Semester II

Discipline: MECHANICAL ENGINEERING

Stream: ME2 (RENEWABLE ENERGY, ENERGY MANAGEMENT, ENERGY ENGINEERING)

222TME100	DESIGN OF EXPERIMENTS	CATEGORY	L	T	P	CREDIT
		Discipline Core	3	0	0	3

Preamble:

Investigators perform experiments in virtually all fields of inquiry, usually to discover something about a particular process or system. In this course, you will learn the basic concepts of experimental design, and the statistical analysis of data. On completion of the course, you would be able to plan and conduct experiments, and analyse the resulting data so that valid conclusions can be drawn.

Course Outcomes:

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

CO 1	Perform statistical analysis of data.
CO 2	Conduct statistical hypothesis tests on mean and variance of populations.
CO 3	Design and analyse single factor experiments.
CO 4	Design and analyse full and fractional factorial experiments.
CO 5	Apply Response Surface Methodology to optimise the response in an experiment.
CO 6	Carry out an experimental project and analyse the results using statistical software.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	3	3	3	3	1	2
CO 2	3	3	3	3	3	1	2
CO 3	3	1	3	3	3		1
CO 4	3	1	3	3	3		1
CO 5	3	1	3	3	3		3
CO 6	3	2	3	3	3	1	3

Assessment Pattern

Bloom's Category	End Semester Examination

Apply	20%
Analyse	20%
Evaluate	10%
Create	10%

Mark distribution

Total Marks	**CIE**	**ESE**	**ESE Duration**
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern: 40 Marks

Course based project/Mini project: 20 Marks.

(Identify a relevant problem and design experiments to be carried out. Analyse the results using a software package like R, Minitab, Design Expert, Python etc. and establish the results between the dependent and independent variables.)

Course based task/ Quiz: 10 Marks

Test paper: 10 Marks

(Test paper shall include minimum 80% of the syllabus.)

End Semester Examination Pattern: 60 Marks

The end semester examination will be conducted by the University for Core Courses. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question paper:

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY SECOND SEMESTER M.TECH DEGREE EXAMINATION			
MECHANICAL ENGINEERING			
222TME100: DESIGN OF EXPERIMENTS			
Max. Marks: 60			Duration: 2.5 Hours
PART A			
		Answer all the questions. Each question carries 5 *marks*	Marks
1		Following data refer to 6 observations on natural frequency (in Hertz) of beams subjected to a load in an experiment: 230.66, 233.05, 232.58, 229.48, and 232.58. Construct a 90% confidence interval for the data.	(5)
2		A cement manufacturer claims that the mean settling time of his cement is not more than 45 minutes. A random sample of 20 bags of cement selected and tested showed an average settling time of 49.5 minutes with a standard deviation of 3 minutes. Test whether the company's claim is true. Use 5 % level of significance.	(5)
3		Describe the roles of randomization, replication and blocking in experimental design.	(5)
4		What are the model adequacy checks generally carried out in a factorial experimental design?	(5)
5		What are the advantages and limitations of fractional factorial designs?	(5)
PART B			
Answer any five full questions. Each question carries 7 *marks.*			
6	(a)	The following data refer to the weights of 10 students (kg) in a class: 63, 64, 59, 58, 65, 70, 56, 68, 60 and 62. Construct a normal probability plot of the data. Does it seem reasonable to assume that the students' weight is normally distributed?	(4)
	(b)	The following data refer to the number of sales of cakes on different days in a season. Represent the data as a box plot. 54, 60, 65, 66, 67, 69, 70, 72, 73, 75, 76	(3)

7	Fifteen adults between the ages of 35 and 50 participated in a study to evaluate the effect of diet and exercise on blood cholesterol levels. The total cholesterol was measured for each person initially, and then three months after participating in an aerobic exercise program and switching to a low-fat diet. The blood cholesterol level data are shown in the following table.	(7)
8	An agricultural officer wants to study the effect of four different fertilizers on the yield (in tons) of a specific crop. Since there might be variability from one plot to another plot, he decides to use the randomized complete block design. The data are presented in the table. Test whether the type of fertilizer used has significant effect on the yield of the crop.	(7)

