub and Schilling, Principles of Communication Systems, McGraw-Hill, New York, 2008.
7. Anokh Singh, Principles of Communication Engineering, S. Chand and Company Ltd., Delhi.

Course Contents and Lecture Schedule

No	Topic	No. of Lecture hours
1	**Analog Modulation:**	
1.1	Need for modulation**,** AM and FM fundamentals .	1
1.2	AM – Frequency spectrum – vector representation – power relations	1
1.3	Generation of AM – DSB, DSB/SC, SSB, VSB	4
1.4	FM – frequency spectrum – power relations	1
2	**Digital Communication**:	
2.1	Sampling process, pulse modulation Techniques-PAM, PWM and PPM.	3
2.2	Principles of digital communication & advantages	1
2.3	PCM encoder and decoder. Applications of data communication.	3
3	**Satellite Communication** :	
3.1	Introduction -Multiple access (MA) techniques-FDMA, TDMA, CDMA, SDMA	3
3.2	Applications in satellite communication wire	1
3.3	MA techniques applications in wired communication ,in satellite communication	2
3.4	Satellite earth station	1
4	**Cellular communication**	
4.1	Basic concepts, frequency reuse, interference cell splitting, sectoring, cell system layout, cell processing, hand off.	3
4.2	Radar systems**-**Radar and navigation: principle of radar and radar equation, block schematics of pulsed radar, radar application	2
4.3	Bluetooth, Zigbee , Wi-Fi, Wi-Max	2
5	**Optical communication**:	
5.1	Introduction to fiber optics, principle, V-Number concept	1
5.2	Attenuation-absorption –scattering losses-bending losses	2
5.3	Types of fibers	1
5.4	Sources-LED ,LASER. detectors –PIN, avalanche, application.	3

Model Question paper

QP CODE: **Duration: 3hours**

Reg. No:---------- **Name: ----------**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIRST SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course code: MRT424

COMMUNICATION ENGINEERING (2019- Scheme)

Mechatronics Branch

PART A (Answer all the questions, each question carries 3 marks)

1. What is modulation?

2. Draw the frequency spectrum of AM and DSB/SC.

3. What are the advantages of digital communication?

4. List the application of data communication.

5. Draw the basic satellite communication systems

6. What are satellite transponders?

7. Draw the block diagram of a radar system

8. Give a brief note on Wi-Fi

9. What is total internal reflection?

10. What is meant by numerical aperture?

PART B (Answer one full question from each module . each question carries 14 marks)

Module 1

11. (a) Derive the basic equation of amplitude modulated wave . (10 marks)

(b) What are the needs for modulation. (4 marks)

12. (a) With a necessary sketch derive the general equation of FM . (8 marks)

(b) Explain any one method of DSB/SC modulation. (6 marks)

Module 2

13. (a) With necessary explanations and block diagram explain PCM. (14 marks)

14. (a) Write a short note on different pulse modulation techniques. (14 marks)

Module 3

15. (a) Explain in detail about multiple access techniques. (14 marks)

16. (a) Differentiate between FDMA and TDMA. (10 marks)

(b) Give a brief note on satellite earth stations. (4 marks)

Module 4

17. (a) Derive the basic RADAR equation. (10 marks)

(b) Differentiate between the Wi-Fi and Wi-Max. (4 marks)

18. (a) Explain the concept of frequency reuse and hand off in cellular communication systems. (10 marks)

(b) Write down the methods to improve cellular capacity. (4 marks)

Module 5

19. Explain in detail about the attenuation mechanism in the optical fiber system. (14 marks)

20. (a) What are LASERS? Explain in detail. (7 marks)

(b) With necessary sketch explain avalanche photo diode. (7 marks)

MRT 434	SPECIAL ELECTRICAL MACHINES AND APPLICATIONS	CATEGORY	L	T	P	CREDIT
		PCC	2	1	0	3

Preamble:

This course aims the students to learn about the basics of some of the special electrical machines and its applications

Prerequisite:

MRT201- ELECTRICAL MACHINES & DRIVES

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

CO 1	Explain the basic concepts of stepper motor.
CO 2	Describe the basic concepts of ac and dc servomotors
CO 3	Explain the basic concepts of induction generator and universal motor
CO 4	Describe the basic concepts of brushless dc motors
CO 5	Explain the basic concepts repulsion and synchronous motors

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	2	1	-	3	3	2	2	1	1	2
CO2	3	1	2	1	-	3	3	2	2	1	1	2
CO3	3	1	2	1	-	3	3	2	2	1	1	2
CO4	3	1	2	1	-	3	3	2	2	1	1	2
CO5	3	1	2	1	-	3	3	2	2	1	1	2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance	: 10 marks
Continuous Assessment Test (2 numbers)	: 25 marks
Assignment/Quiz/Course project	: 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum 2 sub-divisions and carry 14 marks.

SYLLABUS

Module 1 – STEPPER MOTOR

Stepper motors – Basic principle – step angle - different types – variable reluctance- permanent magnet – hybrid type – comparison – theory of operation – stepper motor drive circuits - characteristics of stepper motor – applications.

Module 2 – AC & DC SERVOMOTORS

AC SERVOMOTOR

AC Servomotors- servomechanism – Construction - principle of operation – performance characteristics – damped AC servomotors – Drag cup servomotor – applications.

DC SERVOMOTOR

DC servomotors – field and armature-controlled DC servomotors – permanent magnet armature controlled – series split field DC servomotor.

Module 3 – INDUCTION GENERATOR & UNIVERSAL MOTOR

INDUCTION GENERATOR

Induction generators – basic principle – characteristics – equivalent circuit – phasor diagram – advantages – disadvantages – applications

UNIVERSAL MOTOR

Universal motor – constructional details – principle of operation – characteristics – speed control – applications.

Module 4 – BRUSHLESS DC (BLDC) MOTORS

BLDC – principle of operation – basic block diagram – voltage fed inverter control – current fed inverter control – comparison between brushless and brushed motors – applications.

Module 5 - REPULSION & SYNCHRONOUS MOTORS

REPULSION MOTORS

Repulsion motors – construction – operation – characteristics – disadvantages – application – types – repulsion-start induction motors – repulsion induction motors.

SYNCHRONOUS MOTORS

Synchronous motors – types – Reluctance motors – Hysteresis motors – permanent magnet synchronous motors construction – operation – characteristics and application (all three motors).

Text Books

1. J.B. Gupta, Electrical Machines, Katson Books
2. E. G. Janardhanan, 'Special Electrical Machines' PHI Learning Private Limited.
3. R Sriniavsan, Special Electrical Machines, Lakshmi publications

Reference Books

1. Rving L. Kosow.'Electrical Machinery and Transformers', Oxford Science Publications.
2. T. J. E. Miller, 'Brushless PM and Reluctance Motor Drives'.C.Larendon Press, Oxford.
3. Theodore Wildi, 'Electric Machines, Drives and Power Systems', Prentice Hall India Ltd.
4. Veinott & Martin,'Fractional & Subfractional hp Electric Motors'.McGraw Hill International Edn

Model Question paper

QP CODE:

Reg. No:---------- **Duration: 3 hours**

Name: ----------

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY EIGHT SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course code: MRT 434

SPECIAL ELECTRICAL MACHINES AND APPLICATIONS

(2019- Scheme)

Mechatronics Branch

PART A

*(Answer **all** the questions, each question carries 3 marks)*

1. Briefly explain step angle.
2. Narrate some of the applications of stepper motors.
3. Explain servomechanism.
4. Compare ac and dc servomotors.
5. Draw torque - slip characteristics of induction generator.
6. Narrate some of the applications of universal motors.
7. Draw basic block diagram of BLDC.
8. Compare brushless and brushed motors.
9. Explain briefly the operation of the repulsion motor.
10. Narrate some of the applications of synchronous motors.

PART B

*(Answer **one** full question from each module. each question carries 14 marks)*

Module 1

11. Explain in detail about different types of stepper motor (14 marks)
12. (a) Explain in detail about stepper motor drive circuits. (8 marks)
    (b) With neat sketch explain the characteristics of stepper motors (6 marks)

Module 2

13. Explain in detail different types of ac servomotors with its performance characteristics (14 marks)

14. Explain in detail different types of dc servomotors (14 marks)

Module 3

15. With neat sketch explain the equivalent circuit and phasor diagram of induction generator. (14 marks)

16. Explain in detail about universal motor (14 marks)

Module 4

17. (a) Explain the construction and operation of BLDC (6 marks)

(b) Compare brushless dc motors with brushed dc motors (4 marks)

(c) Narrate some of the application s of BLDC (4 marks)

18. With circuit diagram explain voltage fed inverter control and current fed inverter control. (14 marks)

Module 5

19. Explain in detail about different types of repulsion motors. (14 marks)

20. Explain in detail about different types of synchronous motors. (14 marks)

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**STEPPER MOTOR**	
1.1	Basic principle – step angle - different types – variable reluctance	1
1.2	Permanent magnet – hybrid type – comparison	2
1.3	Theory of operation – stepper motor drive circuits	2
1.4	Characteristics of stepper motor	1
1.5	Applications	1
2	**AC SERVOMOTOR**	
2.1	AC Servomotors- servomechanism – Construction	1
2.2	Principle of operation – performance characteristics	1
2.3	Damped AC servomotors	1
2.4	Drag cup servomotor – applications	1
	DC SERVOMOTOR	
2.5	Field and armature-controlled DC servomotors	1
2.6	Permanent magnet armature controlled	1
2.7	Series split field DC servomotor	1
3	**INDUCTION GENERATOR**	
3.1	Basic principle – characteristics	1
3.2	Equivalent circuit	1
3.3	Phasor diagram	1
3.4	advantages – disadvantages – applications	1
	UNIVERSAL MOTOR	
3.5	Constructional details – principle of operation	1
3.6	Characteristics	1
3.7	Speed control – applications	1
4	**BRUSHLESS DC (BLDC) MOTORS**	
4.1	Principle of operation – basic block diagram	1
4.2	Voltage fed inverter control	2
4.3	Current fed inverter control	2
4.4	Comparison between brushless and brushed motors – applications	1
5	**REPULSION & SYNCHRONOUS MOTORS**	
5.1	Construction – operation	0.5
5.2	Characteristics	0.5
5.3	Disadvantages – application	0.5
5.4	Types – repulsion-start induction motors	0.5
5.5	Repulsion induction motors	0.5
	SYNCHRONOUS MOTORS	
5.6	Synchronous motors	0.5

5.7	Types – Reluctance motors – Hysteresis motors	2
5.8	Permanent magnet synchronous motors construction – operation – characteristics and application	2

CODE	COURSE NAME	CATEGORY	L	T	P	Credits
MRT444	METALLURGY & MATERIALS ENGINEERING	PEC	2	1	0	3

Preamble: Understanding of the correlation between the chemical bonds and crystal structure of metallic materials to their mechanical properties. Recognize the importance of crystal imperfections including dislocations in plastic deformation. Learning about different phases and heat treatment methods to tailor the properties of Fe-C alloys. Examine the mechanisms of materials failure through fatigue and creep. To determine properties of unknown materials and develop an awareness to apply this knowledge in material design.

Prerequisite: Engineering Physics and Engineering Chemistry

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

CO 1	Understand the basic chemical bonds, crystal structures (BCC, FCC, and HCP), and their relationship with the properties.
CO 2	Analyze the microstructure of metallic materials using phase diagrams and modify the microstructure and properties using different heat treatments.
CO 3	Quantify mechanical integrity and failure in materials.
CO 4	Apply the basic principles of ferrous and non-ferrous metallurgy for selecting materials for specific applications.
CO 5	Define and differentiate engineering materials on the basis of structure and properties for engineering applications.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3											
CO 2		3										
CO 3				2								
CO 4					3							
CO 5												2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	13	13	25
Understand (K2)	7	7	15
Apply (K3)	15	15	30
Analyse (K4)	5	5	10
Evaluate (K5)	5	5	10
Create (K6)	5	5	10

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum 2 subdivisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. What are the attributes of atomic and crystalline structures into the stress - strain curve?
2. Explain the significance of long range and short range order of atomic arrangement on mechanical strength.
3. What is the difference between an allotrope and a polymorphism?
4. Draw the (112) and (111) planes in a simple cubic cell.

Course Outcome 2 (CO2)

1. What is the driving force for recrystallisation and grain growth of metallic crystals?
2. What is the driving force for the formation of spheroidite.
3. What is tempered martensite?
4. Why are 100 % pure metals weak in strength?

Course Outcome 3 (CO3):

1. A small hole is drilled through a steel plate ahead of a crack, whether it can stop the crack's progress until repairs can be made. Explain in detail and derive the equation for the principle.
2. Draw and explain S-N curves for ferrous and non-ferrous metals. Explain different methods to improve fatigue resistance.
3. Explain different stages of creep; Give an application of creep phenomenon. What is superplasticity?

Course Outcome 4 (CO4):

1. What are the classification, compositions and applications of high speed steel? identify 18:4:1

2. Describe the composition, properties, and use of Bronze and Gun metal.

3. Explain the importance of all the non-ferrous alloys in automotive applications. Elaborate on the composition, properties and typical applications of any five non-ferrous alloys.

Course Outcome 5 (CO5):

1. Carbon is allowed to diffuse through a steel plate 15 mm thick. The concentrations of carbon at the two faces are 0.65 and 0.30kgC/m3Fe, which are maintained constant. If the pre-exponential and activation energy are 6.2x10- 7m2 /s and 80,000 J/mol, respectively, compute the temperature at which the diffusion flux is 1.43 x 10- 9 kg/m2 –s
2. Explain the fundamental effects of alloying elements in steel on polymorphic transformation temperatures, grain growth, eutectoid point, retardation of the transformation rates, formation and stability of carbides.
3. Describe the kind of fracture which may occur as a result of a loose fitting key on a shaft.

Model Question paper

QP CODE:

PAGES: 3

Reg. No:_____

Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY EIGHTH SEMESTER
B.TECH DEGREE EXAMINATION,
MONTH & YEAR
Course Code: MRT444

Course Name: METALLURGY AND MATERIAL ENGINEERING

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all questions. Each question carries 3 Marks

1. What is a slip system? Describe the slip systems in FCC, BCC and HCP metals
2. NASA's Parker Solar Probe will be the first-ever mission to "touch" the Sun. The spacecraft, about the size of a small car, will travel directly into the Sun's atmosphere about 4 million miles from the earth surface. Postulate the coolant used in the parker solar probe with chemical bonds.
3. What is the driving force for grain growth during heat treatment
4. What are the roles of surface imperfections on crack initiation
5. Explain the difference between hardness and hardenability.
6. What is tempered martensite? Explain its structure with sketch
7. Postulate, why cast irons are brittle?
8. How are properties of aluminum affected by the inclusion of (a) copper and (b) silicon as alloying elements?
9. What is the grain size preferred for creep applications? Why. Explain thermal fatigue?
10. Explain fracture toughness and its attributes into a screw jack?.

PART B (14 x 5 = 70 Marks)

Answer any one full question from each module. Each question carries 14 marks

Module 1

11.	a.	Calculate the APF of SC, BCC and FCC	7
	b.	What is slip system and explain why FCC materials exhibit ductility and BCC and HCP exhibit brittle nature with details of slip systems	7
12.		Explain the effect of: (i) Grain size; (ii) Grain size distribution and (iii) Grain orientation (iv) Grain shape on strength and creep resistance with neat sketches. Attributes of Hall-Petch equation and grain boundaries	14

Module 2

13.	a.	Describe step by step procedure for metallographic specimen preparation? Name different types of etchants used for specific metals and methods to determine grain size.	7
	b.	Carbon is allowed to diffuse through a steel plate 15 mm thick. The concentrations of carbon at the two faces are 0.65 and 0.30 kgC/m3Fe, which are maintained constant. If the preexponential and activation energy are 6.2x10- 7m2 /s and 80,000 J/mol, respectively, compute the temperature at which the diffusion flux is 1.43 x 10- 9 kg/m2 -s	7
14.	a.	Explain the fundamental differences of SEM and TEM with neat sketches.	7
	b.	A beam of X-rays wavelength 1.54Å is incident on a crystal at a glancing angle of 8° 35’ when the first order Bragg’s reflection occurs calculate the glancing angle for third order reflection	7

Module 3

15.		Postulate with neat sketches, why are 100% pure metals weaker? What are the primary functions of alloying? Explain the fundamental rules governing the alloying with neat sketches and how is it accomplished in substitution and interstitial solid solutions	14
16.		Draw the isothermal transformation diagram of eutectoid steel and then sketch and label (1) A time temperature path that will produce 100% pure coarse and fine pearlite (2) A time temperature path that will produce 50% martensite and 50% bainite (3) A time temperature path that will produce 100% martensite (4) A time temperature path that will produce 100% bainite	14

Module 4

17.		Explain the effect of, polymorphic transformation temperature, formation and stability of carbides, grain growth, displacement of the eutectoid point, retardation of the transformation rates, improvement of corrosion resistance on adding alloy elements to steel	14
18.		Give the composition, microstructure, properties and applications of (i) Gray iron and SG iron. (ii) White iron and Gray iron. (iii) Malleable iron and Gray iron. (iv) Gray iron and Mottled iron, (v) SG iron and Vermicullar Graphite Iron	14

Module 5

19.	a.	A small hole is drilled through a steel plate ahead of a crack, whether it can stop the crack's progress until repairs can be made or not? Explain in detail and derive the equation	7
	b.	What is ductile to brittle transition in steel DBTT? What are the factors affecting ductile to brittle transition? Narrate with neat sketch	7
20.		Classify ceramics with radius ratio with neat sketches. Explain with an example for each of the AX, AmXp, AmBmXp type structures in ceramics with neat sketch	14

Syllabus

Module 1 (7 hours)

Classification of crystal imperfections - forest of dislocation, role of surface defects on crack initiation- Burgers vector –Frank Read source - Correlation of dislocation density with strength and nano concept - high and low angle grain boundaries– driving force for grain growth and applications - Polishing and etching - X – ray diffraction, simple problems –SEM and TEM - Diffusion in solids, fick's laws, mechanisms, applications of diffusion in mechanical engineering, simple problems.

Module 2 (9 hours)

Classification of crystal imperfections - forest of dislocation, role of surface defects on crack initiation- Burgers vector –Frank Read source - Correlation of dislocation density with strength and nano concept - high and low angle grain boundaries– driving force for grain growth and applications - Polishing and etching - X – ray diffraction, simple problems –SEM and TEM - Diffusion in solids, fick's laws, mechanisms, applications of diffusion, simple problems

Module 3 (8 hours)

Phase diagrams: - need of alloying - classification of alloys - Hume Rothery`s rule - equilibrium diagram of common types of binary systems: five types - Coring - lever rule and Gibb`s phase rule - Reactions- Detailed discussion on Iron-Carbon equilibrium diagram with microstructure and properties -Heat treatment: - TTT, CCT diagram, applications - Tempering- Hardenability, Jominy end quench test, applications- Surface hardening methods.

Module 4 (6 hours)

Strengthening mechanisms - cold and hot working - alloy steels: how alloying elements affecting properties of steel - nickel steels - chromium steels - high speed steels -cast irons - principal non ferrous alloys.

Module 5 (6 hours)

Fatigue: - creep -DBTT - super plasticity - need, properties and applications of composites, super alloy, intermetallics, maraging steel, Titanium - Ceramics:- structures, applications.

Text Books

1. Callister William. D., Material Science and Engineering, John Wiley, 2014
2. Higgins R.A. - Engineering Metallurgy part - I – ELBS,1998

Reference Books

1. E Avner H Sidney, Introduction to Physical Metallurgy, Tata McGraw Hill,2009
2. Anderson J.C. et.al., Material Science for Engineers, Chapman and Hall,1990

3. Clark and Varney, Physical metallurgy for Engineers, Van Nostrand,1964 4
4. Dieter George E, Mechanical Metallurgy, Tata McGraw Hill, 1976
5. Raghavan V, Material Science and Engineering, Prentice Hall,2004
6. Reed Hill E. Robert, Physical metallurgy principles, 4th edition, Cengage Learning,2009
7. Myers Marc and Krishna Kumar Chawla, Mechanical behavior of materials, Cambridge University press,2008
8. Van Vlack -Elements of Material Science - Addison Wesley,1989
9. https://nptel.ac.in/courses/113/106/11310603s.

COURSE CONTENT AND LECTURE SCHEDULE

No	Topic	No. of Lectures
1	**Module 1**	
1.1	Earlier and present development of atomic structure; attributes of ionization energy and conductivity, electronegativity; correlation of atomic radius to strength; electron configurations; - Primary bonds: - characteristics of covalent, ionic and metallic bond: attributes of bond energy, cohesive force, density, directional and non-directional - properties based on atomic bonding:- attributes of deeper energy well and shallow energy well to melting temperature, coefficient of thermal expansion - attributes of modulus of elasticity in metal cutting process -Secondary bonds:- classification- hydrogen bond and anomalous behavior of ice float on water, application- specific heat, applications. (Brief review only).	2
1.2	Crystallography:- Crystal, space lattice, unit cell- SC, BCC, FCC, atomic packing factor and HCP structures - short and long range order - effects of crystalline and amorphous structure on mechanical properties	1
1.3	Coordination number and radius ratio; theoretical density; simple problems - Polymorphism and allotropy.	1
1.4	Miller Indices: - crystal plane and direction - Attributes of miller indices for slip system, brittleness of BCC, HCP and ductility of FCC - Modes of plastic deformation: - Slip and twinning.	1
1.5	Schmid's law, equation, critical resolved shear stress, correlation of slip system with plastic deformation in metals and applications	1
1.6	Mechanism of crystallization: Homogeneous and heterogeneous nuclei formation, under cooling, dendritic growth, grain boundary irregularity - Effects of grain size, grain size distribution, grain shape, grain orientation on dislocation/strength and creep resistance - Hall - Petch theory, simple problems.	1
2	**Module 2**	
2.1	Classification of crystal imperfections: - types of point and dislocations.	1
2.2	Effect of point defects on mechanical properties - forest of dislocation, role of surface defects on crack initiation - Burgers vector.	1
2.3	Dislocation source, significance of Frank-Read source in metals deformation - Correlation of dislocation density with strength and nano concept, applications	1
2.4	Significance high and low angle grain boundaries on dislocation – driving force for grain growth and applications during heat treatment	1

2.5	Polishing and etching to determine the microstructure and grain sizeFundamentals and crystal structure determination by X – ray diffraction, simple problems –SEM and TEM.	2
2.6	Diffusion in solids, fick's laws, mechanisms, applications of diffusion in mechanical engineering, simple problems.	1
3	**Module 3**	
3.1	Phase diagrams: - Limitations of pure metals and need of alloying - classification of alloys, solid solutions, Hume Rothery`s rule - equilibrium diagram of common types of binary systems: five types.	1
3.2	Coring - lever rule and Gibb`s phase rule - Reactions: - monotectic, eutectic, eutectoid, peritectic, peritectoid.	1
3.3	Detailed discussion on Iron-Carbon equilibrium diagram with microstructure and properties changes in austenite, ledeburite, ferrite, cementite, special features of martensite transformation, bainite, spheroidite etc.	1
3.4	Heat treatment: - Definition and necessity – TTT for a eutectoid iron–carbon alloy, CCT diagram, applications - annealing, normalizing, hardening, spheroidizing	1
3.5	Tempering:- austempering, martempering and ausforming - Comparative study on ductility and strength with structure of pearlite, bainite, spherodite, martensite, tempered martensite and ausforming.	1
3.6	Hardenability, Jominy end quench test, applications- Surface hardening methods:- no change in surface composition methods :- Flame, induction, laser and electron beam hardening processes- change in surface composition methods :carburizing and Nitriding; applications	2
4	**Module 4**	
4.1	Cold working: Detailed discussion on strain hardening; recovery; recrystallization, effect of stored energy; re- crystallization temperature - hot working, Bauschinger effect and attributes in metal forming	1
4.2	Alloy steels:- Effects of alloying elements on steel: dislocation movement, polymorphic transformation temperature, alpha and beta stabilizers, formation and stability of carbides, grain growth, displacement of the eutectoid point, retardation of the transformation rates, improvement in corrosion resistance, mechanical properties	1
4.3	Nickel steels, Chromium steels etc. – change of steel properties by adding alloying elements: - Molybdenum, Nickel, Chromium, Vanadium, Tungsten, Cobalt, Silicon, Copper and Lead - High speed steels - Cast irons: Classifications; grey, white, malleable and spheroidal graphite cast iron etc, composition, microstructure, properties and applications - Principal Non ferrous Alloys: - Aluminum, Copper, Magnesium, Nickel, study of composition, properties, applications, reference shall be made to the phase diagrams whenever necessary.(Topic 4.3 may be considered as a assignment).	2

4.4	Fatigue: - Stress cycles – Primary and secondary stress raisers - Characteristics of fatigue failure, fatigue tests, S-N curve	1
4.5	Factors affecting fatigue strength: stress concentration, size effect, surface roughness, change in surface properties, surface residual stress - Ways to improve fatigue life – effect of temperature on fatigue, thermal fatigue and its applications in metal cutting	2
5	**Module 5**	
5.1	Fracture: – Brittle and ductile fracture – Griffith theory of brittle fracture – Stress concentration, stress raiser – Effect of plastic deformation on crack propagation - transgranular, intergranular fracture - Effect of impact loading on ductile material and its application in forging, applications - Mechanism of fatigue failure.	1
5.2	Structural features of fatigue: - crack initiation, growth, propagation - Fracture toughness (definition only), applications - Ductile to brittle transition temperature (DBTT) in steels and structural changes during DBTT, applications.	1
5.3	Creep: - Creep curves – creep tests - Structural change:- deformation by slip, sub-grain formation, grain boundary sliding - Mechanism of creep deformation - threshold for creep, prevention against creep - Super plasticity: need and applications	1
5. 4	Present value method, life cycle costing approach.	1
5.4	Composites: - Need of development of composites; fiber phase; matrix phase; only need and characteristics of PMC, MMC, and CMC	1
5.5	Modern engineering materials: - only fundamentals, need, properties and applications of, intermetallics, maraging steel, super alloys, Titanium Ceramics:-coordination number and radius ratios- AX, AmXp, AmBmXp type structures – applications	2

MRT 454	STATISTICAL QUALITY CONTROL	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble:

Quality control is an important activity involved for ensuring the quality of products and services before delivery to the customer. Statistics deals with collection and analysis of data and statistical quality control is primarily collection and analysis of quality related data from manufacturing or service processes. A number of proven statistical quality control techniques are available which are widely adopted. This course is addressing the most widely adopted statistical quality control techniques in organizations.