Subject	1	2	3	4	5	6	7	8	9	10	11	12
Before	265	240	258	295	251	245	287	314	260	279	283	240
After	229	231	227	240	238	241	234	256	247	239	246	218

Plot	**Fertilizer**			
	A	B	C	D
1	100	150	120	70
2	80	70	110	100
3	68	90	85	78
4	125	138	60	124

9		An oil company wants to test the effect of four different blends of gasoline (A, B, C, D) on fuel efficiency. The company has used four cars for testing the four types of fuel. To control the variability due to cars and drivers, Latin square design has been used. The collected data from the experiment is shown in the table below. Analyse the data and test whether the four blends of gasoline, cars and the drivers significantly affect the fuel efficiency.	(7)

Driver	Cars			
	I	II	III	IV
1	D = 15.5	B = 33.9	C = 13.2	A = 29.1
2	B = 16.3	C = 26.6	A=19.4	D = 22.8
3	C = 10.8	A = 31.1	D = 17.1	B = 30.3
4	A = 14.7	D = 34.0	B = 19.7	C = 21.6

10		The yield of a chemical process is being studied. The two most important variables are thought to be the pressure and temperature. Three levels of each factor are selected, and a factorial experiment with two replicates is performed. The yield data are given in the table below. Analyse the data and	(7)

Temperature (^oC)	Pressure (psi)		
	200	215	230
150	90.4	90.7	90.2
	90.2	90.6	90.4
160	90.1	90.5	89.9
	90.3	90.6	90.1
170	90.5	90.8	90.4
	90.7	90.9	90.1

draw conclusions. Use $\alpha = 0.05$

11		A 2^3 factorial design was used to develop a nitride etch process on a plasma etching tool. The design factors are the gap between the electrodes (A), the gas flow (B), and the power applied to the cathode (C). Each factor is run at two levels, and the design is replicated twice. The response variable is the	(7)

etch rate for silicon nitride. The data are given in the table below. Analyse the data to identify the significant factors and interactions.

Coded factors			**Etch rate**	
A	**B**	**C**	**Replication 1**	**Replication 2**
-1	-1	-1	550	604
1	-1	-1	669	650
-1	1	-1	633	601
1	1	-1	642	635
-1	-1	1	1037	1052
1	-1	1	749	868
-1	1	1	1075	1063
1	1	1	729	860

12 The yield of a melting furnace in a foundry is suspected to be affected by the temperature 'T' and melting time 'M'. The data of this experiment with one replication in different treatment combinations are summarized in the table below. Further, five replications are taken at the centre point. Fit a first order response surface for this problem to determine the optimum settings for the temperature and melting time at a significance level of 0.05. (7)

		Melting time	
		60 min.	66 min.
Temperature	400°C	75	77
	410°C	80	84
Centre point replications	1	79	
	2	78	
Temperature (405°C)	3	76	
	4	79	
Melting time (63	5	80	

Syllabus:

Module 1

Introduction to Design of Experiments: One factor at a time experiments and designed experiments; Role of DoE in experimentation. Application of software packages for designing experiments.
Basic statistical concepts: Probability distributions; pdf and cdf; mean and variance. Normal and Student's *t* distributions; Normal probability plot. Tables and charts to represent data; Stem and leaf; Box plot; Pareto chart.
Sampling distribution of the mean: Central Limit Theorem. Constructing Confidence Intervals for a single mean, variance, and difference of two means.

Module 2

Hypothesis Testing: Hypothesis testing of single means. Testing of two means - with known and unknown population variance. Paired t-test. Testing of variances. Analysis of Variance (ANOVA).

Module 3

Single Factor Experiments: Completely randomized design. Replication, Randomization, Blocking. Randomized complete block design. Latin square design.

Model adequacy checking: Residual plots.

Module 4

Factorial experiments: Two and three factors full factorial experiments. 2-level full factorial experiments. Effects and contrasts; Yate's algorithm. Single replicate case. Addition of central points to the 2^k design. Blocking and confounding in the 2^k factorial design.

Module 5

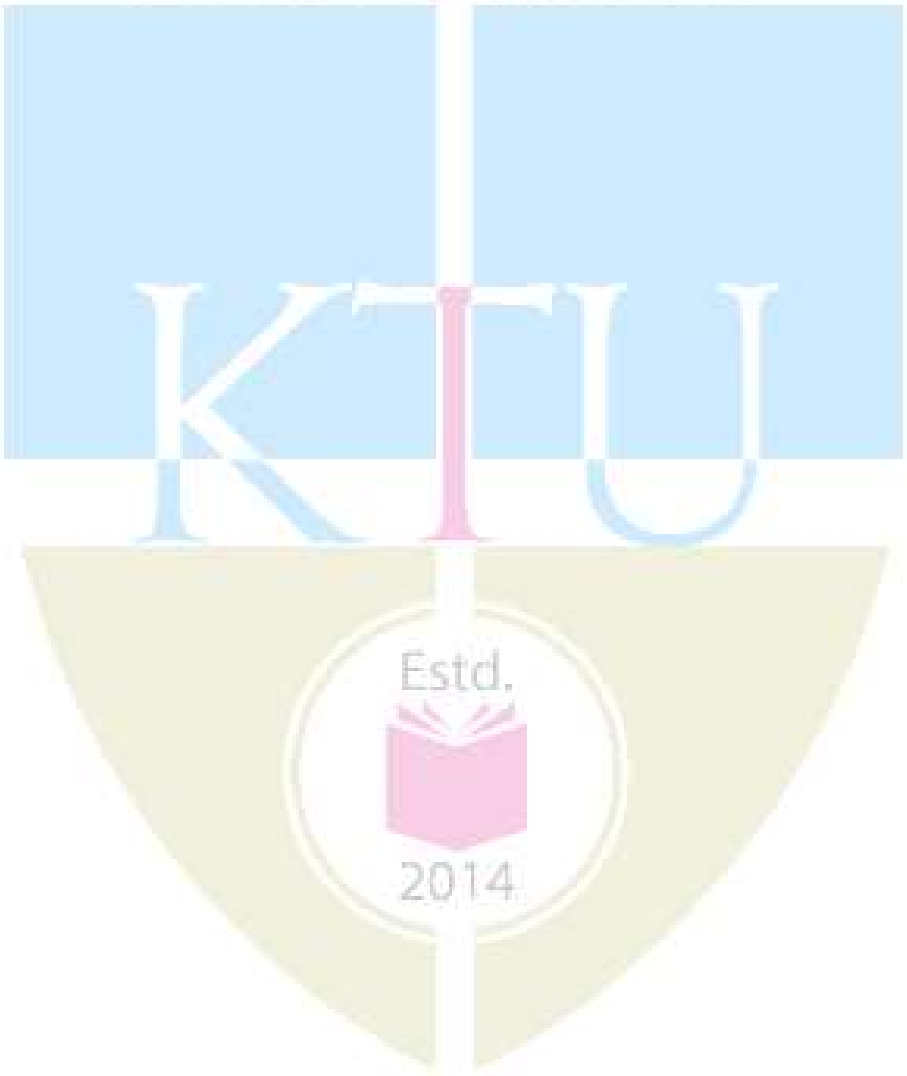
Fractional Factorial Experiments: 2-level fractional factorial design. One-half fraction of the 2^k design. Alias structures in fractional factorial designs; Confounding; Design resolutions.
Response Surface Methodology: Central Composite Design.