Prerequisite: Basics of statistics

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

	Cos	Bloom's Knowledge Level
CO 1	Understand the concept of SQC, probability and distributions	K2
CO 2	Apply and analyse control chart for variables	K3
CO 3	Apply and analyse control chart for attributes	K3
CO 4	Apply and analyse acceptance sampling by attributes	K3
CO 5	Understand standard acceptance sampling systems	K2

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	2	2	2	2								2
CO 2	3	3	3	2								2
CO 3	3	3	3	2								2
CO 4	3	3	3	2								2

CO 5	2	2	2	2								2

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	**CIE**	**ESE**	**ESE Duration**
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions Course

Outcome 1 (CO1):

1. Give the classification of various SQC approaches
2. Differentiate discrete and continuous probability distributions

Course Outcome 2 (CO2)

1. Discuss the application of control charts for variables.
2. How can control chart patterns be interpreted?

Course Outcome 3(CO3):

1. Discuss the application of control charts for attributes.
2. How can you interpret the variation of control below LCL in attribute control charts?

Course Outcome 4 (CO4):

1. Discuss the application of AOQ and AOQL in an industry scenario.
2. How is rectifying inspection adopted?

Course Outcome 5 (CO5):

1. What are the applications of standard acceptance sampling systems?
2. How Indian standards of sampling inspection are adopted.

Model Question Paper

QP CODE: **TOTAL PAGES**

Reg No:_____ **Name :**_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

EIGHTH SEMESTER B.TECH DEGREE EXAMINATION,(MONTH & YEAR)

Course Code: MRT 454

Course Name: STATISTICAL QUALITY CONTROL

Time: 3 Hours **Max: 100 Marks**

Part A

(Answer all questions. Each question carries three marks.)

1. Define the terms quality and quality control.
2. Differentiate between population and sample with examples.
3. Define process capability.
4. Differentiate between control limits and specification limits.
5. Differentiate between attributes and variables with examples.
6. What are cumulative sum charts?
7. Why sampling is preferred in place of 100% inspection?
8. Give any two criteria for sample selection.
9. What are standard acceptance sampling systems?
10. How sampling is adopted in continuous production?

Part B

(Answer one full question from each module, each question carries 14 marks)

Module - 1

11a. Differentiate between discrete and continuous probability distributions with examples.

OR

11b. Describe in detail the seven QC tools with example of their application areas.

Module - 2

12 a. Discuss in detail the procedure for the construction of control chart for variables with the help of examples.

OR

12 b. What are control chart patterns? Describe the interpretation of control chart patterns and the conclusions on the process based on patterns.

Module - 3

13 a. Discuss in detail the procedure for the construction of control chart for defectives – P Chart with the help of examples.

OR

13b. Discuss in detail the procedure for the construction of control chart for defects – C Chart with the help of examples.

Module -4

14 a. Discuss the operating characteristic curve in acceptance sampling. Explain the terms AQL, LTPD, producers risk and consumer's risk.

OR

14b. Differentiate between double sampling and multiple sampling with examples.

Module - 5

15a. Discuss the application of standard acceptance sampling systems MIL STD with examples.

OR

15b. Discuss the salient features of Indian standards of acceptance sampling.

Syllabus

Module 1 - (7 Hours)

Quality and statistical concepts for quality control: – Population and sample - Probability – Discrete and continuous probability distributions – probability approximations – seven QC tools

Module 2- (7 Hours)

Statistical process control for variables: – process capability analysis - Control charts for variables – X and R charts for process control - Control procedure and interpretation – Control limits and specification limits – monitoring – relationships – control chart patterns and interpretation

Module 3- (7 Hours)

Statistical process control for attributes: - Control charts for attributes and individual measurements – control charts for non-conforming rejections p-chart, np chart– control chart for non-conformities – c chart - multiple units – moving average charts – cumulative sum charts

Module 4- (7 Hours)

Acceptance sampling by attributes – economics of sampling - selection of samples – operating characteristic curve – AOQ, AOQL - single sampling – double sampling – multiple sampling – Rectifying inspection

Module 5- (7 Hours)

Standard acceptance sampling systems – MIL – STD for attributes and variables – Dodge roming sampling plans – Indian standard – acceptance sampling for continuous production

Reference Books

1. K. Krishnaiah, Applied statistical quality control and improvement , PHI Learning P Ltd, 2014
2. Eugene L Grant, Richard S Leavenworth, Statistical Quality Control, Tata McGraw- Hill edition
3. James R. Evans, William M. Lindsay, The management and control of quality, Thomson South-western

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
	Module 1 – 7 hours	
1.1	Quality and statistical concepts	1
1.2	Concepts of Quality Control	1
1.3	Population and sample	1
1.4	Probability	1
1.5	Discrete and continuous probability distributions	1
1.6	Probability approximations	1
1.7	Seven QC tools	1
	Module 2 – 7 hours	
2.1	Statistical process Control for variables - Introduction	1
2.2	Process capability analysis	1
2.3	Control charts for variables - X and R charts for process control	1
2.4	Control procedure and interpretation	1
2.5	Control limits and specification limits – monitoring – relationships	1
2.6	Control chart patterns and interpretation	2
	Module 3 – 7 hours	
3.1	Statistical process Control for attributes: Introduction	1
3.2	Control charts for attributes and individual measurements	1
3.3	Control charts for non-conforming rejections p-chart, np chart	1
3.4	Control chart for non-conformities – c chart	2
3.5	Moving average charts – cumulative sum charts	2
	Module 4 – 7 hours	
4.1	Acceptance sampling by attributes - Introduction	1
4.2	Economics of sampling - selection of samples	1

4.3	Operating characteristic curve – AOQ, AOQL	1
4.4	Single sampling – double sampling	2
4.5	Multiple sampling – Rectifying inspection	2
	Module 5 – 7 hours	
5.1	Standard acceptance sampling systems - Introduction	1
5.2	MIL – STD for attributes and variables	1
5.3	Dodge roming sampling plans	1
5.4	Indian standard for sampling inspection procedures	2
5.5	Acceptance sampling for continuous production	2

MRT464	HYBRID AND ELECTRIC VEHICLES	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: This course aims the students to learn about the introduction of vehicle dynamics and basic concept of Electric vehicles, hybrid vehicles, selection and control.

Prerequisite: NIL

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

CO 1	Choose a suitable drive scheme for developing an electric hybrid vehicle depending on resources, and to design and develop basic schemes of electric vehicles
CO 2	Design and develop basic schemes of hybrid electric vehicles
CO 3	Choose proper energy storage systems for vehicle applications
CO 4	Choose design of various components for vehicle applications
CO 5	Identify various communication protocols and technologies used in vehicle networks.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	1						3	2				
CO 2	2				3							3
CO 3		3			3							3
CO 4	1				2		3					
CO 5	2									1		2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Brief various social and environmental importance of hybrid and electric vehicles.

2. Explain gradeability.

3. Explain different hybrid drive train topologies?

Course Outcome 2 (CO2)

1. Explain different electric drive train topologies?

2. List the components of electric and hybrid vehicles.

3. explain different types of choppers used in EVS.

Course Outcome 3(CO3):

1. Explain fuel cell?

2. Compare fuel cell and super capacitors?

3. Define Peukart's coefficient.

Course Outcome 4 (CO4):

1. What are the factors on which the sizing of electric motors for electric vehicle depends?

2. What are the steps in designing power electronics for hybrid Electric vehicle?

3. Describe the factors in selection of energy storage systems?

Course Outcome 5 (CO5):

1. What are the advantages of fuzzy logic-based energy management control strategy in hybrid vehicles?

2. With the help of block diagram, explain the battery management supporting system of hybrid vehicle

3. With the help of block diagram, explain the hierarchical power and data transmission networks of hybrid vehicles.

Model Question paper

QP CODE:

Reg. No:----------

Name: ----------

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIRST SEMESTER B.TECH

DEGREE EXAMINATION, MONTH & YEAR

Course code: MRT464 **Duration: 3hours**

HYBRID AND ELECTRIC VEHICLES

(2019- Scheme)

Mechatronics Branch

PART A

(Answer all the questions, each question carries 3 marks)

1. Compare the performance of ICE based conventional vehicles and electric vehicles.
2. What is meant by "gradeability" of vehicles? Explain with mathematical expression.
3. Brief different motors in electric traction?
4. Explain fuel efficiency?
5. Explain the working of fuel cell and also state its limitations.
6. How is it possible to use fly wheel as an energy storage device for electric vehicle?
7. List various components of CAN?
8. Explain the concept of matching of electric machine and ICE engines?
9. What are the supporting subsystems in an electric/hybrid vehicle?
10. What are the advantages of fuzzy logic-based energy management control strategy in hybrid vehicles?

PART B

*(Answer **one** full question from each module .each question carries 14 marks)*

Module 1

11.(a)	Draw and explain architecture and power flow control of series parallel hybrid electric vehicle.	(10 marks)
(b)	What are the resistive forces acting on a four-wheel vehicle?	(4 marks)
12.	Explain the power flow control modes for a hybrid vehicle	(14 marks)

Module 2

13.(a)	How the electric motors used in EVs differs from that of used in industrial application?	(7 marks)
(b)	Classify the electric motors drives for EV and HEV application.	(7 marks)
14.	With the help of neat diagrams explain the four-quadrant chopper-based speed control of DC motors.	(14 marks)

Module 3

15.(a)	What is Peukart's capacity of battery? What are the significance applications? Calculate the Peukart's capacity of a 135Ahr battery with C10 (10Ahr) rating. (Peukart's coefficient is 1.2)	(10 marks)

(b)	Compare different batteries based on their specific energy, specific power and suitability for EV/HEV applications.	(4 marks)
16.(a)	Explain the operation, advantage and disadvantages of fly wheel energy storage	(7 marks)
(b)	Explain the working of fuel cell and also state its limitation	(7 marks)

Module 4

17.(a)	What are the factors on which the sizing of electric motors for electric vehicles depend?	(10 marks)
(b)	What are the steps in designing power electronics for hybrid Electric vehicles?	(4 marks)
18.	Discuss the possible power converter topologies that can be used in induction motor drive for EV/HEV.	(14 marks)

Module 5

19.(a)	With the help of a neat figure, explain the epicyclic gear transmission system used in electric vehicles.	(10 marks)
(b)	Draw the typical torque - speed envelope curves of drive train motors and show the continuous, intermittent and peak overload ratings.	(4 marks)
20.(a)	With the help of block diagram, explain the hierarchical power and data transmission networks of hybrid vehicles.	(10 marks)
(b)	State and explain the optimal control problem associated with hybrid vehicle.	(4 marks)

Syllabus

Module 1

Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies.

Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance.

Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.

Module 2

Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis.

Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives.

Module 3

Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Hybridization of different energy storage devices.

Module 4

Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power Electronics, selecting the energy storage technology, Communications, supporting subsystems: In vehicle networks- CAN.

Module 5

Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies.

Text Books

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.

2. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press , 2004.

Reference Books

1. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.

2. Chris Mi, M. Abul Masrur, David Wenzhong Gao, Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, John Wiley & Sons Ltd. , 2011.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Introduction to Hybrid Electric Vehicles:**	
1.1	History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies.	3
1.2	**Conventional Vehicles:** Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance.	3
1.3	**Hybrid Electric Drive-trains**: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.	3
2	**Electric Drive-trains**:	
2.1	Basic concept of electric traction, introduction to various electric drive-train topologies	3
2.2	Power flow control in electric drive-train topologies, fuel efficiency analysis.	2
2.3	**Electric Propulsion unit:** Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives	3
3	**Energy Storage**:	
3.1	Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis	3
3.2	Fuel Cell based energy storage and its analysis,	1
3.3	Hybridization of different energy storage devices	2
4	**Sizing the drive system:**	
4.1	Matching the electric machine and the internal combustion engine (ICE),	1
4.2	Sizing the propulsion motor, sizing the power Electronics, selecting the energy storage technology,	3
4.3	Communications, supporting subsystems: In vehicle networks- CAN	2
5	**Energy Management Strategies:**	
5.1	Introduction to energy management strategies used in hybrid and electric vehicles	2
5.2	classification of different energy management strategies	2
5.3	Comparison of different energy management strategies.	2

MRT 474	OPERATIONS MANAGEMENT	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: The objectives of this course are to impart the ability to analyse the manufacturing operations of a firm, understand the importance of various factors of production, learn methods and techniques to effectively manage inventory of an organisation, learn how to schedule and sequence activities to improve organizational operations and to understand the methods to manage supply chain of materials and information in an organisation to make decisions in dynamic environment.

Prerequisite:

The students should be able to understand the random behaviour of systems and the results of random nature. Knowledge of normal distribution and use of standard tables should be known to the students.

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

CO 1	Demonstrate various methods of demand forecasting and apply these techniques to example problems
CO 2	Demonstrate basic inventory models with selective inventory control
CO 3	Define aggregate planning and solve problems related to different strategies.
CO 4	Construct computerized location planning and the comparison of different layouts.
CO 5	Construct appropriate job shop production activity planning and understand BPR and ERP.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3										
CO 2	3	3										
CO 3	3	3										
CO 4	2		3		3		2					
CO 5	3		2									

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Discuss different forecasting models with their suitability with respect to the type of product.
2. Compare the methods of moving average and exponentially smoothed forecasting methods.
3. Demonstrate how a forecasting method is suitable to a data based on forecast errors.

Course Outcome 2 (CO2)

1. Discuss the assumptions based on which the basic inventory model is developed.
2. What are the probabilistic inventory models? How do periodic and continuous inventory systems address the variability?

3.Discuss different service level measures in inventory systems.

Course Outcome 3(CO3):

1. Explain the use of exchange curves with regard to inventory systems.
2. Explain different aggregate planning strategies.
3. Write notes on master production schedules and use of BoM.

Course Outcome 4 (CO4):

1. Discuss the role of subjective and objective factors in site selection for a facility.
2. Explain different plant layouts and compare them.
3. Write notes on different computer assisted layout planning programs.

Course Outcome 5 (CO5):

1. Demonstrate the scheduling activities in a job shop.
2. Show how the different dispatch rules provide different sequences to a problem.
3. Demonstrate the working of Kanban.

Model Question paper

QP CODE: **TOTAL PAGES**

Reg No:_____ **Name :**_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

EIGHTH SEMESTER B.TECH DEGREE EXAMINATION,(MONTH & YEAR)

Course Code: MRT 474

Course Name: Operations Management

Max. Marks: 100 **Duration: 3 Hours**

PART A

Answer all Questions. Each question carries 3 Marks

1) Illustrate the effect of trend, seasonality and cyclic nature in the demand pattern of a commodity
2) Write down the equation to represent the Winter's model of forecasting and explain the terms in it.
3) How are safety stocks calculated? Provide an example.
4) What is meant by selective inventory control? Discuss the applications.
5) Name and explain any two safety stock policies.
6) Explain disaggregation method used in BoM.
7) Compare fixed position layout and process layout.
8) Why is line balancing considered important in a plant? How is it achieved?
9) Discuss briefly the transition from MRP to MRP-II
10) Explain any two priority dispatch rules.

PART B

Answer any one full question from each module. Each full question carries 14 Marks

Module 1

11) (a) List and explain the different forecast errors. Discuss the significance and use of each of them. (4)

(b) The demand for an item for the last twelve months are as follows.

Month	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Demand	450	440	460	510	520	495	475	560	510	520	540	550

Determine the three months moving average forecast and weighted moving average with weights 0.25, 0.25, and 0.50, respectively. How do the forecasts by these methods differ?

(10)

12) (a) Explain how the exponentially smoothed forecasts include the oldest information in it as compared to a moving average forecast method. (4)

(b) Explain the complete Winter's model. Discuss each term in the equation. (10)

Module 2

13) (a) List all the assumptions on which the basic inventory model is developed. (4)

(b) An inventory system has setup costs Rs. 500/- and the holding costs are equivalent to 40% of the unit cost. The annual demand for the item is 10000 units. Calculate the economic order quantity with unit cost of the item Rs. 10/-. (10)

14) (a) Differentiate P-system and Q-system in inventory control. How are the controls different in these systems? (4)

(b) Five items in an inventory system has the following details.

Item	1	2	3	4	5
Annual demand	5,000	1,000	10,000	5,000	1,500
Cost (Rs.)	2	2	8	1	2

Classify the items using the ABC system. (10)

Module 3

15) (a) What impacts does stock out situations have in an inventory system? (4)

(b) Two inventory items have the following data.

Item	Annual usage	Cost per setup	Value per unit
A	10,000	125	10
B	5,000	187	15

What carrying cost percentage makes the order quantities Q_A=1586 and Q_B=1122 optimal? (10)

16) (a) Discuss a master production schedule taking an example of a product with two different sub assemblies, each having three different components used twice, and four individual items one each and three individual items two each. (4)

(b) Prepare the product structure tree for a standard bicycle. (10)

Module 4

17) (a) Discuss the preparation and use of REL diagrams. (4)

(b) Five different alternate locations are available for starting a new production facility. Discuss how the weighted score method can be used to evaluate the suitability of the sites. How do weights and scores are assigned? (10)

18) (a) Write notes on any four important subjective factors in site selection. (4)

(b) Write notes on any two systematic layout planning software packages. Name and explain the steps in SLP. (10)

Module 5

19) (a) Discuss shop loading with a suitable example. (4)

(b) Discuss the dispatch policies: critical ratio, shortest processing time, slack per remaining operations, and first come first served and compare them on their performance. (10)

20) (a) Differentiate pull and push manufacturing systems. (4)

(b) Explain the working of Kanban system with the help of an example. (10)

Syllabus

Module 1

Demand forecasting: methods-causal and time series models, moving average, exponential smoothing methods. Trend, cycle and seasonality components, Winter's complete model. Analysis of forecast error, comparison of forecasting methods based on errors.

Module 2

Basic inventory models: assumptions and performance measures. Inventory systems under risk, service levels, safety stock, joint determination of Q and R, time varying demands – Selective Inventory Control.

Module 3

Aggregate inventory management: Exchange curves, stock out situations, safety stock policies, distribution inventory systems. Aggregate planning: definition, value of decision rules, aggregate planning strategies, methods – Master production schedule - bill of material, structuring BOM, disaggregation techniques, managing and maintenance of MPS.

Module 4

Location Planning factors - Factor rating and centre of gravity methods. Plant layout: Types of layouts, Comparison of layouts, Systematic Layout Planning (SLP), Design procedures and methods, Software packages for SLP. Models for assembly line balancing. Capacity planning and control, controlling continuous production, batch processing technique.

Module 5

Job Shop production activity planning, scheduling, shop loading, sequencing, priority rules for dispatching jobs.

Advances in production systems: Introduction to Business Process Re-engineering, Enterprise Resource Planning, ERP II, Toyota Production System, World Class Manufacturing Concepts, Kanban - Push Vs Pull systems, Just-in time systems.

Reference Books & Text Books

1. Buffa S., Modern Production /Operations Management ,8/e, John Wiley & Sons, 1987.
2. Gaither N. and G. Frazier, Operations Management, Thomson learning, 2002.
3. Heizer J. and B. Render, Operations Management, 11/e, Pearson Education, 2013.
4. Hopp W. J. and M. L. Spearman, Factory Physics: Foundations of Manufacturing Management, 3/e, McGraw Hill, 2008.
5. Krajewski L. J. and L. P. Ritzman, Operations Management: Strategy and Analysis, Pearson Education, 2002.
6. Mahadevan B., Operations Management, Pearson Education, 2010.
7. Narasimhan S. L., D. W. McLeavy, and P. J. Billington, Production Planning and inventory Control, 2/e, Prentice Hall, 1995.
8. Panneerselvam R., Production and Operations Management, 2/e, Prentice Hall, 2005.

9. Riggs J. L., Production Systems: Planning, Analysis and Control, John Wiley & Sons, 1976.

10. Samson D. and P. J. Singh, Operations Management: An Integrated Approach, Cambridge University Press, 2010.

11. Silver E. A., D. F. Pyke and R. Peterson, Inventory Management and Production Planning and Scheduling, 3/e, John Wiley & Sons, 1998.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	Demand forecasting (7 hours)	
1.1	Forecasting methods-causal and time series models, moving average, exponential smoothing methods.	3 hours
1.2	Trend, cycle and seasonality components, Winter's complete model.	2 hours
1.3	Analysis of forecast error, comparison of forecasting methods based on errors.	2 hours
2	Basic inventory models (7 hours)	
2.1	Basic inventory system assumptions and performance measures	2 hours
2.2	Inventory systems under risk, service levels, safety stock	2 hours
2.3	Joint determination of Q and R	2 hours
2.4	Time varying demands – Selective Inventory Control.	1 hour
3	Aggregate inventory management (7 hours)	
3.1	Exchange curves, stock out situations, safety stock policies	2 hours
3.2	Distribution inventory systems	1 hour
3.3	Aggregate planning: definition, value of decision rules, aggregate planning strategies, methods	2 hours
3.4	Master production schedule - bill of material, structuring BOM, disaggregation techniques, managing and maintenance of MPS	2 hours
4	Location Planning (7 hours)	

4.1	Factors influencing location planning -Factor rating and centre of gravity methods.	2 hours
4.2	Plant layout: Types of layouts, Comparison of layouts,	2 hours
4.3	Systematic Layout Planning (SLP), Design procedures and methods, Software packages for SLP.	1 hours
4.4	Models for assembly line balancing. Capacity planning and control	1 hours
4.5	Controlling continuous production, batch processing technique	1 hour
5	Job shop Scheduling & Modern Production Systems (7 hours)	
5.1	Activity planning, scheduling, shop loading, sequencing,	2 hours
5.2	Priority rules for dispatching jobs.	1 hours
5.3	Introduction to Business Process Re-engineering, Enterprise Resource Planning, ERP II, Toyota Production System	2 hours
5.4	World Class Manufacturing Concepts, Kanban - Push Vs Pull systems, Just-in-time systems.	2 hours

CODE	COURSE NAME	CATEGORY	L	T	P	Credits
MRT416	ADVANCED MICROPROCESSOR AND MICROCONTROLLER	PEC	2	1	0	3

Preamble:

The objectives of the course are:

- To study the Architecture of microprocessor 8086 & PIC microcontroller
- To study the addressing modes & instruction set of 8086 & PIC microcontroller.
- To introduce the need & use of Interrupt structure 8086 & PIC microcontroller.

Prerequisite: Microprocessor & embedded system

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

CO 1	Explain the architecture of 8086 microprocessor
CO 2	Develop assembly language programs for 8086 microprocessors
CO 3	Understand the interfacing of various ICs with 8086
CO 4	Explain the architecture of PIC microcontroller
CO5	Develop embedded C program for PIC microcontroller

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	2									3
CO 2	3	2	2									3
CO 3	3	2	2									3
CO 4	3	2	2		3							3
CO5	3	2	2		3							3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	10	10	20
Understand (K2)	20	20	30
Apply (K3)	10	10	30
Analyse (K4)	10	10	20
Evaluate (K5)			
Create (K6)			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance	: 10 marks
Continuous Assessment Test (2 numbers)	: 25 marks
Assignment/Quiz/Course project	: 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum 2 subdivisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. With a neat sketch explain the architecture of 8086 microprocessor.
2. Illustrate in detail about the maximum mode of 8086 microprocessor.

Course Outcome 2 (CO2)

1. Describe about addressing modes of 8086 with examples.
2. Develop an assembly program for BCD addition.

Course Outcome 3 (CO3):

1. How can we interface 8259 with 8086?
2. Explain in detail about the data transfer modes of 8255.

Course Outcome 4 (CO4):

1. Explain the architecture of PIC microcontroller with neat sketches.
2. Discuss briefly about interrupts of PIC microcontroller.

Course Outcome 5 (CO5):

1. Develop an embedded c program for interfacing LCD with PIC microcontroller.
2. Develop an embedded c program for interfacing ADC with PIC microcontroller.