Course Plan

No.	Topic	No. of Lectures
1	**Introduction to Design of Experiments**	
1.1	One factor at a time experiments and designed experiments; Role of DoE in experimentation.	1
1.2	Application of software packages for designing experiments.	1
1.3	Basic statistical concepts; Probability distributions; pdf and cdf; mean and variance.	1
1.4	Normal and Student's *t* distributions; Normal probability plot.	1
1.5	Tables and charts to represent data; Stem and leaf; Box plot; Pareto chart.	1
1.6	Sampling distribution of the mean; Central Limit Theorem.	1
1.7	Constructing Confidence Intervals for a single mean, variance, and difference of two means.	2
2	**Hypothesis Testing**	
2.1	Hypothesis testing of single means.	2
	Testing of two means - with known and unknown population variance.	2
2.2	Paired t-test.	1
2.3	Testing of variances.	1
2.4	Analysis of Variance.	2
3	**Single Factor Experiments**	
3.1	Completely randomized design.	2
3.2	Replication, Randomization, Blocking.	1
3.3	Randomized complete block design.	2
3.4	Latin square design.	1
3.5	Model adequacy checking; residual plots.	2
4	**Factorial experiments**	
4.1	Two and three factors full factorial experiments.	2
4.2	2^k full factorial experiments.	2
4.3	Effects and contrasts; Yate's algorithm.	1
4.4	Single replicate case.	1
4.5	Addition of central points to the 2^k design.	1
4.6	Blocking and confounding in the 2^k factorial design.	1
5	**Fractional Factorial Experiments**	
5.1	2-level fractional factorial design.	2
5.2	Alias structures in fractional factorial designs; Confounding; Design resolutions.	2
5.3	Response Surface Methodology.	2
5.4	Central Composite Design.	2

Reference Books

1. Montgomery, D. C. (2001). Design and analysis of experiments, John Wiley, New York.
2. Montgomery, D. C. & Runger, G. C. (2007). Applied Statistics and Probability for Engineers, John Wiley, New York.
3. Krishnaiah, K. & Shahabudeen, P. (2012). Applied Design of Experiments and Taguchi Methods, PHI, New Delhi.
4. George, E. P., et al. (2005). Statistics for experimenters: design, innovation, and discovery, John Wiley, New York.
5. Panneerselvam, R. (2012), Design and Analysis of Experiments, PHI, New Delhi



222TME002	ENERGY AUDIT AND MANAGEMENT	CATEGORY	L	T	P	CREDIT
		PROGRAM CORE	3	0	0	3

Preamble:

To impart knowledge about energy cost saving methods and energy audit.

Course Outcomes:

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

CO 1	Explain the importance of energy management in industry and identify energy cost reduction methods in industries.
CO 2	Identify the energy saving opportunities in boiler and steam distribution systems
CO 3	Identify the energy saving opportunity in HVAC
CO 4	Identify and implement energy saving opportunities in Motor and lighting systems
CO 5	Prepare energy audit reports
CO 6	Perform economic analysis in energy management scenario

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	2			2	2		
CO 2				2			
CO 3				2			
CO 4				2			
CO 5		3			3		
CO 6					3		3

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	50%
Analyse	40%
Evaluate	10%

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Micro project/Course based project: 20 marks

Course based task/Seminar/Quiz: 10 marks

Test paper 1 no: 10 marks

The project shall be done individually. Group projects are not permitted. Test paper shall include a minimum of 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the University. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum of one question from each module of which the student shall answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

Model Question paper

QP CODE:

Reg. No:_____
Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY SECOND SEMESTER M.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: 222TME002

Course Name: **Energy Audit and Management**

Max. Marks: 60 Duration: 2.5 Hrs

Part A

Answer all questions. Each question carries 5 marks

1. List any five instruments required for conducting an energy audit and mention its use.
2. Identify the various methods for energy savings in a boiler
3. Explain different types of electrical energy tariffs
4. Explain EER of a refrigerator
5. What is meant by a simple payback period? Calculate a simple payback period for a boiler that costs Rs.75.00 lakhs to purchase and Rs.5 lakhs per year on an average to operate and maintain and is expected to annually save Rs.30 lakhs?

Part B

Answer any 5 full questions. Each question carries 7 Marks

6. Explain preliminary and detailed energy audit
7. Steam required for a process is 6 TPH at 10 bar. The constituents in a fuel are Carbon-84%, Hydrogen-11 %, Oxygen-1%, Sulphur-2% and ash 2%.Specific heat of flue gas-0.27 kCal/kg. Calorific value of fuel-10000 kCal/kg. Specific heat of super heated water vapour is 0.45 kCal/kg ^{o}C. Percentage of oxygen in flue gas is 6%.Flue gas temperature is 240 ^{o}C and ambient temperature 30 ^{o}C .Radiation and other losses are 2%.Calculate efficiency of boiler by indirect method
8. How do you evaluate the performance of an HVAC system? Explain energy saving opportunities in the HVAC system.