Model Question paper

QP CODE:

PAGES: 3

Reg. No:_____

Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY EIGHTH SEMESTER

B.TECH DEGREE EXAMINATION,

MONTH & YEAR

Course Code: MRT416

Course Name: ADVANCED MICROPROCESSOR AND MICROCONTROLLER

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all questions. Each question carries 3 Marks

1. Discuss about the pin configuration of 8086.
2. Explain briefly about the DMA mechanism.
3. Write a short note on logical instructions of 8086.
4. Develop a program to sort N numbers in ascending order.
5. How can we interface 8237 DMA controller with 8086.
6. Discuss briefly about Mode 0 and Mode 1 of 8255.
7. Explain about status registers in PIC microcontroller.
8. Discuss briefly about the program memory of PIC microcontroller.
9. List out the instruction set of PIC microcontroller.
10. Explain briefly about the timers in PIC microcontroller.

PART B (14 x 5 = 70 Marks)

Answer any one full question from each module. Each question carries 14 marks

Module 1

11. a. With a neat sketch explain the architecture of 8086 microprocessor. 10

    b. Write a short note on flag register of 8086 microprocessor. 4

12. a. Explain in detail about the maximum mode configuration of 8086. 7

    b. Write a short note about the interrupts in 8086. 7

Module 2

13.	a.	Explain in detail about the addressing modes of 8086.	7
	b.	Develop an assembly program to sort N numbers in ascending order.	7
14.	a.	Explain with example about Processor control and transfer control instructions.	7
	b.	Develop an assembly program to find the largest number in an array.	7

Module 3

15.	a.	With a neat sketch explain the architecture of 8255 PPI.	8
	b.	Interpret in detail about the 8237 DMA controller.	6
16.	a.	Explain about how 8259 interface with 8086.	7
	b.	Illustrate in detail about the Programmable communication Interface 8251.	7

Module 4

17.	a.	With a neat sketch explain the architecture of PIC microcontroller.	8
	b.	Write a short note about the salient features of PIC microcontroller.	6
18.	a.	Interpret in detail about the memory organization of PIC microcontroller.	8
	b.	Give a brief description about the timer modules of PIC microcontroller.	6

Module 5

19.	a.	Elucidate in detail about the addressing modes of PIC microcontroller.	8
	b.	Develop an embedded c program for interfacing LCD with PIC microcontroller.	6
20.	a.	Develop an embedded c program for interfacing 4x4 matrix keyboard with PIC microcontroller.	8
	b.	Develop an embedded c program for serial communication in PIC microcontroller.	6

Syllabus

Module 1 – Architecture of 8086

Architecture of Intel 8086 processor, Pin description 8086 configurations: Minimum mode and Maximum mode, Timing diagrams, Interrupts: Interrupt mechanism Types and priority Interrupt vector table, DMA.

Module 2 – Programming 8086

8086 Addressing modes, Instruction set- Data transfer Instructions String Instructions Logical Instructions, Arithmetic Instructions, transfer control Instructions, Processor control instructions, Arithmetic operations, Code conversion.

Module 3 – 8086 Interface

Programmable Peripheral interface (8255) –Mode 0,1,2 operations-Interval timer application 8253-programmable interrupt controller 8259-Programmable communication Interface (8251)-DMA Controller 8237.

Module 4 – Introduction to PIC microcontroller

Introduction, salient features, Architecture, Registers, Memory organization-Program memory, data memory, timer modules, interrupts.

Module 5 – Programming PIC Microcontroller

Addressing mode, Instruction set, Embedded C program to interface LED, LCD and 4x4 matrix keyboard, Program to signal generation using timers, Program for serial communication and ADC.

Text Books

1. A.K. Roy, K.M. Bhurchandi, *Advanced Microprocessors and Peripherals* McGraw- Hill International
2. Douglas V Hall, *Microprocessors And Interfacing Programming and Hardware* Tata McGraw-Hill
3. Danny Causey, Muhammad Ali Mazidi, Rolin McKinlay PIC Microcontroller and Embedded Systems: Using Assembly and C for PIC18, · MicroDigitalEd, 2016

Reference Books

1. N.Senthil Kumar, M.Saravanan, S.Jeevananthan, „Microprocessors and Microcontrollers", Oxford, 2013.
2. Tim Wilmshurst , Designing Embedded Systems with PIC Microcontrollers, Elsevier Science,2006.

Course Plan

No	Topic	No. of Lectures
1	**Module 1**	
1.1	Architecture of Intel 8086 processor Pin description 8086 configurations	2
1.2	Minimum mode and Maximum mode, Timing diagrams	3
1.3	Interrupts: Interrupt mechanism Types and priority Interrupt vector table, DMA	2
2	**Module 2**	
2.1	8086 Addressing modes,	2
2.2	Instruction set- Data transfer Instructions String Instructions Logical Instructions, Arithmetic Instructions	3
2.3	Transfer control Instructions, Processor control instructions, Arithmetic operations, Code conversion.	2
3	**Module 3**	
3.1	Programmable Peripheral interface (8255) –Mode 0,1,2 operations-	2
3.2	Interval timer application 8253-programmable interrupt controller 8259-	2
3.3	Programmable communication Interface (8251)-DMA Controller 8237.	3
4	**Module 4**	
4.1	Introduction, salient features, Architecture	3
4.2	Registers, Memory organization-Program memory	2
4.3	Data memory, timer modules, interrupt	2
5	**Module 5**	
5.1	Addressing mode, Instruction set	2
5.2	Embedded C program to interface LED, LCD and 4x4 matrix keyboard	2
5.3	Program to signal generation using timers, Program for serial communication and ADC.	3

MRT 426	NANOELECTRONICS	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: This course aims to understand the physics behind mesoscopic systems and working of nanoelectronics devices.

Prerequisite: PHT100 Engineering Physics A, ECT201 Solid State Devices

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

CO 1	Explain quantum mechanical effects associated with low dimensional semiconductors
CO 2	Explain different processes involved in the fabrication of nanoparticles and nanolayers
CO 3	Explain different techniques for characterizing nano layers and particles
CO 4	Explain the different transport mechanisms in nano structures
CO 5	Illustrate the operating principle of nanoscale electronic devices like SET, Resonant tunnelling devices, Quantum lasers etc.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2											
CO2	2											
CO3	1											
CO4	2											

CO5	2											

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	20
Understand	35	35	70
Apply	5	5	10
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	**CIE**	**ESE**	**ESE Duration**
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum of two sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1): Explain the quantum mechanical effects associated with low dimensional semiconductors.

1. Derive the expression for density of states in a 1D nanomaterial.
2. Compare and contrast triangular, square and parabolic quantum wells.
3. Solve numerical problems to find whether the given material is a nanometric one.

Course Outcome 2 (CO2) : Explain different processes involved in the fabrication of nanoparticles and nanolayers.

1. Explain Sol-Gel process for synthesis of nanoparticles.
2. Explain the different steps involved in CVD process for fabricating nanolayers.
3. DC sputtering cannot be used for the coating of non- conducting materials. Justify.

Course Outcome 3 (CO3): Explain different techniques for characterizing nano layers and particles.

1. Illustrate the working principle of an AFM.
2. Explain the different emission and interactions between electron beam and the specimen.
3. Explain the principle of operation of an XRD.

Course Outcome 4 (CO4): Explain different transport mechanisms in nano structures.

1. Explain Kronig Penney model of a super lattice.
2. Explain modulation doping with an example.
3. Explain the different scattering events encountered by a carrier during parallel transport under the influence of an electric field.

Course Outcome 5 (CO5): Illustrate the operating principle of nanoscale electronic devices like SET, Resonant tunnelling devices, Quantum lasers etc.

1. Explain Coulomb blockade effect. Illustrate the working of a single electron transistor.
2. Draw the schematic representation of the conduction band of a resonant tunnel diode for (a) no voltage applied (b) increasing applied voltages. Explain its I-V characteristics.
3. MODFETS are high electron mobility transistors. Justify.

Syllabus

Module I

Introduction to nanotechnology, Limitations of conventional microelectronics, characteristic lengths in mesoscopic systems, Quantum mechanical coherence.

Low dimensional structures - Quantum wells, wires and dots, Density of states of 1D and 2D nanostructures.

Basic properties of square quantum wells of finite depth, parabolic and triangular quantum wells

Module II

Introduction to methods of fabrication of nano-layers: physical vapour deposition- evaporation & Sputtering, Chemical vapour deposition, Molecular Beam Epitaxy, Ion Implantation, Formation of Silicon Dioxide- dry and wet oxidation methods.

Fabrication of nano particle- grinding with iron balls, laser ablation, reduction methods, sol gel, self assembly, precipitation of quantum dots.

Module III

Introduction to characterization of nanostructures: Principle of operation of Scanning Tunnelling Microscope, Atomic Force Microscope, Scanning Electron microscope - specimen interaction, X-Ray Diffraction analysis

Module IV

Quantum wells, multiple quantum wells, Modulation doped quantum wells, concept of super lattices Kronig - Penney model of super lattice.

Transport of charge in Nanostructures - Electron scattering mechanisms, Hot electrons, Resonant tunnelling transport, Coulomb blockade, Effect of magnetic field on a crystal. Aharonov-Bohm effect, the Shubnikov-de Hass effect.

Module V

Nanoelectonic devices - MODFETS, Single Electron Transistor, CNT transistors – Properties of graphene.

Resonant tunnel effect, RTD, RTT, Hot electron transistors
Quantum well laser, quantum dot LED, quantum dot laser

Text Books

1. J.M. Martinez-Duart, R.J. Martin Palma, F. Agulle Rueda Nanotechnology for Microelectronics and optoelectronics , Elsevier, 2006
2. W.R. Fahrner, Nanotechnology and Nanoelctronics, Springer, 2005

Reference Books

1. Chattopadhyay, Banerjee, Introduction to Nanoscience & Technology, PHI 2012
2. Poole, Introduction to Nanotechnology, John Wiley 2006.
3. George W. Hanson, Fundamentals of Nanoelectronics, Pearson Education, 2009.
4. K. Goser, P. Glosekotter, J. Dienstuhl, Nanoelectronics and nanosystems, Springer 2004.
5. Supriyo Dutta, Quantum Transport- Atom to transistor, Cambridge, 2013.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**MODULE 1**	
1.1	Introduction to nanotechnology, Limitations of conventional microelectronics	1
1.2	Characteristic lengths in mesoscopic systems	1
1.3	Quantum mechanical coherence, Schrodinger's equation, Low dimensional structures - Quantum wells, wires and dots	1
1.4	Density of states of 1D and 2D nanostructures	2
1.5	Basic properties of square quantum wells of finite depth, parabolic and triangular quantum wells	2
2	**MODULE 2**	
2.1	Introduction to methods of fabrication of nano-layers: physical vapour deposition- evaporation & Sputtering,	2
2.2	Chemical vapour deposition, Molecular Beam Epitaxy	2
2.3	Ion Implantation, Formation of Silicon Dioxide- dry and wet oxidation methods	2
2.4	Fabrication of nano particle- grinding with iron balls, laser ablation, reduction methods	1
2.5	Sol - Gel, self assembly, precipitation of quantum dots.	2
3	**MODULE 3**	

3.1	Introduction to characterization of nanostructures: Principle of operation	2
	of Scanning Tunnelling Microscope	
3.2	Atomic Force Microscope	1
3.3	Scanning Electron microscope - specimen interaction.	1
3.4	X-Ray Diffraction analysis	1
4	**MODULE 4**	
4.1	Quantum wells, multiple quantum wells, Modulation doped quantum wells, concept of super lattices	2
4.2	Kronig - Penney model of super lattice.	1
4.3	Transport of charge in Nanostructures - Electron scattering mechanisms, Hot electrons	1
4.4	Resonant tunnelling transport, Coulomb blockade	1
4.5	Quantum transport in nanostructures - Coulomb blockade	1
4.6	Effect of magnetic field on a crystal. Aharonov-Bohm effect	1
4.7	Shubnikov-de Hass effect	1
5	**MODULE 5**	
5.1	Nano electonic devices- MODFETS	1
5.2	Single Electron Transistor	1
5.3	CNT transistors , Properties of graphene	1
5.4	RTD, RTT, Hot electron transistors	2
5.5	Quantum well laser, quantum dot LED, quantum dot laser	2

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

MODEL QUESTION PAPER

MRT 426

NANOELECTRONICS

Time: 3 hours **Max. Marks:100**

PART A

Answer ***all*** questions. Each question carries ***3 marks***.

1. Explain any three characteristic lengths in mesoscopic systems.
2. Explain the terms (i) coherence length (ii) phase coherence.
3. Explain Laser ablation method for nanoparticle fabrication.
4. DC sputtering cannot be used for coating of non-conducting materials. Justify
5. Explain two different modes of operation of a STM.
6. Explain XRD method for characterizing nano materials.
7. Differentiate between the two types of multiple quantum wells.
8. Explain Aharonov-Bohm effect.
9. Explain why MODFETs are called high electron mobility transistors.
10. List any six properties of graphene.

PART B

Answer ***any one*** question from each module. Each question carries 14 marks.

MODULE I

11. (a) Show that DOS in a 2D material is independent of energy. (8 marks)

(b) Explain any three physical limitations in reducing the size of devices in Nano metric scale. (6 marks)

12. Compare and contrast square, parabolic and triangular quantum wells (14 marks)

MODULE II

13. (a) Illustrate the process of Molecular Beam Epitaxi for fabricating nano layers. (8 marks)

(b) Differentiate between dry oxidation and wet oxidation techniques (6 marks)

14. (a) Sketch and label a CVD reactor and explain the different steps involved in the CVD process. (8 marks)

(b) Explain the reduction method for nano particle fabrication(6 marks)

MODULE III

15. Explain the different specimen interactions of an electron beam and illustrate the working of a SEM
(14 marks)

16. Explain the principle of operation of an AFM. Explain the different modes of operation.
(14 marks)

MODULE IV

17. (a) Explain Kronig–Penney model of a super lattice. What is meant by Zone folding?
(10 marks)

18. (a)Explain the concept of hot electrons in parallel transport (4 marks)
(b)Explain Coulomb Blockade effect (8 marks)
(c)Illustrate resonant tunneling effect. (6 marks)

MODULE V

19. (a) Draw the schematic and explain the working of a single electron transistor
(8 marks)
(b)Explain working of resonant tunneling diodes
(6 marks)

20. (a) Illustrate the working of a quantum well laser
(6 marks)
(b)Explain the different types of Carbon Nanotube transistors
(8 marks)

MRT 436	NON-LINEAR SYSTEMS AND CONTROL	CATEGORY	L	T	P	CREDIT
		T	2	1	0	3

Preamble:

Nonlinear control theory is the area of control theory which deals with systems that are nonlinear, time-variant, or both. Control theory is an interdisciplinary branch of engineering and mathematics that is concerned with the behaviour of dynamical systems with inputs, and how to modify the output by changes in the input using feedback, feedforward, or signal filtering. The system to be controlled is called the "plant". One way to make the output of a system follow a desired reference signal is to compare the output of the plant to the desired output, and provide feedback to the plant to modify the output to bring it closer to the desired output.

Prerequisite: Nil

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

CO 1	Introduce the need and concept of a nonlinear system.
CO 2	Impart knowledge about different strategies adopted in the analysis of nonlinear systems.
CO 3	Design feedback control systems for nonlinear systems.
CO 4	Analyse the stability of nonlinear systems.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	**3**	2										1
CO 2	**3**	3										1
CO 3	**3**	3										1
CO 4	**3**	2										1

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern:
There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Discuss the characteristics of non-linear systems?
2. Identify and classify the equilibrium solutions of nonlinear systems.
3. Analyse the qualitative behaviour of a given system about its equilibrium points and plot a rough sketch of the phase portrait.
4. Problems to identify the type of bifurcation. (Saddle-node and Pitchfork only)

Course Outcome 2 (CO2)

1. Identify the existence of limit cycles using the Poincare Bendixson theorem.
2. Identify the non-existence of limit cycles using Bendixson's theorem.
3. Problems to check the existence and uniqueness of initial value problems.

Course Outcome 3(CO3):

1. Explain the concept of stability (local and global), instability in the sense of Lyapunov.
2. Apply Lyapunov direct/indirect methods to analyse the stability of nonlinear systems.
3. Analyse the stability using LaSalle's invariance theorem.
4. Examine whether a given system transfer function is positively real or not.
5. Explain sector nonlinearity and absolute stability.

6. Examine the stability of the sector nonlinearity using Circle criterion.
7. Explain Popov criterion for stability.

Course Outcome 4 (CO4):

1. Define feedback control problem - state feedback and output feedback.
2. Use state feedback control law for stabilizing a given system.
3. Explain the concept of input-state and input-output linearization.
4. Examine whether a given system is input-output linearizable.
5. Explain stabilization via integral control.

Model Question paper

Course Code: MRT 436

Course Name: NON LINEAR SYSTEMS AND CONTROL

Max.Marks:100 **Duration: 3 Hours**

PARTA

Answer all Questions. Each question carries 3 Marks

1. What are bifurcations?
2. What are limit cycles? Give significance and classify them based on stability
3. State the conditions for uniqueness and existence of solutions.
4. Define Poincare Index theorem
5. Check the stability of the nonlinear system using Lyapunov direct method.

   $(x\_1)^{\cdot}$ =x-2
6. What is meant by domain of attraction of a given system?
7. What are positive real transfer functions? Check whether G(s)= [s + 2] / [s + 3] i s a positive real transfer function.
8. Define absolute stability.
9. Define KYP Lemma
10. Explain memoryless systems and passivity.

PART B

Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. Model a given nonlinear system.
12. The nonlinear dynamic equation for a pendulum is given by $ml((\theta))^{\cdot} = -mgsin(\theta) - kl((\theta))^{\cdot}$ where 'l=1' is the length of the pendulum, 'm' is the mass of the bob, and θ is the angle subtended by the rod and the vertical axis through the pivot point. 'g' is the gravitational constant. Choose 'k/m=1'. Find all the equilibria of the system and determine if the equilibria are stable or not.

Module 2

13. What is saddle-node and Pitch fork bifurcation?

14. Check whether the following functions are locally Lipchitz. Give reasons for your claim.

    a. f(x,y) =2xy1/3 for (x,y) = [0,0]

    b. f(t,x) =2tx2 for (x,y) = [0,3]

Module 3

15. Construct Lyapunov functions using Variable gradient and Krasovskii's method.

16. Use variable gradient method to find a suitable Lyapunov function for the system given below

    a. $(x\_1)^{\cdot} = -2x\_1$

    b. $(x\_1)^{\cdot} = -2x\_2 + 2x\_1 \ [\![x\_2]\!]\ \text{^}2$

Module 4

17. Use the variable gradient method to find a suitable Lyapunov function for the system given below

$$(x\_1)^{\cdot} = -2x\_1 \ (x\_1)^{\cdot} = -2x\_2 + 2x\_1 \ [\![x\_2]\!]\ \text{^}2$$

18. State LaSalle's invariance principle. Show that the origin is locally asymptotically stable for the following system using LaSalle's principle.

$$(x\_1)^{\cdot} = x\_2 \ (x\_2 = -3x\_2)^{\cdot} - \ [\![x\_1]\!]\ \text{^}3$$

Module 5

19. Check whether the given system can be input-output linearized for output $y = x\_1$

$$(x\_1)^{\cdot} = x\_1$$

20. With a suitable feedback control law, linearize the following system

$$(x\_1)^{\cdot} = a \sin x\_2$$

$$(x\_2)^{\cdot} = -\ [\![x\_1]\!]\ \text{^}2 + u$$

Syllabus

Module 1 : Introduction and background (7 hours)

Non-linear system characteristics and mathematical modelling of a non-linear system, Classification of equilibrium points, Stability of a nonlinear system based on equilibrium points, Bifurcation (construction not included), Phase plane analysis of nonlinear systems.

Module 2 : Nonlinear characteristics (7 hours)

Periodic solution of nonlinear systems and existence of limit cycle, Open sets, closed sets, connected sets, Invariant set theorem, Bendixson's theorem and Poincare-Bendixson criteria, Existence and uniqueness of solutions to nonlinear differential equations (Proofs not required), Lipschitz condition.

Module 3 : Stability Analysis (7 hours)

Lyapunov stability theorems (Proofs not required)- local stability - local linearization and stability in the small- region of attraction, the direct method of Lyapunov, Construction of Lyapunov functions - Variable gradient and Krasovskii's methods, La Salles's invariance principle.

Module 4 :Analysis of feedback systems (7 hours)

Passivity and loop transformations, KYP Lemma (Proof not required), Absolute stability, Circle Criterion, Popov Criterion.

Module 5 : Nonlinear control systems design (7 hours)

Feedback linearization, Input state linearization method, Input-output linearization method ,Stabilization - regulation via integral control- gain scheduling

Text Book:

1. Khalil H. K., "Nonlinear Systems", 3/e, Pearson, 2002

2. Gibson J. E., "Nonlinear Automatic Control", Mc Graw Hill, 1963

3. Slotine J. E. and Weiping Li, "Applied Nonlinear Control", Prentice-Hall, 1991

References:

1. Alberto Isidori, "Nonlinear Control Systems: An Introduction", Springer-Verlag, 1985.

2. M. Vidyasagar, "Nonlinear Systems Analysis", Prentice-Hall, India, 1991.

3. Shankar Sastry, “Nonlinear System Analysis, Stability and Control”, Springer, 1999.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Introduction and background (7 hours)**	
1.1	Non-linear system characteristics and mathematical modelling of a non-linear system.	2
1.2	Classification of equilibrium points, Stability of a nonlinear system based on equilibrium points.	2
1.3	Bifurcation (construction not included), Phase plane analysis of nonlinear systems.	3
2	**Nonlinear characteristics (7 hours)**	
2.1	Periodic solution of nonlinear systems and existence of limit cycles	2
2.2	Open sets, closed sets, connected sets, Invariant set theorem, Bendixson's theorem and Poincare-Bendixson criteria	3
2.3	Existence and uniqueness of solutions to nonlinear differential equations (Proofs not required), Lipschitz condition.	2
3	**Stability Analysis (7 hours)**	
3.1	Lyapunov stability theorems (Proofs not required)- local stability - local linearization and stability in the small- region of attraction	2
3.2	The direct method of Lyapunov.	2
3.3	Construction of Lyapunov functions, La Salles's invariance principle	3
4	**Analysis of feedback systems (7 hours)**	
4.1	Passivity and loop transformations	2
4.2	KYP Lemma (Proof not required), Absolute stability	2
4.3	Circle Criterion ,Popov Criterion	3
5	**Nonlinear control systems design (7 hours)**	
5.1	Feedback linearization	2
5.2	Input state linearization method	2
5.3	Input-output linearization method ,Stabilization - regulation via integral control- gain scheduling	3

CODE	COURSE NAME	CATEGORY	L	T	P	Credits
MRT446	DYNAMICS OF MACHINERY	PEC	2	1	0	3

Preamble: This course mainly covers the topics namely force analysis of engines, turning moment diagrams, balancing of rotating and reciprocating machines and stability analysis of vehicles. Analysis of free and forced vibration of single degree of freedom systems are included.

Prerequisite: Engineering Mechanics

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

CO 1	Analyse forces in a four bar mechanism
CO 2	Draw turning moment diagrams for steam engines and internal combustion engines.
CO 3	Calculate the unbalanced masses in rotating and reciprocating machines
CO 4	Calculate gyroscopic couple and do stability analysis of vehicles
CO 5	Analyse free and forced vibrations of single degree of freedom systems

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	2									
CO 2	3	3	2									
CO 3	3	3	2									
CO 4	3	3	2									
CO 5	3	3	2									

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	10	10	10
Understand (K2)	20	20	20
Apply (K3)	20	20	70
Analyse (K4)			
Evaluate (K5)			
Create (K6)			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance	: 10 marks
Continuous Assessment Test (2 numbers)	: 25 marks
Assignment/Quiz/Course project	: 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum 2 subdivisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain D' Alembert's principle.
2. Determine analytically the forces such as piston effort, force in the connecting rod and side thrust on the cylinder walls of a reciprocating engine.
3. Draw the force polygon of a four bar mechanism.

Course Outcome 2 (CO2)

1. Define coefficient of fluctuation of energy.
2. Draw turning moment diagrams for single cylinder double stroke steam engine.
3. Find the centrifugal stress in a flywheel for a given tangential speed.

Course Outcome 3 (CO3):

1. Distinguish between static balancing and dynamic balancing.
2. What is single plane balancing? Explain.
3. Draw the force polygon and couple polygon when several masses rotate in different (parallel) planes.

Course Outcome 4 (CO4):

1. Derive an expression relating the stress in a flywheel and its linear speed.
2. Describe with neat sketches the effects of gyroscopic couple on pitching, rolling and steering of a ship.
3. Find an expression for the angle of heel for a two wheeler.

Course Outcome 5 (CO5):

1. Explain the energy method and Newton's method to determine the natural frequencies of a single degree of freedom system.
2. Derive an expression for the logarithmic decrement.

3. Find the forced response of a damped single degree of freedom vibrating system subjected to a harmonic excitation.

Model Question paper

QP CODE:

PAGES: 3

Reg. No:_____

Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY EIGHTH SEMESTER

B.TECH DEGREE EXAMINATION,

MONTH & YEAR

Course Code: MRT446

Course Name: DYNAMICS OF MACHINERY

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all questions. Each question carries 3 Marks

1. Explain virtual work method of force analysis of a four-bar mechanism.
2. What is meant by equivalent dynamic systems?
3. Define coefficient of fluctuation of energy and coefficient of fluctuation of speed.
4. Why flywheels are required?
5. Distinguish between static and dynamic balancing.
6. What is meant by partial balancing? List the effects of partial balancing.
7. Describe the effect of gyroscopic couple on the stability of a two-wheeler while negotiating a curve.
8. Define coefficient of fluctuation of speed and coefficient of fluctuation of energy.
9. Explain the energy method of obtaining the natural frequency of a single degree of freedom vibrating system.
10. Explain transmissibility.