9. In a refrigeration plant the chilled water flow rate is 180 m^3/h. Temperature rise of chilled water after picking the refrigeration load is 4^oC.Water flow rate through the condense is 320 m^3/h and temperature rise of condenser water is 10 ^oC .Find refrigeration load and condenser load in Tonnes of refrigeration

10. A paper manufacturing company has a contract demand of 5000 kVA with the power supply company. The average maximum demand of the plant is 3850 kVA/month at a power factor of 0.95. The maximum demand is billed at the rate of Rs.500/kVA/month. The minimum billable maximum demand is 75% of the contract demand. An incentive of 0.5% reduction in energy charges component of the electricity bill is provided for every 0.01 increase in power factor over and above 0.95. The average energy charge component of the electricity bill per month for the plant is Rs. 20lakhs. The plant decides to increase the power factor to unity by installing capacitor banks. Find the annual reduction in demand component charges and energy component charges? Find the kVAR required to improve the power factor from 0.95 to unity?

11. With schematic diagram explain any two types of co-generation systems

12. Calculate NPV of a project which is having following cash flows.Assume a discount rate is 8%

Investment	Rs.100000
Year	Cash flow in Rs.
1	20000
2	20000
3	30000
4	30000
5	30000

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**General Principle of Energy management**	
1.1	General principles of Energy conservation and management	1
1.2	Energy Conservation Acts –Role of BEE Energy audit definition, need, types of energy audit	1
1.3	Preliminary and detailed audit	1
1.4	Energy audit Instruments	1
1.5	Energy audits reports -Case study	2
1.6	Financial techniques-CUSUM technique.	2
2	**Boilers and steam distribution systems**	
2.1	Types of boilers	1
2.2	Combustion in boilers, types of fuels, Stoichiometry	1
2.3	Performance evaluation of boiler	1
2.4	Feed water treatment and blowdown process	1
2.5	Energy conservation opportunities in boilers	1
2.6	Assessment of steam distribution losses, Steam leakages, Steam trapping,	2
2.7	Classifications of waste heat recovery systems	1
2.8	Cogeneration system and types of cogeneration(Concept only)	1
3	**Refrigeration, HVAC and Waste heat recovery systems**	
3.1	HVAC system and its working	1
3.2	Coefficient of performance calculations	1
3.3	Factors affecting Refrigeration and Air conditioning system performance	1
3.4	Energy saving opportunities in refrigeration and air conditioning, EER and SEC evaluation	2

3.5	Types and applications of cooling towers, basics and performance analysis	2
4	**Energy management in Electrical systems**	
4.1	Energy management planning with case study in Electrical systems	2
4.2	Types of Industrial Loads, Types of electrical tariffs	1
4.3	Peak Demand controls, Methodologies	2
4.4	Role of Power factor in industries and role of power factor improvements –calculations	2
4.5	Energy management opportunities in Lighting and Motors	1
5	**Economic evaluations**	
5.1	Cash flow studies	1
5.2	Pay-back method(Numerical Problems)	1
5.3	Average rate of return method (Numerical problems)	1
5.4	Internal rate of return method(Numerical Problems)	2
5.5	present value method(Numerical Problems)	1
5.6	life cycle costing approach with case study	2

Reference Books

1. Albert Thumann, William J. Younger, Handbook of Energy Audits, CRC Press, 2003.
2. Charles M. Gottschalk, Industrial energy conservation, John Wiley & Sons, 1996.
3. Craig B. Smith, Energy management principles, Pergamon Press.
4. D. Yogi Goswami, Frank Kreith, Energy Management and Conservation Handbook, CRC Press, 2007
5. G.G. Rajan, Optimizing energy efficiencies in industry -, Tata McGraw Hill, Pub. Co., 2001
6. IEEE recommended practice for energy management in industrial and commercial facilities,
7. M Jayaraju and Premlet, Introduction to Energy Conservation And Management, Phasor Books, 2008