PART B (14 x 5 = 70 Marks)

Answer any one full question from each module. Each question carries 14 marks

Module 1

11.	a.	A slider crank mechanism of crank radius 60 mm and connecting rod length 240 mm is acted upon by 2 kN gas force at its piston. Calculate the torque to be applied on the crank to make the mechanism in static equilibrium when the crank makes 60° with the line of stroke. Use the graphical method.	9
	b.	Distinguish between static and dynamic force analyses.	5
12.	a.	State and explain D' Alembert's principle	4
	b.	The ratio of connecting rod length to crank length of a vertical gasoline engine is 4. The engine bore and stroke are 8 cm and 10 cm respectively. The mass of the reciprocating parts is 1 kg. The gas pressure on the piston is 6 bar, when it has moved 40° from the inner dead centre during the power stroke. Determine: (i) net load on the piston (ii) net load on the gudgeon pin and the crank pin (iii). thrust on the cylinder walls (iv) thrust on the crank bearing.	10

Module 2

13.	a.	Derive an expression for the centrifugal stress in a flywheel as a function of the tangential velocity.	5
	b.	A machine is coupled to a two stroke engine which produces a torque of 800+180 sin 3θ Nm where θ is the crank angle. The mean engine speed is 400 rpm. The flywheel and the other rotating parts attached to the engine have a mass of 350 kg at a radius of gyration of 220 mm. Calculate: i) the power of the engine and ii) the total fluctuation of speed of the flywheel.	9
14.	a.	Draw the turning moment diagram for a 4 stroke diesel engine.	4
	b.	The turning moment diagram for a multi cylinder engine has been draw to a scale of 1 cm to 5000 Nm torque and 1 cm to 60° respectively. The intercepted areas between output torque curve and mean resistance line taken in order from one end are: -0.3; +4.1; -2.8; +3.2; -3.3; +2.5; -3.6; +2.8; -2.6 square cm when the engine is running at 800 rpm. The engine has a stroke of 30 cm and the fluctuation of speed is not to exceed 2% of the mean speed. Determine a suitable diameter and cross-section of the flywheel rim for a limiting value of shaft centrifugal stress of 280 x 105 N/m^2. The material density may be assumed as 7.2 g/cm^3 . Assume thickness of the rim to be ¼ of the width.	10

Module 3

15. a. Four masses 200 kg, 300 kg, 240 kg and 260 kg with radii of rotation are positioned at 20 cm, 15 cm, 25 cm and 30 cm respectively. Their corresponding angular positions with respect to mass 200 kg are 45°, 75° and 135°. Find the magnitude and position of the balancing mass required if the radius of rotation is 20 cm. 10

b. Dynamically balanced system is statically balanced, but not vice versa. Give your comments. 4

16. a. Describe the effects of partial balancing of reciprocating engines. 5

b. Four masses are attached to shaft at planes A, B, C and D at equal radii. The distance of planes B, C and D from A are 50 cm, 60 cm and 130 cm respectively. The masses at A, B and C are 60 kg, 55 kg and 80 kg respectively. If the system is in complete balance, determine the mass at D and the position of masses B, C and D with respect to A. 9

Module 4

17. a. Explain spin vector, precession vector, gyroscopic applied torque vector and gyroscopic reactive torque vector. 4

b. Explain the effects of gyroscopic couple on the stability of a four wheeler while it negotiates a curve. 10

18. a. What is the function of a flywheel? 4

b. Determine the maximum and minimum speeds of a flywheel of mass 25 kg and radius of gyration of 10 cm when the fluctuation of energy is 54.5 Nm. The mean speed of the engine is 1000 rpm. 10

Module 5

19. a. A machine of mass 1000 kg is acted upon by an external force of 2450 N at a speed of 1500 rpm. To reduce the effect, vibration isolators made of rubber having a static deflection of 2 mm under the machine load and an estimated damping factor of 0.2 are used. Determine the following: (i). Force transmitted to the foundation (ii). Amplitude of vibration of machine (iii). Phase lag between the transmitted force and the displacement of mass. 10

b. Distinguish between motion transmissibility and displacement transmissibility. 4

20. a. A damped spring mass system has mass 3 kg, stiffness 100 N/m and damping coefficient 3 Ns/m. Determine the following: (i) Damping ratio (ii). Damped natural frequency (iii) Logarithmic decrement (iv) Ratio of two successive amplitudes. 8

b. Describe briefly Newton's method and energy method used for obtaining the natural frequencies. 6

Syllabus

Module 1

Static and dynamic force analysis of mechanisms (four bar linkages only)-graphical method, virtual work method -D'Alembert's principle-equivalent dynamic systems-reciprocating engine force analysis.

Module 2

Energy Efficiency in Electricity Utilization:

Flywheels-turning moment diagrams for steam engines-four stroke internal combustion engine and multi cylinder engines-coefficient of fluctuation of speed-coefficient of fluctuation of energy-design of flywheels.

Module 3

Balancing: static balancing-dynamic balancing-balancing of several masses revolving in a single plane-several masses in different parallel planes-balancing of single cylinder reciprocating engines-partial balancing and its effects-balancing of multi cylinder inline engines.

Module 4

Gyroscopic couple-effects on the stability of automobiles-two wheeler and four wheeler, stability of ships and air crafts-Flywheels-turning moment diagrams-coefficient of fluctuation of energy, coefficient of fluctuation of speed.

Module 5

Vibration-free vibration of single degree of freedom systems-equation of motion-Newton's method-energy method-natural frequency-undamped and damped systems-logarithmic decrement-forced vibration-response of SDOF systems to harmonic excitation-whirling of shaft-vibration absorber-transmissibility.

Text Books

1. Ballaney, P. L. Theory of machines and mechanisms. Khanna Publishers, 2010.
2. Rattan S S, Theory of Machines, Tata McGraw-Hill Education, 2005.

Reference Books

1. Charles E Wilson and J Peter Sadler, Kinematics and Dynamics of Machinery, Tata McGraw-Hill Education, 2008.
2. Amithabha Ghosh and Asok Kumar Malik, Theory of Mechanisms and Machines, East West Press, 2011 3. Thomas Bevan, Theory of Machines, Pearson, 2013

Teaching Plan

No	Topic	No. of Lectures
1	**Module 1**	
1.1	Static analysis of mechanisms-graphical method-four bar mechanisms	3
1.2	Virtual work method -D'Alembert's principle-equivalent dynamic systems	3
1.3	Reciprocating engine force analysis	1
2	**Module 2**	
2.1	Flywheels, turning moment diagrams-steam engines-four stroke internal combustion engines and multi cylinder engines	3
2.2	Multi cylinder engine-coefficient of fluctuation of speed coefficient of fluctuation of energy-design of flywheels	3
3	**Module 3**	
3.1	Static and dynamic balancing- balancing of several masses in a single plane-force polygon	2
3.2	Balancing of several masses in parallel planes-couple polygon	2
3.3	Balancing of reciprocating masses-effects of partial balancing	2
3.4	Balancing of multi cylinder in-line engines	2
4	**Module 4**	
4.1	Gyroscopic couple-introduction-spin, precession and applied couple vectors	2
4.2	Effects of gyroscopic couple on the stability of two wheeler and four wheeler	1
4.3	Effects on the stability of sea vessels and air crafts	2
4.4	Flywheels-turning moment diagrams-coefficient of fluctuation of energy, coefficient of fluctuation of speed	2
5	**Module 5**	
5.1	Vibration-free vibration of single degree of freedom systems equation of motion-Newton's method-energy method-natural frequency	3
5.2	Damped systems-logarithmic decrement-forced vibration-response of SDOF systems to harmonic excitation	2
5.3	Whirling of shaft-vibration absorber- transmissibility	2

CODE	COURSE NAME	CATEGORY	L	T	P	Credits
MRT456	ERGONOMICS	PEC	2	1	0	3

Preamble: The objective of this subject is to provide first-time students from various engineering disciplines with a greater awareness of the industrial systems contexts in which Principles of Ergonomics is used. The subject provides an outline on system concepts and development of humanised systems. The subject enables students to acquaint with the application of ergonomic aspects in design processes.

Prerequisite: Nil

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

CO 1	Outline the body mechanics and principles of applied anthropometry
CO 2	Identify the human factors pertaining to static work
CO 3	Identify the various categories of work induced Stress and Fatigue
CO 4	Choose the different parameters of Vision and Hearing as applied to Workstation design
CO 5	Model the human interaction with systems

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	2	3	2									3
CO 2	3	3	2									3
CO 3	3	3	2									3
CO 4	3	3	2									
CO 5	3	3	2									

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	10	10	20
Understand (K2)	15	15	30
Apply (K3)	15	15	30
Analyse (K4)	5	5	10
Evaluate (K5)	5	5	10
Create (K6)			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance	: 10 marks
Continuous Assessment Test (2 numbers)	: 25 marks
Assignment/Quiz/Course project	: 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum 2 subdivisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Evaluate the interaction between man and machine in the case of an operator assigned to monitor manually an electrical motor used for water supply for public., Prepare a check list for integrating human factors in the system.

Course Outcome 2 (CO2)

1. What are the factors affecting physical work capacity?
2. Propose a job relaxation scheme for head load workers working in high range places?

Course Outcome 3 (CO3):

1. Develop a methodology for manual operation of a steam exhaust valve considering the discomfort due to noise caused in design perspectives.
2. What are the preventive measures to be implemented for human safety in operational aspects?

Course Outcome 4 (CO4):

1. Enumerate design considerations for visual displays.

Course Outcome 5 (CO5):

1. Discuss human factors to be considered in the design of a CAD work station.

Model Question paper

QP CODE:

PAGES: 3

Reg. No:_____

Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY EIGHTH SEMESTER

B.TECH DEGREE EXAMINATION,

MONTH & YEAR

Course Code: MRT456

Course Name: ERGONOMICS

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all questions. Each question carries 3 Marks

1 Write any six check points in general human factors engineering checklist

2 Comment on the task stress and postural stress of a dentist while in a tooth repair.

3. A man is at the age of 60 years . His heart rate, while he is carrying the suitcase, is 160 beats/min. Is this excessive?

4. A laborer is working at 45% of his VO2 max. How long will he be able to work before exhaustion?

5. Discuss what is meant by fatigue. How would an ergonomist go about investigating complaints of fatigue in manual work?

6. What is work space? How does it vary from person to person?

7. Enumerate design considerations for visual displays.

8. Describe the design considerations for VE development.

9. Discuss human factors to be considered in the design of a CAD work station.

10. What is the influence of gender in the design of assembly processes.

PART B (14 x 5 = 70 Marks)

Answer any one full question from each module. Each question carries 14 marks

Module 1

11.	Evaluate the interaction between man and machine in the case of an operator assigned to monitor manually an electrical motor used for water supply for public., Prepare a check list for integrating human factors in the system.	14
12.	Discuss on HFE considerations in manual sanitizer disposer in a pandemic time. Design an improved risk-free method for its disposal and compare HFE issues.	14

Module 2

13.	A man of 60 Kg weight is lifting a 40 Kg weighed luggage from its foot level, analyse the stresses induced in his body structure and its after effects. Compare the stresses if it were lifted by using chain pulley block.	14
14.	What are the factors affecting physical work capacity? Propose a job relaxation scheme for head load workers working in high range places.`	14

Module 3

15.a	Propose a Layout for visual display Terminal for an open office.	7
b.	Suggest steps that can eliminate direct and indirect glares from a LED monitor.	7
16.	Develop a methodology for manual operation of a steam exhaust valve considering the discomfort due to noise caused in design perspectives. What are the preventive measures to be implemented for human safety in operational aspects?	14

Module 4

17.	What are the factors to be considered in the design of the steering wheel for an automotive with human engineering aspect.	14
18.	Explain how the technological developments in automotive lightings relax an ergonomic engineer.	14

Module 5

19.	In a particular machine, the most frequently used manual device is mounted at a height of 1.5 Metres from ground. The operators in various shifts are of heights are	14

140 CMS, 152 CMS, 168 CMS, 172 CMS, 198CMS. Find a suitable solution so that the operators are comfortable.

20. Compare the level of human safety levels in a distributed controlled power station with that of a fully manually operated plant. 14

Syllabus

Module 1: Introduction to Ergonomics (9 hours)

Humanise work, Basis Body Mechanics, Anatomy of Spine and Pelvis for postures, Stability and Postural Adaptation, Musculoskeletal Disorders in Work Spaces, Behavioural Aspects of Postures, Sources of Human Variability, Principles of Applied Anthropometry, Application of Anthropometry in Design, Design for Everyone, Personal Space.

Module 2: Static Work (10 hours)

Design of Standing and Sitting, Workstation Design, Work Surface Design, Visual Display Units, Guidelines for Design of Static and Repetitive Works, Ergonomic Interventions, Handle Design, Keyboard Design, Anatomy and Biomechanics of Manual Handling, Prevention of Injuries in Manual Handling, Design of Manual Handling Task, Carrying.

Module 3: Work Induced Stress and Fatigue (8 hours)

Muscle Structure - Function and Capacity, Factors Affecting Physical Work Capacity, Applied Physiology in Work Space, Measurement of Physiological Cost of Work, Comfort and the Indoor Climate, Protection Against Extreme Climates.

Module 4: Vision and Hearing (9 hours)

Eye Vision, Measurement of Light, Lighting Design Consideration, Visual Fatigue, Eye Strain and Near Work, Indoor Lighting – Psychological Aspects, Measurement of Sound, Ear Protection, Design of Acoustic Environment, Industrial Noise Control, Design of Visual Displays, Design of Audio Displays, Design of Controls, Combining Displays and Controls, Virtual Environment.

Module 5: Human System Interaction (9 hours)

Human Error and Equipment Design, Mental Workload in Human Machine Interaction, Characteristics of Human Machine Interaction, Prevention of Human Error, Human Computer Interaction, Human Centred Design Process for Interactive Systems, Human Computer Dialogue, System Design Methods for Ergonomics, Cross Cultural Considerations.

Reference Books

1. Introduction to human factors and ergonomics, R.S Bridger CRC Press Tylor and Francis group.
2. ERGONOMICS in the Automotive Design Process Vivek D. Bhise CRC press Tylor and francis group.
3. Human factors method for improving performance in the process industries, Dennis Attwood , et.al, John wiley and sons Inc. Publications.
4. A guide to human factors and ergonomics, Martin Helander, CRC Press Tylor and Francis group.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	
1.1	Humanise work	0.5
1.2	Basis Body Mechanics	0.5
1.3	Anatomy of Spine and Pelvis for postures	0.5
1.4	Stability and Postural Adaptation	0.5
1.5	Musculoskeletal Disorders in Work Spaces	1
1.6	Behavioural Aspects of Postures	1
1.7	Sources of Human Variability	1
1.8	Principles of Applied Anthropometry, Application of Anthropometry in Design	1
1.9	Design for Everyone, Personal Space	1
2	**Module 2**	
2.1	Design of Standing and Sitting	1
2.2	Workstation Design	0.5
2.3	Work Surface Design	0.5
2.4	Visual Display Units	0.5
2.5	Guidelines for Design of Static and Repetitive Work	0.5
2.6	Ergonomic Interventions	0.5
2.7	Handle Design, Keyboard Design	0.5
2.8	Anatomy and Biomechanics of Manual Handling	1
2.9	Prevention of Injuries in Manual Handling, Design of Manual Handling Task	1
2.10	Carrying	1
3	**Module 3**	
3.1	Muscle Structure - Function and Capacity	1
3.2	Factors Affecting Physical Work Capacity	1
3.3	Applied Physiology in Work Space	2
3.4	Measurement of Physiological Cost of Work	1
3.5	Comfort and the Indoor Climate	1
3.6	Protection Against Extreme Climates	1

4	**Module 4**	
4.1	Eye Vision, Measurement of Light, Lighting Design Consideration	0.5
4.2	Visual Fatigue, Eye Strain and Near Work	0.5
4.3	Indoor Lighting – Psychological Aspect	0.5
4.4	Measurement of Sound, Ear Protection, Design of Acoustic Environment	0.5
4.5	Industrial Noise Control	1
4.6	Design of Visual Displays	1
4.7	Design of Audio Displays	1
4.8	Design of Controls, Combining Displays and Control	1
4.9	Virtual Environment	1
5	**Module 5**	
5.1	Human Error and Equipment Design	0.5
5.2	Mental Workload in Human Machine Interaction	0.5
5.3	Characteristics of Human Machine Interaction	0.5
5. 4	Prevention of Human Error	0.5
5.5	Human Computer Interaction	1
5.6	Human Centred Design Process for Interactive Systems	1
5.7	Human Computer Dialogue	1
5.8	System Design Methods for Ergonomics	1
5.9	Cross Cultural Considerations	1

CODE	COURSE NAME	CATEGORY	L	T	P	Credits
MRT466	ENERGY MANAGEMENT AND AUDITING	PEC	2	1	0	3

Preamble:

This course introduces basic knowledge about energy management and audit. Energy management opportunities in electrical and mechanical systems are discussed. Demand side management and ancillary services are explained. Economic analysis of energy conservation measures are also described.

Prerequisite: Nil

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

CO 1	Analyse the significance of energy management and auditing.
CO 2	Discuss the energy efficiency and management of electrical loads.
CO 3	Apply demand side management techniques.
CO 4	Explain the energy management opportunities in industries.
CO 5	Compute the economic feasibility of the energy conservation measures.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	2					1	1		1			
CO 2	2		1	1		1	1					
CO 3	2		1	1		1	1					
CO 4	2		1	1		1	1					
CO 5	2										2	

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	15	15	30
Understand (K2)	20	20	40
Apply (K3)	15	15	30
Analyse (K4)			
Evaluate (K5)			
Create (K6)			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance	: 10 marks
Continuous Assessment Test (2 numbers)	: 25 marks
Assignment/Quiz/Course project	: 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum 2 subdivisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Define energy management.

2. List the different phases involved in energy management planning.

3. State the need for energy audit.

Course Outcome 2 (CO2)

1. State the different methods which can be adopted to reduce energy consumption in lighting.

2. Describe how energy consumption can be reduced by energy efficient motors.

3. Discuss the maximum efficiency standards for distribution transformers.

Course Outcome 3 (CO3):

1. Discuss the different techniques of DSM.

2. Illustrate the different techniques used for peak load management.

3. Explain the different types of ancillary services.

Course Outcome 4 (CO4):

1. Define Coefficient of performance.

2. Demonstrate how waste heat recovery can be done.

3. Describe how energy consumption can be reduced by cogeneration.

Course Outcome 5 (CO5):

1. State the need for economic analysis of energy projects.

2. Define pay back period.

3. Demonstrate how life cycle costing approach can be used for comparing energy projects.

Model Question paper

QP CODE:

PAGES: 3

Reg. No:_____

Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY EIGHTH SEMESTER

B.TECH DEGREE EXAMINATION,

MONTH & YEAR

Course Code: MRT466

Course Name: ENERGY MANAGEMENT AND AUDITING

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all questions. Each question carries 3 Marks

1. Explain what you mean by power quality audit.
2. Write notes on building management systems.
3. Compare the efficacy of different light sources.
4. Write notes on design measures for increasing efficiency in transformers.
5. Discuss the benefits of demand side management.
6. Explain the benefits of power factor improvement.
7. Discuss any two opportunities for energy savings in steam distribution.
8. Explain the working of a waste heat recovery system.
9. What are the advantages and disadvantages of the payback period method?
10. Write notes on computer aided energy management systems.

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PART B (14 x 5 = 70 Marks)

Answer any one full question from each module. Each question carries 14 marks

Module 1

11. a. With the help of case studies, explain any four energy management principles. 8

	b.	Explain the different phases of energy management planning.	6
12.	a.	Explain the different steps involved in a detailed energy audit.	7
	b.	Discuss the different instruments used for energy audit.	7

Module 2

13.	a.	With the help of case studies, explain any four methods to reduce energy consumption in lighting.	8
	b.	Explain how energy efficient motors help in reducing energy consumption.	6
14.	a.	With the help of case studies, explain any four methods to reduce energy consumption in motors.	8
	b.	Define cascade efficiency of an electrical system. How it can be calculated?	6

Module 3

15.	a.	Explain the different techniques of demand side management.	6
	b.	The load on an installation is 800 kW, 0·8 lagging p.f. which works for 3000hours per annum. The tariff is Rs 100 per kVA plus 20 paise per kWh. If the power factor is improved to 0·9 lagging by means of loss-free capacitors costing Rs 60 per kVAR, calculate the annual saving effected. Allow 10% per annum for interest and depreciation on capacitors.	8
16.	a.	Discuss the importance of peak demand control. Explain the different methods used for that.	8
	b.	Explain the different types of ancillary services.	6

Module 4

17.	a.	Explain any four energy conservation opportunities in furnaces	7
	b.	Explain the working of different types of cogeneration systems.	7
18.	a.	Discuss the different energy conservation opportunities in boiler.	7
	b.	Explain any five energy saving opportunities in heating, ventilating and air conditioning systems.	7

Module 5

19. a. Calculate the energy saving and payback period which can be achieved by replacing a 11 kW, existing motor with an EEM. The capital investment required for EEM is Rs. 40,000/-. Cost of energy/kWh is Rs. 5. The loading is 70% of the rated value for both motors. Efficiency of the existing motor is 81% and that of EEM is 84.7%. 8

b. Compare internal rate of return method with present value method for the selection of energy projects. 6

20. a. Explain how the life cycle costing approach can be used for the selection of energy projects. 6

b. The cash flow of an energy saving project with a capital investment cost of Rs. 20,000/- is given in the table below. Find the NPV of the project at a discount rate of 10%. Also find the Internal Rate of Return of the project. 8

Year	Cash flow
1	7000
2	7000
3	7000
4	7000
5	7000
6	7000

Syllabus

Module 1 (7 hours)

Energy Management - General Principles and Planning:

General principles of energy management and energy management planning.

Energy Audit: Definition, need, types and methodologies. Instruments for energy audit, Energy audit report - Power quality audit.

Energy conservation in buildings: ECBC code (basic aspects), Building Management System (BMS).

Module 2 (9 hours)

Energy Efficiency in Electricity Utilization:

Electricity transmission and distribution system, cascade efficiency.

Lighting: Modern energy efficient light sources, life and efficacy comparison with older light sources, energy conservation in lighting, use of sensors and lighting automation.

Motors: Development of energy efficient motors and the present status, techniques for improving energy efficiency, necessity for load matching and selection of motors for constant and variable loads.

Transformers: Present maximum efficiency standards for power and distribution transformers, design measures for increasing efficiency in electrical system components.

Module 3 (8 hours)

Demand side Management: Introduction to DSM, Benefits of DSM, different techniques of DSM **–** time of day pricing, multi-utility power exchange model, time of day models for planning.

Load management, load priority technique, peak clipping, peak shifting, valley filling, strategic conservation, energy efficient equipment.

Power factor improvement, numerical examples.

DSM and Environment.

Ancillary services: Introduction of ancillary services – Types of Ancillary services

Module 4 (6 hours)

Energy Management in Industries and Commercial Establishments:

Boilers: working principle - blow down, energy conservation opportunities in boiler.

Steam: properties of steam, distribution losses, steam trapping. Identifying opportunities for energy savings in steam distribution.

Furnace: General fuel economy measures, energy conservation opportunities in furnaces.

HVAC system: Performance and saving opportunities in Refrigeration and Air conditioning systems.

Heat Recovery Systems:

Waste heat recovery system - Energy saving opportunities.

Cogeneration: Types and schemes, optimal operation of cogeneration plants, combined cycle electricity generation.

Module 5 (6 hours)

Energy Economics:

Economic analysis: methods, cash flow model, time value of money, evaluation of proposals, pay-back period, average rate of return method, internal rate of return method, present value method, life cycle costing approach. Computer aided Energy Management Systems (EMS).

Reference Books

1. Energy Conservation Act – 2001 and Related Rules and Standards.
2. Publications of Bureau of Energy Efficiency (BEE).
3. Albert Thumann, William J. Younger, Handbook of Energy Audits, CRC Press, 2003.
4. IEEE recommended practice for energy management in industrial and commercial facilities
5. D. Yogi Goswami, Frank Kreith, Energy Management and Conservation Handbook, CRC Press, 2007.
6. Operation of restructured power systems Kankar Bhattacharya, Jaap E. Daadler, Math H.J Bollen, Kluwer Academic Pub., 2001.
7. Wayne C. Turner, Energy management Hand Book - the Fairmount Press, Inc., 1997
8. Charles M. Gottschalk, Industrial energy conservation, John Wiley & Sons, 1996.

COURSE PLAN

No	Topic	No. of Lectures
1	**Energy Management - General Principles and Planning; Energy audit (7 hours)**	
1.1	Energy management; General principles of energy management	2
1.2	Energy management planning	1
1.3	**Energy audit:** Definition, need, types and methodologies.	2
1.4	Instruments for energy audit, Energy audit report. Power quality audit	1
1.5	ECBC code (basic aspects), Building Management System (BMS).	1
2	**Energy management in Electricity Utilization (7 hours)**	
2.1	Electricity transmission and distribution system, cascade efficiency.	1
2.2	Energy management opportunities in Lighting: Modern energy efficient light sources, life and efficacy comparison with older light sources, energy conservation in lighting, use of sensors and lighting automation.	2
2.3	Energy management opportunities in Motors: Development of energy efficient motors and the present status, techniques for improving energy efficiency, necessity for load matching and selection of motors for constant and variable loads.	2
2.4	Transformers: Present maximum efficiency standards for power and distribution transformers, design measures for increasing efficiency in electrical system components.	2
3	**Demand side Management and Ancillary service management:(8 hours)**	
3.1	Introduction to DSM, benefits of DSM, different techniques of DSM, DSM and Environment.	2

3.2	Time of day pricing, multi-utility power exchange model, time of day models for planning.	2
3.3	Load management, load priority technique, peak clipping, peak shifting, valley filling, strategic conservation, energy efficient equipment.	1
3.4	Power factor improvement, simple problems.	1
3.5	Introduction of ancillary services – Types of Ancillary services	2
4	**Energy Management in Industries and Commercial Establishments (7hours):**	
4.1	Boilers: working principle - blow down, energy conservation opportunities in boiler.	2
4.2	Steam: properties of steam, distribution losses, steam trapping. identifying opportunities for energy savings in steam distribution.	1
4.3	Furnace: General fuel economy measures, energy conservation opportunities in furnaces.	1
4.4	Performance and saving opportunities in Refrigeration and Air conditioning systems.	2
4.5	Waste heat recovery system - Energy saving opportunities. Cogeneration: types and schemes, optimal operation of cogeneration plants, combined cycle electricity generation.	1
5	**Energy Economics (6 hours)**	
5.1	Economic analysis methods	1
5.2	Cash flow model, time value of money, evaluation of proposals	1
5.3	Pay-back method, average rate of return method, internal rate of return method	2
5.4	Present value method, life cycle costing approach.	1
5.4	Computer aided Energy Management Systems (EMS).	1

MRT476	TOTAL QUALITY MANAGEMENT AND SIX SIGMA	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble

This course helps the students to understand the basic concepts of Quality, Total quality management and six sigma. Students will get exposure to various quality related problems and the solution to such problems through various problem-solving tools.

Prerequisite

Nil

Course outcomes

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

CO 1	Understand basic concepts of quality highlighting the contributions by quality gurus
CO 2	Acquire knowledge on TQM axioms and focus on customer-centric approach with team work
CO 3	Apply various tools and techniques of quality management
CO 4	Understand the various quality management systems
CO 5	Understand basic concepts and DMAIC phase of Six Sigma

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	2	1									3	2
CO 2	2	1									3	2
CO 3	3	2						2	3		3	2
CO 4	2	1					2	3	2		3	2
CO 5		3			3		2		2			2

Strong -3 Medium -2 Weak -1

Assessment pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	Test 1	Test 2	
Remember	10	10	20
Understand	20	20	20
Apply	20	20	60
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	Continuous Internal Evaluation	End Semester Examination	End Semester Examination Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course level assessment questions

Course Outcome 1 (CO1)

1. Define quality and explain different dimensions of it.
2. Describe the main contributions by quality gurus.
3. Discuss on the benefits of TQM and the obstacles to its implementation.

Course Outcome 2 (CO2)

1. Describe the axioms of TQM and Deming's contribution.
2. Elaborate on customer satisfaction.
3. Explain the importance of employee involvement, empowerment and teamwork.

Course Outcome 3 (CO3)

1. Illustrate the seven basic tools of quality.
2. Explain benchmarking process and different types of bench marking.
3. Explain Process Decision Program Chart (PDPC).

Course Outcome 4 (CO4)

1. Explain the ISO quality management system.
2. Describe the ISO 9001 requirements.
3. Discuss on quality systems for Environmental Management

Course Outcome 5 (CO5)

1. Explain the evolution of six sigma concept.
2. Explain sig sigma roles and responsibilities
3. Illustrate DMAIC process.

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
EIGHTH SEMESTER B. TECH DEGREE EXAMINATION

COURSE CODE: MRT 476
COURSE NAME: TOTAL QUALITY MANAGEMENT AND SIX SIGMA

Max. Marks: 100 **Duration: 3 Hours**

PART A
Answer all Questions. Each question carries 3 Marks

1) Define quality. Explain different dimensions of it.
2) Mention in brief the contributions of 1) Deming 2) Juran.
3) Explain the axioms of TQM.
4) What do you understand by quality statements?
5) Write short notes on 1) Check sheet 2) Histogram.
6) Write short notes on 1) Affinity diagram 2) Tree diagram.
7) Name the steps involved in implementation of ISO 9001.
8) What are the benefits of environmental management system?
9) Explain process capability.
10) Explain the importance of SIX Sigma concept in manufacturing industries.

(10x3=30 marks)

PART B
Answer any one full question from each module. Each full question carries 14 Marks

Module 1

11) (a) Define TQM. Differentiate on the old and new cultures of TQM (7 marks)

(b) Explain the contributions made by 1) Crossby, 2) Fiegenbaum and 3) Ishikawa (7 marks)

Or

12) Elaborate on the obstacles and benefits of TQM. (14 marks)

Module 2

13) Explain Deming's fourteen points on quality management. (14 marks)

Or

14) (a) Explain the customer perception on quality. (7 marks)

(b) Describe the terms employee involvement and empowerment. (7 marks)

Module 3

15) Explain in detail the seven basic tools of quality. (14 marks)

Or

16) Explain new management tools for quality improvement with case examples. (14 marks)

Module 4

17) Explain in detail the implementation steps of ISO 9001 (14 marks)

Or

18 Explain quality system for Environmental Management (14 marks)

Module 5

19) Explain the roles and responsibilities of
(a) Master black belts
(b) Black belts
(c) Green belts (14 marks)

Or

20) Explain DMAIC process with a case example. (14 marks)

Syllabus

Module 1: Introduction to quality and TQM (7 hours)

Introduction to the concept of quality - definition, quality quantified, dimensions of quality, TQM – definition, new and old cultures, Gurus of TQM – Deming, Juran, Shewhart, Crossby, Fiegenbaum, Ishikawa, Taguchi – their main contributions, Obstacles to TQM, Benefits of TQM.

Module 2: Axioms of TQM, Customer satisfaction and Employee involvement (7 hours)

TQM axioms – commitment, scientific knowledge and involvement, Deming's fourteen points on quality management, Quality Council, Quality statements, customer satisfaction – customer perception of quality, customer retention, Employee involvement - motivation, empowerment, team and teamwork, suggestion system.

Module 3: Continuous process improvement and QFD (7 hours)

Continuous process improvement - Juran's quality trilogy, Seven basic tools of quality – flow chart or run chart, check sheet, histogram, Preto diagram, cause and effect diagram, scatter diagram and control charts, Benchmarking, New management tools – affinity diagram, inter relationship digraphs, tree diagram, matrix diagram, prioritization matrices, Process Decision Program Chart (PDPC), activity network diagram

Module 4: Quality Management Systems (7 hours)

Quality Management Systems (QMSs) : Introduction, Benefits of ISO Registration, ISO 9000 Series of standards, sector-specific standards - AS 9100, ISO/TS 16949 and TL 9000, ISO 9001 requirements - implementation, documentation, internal audits, registration, Environmental Management System.

Module 5: Quality improvement through Six Sigma (7 hours)

Six sigma –meaning- History of six sigma- working of six sigma-Process capability – meaning, significance and measurement – Six sigma roles and responsibilities- DMAIC process- Define phase- Measure phase- Aanalyse phase- Improve phase- Control phase- Case examples of DMAIC. Six sigma in manufacturing industries- Six sigma in service industries.

Text Books

1. Besterfield, D.H., Besterfield, C., Besterfield, G.H., Besterfield M., Urdhwareshe H., Urdhwareshe R. (2019). *Total Quality Management*, 5th Edition, Pearson Education.

Reference Books

1. James, R.E., and William, M.L. (2012). *The Management and Control of Quality*, 8e, Cengage Learning.
2. Janakiraman, B. and Gopal, R.K. (2008). *Total Quality Management - Text and Cases*, Prentice Hall India.
3. Logothetis N. (2003). *Managing for Total Quality - From Deming to Taguchi and SPC*, Prentice Hall of India.
4. Narayana, V., & Sreenivasan, N.S. (1996). *Quality Management – Concepts and Tasks*, New Age International.
5. Suganthi, L., & Samuel, A. (2011). *Total Quality Management*, Prentice Hall India.
6. Pyzdek, T., and Keller, P. (2018). *The Six Sigma Handbook*, 5e, McGraw-Hill.
7. International Six sigma institute. (2014). *Six Sigma Revealed*, International Six sigma institute.

Additional Web Reference Material

1. NPTEL, *Total Quality Management - I*, IIT Kanpur
   https://nptel.ac.in/courses/110104080
2. NPTEL, *Six Sigma*, IIT Kharagpur
   https://nptel.ac.in/courses/110105123
3. UDEMY, *Quality Management System Auditor Course* (3.5 hours)
   https://www.udemy.com/iso-90012015-quality-management-system-auditor-course/
4. UDEMY, *ISO 9001 transition course* (10 hours)
   https://www.udemy.com/iso-9001-2015/
5. UDEMY, *ISO 14001:2015 Environmental management system* (2 hours)
   https://www.udemy.com/iso-140012015-environmental-management-system/
6. UDEMY, *OHSAS 18001* (2.5 hours)
   https://www.udemy.com/complete-health-and-safety-auditor-course-ohsas-18001/

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures
1	**Introduction to quality and TQM (7 hours)**	
1.1	Introduction to the concept of Quality - definition, quality quantified, dimensions of quality	2 hours
1.2	TQM – definition, new and old cultures, Gurus of TQM – Deming, Juran, Shewhart, Crossby, Fiegenbaum, Ishikawa, Taguchi – their main contributions.	3 hours
1.3	Obstacles to TQM, Benefits of TQM.	2 hours
2	**Axioms of TQM, Customer satisfaction and Employee involvement (7 hours)**	
2.1	TQM axioms –commitment, scientific knowledge and involvement, Deming's fourteen points on quality management.	2 hours
2.2	Quality Council, Quality statements, customer satisfaction – customer perception of quality, customer retention.	2 hours
2.3	Employee involvement - motivation, empowerment, team and teamwork, suggestion system.	3 hours
3	**Continuous process improvement and QFD (7 hours)**	
3.1	Continuous process improvement - Juran's quality trilogy, PDSA cycle.	2 hours
3.2	Kaizen, Six-sigma, Seven basic tools of quality – flow chart or run chart, check sheet, histogram, pareto diagram, cause and effect diagram, scatter diagram and control charts.	2 hours
3.3	New management tools – affinity diagram, inter relationship digraphs, tree diagram, matrix diagram, prioritization matrices. Process Decision Program Chart (PDPC), activity network diagram	3 hours
4	**Quality Management Systems (7 hours)**	
4.1	Quality Management Systems (QMSs) : Introduction, Benefits of ISO Registration, ISO 9000 Series of standards.	3 hours
4.2	Sector-specific standards - AS 9100, ISO/TS 16949 and TL 9000, ISO 9001 requirements - implementation, documentation, internal audits, registration	3 hours
4.3	Environmental Management System.	1 hour
5	**Quality improvement through Six Sigma (7 hours)**	
5.1	Six sigma, meaning, history of six sigma	1 hour
5.2	Working of six sigma	1 hour
5.3	Process capability – meaning, significance and measurement	1 hour
5.4	Six sigma roles and responsibilities	1 hour
5.5	DMAIC process- Define phase-Measure phase- Analyze phase-Improve phase- Control phase. Six sigma in manufacturing industries- Six sigma in service industries. Case studies.	3 hours
		35 hours

MRT 418	WIRELESS AND SENSOR NETWORKS	CATEGORY	L	T	P	Credits	Year of Introduction
		PEC	2	1	0	3	2019

Preamble:

To make students familiar with basis of wireless sensors

To provide knowledge on design and develop the wireless sensor networks

To determine the modern application of wireless sensors in real time technological challenges.

Prerequisite: Sensors and Actuators

Course Outcomes - At the end of the course students will be able to

CO 1	Design wireless sensor network system for different applications under consideration.
CO 2	Understand the hardware details of different types of sensors and select right type of sensor for various applications.
CO 3	Understand radio standards and communication protocols to be used for wireless sensor network-based systems and application.
CO 4	Use operating systems and programming languages for wireless sensor nodes, performance of wireless sensor networks systems and platforms.
CO 5	Handle special issues related to sensors like energy conservation and security challenges

Mapping of course outcomes with program outcomes (Minimum requirements)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	2	-	-	-	-	-	-	-	-		-	3
CO 2	2	-	2	-	-	-	-	-	-	-	-	3
CO 3	2	-	-	-	-	-	-	-	-	-	-	3
CO 4	2	-	2	-	-	-	-	-	-	-	-	3
CO 5	3	-	-	2	-	-	-	-	-	-	-	3

ASSESSMENT PATTERN

Bloom's taxonomy	Continuous Assessment Tests		End Semester Examination (Marks)
	Test 1 (Marks)	Test 11 (Marks)	
Remember	25	25	25
Understand	15	15	45
Apply	10	10	30
Analyze			
Evaluate			
Create			

Mark distribution

Total Marks	CIE marks	ESE marks	ESE duration
150	50	100	3 Hours

Continuous Internal Evaluation (CIE) Pattern:

Attendance	10 marks
Regular class work/tutorials/assignments	15 marks
Continuous Assessment Test(Minimum 2 numbers)	25 marks

End semester pattern:- There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum 2 sub-divisions and carry 14 marks.

COURSE LEVEL ASSESSMENT QUESTIONS

Part -A

Course Outcome 1 (CO1): Design wireless sensor network system for different applications under consideration.

1. Compare sensor and traditional networks
2. Discuss in detail about the functional architecture of the sensor network.
3. List the components of WSN.
4. Define sensor network node
5. List the applications of WSN

Course Outcome 2 (CO2): Understand the hardware details of different types of sensors and select the right type of sensor for various applications.

1. Describe about mica2
2. Describe about micaZ
3. Discuss in detail about tinyOS
4. Discuss in detail about RetOS
5. Compare MANTIS and Contiki

Part -B

Course Outcome 3 (CO3): Understand radio standards and communication protocols to be used for wireless sensor network-based systems and applications.

1. Discuss in detail about time synchronization protocol
2. Compare transport layer protocol and network layer protocol
3. Discuss in detail about Zigbee

Course Outcome 4 (CO4): Use operating systems and programming languages for wireless sensor nodes, performance of wireless sensor networks systems and platforms.

1. Explain ToA,TdoA and AoA
2. Explain about positioning and location tracking algorithms.
3. With neat sketch discuss in detail about network based tracking

Course Outcome 5 (CO5): Handle special issues related to sensors like energy conservation and security challenges

1. Discuss the base challenges in sensor data.
2. Investigate in detail about types of aggregation.
3. How to select the best aggregation point.

SYLLABUS

MODULE – 1

Basics Concepts about Sensor Networks: Introduction –Difference between sensor networks and traditional networks- Functional architecture of sensor networks—Individual components of WSN-Sensor network node--Applications-Habitat monitoring-Tracking chemical plumps- Smart transportation.

MODULE - II

Hardware (Nodes): mica2, micaZ, telosB, cricket, Imote2, tmote, btnode, and Sun SPOT, Software (Operating Systems): tinyOS, MANTIS, Contiki, and RetOS

MODULE - III

Communication Protocols: Time synchronization protocols-Transport Layer protocol -Network layer protocol-Data link protocol-medium access control-The S-MAC protocol IEEE 802.15.4 standard and Zigbee - Error Control.

MODULE - IV

Tracking Technologies: Tracking scenario –Problem formulation –Sensing model-Fundamentals-ToA, TDoA, and AoA Positioning by signal strength-positioning and location tracking algorithms-Trilateration Multilateration-Pattern matching-Nearest neighbor algorithms - probability based algorithms location tracking-network based tracking

MODULE - V

Sensor Network Data Bases: Sensor data base challenges- Querying the physical environment-High level data base organization Data aggregation-types of aggregation-Packet level aggregation-total aggregation-Geographic aggregation-selection of the best aggregation points-Problem with high data rate.

Text Books

1. Holger Karl and Andreas Willig, “Protocols and Architectures for Wireless Sensor Networks”, John Wiley & Sons, 2005.
2. Zhao and L. Guibas, “Wireless Sensor Networks”, Morgan Kaufmann, San Francisco, 2004
3. C. S. Raghavendra, K.M.Shivalingam and T.Znati, “Wireless Sensor Networks”, Springer, New York, 2004

Reference

1. Anna Hac, “Wireless Sensor Network Designs”, John Wiley & Sons, 2004.
2. Kazem Sohraby, Daniel Minoli and Taieb Znati, “Wireless Sensor Networks: Technology, Protocols, and Applications”, Wiley Inter Science, 2007.
3. Mohammad Ilyas and Imad Mahgoub, “Handbook of Sensor Networks: Compact Wireless and Wired Sensing Systems” CRC Press, 2009.
4. Feng Zhao, Leonidas J. Guibas, “Wireless Sensor Networks: An Information Processing Approach” Morgan Kaufmann Publishers, 2004

MODEL QUESTION PAPER

WIRELESS AND SENSOR NETWORKS - MRT 418

Max. Marks : 100 **Duration : 3 Hours**

Part – A

(Answer all questions, each question carries 3 marks)

1. Define sensor network node.
2. List the applications of WSN.
3. Describe about mica2.
4. Describe about micaZ.
5. List the error control methods in communication protocols.
6. Discuss data link protocol.
7. Define ToA.
8. Define TdoA.
9. What are the high level database organization.
10. Discuss about nearest neighbor algorithm.

PART -B

Answer one full question from each module.

MODULE – 1

11. Compare sensor and traditional networks. (14 marks)

OR

12. Discuss in detail about the functional architecture of the sensor network. (14 Marks)

13. Discuss in detail about tinyOS. (14 Marks)	
	OR
14. Discuss in detail about RetOS. (14 Marks)	
15. Compare transport layer protocol and network layer protocol. (14 marks)	
	OR
16.	Briefly explain the S-MAC protocol IEEE 802.15.4 standard and Zigbee.(14 Marks)
	MODULE – 4
17.	Explain about positioning and location tracking algorithms. (14 Marks)
	OR
18. With a neat sketch discuss in detail about network based tracking. (14 Marks)	
	MODULE – 5
19.	Discuss the base challenges in sensor data. (14 Marks)
	OR
20.	Investigate in detail about types of aggregation. (14 Marks)

COURSE CONTENT AND LECTURE SCHEDULES.

Module	TOPIC	No. of hours	Course outcomes
1.1	Introduction	2	CO1
1.2	Difference between sensor networks and traditional networks	1	CO1
1.3	sensor node architecture	1	CO1
1.4	Functional architecture of sensor networks	1	CO1
1.5	Individual components of WSN	1	CO1
1.6	Sensor network node	1	CO1
1.7	Applications	1	CO1
2.1	mica2, micaZ,	1	CO2
2.2	telosB, cricket, Imote2	1	
2.3	tmote, btnode, and Sun SPOT	1	CO2
2.4	Software (Operating Systems)	1	
2.5	tinyOS, MANTIS	1	CO2
2.6	tinyOS, MANTIS	1	
3.1	Time synchronization protocols	1	CO3
3.2	Transport Layer protocol	1	
3.3	Network layer protocol	1	CO3
3.4	Data link Protocol	1	
3.5	medium access control	1	CO3
3.6	The S-MAC protocol - IEEE 802.15.4 standard and Zigbee	1	CO3
3.7	Error Control	1	CO3
4.1	Tracking scenario – Problem formulation	1	CO4
4.2	Sensing model – Fundamentals - ToA, TDoA, and AoA Positioning by signal strength	1	CO4
4.3	positioning and location tracking algorithms –Trilateration - Multilateration	3	CO4
4.4	Pattern matching - Nearest neighbor algorithms, location tracking	1	CO4
4.5	network based tracking	1	CO4
5.1	Sensor data base challenges -Querying the physical environment	2	CO5

5.2	High level data base Organization	1	CO5
5.3	Data aggregation - types of aggregation - Packet level aggregation - total aggregation - Geographic aggregation	2	CO5
5.4	selection of the best aggregation points	1	CO5
5.5	Problem with high data rate	1	CO5

CODE	COURSE NAME	CATEGORY	L	T	P	Credits
MRT 428	Bio Mechatronics	PEC	2	1	0	3

Preamble:
The course enables the students to:

- Understand types of sensors used in biomedical applications.
  be familiar with various equipment in bio-medical applications and the techniques of diagnosis

Prerequisite: NIL

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

CO 1	Understand types of sensors
CO 2	Understand the electrical activity of heart
CO 3	Understand the electrical activity of brain
CO 4	Understand the measurement of Physiological Parameters
CO 5	Understand the Biomedical Equipment's

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	3	3	2									
CO 2	3	3	2									
CO 3	3	3	2									
CO 4	3	3	2									
CO 5	3	3	2									

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	10	10	10
Understand (K2)	20	20	20
Apply (K3)	10	10	50
Analyse (K4)	10	10	20
Evaluate (K5)			
Create (K6)			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:
Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum 2 subdivisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. What do you mean by refractory period?
2. Differentiate between polarisable and non-polarisable electrodes.

Course Outcome 2 (CO2)

1. How is cardiac muscle different from other muscles?
2. What is a pace maker?

Course Outcome 3 (CO3):

1. What is EEG?
2. Explain the electrical activity of the brain.

Course Outcome 4 (CO4):

1. Explain a method for blood pressure measurement.
2. How is blood flow measured?

Course Outcome 5 (CO5):

1. Explain the concept of centralised patient monitoring system.
2. What are the hazards associated with biomedical instruments?

Model Question paper

QP CODE:

PAGES: 3

Reg. No:_____

Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY EIGHTH SEMESTER

B.TECH DEGREE EXAMINATION,

MONTH & YEAR

Course Code: MRT 428

Course Name: BIOMECHATRONICS

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all questions. Each question carries 3 Marks

1. Differentiate between the action potential and resting potential in human body
2. Write a short note on Electrode electrolyte interface
3. Write a short note on action potentials in cardiac muscle
4. Write the significance of refractoriness
5. Draw a typical brain wave and explain.
6. How do you place electrodes in EEG?
7. What is blood pressure? What are the factors affecting its measurement?
8. What is the need of blood flow measurement?
9. Explain the scope of biomedical instrumentation.
10. What are the hazards associated with biomedical instruments?

PART B (14 x 5 = 70 Marks)

Answer any one full question from each module. Each question carries 14 marks

Module 1

11.	a.	Explain a biological cell structure and define different potentials associated with cell.	10
	b.	What do you mean by refractory period?	4
12.	a.	Give a detailed narration of different bio electrodes used for biomedical instrumentation.	14

Module 2

13.	a.	With the help of necessary figure explain the working of cardiovascular system of human body.	7
	b.	Describe the working of electronic pacemaker with necessary diagram	7
14.	a.	What is cardiac vector? Explain ECG leads with necessary figures.	7
	b.	Explain events related to different waves in Electro Cardiac Graph	7

Module 3

15.	a.	What are brain waves? Write notes on measurement of EEG with necessary block diagram.	8
	b.	Write brief note on measurement of nerve conduction velocity.	6
16.	a.	Explain the different stages of sleep.	7
	b.	Explain a brain wave. What are its characteristics.	7

Module 4

17.	a.	Explain one method of blood flow measurement.	8
	b.	With the help of neat diagram explain vector cardiography	6
18.	a.	With the help of neat diagram explain phonocardiography	6
	b.	With help of neat diagram write how the oscillometric method helps to measure Blood Pressure.	8

Module 5

19.	a.	Explain the working of MRI scanner.	7
	b.	Explain heart lung machine with the help of neat diagram.	7
20.	a.	Explain the concept of centralised patient monitoring system.	8
	b.	Write a note on patient safety when biomedical instruments are operated.	6

Syllabus

Module 1 – Bio potential and Bio electrodes

Cell structure – electrode – electrolyte interface- electrode potential- resting and action potential – electrodes for their measurement- Propagation of nerve impulses, Refractory period- Electrode electrolyte interface, Half-cell potential, Polarisable and Non-polarisable electrodes - Skin electrode interface – Bio-electrodes: Surface- Micro-. Needle electrodes - Equivalent circuits of electrodes

Module 2 - Electrical Activity of the heart

Cardiac muscle, Action potentials in cardiac muscle, SA node, Origin and propagation of rhythmical excitation & contraction, refractoriness, regular and ectopic pace makers, Electrocardiogram - Einthoven triangle, Standard 12-lead configurations - ECG Machine, Arrhythmias.

Module 3 - Electrical Activity of the brain

Electrical activity of brain – Sleep stages, Brain waves, waveforms & measurements, Evoked potentials, 10-20 electrodes placement system for EEG - EEG machine.

Module 4 - Measurement of Physiological Parameters

Electrocardiograph measurements – blood pressure measurement: by ultrasonic method – plethysonography – blood flow measurement by electromagnetic flow meter cardiac output measurement by dilution method – phonocardiography – vector cardiography

Module 5 - Biomedical Equipment's

Heart lung machine – artificial ventilator –– Basic ideas of CT scanner – MRI and ultrasonic scanner – cardiac pacemaker – DC – defibrillator patient safety - electrical shock hazards- Centralized patient monitoring system

Text Books

1. Arthur C. Guyton : Textbook of Medical Physiology, Prism Books (Pvt) Ltd &W.B.Saunders Company, 12th edition, 2012
2. Khandpur R S: Handbook of Medical Instrumentation, Tata McGraw Hill, New Delhi.2004.
3. Arumugam M., "Bio Medical Instrumentation", Anuradha agencies Pub., 2002

Reference Books

1. Electronics in Medicine and Biomedical Instrumentation by Nandini K. Jog PHI Second Edition 2013.
2. Hermann K P. Neubert, Instrument Transducer – An Introduction to their performance and design, 1975.
3. Harry N, Norton, Biomedical sensors – fundamentals and application, 1982
4. L.A. Geddes, L.E. Baker, Principles of applied Biomedical Instrumentation ,Third edition,2008.