8. Paul O'Callaghan, Energy management, McGraw Hill Book Co. 10. Wayne C. Turner, Energy management Hand Book - - The Fairmount Press, Inc., 1997.
9. Wayne C. Turner, Energy management Hand Book - - The Fairmount Press, Inc., 1997.
10. Bureau of energy efficiency website (BEE India handouts)

PROGRAM ELECTIVE III

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EME012	BUILDING MANAGEMENT SYSTEM	PROGRAM ELECTIVE 3	3	0	0	3

Preamble:

A building management system (BMS) is an effective tool for monitoring and optimizing the facility systems of a building. The major aim of the BMS is to ensure safety and efficient operation of the mechanical, electrical and electromechanical services in a facility. Such services can include power, heating, ventilation, air-conditioning, and physical access control, pumping stations, elevators and lights. This Course provides a simple understanding of components and design features of a building management system. Ideally suited to those with a little or no knowledge of the subject.

Course Outcomes:

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

CO 1	Understand the components of building management system.
CO 2	Understand the monitoring the equipment's functions.
CO 3	Understand the functioning of the equipment coming under BMS
CO 4	Understand the controls pertaining to BMS.
CO 5	Understand the logical sequencing of equipment coming under BMS

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1						2	
CO 2						2	
CO 3						2	
CO 4						3	
CO 5						2	

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	25% (roughly)
Analyse	25% (roughly)
Evaluate	50% (roughly)
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred)	**15 marks**
Course based task/Seminar/Data collection and interpretation	**15 marks**
Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus)	**10 marks**

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

The marks obtained for the ESE for a programme elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each programme elective course shall be normalized accordingly. For example, if the average end semester mark % for a core course is 40, then the maximum eligible mark % for a programme elective course is 40+20 = 60 %.

Model Question Paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SECOND SEMESTER M.TECH. DEGREE EXAMINATION

222EME012– BUILDING MANAGEMENT SYSTEM

Max. Marks: 60 **Duration: 2.5 Hours**

Part A

(Answer *all* questions – each question carries 5 marks)

1) What are the components of the BMS?
2) List out different types of valves used in cooling water circuit
3) What are the control points for the automatic controls for central cooling and/or heating plants?
4) Explain the working principle of a beam detector.
5) Explain schematically the communication between three devices using different protocols.

(5 x 5 =25 marks)

Part B

(Answer *any* 5 questions – each question carries 7 marks)

6) Explain the working of a Variable-Air-Volume System with Reheat and Induction and Fan-Powered Devices.
7) Schematically lay out a combination air–water system where fan–coil units in each room are used for heating with related equipment. Discuss the general method of control for (a) the supplied air and (b) the fan–coil units.

8) Explain in detail the procedure for selection and location of supply air outlets in centralized air conditioning system

9) Find the heat transfer rate required to warm 42.5 m3/min of air at 15^0C and 90 percent relative humidity to 45^0C without the addition of moisture.

10) Explain different types of Automatic Fire Alarm Systems along with different modes of control.

11) Classify fire. Explain the methods used for fire detection.

12) Explain how the space utilization matrices are useful in building management system.

(5 x 7 =35 marks)

Syllabus

Module	Content	Hours
1	Introduction to Building management system- sub systems, Functions of Building Management, Subsystems, Properties of air, Psychrometric processes, Heating, cooling, Cooling and dehumidification, Heating and humidification. Components of HVAC- Air handling systems	8
2	Chillers and cooling towers - Flooded chillers, Direct expansion (DX) chillers, Package chillers. Different types. ASHRE standards. Cooling towers- Open-circuit cooling towers, Closed-circuit towers. Boiler- Hot water boilers, Steam boilers, Fire tube, water tube and Thermal liquid boilers. Types of pumps- Centrifugal pumps, different types of valves. Fans - Variable speed control fans. Motors- Variable speed control motors, Variable-frequency drive (VFD) controller, Relays and transducers	8
3	Controls of HVAC- Control loops, Control modes, Two-position controllers, Modulating controllers. Control valves., Wheatstone bridge, Thermostats, Humidistats, Pressure switches, Evaporator pressure regulation valves, Shut off valves. General concept of System and Equipment Selection, Pressure sensors, Condenser pressure regulators, Check valves VFD in chillers. Sequencing of chillers	8