Course Plan

No	Topic	No. of Lectures
1	**Module 1-** Bio potential and Bio electrodes	
1.1	Cell structure – electrode – electrolyte interface- electrode potential- resting and action potential – electrodes for their measurement-	3
	Propagation of nerve impulses, Refractory period-Electrode electrolyte interface, Half-cell potential, Polarisable and Non-polarisable electrodes - Skin electrode interface	2
	Bio-electrodes: Surface- Micro-. Needle electrodes - Equivalent circuits of electrodes	2
2	**Module 2-** Electrical Activity of the heart	
2.1	Cardiac muscle, Action potentials in cardiac muscle, SA node,	3
	Origin and propagation of rhythmical excitation & contraction, refractoriness, regular and ectopic pace makers,	2
	Electrocardiogram - Einthoven triangle, Standard 12-lead configurations - ECG Machine, Arrhythmias	2
3	**Module 3-** Electrical Activity of the brain	
3.1	Electrical activity of brain – Sleep stages,	2
	Brain waves, waveforms & measurements, Evoked potentials,	2
	10-20 electrodes placement system for EEG - EEG machine.	3
4	**Module 4-** Measurement of Physiological Parameters	
4.1	Electrocardiograph measurements – blood pressure measurement: by ultrasonic method – plethysonography –	5-2-0
5	**Module 5 -** Biomedical Equipment's	
5.1	Heart lung machine – artificial ventilator — Basic ideas of CT scanner – MRI and ultrasonic scanner – cardiac pacemaker – DC – defibrillator patient safety - electrical shock hazards- Centralized patient monitoring system	5-2-0

MRT438	INDUSTRIAL INSTRUMENTATION	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: This course aims the students to learn about the basic concept of industrial instrumentation.

Prerequisite: NIL

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

CO 1	Explain various temperature measurement devices.
CO 2	Understand various pressure measurement devices.
CO 3	Explain various viscosity measurement devices.
CO 4	Understand various flow measurement devices.
CO 5	Explain various level measurement devices and anemometers.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	1				2	3						
CO 2	1		2		3							
CO 3	3				2	1						
CO 4	3				2	1						
CO 5	3				2	1						

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. What are the advantages of the four wire RTD measurement method?
2. What are the applications of P/I converters?
3. Explain the working principle of Johnson noise thermometer.

Course Outcome 2 (CO2)

1. With a neat diagram explain the working of Suction pyrometers.
2. List the types, discuss any three mechanical type low range pressure measuring instruments
3. Explain any instrument used for low pressure measurement

Course Outcome 3(CO3):

1. Explain capillary type viscometer used in laboratory.
2. Give a note on efflux cup viscometers.
3. Explain centrifugal gas densitometer.

Course Outcome 4 (CO4):

1. Explain the working of Rotameter
2. Explain the function of provers in flow meters
3. Explain the working principle of pitot tube.

Course Outcome 5 (CO5):

1. Explain displacer type level switches.
2. Explain how laser Doppler anemometer can be used for Flow measurement.
3. Explain magnetic coupled level switch.

Model Question paper

QP CODE:

Reg. No:----------

Name: ----------

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIRST SEMESTER B.TECH

DEGREE EXAMINATION, MONTH & YEAR

Course code: MRT 438 **Duration: 3hours**

INDUSTRIAL INSTRUMENTATION (2019- Scheme)

Mechatronics Branch

PART A

*(Answer **all** the questions, each question carries 3 marks)*

1. Explain the working of fluidic temperature sensors.

2. Explain the measurement using RTD.

3. Explain the working of a bourdon gauge.
4. List the advantages and disadvantages of ionization gauges.

5. Briefly explain how Ostwald viscometer is used for measuring kinematic viscosity?
6. Explain the principle of centrifugal gas densitometer.

7. Explain the working of cross correlation flow meters.

8. Give note on v-cone flow meters?

9. Making use of a neat sketch explain the construction and working of capacitance type level gauge for non-conducting liquids.

10. Explain the application of rotating paddle switches in level measurement.

PART B

*(Answer **one** full question from each module .each question carries 14 marks)*

Module 1

11.(a)	Giving suitable graphs, illustrate the difference between PTC and NTC thermistors. Compare sensitivity of RTD with that of thermistor?	(7 marks)
(b)	With neat diagram explain pneumatic pyrometers	(7marks)
12.(a)	Explain with a neat sketch the construction and working of a Mc-Leod gauge.	(7 marks)
(b)	Describe the 3-wire and 4 -wire method of RTD measurement and compare its performance during measurement.	(7 marks)

Module 2

13.(a)	With the help of a neat sketch, explain how a McLeod gauge helps accurate measurement of pressure.	(7 marks)
(b)	How flapper nozzle system is adapted in differential pressure measurement	(7 marks)
14.	Briefly explain how well type manometer gives higher sensitivity than a U-tube manometer.	(14 marks)

Module 3

15. (a)	Explain the construction and working of Saybolt viscometer?	(9 marks)
(b)	Give a note on efflux cup viscometers	(5 marks)
16 .(a)	Compare Newtonian and Non-Newtonian fluids	(4 marks)
(b)	What is the principle of viscosity measurement? Explain any one viscometer in detail.	(10 marks)

.Module 4

17.(a)	Explain the principle of any one positive displacement flow meter.	(10 marks)
(b)	Explain the function of provers in flow meters	(4 marks)
18.	Explain the working of two types of ultrasonic flow meter.	(14 marks)

Module 5

19.(a)	Explain the working of gamma ray based level measuring instrument.	(10 marks)
(b)	Distinguish between displacer and float type level gauges	(4 marks)
20.(a)	With a neat sketch explain hot wire anemometer can be used for flow measurement?	(7 marks)
(b)	Give a note on level switches	(7 marks)

Syllabus

Module 1

Temperature measurement: Principle and types, construction requirements for industry, applications of- Resistance temperature detector (RTD), Thermistors.

Pneumatic and suction pyrometers, integrated circuit sensors, diode type sensors, ultrasonic thermometers, Johnson noise thermometer, fluidic sensors, spectroscopic temperature measurements, thermograph, temperature switches and thermostats.

Module 2

Pressure measurement basics: mechanical type instruments, electromechanical type, low pressure measurement, related accessories, pressure measuring standards, selection and application. Transmitter definition, classification, pneumatic transmitters- force balance type, torque balance type, two wire and four wire transmitters.

Module 3

Measurement of viscosity: definitions, units, Newtonian and Newtonian behaviour, measurement of viscosity using laboratory viscometers, industrial viscometers. Viscometer selection and application. Measurement of density, definitions, units, liquid density measurement, gas.

Module 4

Flow measurement: Introduction, definitions and units, classification of flow meters, pitot tubes, positive displacement liquid meters and provers, positive displacement gas flow meters, variable area flow meters.

Target flow meters: V-cone flow meters purge flow regulators, flow switches, flow meter calibration concepts, flow meter selection and application.

Module 5

Anemometers: Hot wire/hot film anemometer, laser Doppler anemometer (LDA), electromagnetic flow meter, turbine and other rotary element flow meters, ultrasonic flow meters, Doppler flow meters, cross correlation flow meters, vortex flow meters.

Level measurement: introduction, float level devices, displacer level devices, rotating paddle switches, diaphragm and differential pressure detectors, microwave level switches, radar and vibrating type level sensors. Level sensor selection and application.

Text Books

1. Patranabis D, "*Principles of Industrial Instrumentation*", 2ndEdition, Tata McGraw Hill, New Delhi, 1997.

2. Spitzer D. W., *Flow measurement*, ISA press, New York, 1998

Reference Books

1. Douglas M. Considine, "*Process / Industrial Instruments & Controls Handbook*", 5th Edition, McGraw Hill, Singapore, 1999.

2. Liptak B.G, "*Process Measurement and Analysis*", 4th Edition, Chilton Book Company, Radnor, Pennsylvania, 2003.

3. Noltingk B.E., *"Instrumentation Reference Book"*, 2ndEdition, Butterworth Heinemann, 1995.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Temperature measurement:**	
1.1	Principle and types, construction requirements for industry, applications of- Resistance temperature detector (RTD)	1
1.2	Thermistors. Pneumatic and suction pyrometers, integrated circuit sensors, diode type sensors,	3
1.3	Ultrasonic thermometers, Johnson noise thermometer, fluidic sensors, spectroscopic temperature measurements, thermograph, temperature switches and thermostats.	3
2	**Pressure measurement basics:**	
2.1	Mechanical type instruments, electromechanical type, low pressure measurement, related accessories,	2
2.2	Pressure measuring standards, selection and application.	2
2.3	Transmitter definition, classification, pneumatic transmitters- force balance type, torque balance type, two wire and four wire transmitters.	3
3	**Measurement of viscosity:**	
3.1	Definitions, units, Newtonian and Newtonian behaviour	2
3.2	Measurement of viscosity using laboratory viscometers, industrial viscometers.	2
3.3	Viscometer selection and application. Measurement of density, definitions, units, liquid density measurement, gas.	3
4	**Flow measurement**	
4.1	Introduction, definitions and units, classification of flow meters	1
4.2	Pitot tubes, positive displacement liquid meters and provers	2
4.3	Positive displacement gas flow meters, variable area flow meters	2
4.4	**Target flow meters:** V-cone flow meters purge flow regulators	1
4.5	Flow switches, flow meter calibration concepts, flow meter selection and application	1
5	**Anemometers:**	
5.1	Hot wire/hot film anemometer, laser Doppler anemometer (LDA), electromagnetic flow meter,	1
5.2	Turbine and other rotary element flow meters, ultrasonic flow meters, Doppler flow meters, cross correlation flow meters, vortex flow meters.	3
5.3	**Level measurement:** introduction, float level devices, displacer level devices, rotating paddle switches, diaphragm and differential pressure detectors.	2
5.4	Microwave level switches, radar and vibrating type level sensors. Level sensor selection and application	1

CODE	COURSE NAME	CATEGORY	L	T	P	Credits
MRT448	HEAT AND MASS TRANSFER	PEC	2	1	0	3

Preamble:

The objectives of the course are:

- To introduce the various modes of heat transfer and to develop methodologies for solving a wide variety of practical heat transfer problems
- To provide useful information concerning the performance and design of simple heat transfer systems
- Conceive the energy balance in any thermal practical situation involving heat transfer mechanisms
- To introduce mass transfer

Prerequisite: Mechanics of Fluids, Engineering Thermodynamics

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

CO 1	Apply principles of heat and mass transfer to engineering problems
CO 2	Analyse and obtain solutions to problems involving various modes of heat transfer
CO 3	Design heat transfer systems such as heat exchangers, fins, radiation shields etc
CO 4	Define laminar and turbulent boundary layers and ability to formulate energy equation in flow systems.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	2									
CO 2	3	3	2									
CO 3	3	3	2									
CO 4	3	3	2									

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	10	10	10
Understand (K2)	20	20	20
Apply (K3)	10	10	50
Analyse (K4)	10	10	20
Evaluate (K5)			
Create (K6)			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum 2 subdivisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. A furnace wall is made up of three layers of thicknesses 250 mm, 100 mm and 150 mm with thermal conductivities of 1.65 W/m.K and 9.2 W/m.K respectively. The inside is exposed to gases at 1250 ℃ with a convection coefficient of 25 W/m^2.K. and the inside surface is at 1100℃, the outside surface is exposed to air at 25℃ with convection coefficient of 12 W/m^2.K. Determine (a) the unknown thermal conductivity K (b) the overall heat transfer coefficient (c) all the intermediate temperatures?.
2. Derive an expression for steady state temperature distribution in a slab with internal heat generation.

Course Outcome 2 (CO2)

1. Distinguish between static balancing and dynamic balancing.
2. A hollow sphere (k = 65 W/mK) of 120 mm inner diameter and 350 mm outer diameter is covered 10 mm layer of insulation (k =10 W/mK). The inside and outside temperatures are 500 ℃ and 50 ℃ respectively. Calculate the rate of heat flow through this sphere

Course Outcome 3 (CO3):

1. Water at the rate of 4 kg/s is heated from 40 ℃ to 55 ℃ in a shell and tube heat exchanger. On the shell side one pass is used with water as the heating fluid and at a mass flow rate of 2 kg/s, and entering the heat exchanger at 95 ℃. The overall heat transfer coefficient is 1500 W/m^2 K. and the average water velocity in the 2 cm diameter tubes is 0.5 m/s. Because of space limitations, the tube length must not exceed 3 m. Calculate the number of tube passes, the number of tubes per pass and the length of the tubes, keeping in mind the design constraints
2. Two large plates, one at 800 K and other at 600 K have emissivities 0.5 and 0.8 respectively. A radiation shield having an emissivity 0.1 on one side and emissivity 0.05 on the other side is placed between the plates. Calculate the heat transfer by radiation per square meter with and without the radiation shield..

Course Outcome 4 (CO4):

1. Explain velocity boundary layer and thermal boundary layer with neat sketches.
2. Air at 40 o C flows over a tube with a velocity of 30 m/s. The tube surface temperature is 120 o C. Calculate the heat transfer coefficient for the following cases: (i) Tube is square with a side of 6 cm (ii) Tube is circular cylinder with a diameter of 6 cm.

Model Question paper

QP CODE:

PAGES: 3

Reg. No:_____

Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY EIGHTH SEMESTER B.TECH DEGREE EXAMINATION,

MONTH & YEAR

Course Code: MRT448

Course Name: HEAT AND MASS TRANSFER

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all questions. Each question carries 3 Marks

1. Discuss about the application of Heisler chart and Schmidt plot in heat transfer analysis.
2. How does a numerical solution method differ from an analytical one? Explain.
3. What are the characteristics of a boundary layer?
4. Write the significance of Nusselt number.
5. What is meant by condensation heat transfer? How it differs from drop wise heat transfer?
6. What are the main factors to be considered for a heat exchanger design?
7. Explain about radiation shape factor.
8. What are the properties of blackbody?
9. Give two examples of mass transfer in day-to-day life.
10. Explain Ficks law of diffusion with suitable assumptions.

PART B (14 x 5 = 70 Marks)

Answer any one full question from each module. Each question carries 14 marks

Module 1

11. a. Derive 3-dimensional unsteady state heat conduction equation with heat generation, in Cartesian co-ordinate system for anisotropic material, 7

    b. A 3 mm diameter and 5m long electric wire is tightly wrapped with a 2 mm thick plastic cover whose thermal conductivity is k = 0.15 W/m-K. Electrical measurements indicate that a current of 10 A passes through the wire and there is a voltage drop of 8 V along the wire. If the insulated wire is exposed to a medium at $T\infty$ = 30°C with a heat transfer coefficient of h = 12 W/m²-K, determine the temperature at the interface of the wire and the plastic cover in steady operation. Also state with reason, whether doubling the thickness of the plastic cover will increase or decrease heat transfer. 7

12. a. Derive an expression for temperature distribution for 1-dimensional slab with varying thermal conductivity. Assume the variation of thermal conductivity of slab as $k = k_0 (1+\beta t)$. 7

b. A square plate heater 15 cm x 15 cm is inserted between two slabs. Slab A is 2 cm thick (k = 50W/m-K) and Slab B is 1cm thick (k = 0.2W/m-K). The outside heat transfer coefficients on side A and side B are 200W/m²-K and 50W/m²-K respectively. The temperature of surrounding air is 25 °C. If rating of heater is 1 KW, find (a) Maximum temperature in the system, and (b) outer surface temperature of the two slabs. 7

Module 2

13. a. Saturated propane at 300 K with a velocity of 25 cm/s flows over a flat plate of length L=2 m. and width w=1 m. maintained at uniform temperature of 400 K. Calculate the local heat transfer coefficient at 1 m. length and the average heat transfer coefficient from L=0 m. to L=2 m. Also find the heat transfer 7

b. Hot air at atmospheric pressure and 80°C enters an 8 m. long uninsulated square duct of cross section 0.2 m. x 0.2 m. that passes through the attic of a house at a rate of 0.15m³/s. The duct is observed to be nearly isothermal at 60°C. Determine the exit temperature of the air. 7

14. a. Air at 15°C, 35 m/s, flows through a hollow cylinder of 4 cm. inner diameter and 6 cm. outer diameter and leaves at 45°C. The tube passes through a room where the room temperature is 65°C and tube wall is maintained at 60°C. Calculate the heat transfer coefficient between the air and the inner tube. 7

b. Consider a 0.6 m. x 0.6 m. thin square plate in a room at 30°C. One side of the plate is maintained at a temperature of 90°C, while the other side is insulated. Determine the rate of heat transfer from the plate by natural convection. If the emissivity of the surface is 1.0, calculate the heat loss by radiation. Also calculate the percentage of heat loss by convection. 7

Module 3

15. a. A counter flow double pipe heat exchanger is to heat water from 20°C to 80°C at a rate of 1.2kg/s. The heating is to be accomplished by geothermal water available at 170°C at a mass flow rate of 2 kg/s. The inner tube is thin walled and has a diameter of 1.5 cm. If the overall heat transfer coefficient of the heat exchanger is 640 W/m²-K, determine the length of the heat exchanger required to achieve the desired heating. Use ε-NTU method 8

b. Derive an expression for LMTD of double pipe, parallel flow heat exchanger. 6

16. a. Steam in the condenser of a power plant is to be condensed at a temperature of 30°C with cooling water from a nearby lake, which enters the tubes of the condenser at 14°C and leaves at 22°C. The surface area of the tubes is 45 m^2 and the overall heat transfer coefficient is 2100 $W/m^2 \cdot °C$. Determine the mass flow rate of the cooling water needed and the rate of condensation of the steam in the condenser. 7

b. In a double pipe heat exchanger, hot fluid with a specific heat of 2300 J/kg enters at 380°C and leaves at 300°C. Cold fluid enters at 25°C and leaves at 210°C. Calculate the heat exchanger area required for (i) Counter flow and (ii) Parallel flow. Take overall heat transfer coefficient as 750 W/m2 K and mass flow rate of hot fluid is 1 kg/s. 7

Module 4

17. a. A 70 mm. thick metal plate with a circular hole of 35 mm. diameter along the thickness is maintained at a uniform temperature 250°C. Find the loss of energy to the surroundings at 27°C, assuming the two ends of the hole to be as parallel discs and the metallic surfaces and surroundings have blackbody characteristics — 6

    b. Two large parallel planes with emissivities of 0.3 and 0.5 are maintained at temperatures of 527°C and 127°C respectively. A radiation shield having emissivities of 0.05 on both sides is placed between them. Calculate, (i) Heat transfer rate between them without shield. (ii) Heat transfer rate between them with shield. — 8

18. a. Two parallel plates of size 1.0 m. by 1.0 m. spaced 0.5 m apart are located in a very large room, the walls of which are maintained at a temperature of 270 C. One plate is maintained at a temperature of 900°C and other at 400°C. Their emissivity's are 0.2 and 0.5 respectively. If the plates exchange heat between themselves and the surroundings, find the net heat transfer to each plate and to the room. Consider only the plate surface facing each other — 8

    b. Two rectangular surfaces are perpendicular to each other with a common edge of 2 m. The horizontal plane is 2 m. long and vertical plane is 3 m long. Vertical plane is at 1200 K and has an emissivity of 0.4. the horizontal plane is 18 °C and has an emissivity of 0.3. Determine the net heat exchange between the planes. — 6

Module 5

19. a. Explain the analogy between heat and mass transfer. — 6

    b. Dry air at 300 C and 1 atm flows over a wet flat plate 600 mm. long at a velocity of 50 m/s. Calculate the mass transfer co-efficient of water vapour in air at the end of the plate. — 8

    Take the diffusion co-efficient of water vapour in air, $D = 0.26 \times 10^{-4}$ m^2/s

20. a. Gaseous hydrogen is stored at elevated pressure in a rectangular steel container of 10 mm. wall thickness. The molar concentration of hydrogen in steel at the inner surface is 2 kg mol/m^3, while the concentration of hydrogen in steel at the outer surface is 0.5 kg mol/m^3 . The binary diffusion coefficient for hydrogen in steel is 0.26×10^{-12} m^2/s. What is the mass flux of hydrogen through the steel — 8

    b. Explain the phenomenon of equimolar counter diffusion. Derive an expression for equimolar counter diffusion between two gases or liquids. — 6

Syllabus

Module 1 - CONDUCTION HEAT TRANSFER

Introduction to heat transfer- thermodynamics and heat transfer-typical heat transfer situations- modes of heat transfer- mechanism of heat transfer- basic laws of heat transfer- thermal conductivity-effect of temperature on thermal conductivity- combined heat transfer mechanism-real life situations of combined heat transfer.

Differential equations of heat conduction-boundary conditions and initial conditions, one dimensional steady state situations – plane wall, cylinder, sphere -concept of thermal resistance, critical radius, conduction with heat generation- Two-dimensional steady state situations, transient conduction, Lumped capacitance model, concept of Heisler chart and Schmidt Plot-Conduction shape factor-Numerical methods of analysis-thermal analysis of rectangular fins

Module 2 - CONVECTION HEAT TRANSFER

Energy Efficiency in Electricity Utilization:

Fundamentals, order of magnitude analysis of momentum and energy equations; hydrodynamic and thermal boundary Layers-Relation between fluid friction and heat transfer-Concepts of fluid mechanics, Differential equation of heat convection, Laminar flow heat transfer in circular pipe – constant heat flux and constant wall temperature, thermal entrance region, Turbulent flow heat transfer in circular pipe, pipes of other cross sections, Heat transfer in laminar flow and turbulent flow over a flat plate, Reynolds analogy, Flow across a cylinder and sphere- Natural convection- basics -free convection heat transfer on a vertical flat plate-empirical relations for free convection heat transfer.

Module 3 - HEAT EXCHANGERS

Condensation heat transfer phenomena- the condensation Number-Boiling heat transfer Phenomena-Simplified relations for boiling heat transfer-Introduction to heat exchangers-types of heat exchangers-the overall heat transfer coefficient-Fouling factor-LMTD analysis of heat exchangers-effectiveness-NTU method-Analysis of variable properties-compact heat exchangers-heat exchanger design consideration.

Module 4 - RADIATION HEAT TRANSFER

Physical mechanism of radiation heat transfer-Radiation properties-; Black body radiation Planck's law, Wein's displacement law, Stefan Boltzmann law, Kirchoff's law; Gray body Radiation shape factors-heat exchange between non -black bodies-Infinite parallel planes-Radiation combined with conduction and convection

Module 5 - MASS TRANSFER

Vibration-free vibration of single degree of freedom systems-equation of motion-Newton's method-energy method-natural frequency-undamped and damped systems-logarithmic decrement-forced vibration-response of SDOF systems to harmonic excitation-whirling of shaft-vibration absorber-transmissibility.

Text Books

1. Sachdeva R.C., Fundamentals of Engineering Heat and Mass Transfer, New Age Science Limited, 2009
2. R.K.Rajput. Heat and mass transfer, S.Chand &Co., 2015
3. Nag P.K., Heat and Mass Transfer, McGrawHill, 2011
4. Kothandaraman C.P., Fundamentals of Heat and Mass Transfer, New Age International, New Delhi,2006

Data Book

1. Heat and Mass Transfer data book: C.P. Kothandaraman, S. Subramanya, New age International Publishers, 2014.

Reference Books

1. Holman J.P, "Heat transfer", Mc Graw-Hill, 10th. Ed.,2009.
2. Yunus A. Cengel, "Heat and Mass Transfer: Fundamentals and Applications" McGraw-Hill Higher Education; 6th edition,2019.
3. Frank P. Incropera and David P. Dewitt, Heat and Mass Transfer, John Wiley and sons,2011.