	Ventilation- Types, Demand-controlled ventilation (DCV), Displacement ventilation (DV), Local exhaust ventilation, Factors affecting energy use in building	
4	Fire detection systems Fire- Classes of fire, Fire protection- Emergency Lighting System, Escape Lighting, Escape Route, Fire detection equipment - Heat Detectors. Fire Detection and Alarm Systems (Automatic Fire Alarm Systems). Multi criteria detector, Beam detector	**8**
5	Building automation system. Principal architecture of a building automation system, Field level, Automation level, Primary and secondary network, Building automation protocols- Internet Protocol, Modbus, BACnet, KNX. Communication between different protocols. Intelligent building- Key issues, Integrated Building Management System (IBMS)	**8**

Course Plan

No	Topic	No. of Lectures
1	Introduction to Building management system- sub systems	
1.1	Building management system -Components of building management system. Hardware, Software, networking protocols. Functions of Building Management, Subsystems. Properties of Air -Humidity ratio, relative humidity, degree of saturation, DPT, DBT, WBT, Enthalpy of moist air Problems using psychrometric chart.	3
1.2	Psychrometric processes- Adiabatic saturation, Heating, cooling, Cooling and dehumidification, Heating and humidification, analysis of cooling and heating coil- by pass factor, adiabatic humidification, mixing of air streams. Principles of refrigeration. Vapor compression and vapour absorption refrigeration systems, Components of refrigeration system. Split and window air conditioners, unitary systems.	2
1.3	Components of HVAC- Air handling systems, Single zone and multi zone AHU, Variable-volume AHU, Package Air-Handling Units, Built-up (Field-Assembled) AHU. Different types of fans- Centrifugal and axial fans. Air movement parameters. - Induction ratio, Entrainment, Throw, Drop. Diffusers- Different types, Dampers, Damper flow characteristics Variable-volume air-handling system	3
2	Chillers	
2.1	Chillers - Flooded chillers, Direct expansion (DX) chillers, Package chillers. Chilled water-cooling loop, Open loop and closed loop systems, ASHRE standards. Chilled water-cooling systems- Air cooled and water-cooled chillers. Vapor Compression chillers and absorption chillers, Different types of absorption chillers- Indirect-fired, single-effect absorption chillers, Indirect-fired, double-effect absorption chillers, The direct-fired absorption chiller.	3

2.2	Cooling towers- Open-circuit cooling towers, Closed-circuit towers . Boiler- Hot water boilers, Steam boilers, Fire tube, water tube and Thermal liquid boilers,. Types of pumps- Centrifugal pumps, different types of valves, water hammer, critical flow.	3
2.3	Fans - Variable speed control fans. Motors- Variable speed control motors, Variable-frequency drive (VFD) controller, Relays and transducers,	2
3	Controls of HVAC. -	
3.1	Control loops, Control modes, Two-position controllers, Modulating controllers.Control valves., Wheatstone bridge, Thermostats, Humidistats, Pressure swithes, Evaporator pressure regulation cvalves, Shut off val;ves. General concept of equipment selection, Criteria for System and Equipment Selection, Pressure sensors , Condenser pressure regulators, Check valves,	3
3.2	Cooling load regulation, Control system for outside air with VAV, building automation systems (BAS) to supervisory control and data acquisition (SCADA) systems, Computer-Based Controls,. Energy management and control system, Energy management and control system, field interface device (FID), Direct digital controller.	3
3.3	VFD in chillers. Sequencing of chillers, Heat Recovery and application. Ventilation- Types, Demand-controlled ventilation (DCV), Displacement ventilation (DV), Local exhaust ventilation, Factors affecting energy use in building	2