Course Plan

No	Topic	No. of Lectures
1	**Module 1**	
1.1	Introduction to heat transfer- thermodynamics and heat transfer-typical heat transfer situations- modes of heat transfer- mechanism of heat transfer	1
1.2	Basic laws of heat transfer- thermal conductivity-thermal conductivity-effect of temperature on thermal conductivity-combined heat transfer mechanism-real life situations of combined heat transfer	1
1.3	Differential equations of heat conduction-boundary conditions and initial conditions	1
1.4	One dimensional steady state situations –plane wall, cylinder, sphere	1
1.5	Concept of thermal resistance, critical radius, conduction with heat generation- Two-dimensional steady state situations	1
1.6	Transient conduction, Lumped capacitance model, concept of Heisler chart and Schmidt Plot	1
1.7	Conduction shape factor-Numerical methods of analysis- thermal analysis of rectangular fins	1
2	**Module 2**	
2.1	Fundamentals, order of magnitude analysis of momentum and energy equations	2
2.2	hydrodynamic and thermal boundary Layers-Relation between fluid friction and heat transfer-Concepts of fluid mechanics	2
2.3	Differential equation of heat convection, Laminar flow heat transfer in circular pipe – constant heat flux and constant wall temperature, thermal entrance region	1
2.4	Turbulent flow heat transfer in circular pipe, pipes of other cross sections, Heat transfer in laminar flow and turbulent flow over a flat plate, Reynolds analogy	1
2.5	Flow across a cylinder and sphere- Natural convection- basics- free convection heat transfer on a vertical flat plate- empirical relations for free convection heat transfer	1
3	**Module 3**	
3.1	Condensation heat transfer phenomena- the condensation Number	1
3.2	Boiling heat transfer Phenomena-Simplified relations for boiling heat transfer	1
3.3	Introduction to heat exchangers-types of heat exchangers-the overall heat transfer coefficient-Fouling factor	2
3.4	LMTD analysis of heat exchangers-effectiveness-NTU method-Analysis of variable properties	2
3.5	compact heat exchangers-heat exchanger design considerations	1
4	**Module 4**	
4.1	Physical mechanism of radiation heat transfer-Radiation properties	1
4.2	Black body radiation Planck's law, Wein's displacement law, Stefan Boltzmann law, Kirchoff's law	3
4.3	Gray body Radiation shape factors-heat exchange between non -black bodies-Infinite parallel planes-Radiation combined with conduction and convection	3
5	**Module 5**	
5.1	Introduction to mass transfer- Molecular diffusion in fluids	1
5.2	Steady state molecular diffusion in fluids under stagnant and laminar flow conditions - Fick's law of diffusion	1
5.3	Types of solid diffusion- mass transfer coefficients in laminar and turbulent flows	1
5.4	Introduction to mass transfer coefficient- Equimolar counter-diffusion-	2

	Correlation for convective mass transfer coefficient- Correlation of mass transfer coefficients for single cylinder	
5.5	Theories of mass transfer- Overall mass transfer coefficients	2

MRT 458	SUPPLY CHAIN MANAGEMENT	CATEGORY	L	T	P	CREDIT
		OEC	2	1	0	3

Preamble

This course helps the students to understand the concept of supply chains and apply the tools and models related to different supply chain problems and decision scenarios.

Prerequisite

The students should have basic knowledge on forecasting techniques, normal distribution and use of standard tables.

Course outcomes

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

CO 1	Illustrate features and models of various supply chains
CO 2	Apply tools on planning of production operations in supply chains
CO 3	Apply techniques and models on inventory decisions in supply chains
CO 4	Illustrate the tools and models for transportation network design decisions in supply chains
CO 5	Understand various decisions connected to supply chain cross functional drivers

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3		2			1	2					1
CO 2	3	3	2		2							1
CO 3	3	3	2		2							1
CO 4	3	3	2		2							1
CO 5	3		2									1

Strong -3 Medium -2 Weak -1

Assessment pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	Test 1	Test 2	
Remember	20	20	10
Understand	40	40	20
Apply	40	40	70
Analyse			
Evaluate			
Create			

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course level assessment questions

Course Outcome 1 (CO1):

1. Explain important supply chain performance measures.
2. Discuss about supply chain restructuring with an example.
3. Illustrate a model for distribution facility location.

Course Outcome 2 (CO2)

1. Discuss how de-seasonalization is done in supply chain forecasting.
2. List out and explain aggregate planning strategies for production chains.
3. Select an advanced line balancing technique and discuss its procedural steps.

Course Outcome 3 (CO3):

1. Explain inventory models related to discounting in supply chains.
2. Illustrate a probabilistic demand inventory model for multi-echelon supply chain.
3. Explain about bullwhip effect and risk pooling.

Course Outcome 4 (CO4):

1. Explain the design options in transportation networks.
2. Choose an advanced scheduling technique in transportation and discuss its procedural steps.
3. Describe the steps for solving vehicle routing problems.

Course Outcome 5 (CO5):

1. Illustrate the importance of supply chain cross functional drivers.
2. Discuss about supplier scoring and assessment.
3. Explain the major obstacles of supply chain coordination.

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SEVENTH SEMESTER B. TECH DEGREE EXAMINATION

COURSE CODE: MRT 458
COURSE NAME: SUPPLY CHAIN MANAGEMENT

Max. Marks: 100 **Duration: 3 Hours**

PART A
Answer all Questions. Each question carries 3 Marks

1) Which are the important supply chain performance measures. Explain.
2) Explain about le-agile and agile supply chains.
3) Discuss about aggregate planning strategies with their pros and cons.
4) Explain about operations planning to respond predictable variability in production.
5) Name and explain any two cycle inventory models.
6) What is meant by bullwhip effect and risk pooling in supply chain? Explain.
7) Explain about risk management in transport network design.
8) Compare different methods of sequencing in transportation.
9) Discuss about sourcing and outsourcing in supply chains.
10) List out and explain the obstacles of supply chain coordination. (10x3=30 marks)

PART B
Answer any one full question from each module. Each full question carries 14 Marks

Module 1

11) (a) List out explain the major supply chain performance drivers and metrics. Discuss the same in context of grocery supply chains. (7 marks)

(b) Discuss the various supply chain echelons and flows involved in a medicine supply chain in India by mentioning the zone of strategic fit. (7 marks)

OR

12) (a) Discuss about distribution networks and models for facility layout decisions. (7 marks)

(b) Determine the optimum retailer location with the following data related to six markets.

Markets	M1	M2	M3	M4	M5	M6
Xn	360	245	234	654	268	546
Yn	356	667	(-)456	457	654	567
Dn	534	254	256	245	(-)249	252
Fn	190	180	170	175	185	165

(7 marks)

Module 2

13) (a) Explain in detail about any two forecasting techniques used for planning demand in supply chains. (7 marks)

(b) Do an optimal aggregate planning using the following information. Assume missed data if any.

month	*demand*		*Item*	*Cost (INR)*		*Other data*	
JAN	3200		material	110		Labour Hours	6/unit

FEB	2200		Inv. holding	25		Start Inventory	1500
MAR	3500		Backlog	350		End inventory	>1000
APR	3000		Labour hiring	750		Labour force	90
MAY	2000		Labour layoff	370		No. of days/m	20
JUN	2500		RT cost	4		No. of shifts	1
JUL	1000		OT cost	6		No. of hours/shft	8
			Subcontracting	30		OT hr. limit	7

(7 marks)

OR

14) (a) Using the given monthly demand data, calculate forecasted demand at a warehouse using two point moving average method. Determine any four forecast errors.
M1:2230; M2:2290; M3:2520; M4:2630; M5:2740; M6:2800; M7:2900; M8:3001 (7 marks)

(b) Discuss about LP modelling in aggregate planning with an example in production scenario. (7 marks)

Module 3

15) (a) Explain about quantity discount inventory model related to supply chains. (7 marks)

(b) Find the optimal order frequency and size for the following three product joint order case when fixed part of ordering cost as Rs.3000/-.

Product	*Demand*	*Unit cost*	*Order cost*	*Carrying cost*
P1	27000	3000	1000	10%
P2	30000	3500	1200	12%
P3	32000	4000	1500	11%

(7 marks)

OR

16) (a) Explain about any two replenishment policies suitable for production inventory management. (7 marks)

(b) The weekly demand of a product at two retailers is normally distributed with a mean of 3,000 and SD of 250. The distributor takes two days to fill an order placed by the retailers. Differentiate the safety inventory and average inventory carried out by these retailers trying for achieving 93% and 96% service levels. (7 marks)

Module 4

17) (a) Discuss the major design options in transportation network with examples. (7 marks)

(b) Using the given cost matrix (five plants – five warehouses) find the optimum allocation and cost of shipping using Vogel's approximation method.

	W1	W2	W3	W4	W5	Supply
P1	10.25	45.09	24.76	51.56	31.98	2500
P2	34.98	34.34	56.32	49.34	23.19	3100
P3	51.56	94.77	14.45	78.92	51.56	2600
P4	49.34	34.23	78.91	56.45	49.34	2700
P5	78.92	23.98	23.17	34.91	78.45	4100
Demand	2000	4200	3200	1900	2900	

(7 marks)

OR

18 (a) Explain about advanced techniques for scheduling and sequencing in transportation.
(7 marks)

(b) Find the optimum schedule and route for the following distribution problem using savings matrix method. (Vehicle capacity 165 units and No. of vehicles 2)

DC	C1	C2	C3	C4	C5	C6	C7	C8
X	10	45	23	8	23	21	34	12
Y	9	12	42	23	12	10	21	18
Demand	35	45	39	29	39	49	51	29

(7 marks)

Module 5

19) (a) Distinguish between 3PL and 4PL providers in supply chains with examples.
(7 marks)

(b) Discuss about pricing and revenue management of multiple customer segments.
(7 marks)

OR

20) (a) Illustrate about Information technology (IT) framework for an Indian supply chain.
(7 marks)

(b) What is supply chain coordination? Explain the managerial levers of supply chain coordination and its effect on performance.
(7 marks)

SYLLABUS

Module 1: Features and Models of Various Supply Chains

Supply Chain – Common features, objectives, structures, decision phases, performance measures, drivers, strategic fit and metrics. Major features of reverse, closed loop, green, lean, agile, le-agile, resilient, dual channel and international supply chains. Introduction to supply chain models used for distribution networks, facility location and facility layout.

Module 2: Planning of Production Operations in Supply Chains

Introduction to forecasting models for supply chains including seasonal models, forecast errors and de-seasonalization. Introduction to aggregate production planning strategies and methods. Operations planning to respond predictable variability in production chain using sequencing, scheduling and line balancing.

Module 3: Inventory Planning Decisions in Supply Chains

Introduction to cycle inventory models, discounting models, multi-item inventory models and production-consumption models related to supply chains. Safety inventory models for continuous review and periodic review. Introduction to models, tools and techniques related to optimal level of product availability, bullwhip effect and risk pooling.

Module 4: Transportation Network Design Decisions in Supply Chains

Design options in transportation network, trade-offs, risk management. Information technology (IT) and risk management related to transportation networks. Methods and techniques for allocation, routing, scheduling and sequencing in transportation. Introduction to vehicle routing problems.

Module 5: Decisions on Supply Chain Cross Functional Drivers

Sourcing, outsourcing, 3PL, 4PL, supplier scoring, contracts, risk sharing, design collaboration. Pricing and revenue management of multiple customer segments, perishable assets, bulk and spot contracts. Information technology (IT) framework for supply chain. Supply chain coordination and its obstacles, managerial levers and effect on performance.

Text Books

1. Chopra, S., Meindl, P. (2016). *Supply Chain Management – Strategy, Planning and Operation*, 6th Edition, Pearson Education.
2. Srinivasan, G. (2018). *Quantitative Models in Operations and Supply Chain Management*, 2nd edition, PHI.

Reference Books

1. Bowersox, D. J. & Closs, D. J. (2017). *Logistical Management: The Integrated Supply Chain Process*, McGraw Hill.
2. Christopher, M. (2011). *Logistics and supply chain management*, 4th Edition, Pearson Education.
3. Levi, D. S., Levi, E. S., Shankar, R., and Kaminsky, P. (2019). *Designing and Managing the Supply Chain*, 3rd edition, McGraw Hill.
4. Shah, J. (2016). *Supply Chain Management: Text and Cases*, 2nd Edition, Pearson Education.
5. Shapiro, J. F. (2006). *Modeling and Supply Chain*, Cengage Learning.
6. Taylor, D. & Brunt, D. (2009). *Manufacturing Operations and Supply Chain Management*, Vikas Thomson Learning.

Additional Web Reference Material

1. NPTEL, *Operations and supply chain management*, IIT Madras
   https://onlinecourses.nptel.ac.in/noc21_mg79/preview
2. NPTEL, *Supply Chain Analytics*, IIT Roorkee
   https://nptel.ac.in/courses/110/107/110107074/
3. Koberg, E., & Longoni, A. (2019). *A systematic review of sustainable supply chain management in global supply chains*, Journal of cleaner production, 207, 1084-1098.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. Of Lectures
1	**Features and Models of Various Supply Chains**	**(7 hours)**
1.1	Supply Chain – Common features, objectives, structures, decision phases, performance measures, drivers, strategic fit and metrics.	3
1.2	Major features of reverse, closed loop, green, lean, agile, le-agile, resilient, dual channel and international supply chains.	2
1.3	Introduction to supply chain models connected to distribution networks, facility location and layout decisions.	2
2	**Planning of Production Operations in Supply Chains**	**(7 hours)**
2.1	Forecasting models for supply chains including seasonal models, forecast errors and de-seasonalization.	2
2.2	Introduction to aggregate production planning strategies, methods and models	2
2.3	Operations planning to respond predictable variability in production chain using sequencing, scheduling and line balancing.	3
3	**Inventory Planning Decisions in Supply Chains**	**(8 hours)**
3.1	Cycle inventory models, discounting models, multi-item inventory models and production-consumption models related to supply chains including multi-echelon systems.	3
3.2	Introduction to safety inventory models for continuous review and periodic review	3
3.3	Introduction to models, tools and techniques related to optimal level of product availability, bullwhip effect and risk pooling.	2
4	**Transportation Network Design Decisions in Supply Chains**	**(7 hours)**
4.1	Design options in transportation network, trade-offs, risk management.	2
4.2	Information technology (IT) and risk management related to transportation networks.	1
4.3	Methods and techniques for allocation, routing, scheduling and sequencing in transportation.	2
4.4	Introduction to vehicle routing problems.	2
5	**Decisions on Supply Chain Cross Functional Drivers**	**(8 hours)**
5.1	Sourcing, outsourcing, 3PL, 4PL, supplier scoring, contracts, risk sharing, design collaboration.	2
5.2	Pricing and revenue management of multiple customer segments, perishable assets, bulk and spot contracts	3
5.3	Information technology (IT) framework for supply chain.	1
5.4	Supply chain coordination and its obstacles, managerial levers and effect on performance.	2

MRT 468	OPTIMIZATION TECHNIQUES	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: This course aims to provide a broad picture of various applications of optimization methods used in engineering.

Prerequisite: NIL

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

CO 1	Formulate and classify different optimisation problems.
CO 2	Apply classical and numerical methods solving linear and non-linear optimisation problems.
CO 3	Apply modern methods of optimisation for solving optimisation problems.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12
CO 1	3	3										2
CO 2	3	3										2
CO 3	3	3										2

Assessment Pattern

Bloom's Category		Continuous Assessment Tests		End Semester Examination
		1	2	
Remember	K1	10	10	10
Understand	K2	20	20	20
Apply	K3	20	20	70
Analyse				
Evaluate				
Create				

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1): Formulate optimisation problems. (K3)

1. Explain different classification of optimization problems
2. Apply basic concepts of mathematics to formulate an optimization problem.
3. Formulation of real world problems as linear programming problems.

Course Outcome 2 (CO2) : Obtain optimised solution using classical methods for constrained and unconstrained problems. (K3)

1. Identify extreme points of a given function and classify them as minimum, maximum or saddle point.
2. Formulate Lagragian equation for constrained problems and solve using KKT conditions.
3. Find optimum solution using Simplex method for the given problem.

Course Outcome 2 (CO2): Obtain optimised solution using numerical methods for non- linear problems. (K3)

1. Apply elimination search and direct root methods for finding the optimal solution
2. Find optimal point of a given function using gradient methods.

Course Outcome 3 (CO3): (K3)

1. Explain different steps in the genetic algorithm.

2. Evaluate the strategies to be adopted for players using game theory.
3. Using algorithms, find the minimum spanning tree and shortest distance for a given network path.
4. Two identical sections of the given networks are connected in parallel. Obtain the two port network parameters of the combination.

SYLLABUS

Module 1 : Introduction to classical method

Engineering applications of optimization, Formulation of design problems as mathematical programming problems.

Classification of optimization problems/techniques.

Classical optimization: unconstrained single and multivariable optimisation, Constrained optimization. Linear, Convex and non-convex optimization problems. KKT conditions.

Module 2 : Linear programming problems

Mathematical formulation of LP Problems, Solving using Simplex method and Graphical method.

Module 3 :Game Theory, Network path models

Game Theory: Introduction, 2- person zero – sum game -Saddle point; Mini-Max and Maxi- Min Theorems (statement only)- Graphical solution (2x n, m x 2 game), dominance property. Introduction to network tree - Minimal Spanning Tree - Prim's Algorithm.

Shortest path problems- solution methods – Dijkstra's Method.

Module 4 : Nonlinear unconstrained optimization

Single variable optimization methods- Fibonacci search method, Newton Raphson method Multi-variable methods- Hook-Jeeves pattern search method, Cauchy's (steepest descent) method.

Module 5 : Modern methods of optimization

Introduction to Genetic algorithm, Basic GA framework GA.

operators: Encoding, Crossover, Selection, Mutation.

Introduction to Fuzzy logic. Fuzzy sets and membership functions. Operations on Fuzzy sets. Optimization of Fuzzy Systems.

Text Books

1. S.S.Rao, Engineering Optimization.; Theory and Practice; Revised 3rd Edition, New Age International Publishers, New Delhi

2.H.A. Taha, " Operations Research", 5/e, Macmillan Publishing Company, 1992.

Kanti Swarup, P.K.Gupta and Man Mohan, Operations Research, Sultan Chand and Sons

Reference Books

1. Kalynamoy Deb. "Optimization for Engineering Design- Algorithms and Examples", Prentice-Hall of India Pvt. Ltd., New Delhi.
2. A. Ravindran, D. T. Phillips, J. J. Solberg, Operations Research – Principles and Practice, John Wiley and Sons.
3. Ashok D Belegundu, Tirupathi R Chandrupatla, "Optimization concepts and Application in Engineering", Pearson Education.
4. Hadley, G. "Linear programming", Narosa Publishing House, New Delhi
5. J. S. Arora, Introduction to Optimum Design, McGraw-Hill Book Company.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Introduction:**	
1.1	Engineering applications of optimization, Formulation of design problems as mathematical programming problems, objective function, constraints.	**1**
1.2	Classification of optimization problems/techniques. Linear, convex, and non-convex.	**2**
1.3	**Unconstrained optimization**: Unconstrained one dimensional necessary and sufficient conditions for optimality	**2**
1.4	Algorithms for one-dimensional unconstrained optimization problem – Fibonnacci, golden section	**2**
		7
2	**Algorithms and Constrained Optimization**	
2.1	Unconstrained multi-dimensional necessary and sufficient conditions for optimality	**2**
2.2	Algorithms for multi-dimensional unconstrained optimization problems – Steepest Descent, Newton's methods	**2**
2.3	**Constrained optimization:** Lagrangian method - First order Necessary KKT Conditions, Second order sufficient conditions, Duality (Concept)	**3**
		7
3	**Linear programming problems**	
3.1	Mathematical formulation of LP Problems	**1**
3.2	Slack, surplus and artificial variables, Reduction of a LPP to the standard form, feasible solutions.	**1**
3.3	Graphical solution method	**2**
3.4	simplex algorithm and solution using tabular method,	**1**
3.5	optimality conditions and degeneracy	**1**
3.6	Duality in linear programming	**1**
		7

4	**Nonlinear unconstrained optimization**	
4.1	Single variable optimization methods- Fibonacci search method,	**2**
4.2	Newton Raphson method	**2**
4.3	Multi-variable methods- Hook-Jeeves pattern search method,	**3**
		7
5	**Modern methods of optimization**	
5.1	Introduction to Genetic algorithm, Basic GA framework	**1**
5.2	GA operators: Encoding, Crossover, Selection, Mutation	**2**
5.3	Introduction to Fuzzy logic.	**1**
5.4	Fuzzy sets and membership functions.	**1**
5.5	Operations on Fuzzy sets.	**1**
5.6	Optimization of Fuzzy Systems	**1**
		7

Simulation Assignments:

Atleast one assignment should be simulation of optimization Problems using MATLAB/ Scilab/ Python. The following simulations .

1. Find the solution of the linear programming problem using simplex method.

$$\text{Minimize } f = -x_1 - 2x_2 - x_3$$

subject to

$$2x_1 + x_2 - x_3 \leq 2$$
$$2x_1 - x_2 + 5x_3 \leq 6$$

Refer MATLAB Solution of LP Problems SS Rao.

2. In an interval reduction problem, the initial interval is given to be 4.68 units. The final interval desired is 0.01 units. Find the number of interval reductions using Fibonacci method.

Ashok D. Belegundu, Tirupathi R. Chandrupatla

3. Given $f = x_1^2 + 2x_2^2 + 2x_1x_2$, a point $\mathbf{x}^1 = (0.5, 1)^T$, with $f_1 \equiv f(\mathbf{x}^1) = 3.25$, apply the Hooke and Jeeves algorithm. Assume step $s = 1, r = 0.25, \varepsilon = 0.001, \alpha = 1$.

Ashok D. Belegundu, Tirupathi R. Chandrupatla

Model Question paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

EIGHTH SEMESTER B.TECH DEGREE EXAMINATION

Course Code: MRT 468

Course Name: OPTIMIZATION TECHNIQUES

Max. Marks: 100 Duration: 3 Hours

PART A

Answer ALL Questions. Each Carries 3 mark.

1	What are the necessary and sufficient conditions for the relative minimum of a function of a single variable?	K2
2	Find the extreme points of the function $f(x_1, x_2) = x_1^3 + x_2^3 + 2x_1^2 + 4x_2^2 + 6$	K3
3	Give five typical applications of optimization techniques in engineering discipline.	K1
4	What is the significance of gradient function in minimization problem?	K2
5	State the duality principle and write the dual of the following LPP. Minimize $Z = 24x_1 + 30x_2$ subject to $2x_1 + 3x_2 \geq 10, 4x_1 + 9x_2 \geq 15, 6x_1 + 6x_2 \geq 20, x_1, x_2 \geq 0$	K3
6	Write a short note on Dijkstra's shortest path algorithm	K1
7	Explain the transformations needed to represent an LPP in standard form	K1
8	State dominance property in game theory	K1
9	Discuss membership function in fuzzy logic	K2
10	Name and describe the main five features of Genetic Algorithm	K2

PART – B

Answer one question from each module; each question carries 14 marks.

Module - I

11 a.	Maximize $f(x) = 2x_1 + x_2 + 10$ subject to $x_1 + 2x_2^2 - 3 = 0$	7

K3

b. Find the extreme points of the function $f(x_1, x_2, x_3) = x_1 + 2x_3 + x_2x_3 - x_1^2 - x_2^2 - x_3^2$. 7

K3

OR

12 a. Determine whether the following matrix is positive or negative definite. 7 K3

$$A = \begin{pmatrix} 3 & 1 & -1 \\ 1 & 3 & -1 \\ -1 & -1 & 5 \end{pmatrix}$$

b. Using method of Lagrange multipliers, Minimize $f(x_1, x_2, x_3) = {x_1}^2 + {x_2}^2 + {x_3}^2$ subject to constraints $4x_1 + {x_2}^2 + 2x_3 = 14$

K3

Module - II

13 a. Solve the following LPP graphically, 14

Minimize $Z=20x_1 + 40x_2$

Subject to the constraints

$36x_1 + 6x_2 \geq 108$

$3x_1 + 12x_2 \geq 36$

$20x_1 + 10x_2 \geq 100$

and $x_1, x_2 \geq 0$

K3

OR

14 Solve the following LPP using simplex method. Maximize $Z = 10x_1 + 15x_2 + 20x_3$ subject to the constraints 14

$2x_1 + 4x_2 + 6x_3 \leq 24, 3x_1 + 9x_2 + 6x_3 \leq 30, x_1, x_2, x_3 \geq 0.$

K3

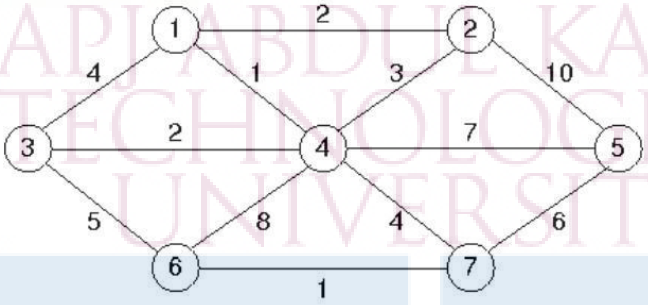
Module - III

15 a. Solve the game using graphical method. 7

Player	B				
A	2	-4	6	-3	5
A	-3	4	-4	1	0

K3

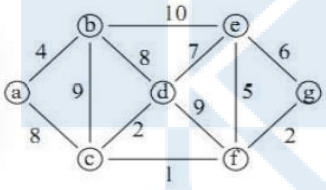
b. Using Dijkstra's method find the shortest path from node 1 to node 7 from the following network path model. 7



K3

OR

16 a. Using Prim's algorithm find the minimum spanning tree and the shortest distance from node 'a' to node 'b'. 7



K3

b. Solve the following payoff matrix using the graphical method.

	1	2	3	4	5
1	-5	5	0	-1	8
2	8	-4	-1	6	-5

a. Find the optimal strategy for player A
b. Find the optimal strategy for player B
c. Value of the game
d. Saddle point

7

K3

Module - IV

17	Solve the non linear unconstrained minimised optimisation problem by Hooke-Jeeves pattern search method by taking $\Delta x_1 = \Delta x_2 = 0.5$ and the starting point as $(x_1, x_2) = (2, -1)$ where $f(x_1, x_2) = x_1^2 + 3x_2^2 + 6x_1x_2 - x_1 - x_2$.	14	CO 3 K3

OR

18	Using Fibonacci method, minimise $f = x^5 - 5x^3 - 20x + 5$ in the interval (0,5) in six steps.	14	K3

Module - V

19 .	Consider membership function of two fuzzy sets $\tilde{A}$ and $\tilde{B}$ are given by $\mu_A(x) = \frac{x}{x+2}$ and $\mu_B(x) = 3^{-x}$. Find the membership function of i) $\tilde{A}^C$ ii) $\tilde{B}^C$, iii) $\tilde{A} \cup \tilde{B}$, iv) $\tilde{A} \cap \tilde{B}$, v) $(\tilde{A} \cup \tilde{B})^C$, where ^{C} is complement.	14	K3

OR

20	Consider the fuzzy relation R defined in A x A. Check whether the fuzzy relation is i) Reflexive, ii) Symmetric and iii) Transitive. $R = \begin{bmatrix} 0.4 & 0.1 & 0.7 \\ 0.1 & 0.2 & 0.2 \\ 0.4 & 0.5 & 0.3 \end{bmatrix}$	7	K3
	b. Explain the working principles of Genetic Algorithms.	7	K2

CODE	COURSE NAME	CATEGORY	L	T	P	Credits
MRT478	ARTIFICIAL INTELLIGENCE	PEC	2	1	0	3

Preamble:
To develop semantic-based and context-aware systems to acquire, organize, process, share and use the knowledge embedded in multimedia content. Research will aim to maximize automation of the complete knowledge lifecycle and achieve semantic interoperability between Web resources and services. The field of Robotics is multi-disciplinary as robots are amazingly complex systems comprising mechanical, electrical, electronic H/W and S/W and issues germane to all these.

Prerequisite: Fuzzy logic, Object oriented programming

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

CO 1	Understand the concepts of Artificial intelligence
CO 2	Interpret different algorithms of AI
CO 3	Solve basic AI problems
CO 4	Apply AI techniques to real-world problems to develop intelligent systems.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	2		**3**							3
CO 2	3	3	3		3							3
CO 3	3	3	3		3							3
CO 4	3	3	3		3							3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	10	10	20
Understand (K2)	20	20	30
Apply (K3)	10	10	30
Analyse (K4)	10	10	20
Evaluate (K5)			
Create (K6)			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:
Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum 2 subdivisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Define Artificial Intelligence

2. What is called materialism?

Course Outcome 2 (CO2)

1. Describe about A* & AO* algorithm.

2. Explain about uniformed search strategies.

Course Outcome 3 (CO3):

1. Explain in detail about first order logic.

2. Illustrate in detail about forward and backward chaining with suitable example.

Course Outcome 4 (CO4):

1. Consider the following sentences :

- John likes all kinds of food .
- Apples are food .
- Chicken is food .
- Anything anyone eats and isn't killed by is food .
- BilI eats peanuts and is still alive .
- Sue eats everything Bill eats.

i) Translate these sentences intoformulas in predicate logic.

ii) ii) Convert the formulas of part a into clause form..

2. Trace the operation of the unification algorithm on each of the following pairs ofliterals:

i) f(Marcus) and f(Caesar)

ii) ii) f(x) and f(g(y))

iii) iii) f(Marcus, g(x, y)) and f(x, g(Caesar, Marcus)).

Model Question paper

QP CODE:

PAGES: 3

Reg. No:_____

Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: MRT478

Course Name: ARTIFICIAL INTELLIGENCE

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all questions. Each question carries 3 Marks

1. State the advantages of Breadth First Search.
2. What is a Commutative production system?
3. Differentiate forward and backward reasoning.
4. Define Fuzzy reasoning.
5. Compare production based systems with frame based systems.
6. Define adaptive learning.
7. What is hierarchical planning?
8. List the characteristic features of an expert system.
9. What is MOLE?
10. Explain briefly about the structure of expert system

PART B (14 x 5 = 70 Marks)

Answer any one full question from each module. Each question carries 14 marks

Module 1

11. a. Exemplify the necessary components to define an AI problem. 7
    b. How much knowledge would be required by a perfect program for the problem of playing chess? Assume unlimited computing power is available. 7
12. a. Explain in detail about the concept of rationality. 7
    b. Write a short note about the structure of agents. 7

Module 2

13. Explain the following types of HilI Climbing search techniques. 14
    i) Simple Hill Climbing.
    ii) Steepest-Ascent Hill Climbing.
    iii) Simulated Annealing.

14.	Discuss Constraint Satisfaction problem with an algorithm for solving a Cryptarithmetic problem.		14

Module 3

15.	Explain the production based knowledge representation technique.		14
16. a.	i. Discuss about Bayesian Theory and Bayesian Network.		7
	ii. Describe in detail about Dempster-Shafer theory		7

Module 4

17.	Illustrate in detail about forward and backward chaining with suitable example.		14
18. a.	Illustrate the use of first order logic to represent knowledge.		8
b.	Give a brief description about Unification.		6

Module 5

19.	Elucidate the expert system architecture :		14
	i)	Rule-based. System architecture.	
	ii)	Associative or Semantic Network Architecture.	
	iii)	Network architecture.	
	iv)	Blackboard System Architecture	
20.	Analyse any two machine learning algorithms with an example.		14

Syllabus

Module 1
AI problems, foundation of AI and history of AI intelligent agents: Agents and Environments, the concept of rationality, the nature of environments, structure of agents, problem solving agents, problem formulation.

Module 2
Searching- Searching for solutions, uniformed search strategies – Breadth first search, depth first Search. Search with partial information (Heuristic search) Hill climbing, A* ,AO* Algorithms, Problem reduction, Game Playing- Adversial search, Games, mini-max algorithm, optimal decisions in multiplayer games, Problem in Game playing, Alpha-Beta pruning, Evaluation functions.

Module 3
Knowledge representation issues, predicate logic- logic programming, semantic nets- frames and inheritance, constraint propagation, representing knowledge using rules, rules based deduction systems. Reasoning under uncertainty, review of probability, Baye's probabilistic interferences and dempstershafer theory.

Module 4
First order logic. Inference in first order logic, propositional vs. first order inference, unification & lifts forward chaining, Backward chaining, Resolution, Learning from observation Inductive learning, Decision trees, Explanation based learning, Statistical Learning methods ,Reinforcement Learning.

Module 5
Expert systems:- Introduction, basic concepts, structure of expert systems, the human element in expert systems how expert systems works, problem areas addressed by expert systems, expert systems success factors, types of expert systems, expert systems and the internet interacts web, knowledge engineering, scope of knowledge, difficulties, in knowledge acquisition methods of knowledge acquisition, machine learning, intelligent agents, selecting an appropriate knowledge acquisition method, societal impacts reasoning in artificial intelligence, inference with rules, with frames: model based reasoning, case based reasoning, explanation & meta knowledge inference with uncertainty representing uncertainty.

Text Books

1. S. Russel and P. Norvig, "Artificial Intelligence – A Modern Approach", SecondEdition, Pearson Education
2. David Poole, Alan Mackworth, Randy Goebel, "Computational Intelligence : a logical approach", Oxford University Press.

Reference Books

1. G. Luger, "Artificial Intelligence: Structures and Strategies for complex problem solving", Fourth Edition, Pearson Education.
2. J. Nilsson, "Artificial Intelligence: A new Synthesis", Elsevier Publishers

Course Plan

No	Topic	No. of Lectures
1	**Module 1**	
1.1	AI problems, foundation of AI and history of AI intelligent agents: Agents and Environments, the concept of rationality, the nature of environments, structure of agents, problem solving agents, problem formulation.	5-2-0
2	**Module 2**	
2.1	Searching- Searching for solutions, uniformed search strategies – Breadth first search, depth first Search. Search with partial information (Heuristic search) Hill climbing, A* ,AO* Algorithms, Problem reduction, Game Playing-Adversial search, Games, mini-max algorithm, optimal decisions in multiplayer games, Problem in Game playing, Alpha-Beta pruning, Evaluation functions.	5-2-0
3	**Module 3**	
3.1	Knowledge representation issues, predicate logic- logic programming, semantic nets- frames and inheritance, constraint propagation, representing knowledge using rules, rules based deduction systems. Reasoning under uncertainty, review of probability, Baye's probabilistic interferences and dempstershafer theory.	5-2-0
4	**Module 4**	
4.1	First order logic. Inference in first order logic, propositional vs. first order inference, unification & lifts forward chaining, Backward chaining, Resolution, Learning from observation Inductive learning, Decision-Trees, Explanation based learning, Statistical Learning methods, Reinforcement Learning.	5-2-0
5	**Module 5**	
5.1	Expert systems:- Introduction, basic concepts, structure of expert systems, the human element in expert systems how expert systems works, problem areas addressed by expert systems, expert systems success factors, types of expert systems, expert systems and the internet interacts web, knowledge engineering, scope of knowledge, difficulties, in knowledge acquisition methods of knowledge acquisition, machine learning, intelligent agents, selecting an appropriate knowledge acquisition method, societal impacts reasoning in artificial intelligence, inference with rules, with frames: model based reasoning, case based reasoning, explanation & meta knowledge inference with uncertainty representing uncertainty.	5-2-0

MRT404	COMPREHENSIVE COURSE VIVA	CATEGORY	L	T	P	CREDIT
		PCC	1	0	0	1

Preamble: The objective of this Course viva is to ensure the basic knowledge of each student in the most fundamental core courses in the curriculum. The viva voce shall be conducted based on the core subjects studied from third to eighth semester. This course helps the learner to become competent in placement tests and other competitive examinations.

Guidelines

1. The course should be mapped with a faculty and classes shall be arranged for practicing questions based on the core courses listed in the curriculum.
2. The viva voce will be conducted by the same three member committee assigned for final project phase II evaluation. It comprises of Project coordinator, expert from Industry/research Institute and a senior faculty from a sister department.
3. The pass minimum for this course is 25.
4. The mark will be treated as internal and should be uploaded along with internal marks of other courses.
5. Comprehensive Viva should be conducted along with final project evaluation by the three member committee.

Mark Distribution

Total marks: 50, only CIE, minimum required to pass : 25 Marks

MRD416	PROJECT PHASE II	CATEGORY	L	T	P	CREDIT
		PWS	0	0	12	4

Preamble:

The course 'Project Work' is mainly intended to evoke the innovation and invention skills in a student. The course will provide an opportunity to synthesize and apply the knowledge and analytical skills learned, to be developed as a prototype or simulation. The project extends to 2 semesters and will be evaluated in the 7th and 8th semester separately, based on the achieved objectives. One third of the project credits shall be completed in 7th semester and two third in 8th semester. It is recommended that the projects may be finalized in the thrust areas of the respective engineering stream or as interdisciplinary projects. Importance should be given to address societal problems and developing indigenous technologies.

Course Objectives

1. To apply engineering knowledge in practical problem solving.
2. To foster innovation in design of products, processes or systems.
3. To develop creative thinking in finding viable solutions to engineering problems.

Course Outcomes [COs]: After successful completion of the course, the students will be able to:

CO1	Model and solve real world problems by applying knowledge across domains (Cognitive knowledge level: **Apply**).
CO2	Develop products, processes or technologies for sustainable and socially relevant applications (Cognitive knowledge level: **Apply**).
CO3	Function effectively as an individual and as a leader in diverse teams and to comprehend and execute designated tasks (Cognitive knowledge level: **Apply**).
CO4	Plan and execute tasks utilizing available resources within timelines, following ethical and professional norms (Cognitive knowledge level: **Apply**).
CO5	Identify technology/research gaps and propose innovative/creative solutions (Cognitive knowledge level: **Analyze**).
CO6	Organize and communicate technical and scientific findings effectively in written and oral forms (Cognitive knowledge level: **Apply**).

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	1	2	2	2	1	1	1	1	2
CO2	2	2	2		1	3	3	1	1		1	1
CO3									3	2	2	1
CO4					2			3	2	2	3	2
CO5	2	3	3	1	2							1

CO6					2			2	2	3	1	1

Abstract POs defined by National Board of Accreditation			
PO #	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	PO7	Environment and Sustainability
PO2	Problem Analysis	PO8	Ethics
PO3	Design/Development of solutions	PO9	Individual and team work
PO4	Conduct investigations of complex problems	PO0	Communication
PO5	Modern tool usage	PO11	Project Management and Finance
PO6	The Engineer and Society	PO12	Lifelong learning

PROJECT PHASE II

Phase 2 Targets

4. In depth study of the topic assigned in the light of the report prepared under Phase - I;
5. Review and finalization of the approach to the problem relating to the assigned topic.
6. Preparing a detailed action plan for conducting the investigation, including teamwork.
7. Detailed Analysis/ Modeling / Simulation/ Design/ Problem Solving/Experiment as needed.
8. Final development of product/ process, testing, results, conclusions and future directions.
9. Preparing a paper for Conference Presentation/ Publication in Journals, if possible.
10. Presenting projects in Project Expos conducted by the University at the cluster level and/ or state level as well as others conducted in India and abroad.
11. Filing Intellectual Property Rights (IPR) if applicable.
12. Preparing a report in the standard format for being evaluated by the Department Assessment Board.
13. Final project presentation and viva voce by the assessment board including the external expert.

Evaluation Guidelines & Rubrics

Total: 150 marks (Minimum required to pass: 75 marks).

14. Project progress evaluation by guide: 30 Marks.
15. Two interim evaluations by the Evaluation Committee: 50 Marks (25 marks for each evaluation).
16. Final evaluation by the Final Evaluation committee: 40 Marks
17. Quality of the report evaluated by the evaluation committee: 30 Marks

(The evaluation committee comprises HoD or a senior faculty member, Project coordinator and project supervisor. The final evaluation committee comprises of Project coordinator, expert from Industry/research/academic Institute and a senior faculty from a sister department).

Evaluation by the Guide

The guide/supervisor must monitor the progress being carried out by the project groups on regular basis. In case it is found that progress is unsatisfactory it should be reported to the Department Evaluation Committee for necessary action. The presence of each student in the group and their involvement in all stages of execution of the project shall be ensured by the guide. Project evaluation by the guide: 30 Marks. This mark shall be awarded to the students in his/her group by considering the following aspects:

Project Scheduling & Distribution of Work among Team members: Detailed and extensive Scheduling with timelines provided for each phase of project. Work breakdown structure well defined. (5)

Literature survey: Outstanding investigation in all aspects. (4)

Student's Diary/ Daily Log: The main purpose of writing daily diary is to cultivate the habit of documenting and to encourage the students to search for details. It develops the students' thought process and reasoning abilities. The students should record in the daily/weekly activity diary the day to day account of the observations, impressions, information gathered and suggestions given, if any. It should contain the sketches & drawings related to the observations made by the students. The daily/weekly activity diary shall be signed after every day/week by the guide. (7)

Individual Contribution: The contribution of each student at various stages. (9)

Completion of the project: The students should demonstrate the project to their respective guide. The guide shall verify the results and see that the objectives are met. (5)

EVALUATION RUBRICS for PROJECT Phase II: Interim Evaluation - 1						
No.	**Parameters**	**Marks**	**Poor**	**Fair**	**Very Good**	**Outstanding**
2-a	Novelty of idea, and Implementation scope [CO5] [Group Evaluation]	**5**	The project is not addressing any useful requirement. The idea is evolved into a non-implementable one. The work presented so far is lacking any amount of original work by the team.	Some of the aspects of the proposed idea can be implemented. There is still lack of originality in the work done so far by the team. The project is a regularly done theme/topic without any freshness in terms of specifications, features, and/or improvements.	Good evidence of an implementable project. There is some evidence for the originality of the work done by the team . There is fresh specifications/ features/improvements suggested by the team. The team is doing a design from fundamental principles, and there is some independent learning and engineering ingenuity.	The project has evolved into incorporating an outstandingly novel idea. Original work which is not yet reported anywhere else. Evidence for ingenious way of innovation which is also Implementable. Could be a patentable / publishable work.
			(0 – 1 Marks)	(2 – 3 Marks)	(4 Marks)	(5 Marks)
2-b	Effectiveness of task distribution among team members. [CO3] [Group Evaluation]	**5**	No task distribution of any kind. Members are still having no clue on what to do.	Task allocation done, but not effectively, some members do not have any idea of the tasks assigned. Some of the tasks were identified but not followed individually well.	Good evidence of task allocation being done, supported by project journal entries, identification of tasks through discussion etc. However, the task distribution seems to be skewed, and depends a few members heavily than others. Mostly the tasks are being followed by the individual members.	Excellent display of task identification and distribution backed by documentary evidence of team brainstorming, and project journal entries. All members are allocated tasks according to their capabilities, and as much as possible in an equal manner. The individual members are following the tasks in an excellent manner.
			(0 – 1 Marks)	(2 – 3 Marks)	(4 Marks)	(5 Marks)
2-c	Adherence to project schedule. [CO4] [Group Evaluation]	**5**	Little or no evidence of continued planning or scheduling of the project. The students did not stick to the plan what they were going to build nor plan on what materials / resources to use in the project. The students do not have any idea on the budget required even after the end of phase - I. No project journal kept or the journal.	There is some improvement in the primary plan prepared during phase I. There were some ideas on the materials /resources required, but not really thought out. The students have some idea on the finances required, but they have not formalized a budget plan. Schedules were not prepared. The project journal has no useful details on the project.	Good evidence of planning done and being followed up to a good extent after phase I. Materials were listed and thought out, but the plan wasn't followed completely. Schedules were prepared, but not detailed, and needs improvement. Project journal is presented but it is neither complete nor updated regularly.	Excellent evidence of enterprising and extensive project planning and follow-up since phase I. Continued use of project management/version control tool to track the project. Material procurement if applicable is progressing well. Tasks are updated and incorporated in the schedule. A well-kept project journal showed evidence for all the above, in addition to the interaction with the project guide.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)

2-d	Interim Results. [CO6] [Group assessment]	**5**	There are no interim results to show.	The team showed some interim results, but they are not complete / consistent to the current stage, Some corrections are needed.	The interim results showed were good and mostly consistent/correct with respect to the current stage. There is room for improvement.	There were significant interim results presented which clearly shows the progress.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
2-e	Presentation [Individual assessment]	**5**	Very poor presentation and there is no interim results. The student has no idea about the project proposal.	Presentation is average, and the student has only a feeble idea about the team work.	Good presentation. Student has good idea about the team's project. The overall presentation quality is good.	Exceptionally good presentation. Student has excellent grasp of the project. The quality of presentation is outstanding.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
Phase-II Interim Evaluation - 1 Total Marks: 25						

EVALUATION RUBRICS for PROJECT Phase II: Interim Evaluation – 2

No	Parameters	Marks	Poor	Fair	Very Good	Outstanding
2-f	Application of engineering knowledge [CO1] [Individual Assessment]	**10**	The student does not show any evidence of applying engineering knowledge on the design and the methodology adopted. The student's contribution in application of engineering knowledge in the project is poor.	The student appears to apply some basic knowledge, but not able to show the design procedure and the methodologies adopted in a comprehensive manner.	The student is able to show some evidence of application of engineering knowledge in the design and development of the project to good extent.	Excellent knowledge in design procedure and its adaptation. The student is able to apply knowledge from engineering domains to the problem and develop solutions.
			(0 – 3 Marks)	(4 – 6 Marks)	(7 - 9 Marks)	(10 Marks)
2-g	Involvement of individual members [CO3] [Individual Assessment]	**5**	No evidence of any Individual participation in the project work.	There is evidence for some amount of individual contribution, but is limited to some of the superficial tasks.	The individual contribution is evident. The student has good amount of involvement in core activities of the project.	Evidence available for the student acting as the core technical lead and has excellent contribution to the project.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
2-h	Results and inferences upon execution [CO5] [Group Assessment]	**5**	None of the expected outcomes are achieved yet. The team is unable to derive any inferences on the failures/ issues observed. Any kind o f observations or studies are not made.	Only a few of the expected outcomes are achieved. A few inferences are made on the observed failures/issues. No further work suggested.	Many of the expected outcomes are achieved. Many observations and inferences are made, and attempts to identify the issues are done. Some suggestions are made for further work.	Most of the stated outcomes are met. Extensive studies are done and inferences drawn. Most of the failures are addressed and solutions suggested. Clear and valid suggestions made for further work.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
2-i	Documentation and presentation. .[CO6] [Individual assessment]	**5**	The individual student has no idea on the presentation of his/her part. The presentation is of poor quality.	Presentation's overall quality needs to be improved.	The individual's presentation performance is satisfactory.	The individual's presentation is done professionally and with great clarity. The individual's performance is excellent.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
Phase-II Interim Evaluation - 2 Total Marks: 25						

EVALUATION RUBRICS for PROJECT Phase II: Final Evaluation						
No	**Parameters**	**Marks**	**Poor**	**Fair**	**Very Good**	**Outstanding**
2-j	Engineering knowledge. [CO1] [Group Assessment]	10	The team does not show any evidence of applying engineering knowledge on the design and the methodology adopted.	The team is able to show some of the design procedure and the methodologies adopted, but not in a comprehensive manner.	The team is able to show evidence of application of engineering knowledge in the design and development of the project to good extent. There is scope for improvement.	Excellent knowledge in design procedure and its adaptation. The team is able to apply knowledge from engineering domains to the problem and develop an excellent solution.
			(0 – 3 Marks)	(4 – 6 Marks)	(7 - 9 Marks)	(10 Marks)
2-k	Relevance of the project with respect to societal and/or industrial needs. [Group Assessment] [CO2]	5	The project as a whole do not have any societal / industrial relevance at all.	The project has some relevance with respect to social and/or industrial application. The team has however made not much effort to explore further and make it better.	The project is relevant to the society and/or industry. The team is mostly successful in translating the problem into an engineering specification and managed to solve much of it.	The project is exceptionally relevant to society and/or industry. The team has made outstanding contribution while solving the problem in a professional and/ or ethical manner.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
2-i	Innovation / novelty / Creativity [CO5] [Group Assessment]	5	The project is not addressing any useful requirement. The idea is evolved into a non-implementable one. The work presented so far is lacking any amount of original work by the team.	Some of the aspects of the proposed idea appears to be practical. There is still lack of originality in the work done. The project is a regularly done theme/topic without any freshness in terms of specifications, features, and/ or improvements.	Good evidence of an implementable project. There is some evidence for the originality of the work done by the team. There is fresh specifications/ features/improvements suggested by the team. The team is doing a design from fundamental principles, and there is some independent learning and engineering ingenuity. Could be translated into a product / process if more work is done.	The project has evolved into incorporating an outstandingly novel idea. Original work which is not yet reported anywhere else. Evidence for ingenious way of innovation which is also Implementable. Could be a patentable publishable work.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
2-m	Quality of results / conclusions / solutions. [CO1] [Group Assessment]	10	None of the expected outcomes are achieved. The team is unable to derive any inferences on the failures/issues observed. Any kind of observations or studies is not made.	Only a few of the expected outcomes are achieved. A few inferences are made on the observed failures/issues. No further work suggested.	Many of the expected outcomes are achieved. Many observations and inferences are made, and attempts to identify the issues are done. Some suggestions are made for further work.	Most of the stated outcomes are met. Extensive studies are done and inferences drawn. Most of the failures are addressed and solutions suggested. Clear and valid suggestions made for further work.
			(0 – 3 Marks)	(4 – 6 Marks)	(7 - 9 Marks)	(10 Marks)

2-n	Presentation - Part I Preparation of slides. [CO6] [Group Assessment].	5	The presentation slides are shallow and in a clumsy format. It does not follow proper organization.	Presentation slides follow professional style formats to some extent. However, its organization is not very good. Language needs to be improved. All references are not cited properly, or acknowledged. Presentation slides needs to be more professional.	Presentation slides follow a good style format and there are only a few issues. Organization of the slides is good. Most of references are cited properly. The flow is good and team presentation is neatly organized. Some of the results are not clearly shown. There is room for improvement.	The presentation slides are exceptionally good. Neatly organized. All references cited properly. Diagrams/Figures, Tables and equations are properly numbered, and l i s ted. Results/ inferences clearly highlighted and readable.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
	Presentation - Part II: Individual Communication [CO6] [Individual Assessment].	5	The student is not communicating properly. Poor response to questions.	The student is able to explain some of the content. The student requires a lot of prompts to get to the idea. There are language issues.	Good presentation/ communication by the student. The student is able to explain most of the content very well. There are however, a few areas where the student shows lack of preparation. Language is better.	Clear and concise communication exhibited by the student. The presentation is outstanding. Very confident and tackles all the questions without hesitation. Exceptional traits of communicator.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
Phase-II Final Evaluation, Marks: 40						

EVALUATION RUBRICS for PROJECT Phase II: Report Evaluation						
Sl. No.	**Parameters**	**Marks**	**Poor**	**Fair**	**Very Good**	**Outstanding**
2-o	Report [CO6]	30	The prepared report is shallow and not as per standard format. It does not follow proper organization. Contains mostly unacknowledged content. Lack of effort in preparation is evident. References are not cited. Unprofessional and inconsistent formatting.	Project report follows the standard format to some extent. However, its organization is not very good. Language needs to be improved. All references are not cited properly in the report. There is lack of formatting consistency.	Project report shows evidence of systematic documentation. Report is mostly following the standard style format and there are only a few issues. Organization of the report is good. Mostly consistently formatted. Most of references/sources are cited/ acknowledged properly.	The report is exceptionally good. Neatly organized. All references cited properly. Diagrams/Figures, Tables and equations are properly numbered, and listed and clearly shown. Language is excellent and follows professional styles. Consistent formatting and exceptional readability.
			(0 - 11 Marks)	(12 - 18 Marks)	(19 - 28 Marks)	(29 - 30 Marks)
Phase - II Project Report Marks: 30						