4	Fire detection systems	
4.1	Fir- Classes of fire, Fire protection- Emergency Lighting System, Escape Lighting, Escape Route, Fire detection equipment - Heat Detectors, Fixed temperature detectors, Point detectors, Line detectors- Different types of heat detectors- RoR detector	3
4.2	Fire Detection and Alarm Systems (Automatic Fire Alarm Systems). Smoke detectors, Flame detectors, Multi criteria detector, Beam detector.	2
4.3	Fire alrm control panel- conventional types, Analogue addressable fire alarm. Contol and monitor modules, Alarm indicators, Loops and zones in control panel. Obscuration, sensitivity, Fault tolerancve	3
5	Building automation system	
5.1	Principal architecture of a building automation system, Field level, Automation level, Primary and secondary network , Building automation protocols- Internet Protocol, Modbus, BACnet, KNX. Communication between different protocols	3
5.2	Lighting- Design for optimal Day lighting, Daylight Modelling, Integrating with Building Automation System, BEMS, Daylight Simulation Model	2
5.3	Intelligent building- Key issues, Integrated Building Management System (IBMS), Space utilization analysis, space utilization metrics- Capacity and occupancy, Overall/space-specific utilization, Cost per head/seat, shared workspacel vs a collaborative workspace, Shared workspaces vs Coworking spaces	3

Reference Books

1. Ronald H. Howell William J. Coad Harry J. Sauer, Jr.: Principles of heating ventilating and air conditioning, ASHRAE, 2013.
2. Roy J. Dossat and Thomas J. Horan, Principles of Refrigeration, Pearson

3. Croome, D.J. and Roberts, B.M., Air conditioning and ventilation of buildings, Pergamon.

4. Steven T. Taylor, P.E. Ross Montgomery, Robert McDowall , Eng.Fundamentals of HVAC Control Systems, ELSEVIER.

5. NJATC, Building Automation: Control Devices and Applications by Njatc
6. Building Control Systems, Butterworth-Heinemann,

Additional reading:

1. .Hermann Merz, Thomas Hansemann, Christof Hubner, Building automation, Springer

2. ASHRAE Handbook – HVAC Systems and Equipment, American Society of Heating, Refrigerating and Air-Conditioning Engineers Inc., Atlanta, USA, 2008.

3. Abrams, D. W., Low Energy Cooling – A guide to the practical application of passive cooling and cooling energy conservation measures, Van Nostrand Reinhold Company, New York, 1985

4. Adam Khafagy, Building management system.

5. Robert O Connor Ceng, Building management system explained

222EME013	EMERGING REFRIGERATION TECHNOLOGIES	Category	L	T	P	Credit
		PROGRAM ELECTIVE 3	3	0	0	3

Preamble: This Course provides a simple understanding of Refrigeration fundamentals and also provides an insight about the recent developments in the field of refrigeration. Ideally suited to those with a little or no knowledge of the subject.

Course Outcomes:

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

CO 1	To understand the basics of refrigeration
CO 2	To understand the working of vapour compression refrigeration systems and suggest methods for improving performance.
CO 3	To understand the working of multi-evaporator systems
CO 4	To understand the types and properties of refrigerants
CO 5	To understand the working of air, vapour absorption, and Magnetic refrigeration systems.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	2	-	2	3	3	-	-
CO 2	2	-	2	3	3	-	-
CO 3	2	-	2	3	3	-	-
CO 4	2	-	2	3	3	-	-
CO 5	2	-	2	3	3	-	-

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	25% (roughly)
Analyse	25% (roughly)
Evaluate	50% (roughly)
Create	-

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred)	**15 marks**
Course based task/Seminar/Data collection and interpretation	**15 marks**
Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus)	**10 marks**

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question Paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER M.TECH. DEGREE EXAMINATION

222EME013 - EMERGING REFRIGERATION TECHNOLOGIES

Max. Marks: 60 **Duration: 2.5 Hours**

Part A
(Answer *all* questions – each question carries 5 marks)

1) What is the unit of refrigeration and how is it defined?
2) Why super heating and sub cooling is preferred in vapour compression cycle?
3) What is the necessity of multi-evaporator systems in refrigeration?
4) How refrigerants are designated?
5) What is magneto-caloric effect?

(5 x 5 =25 marks)

Part B
(Answer *any* 5 questions – each question carries 7 marks)

6) Carnot refrigeration cycle absorbs heat at 270 K and rejects heat at 300 K.

   (a) Calculate the coefficient of performance of this refrigeration cycle.

   (b) If the cycle is absorbing 1130 kJ/min at 270 K, how many kJ of work is required per second.

   (c) If the Carnot heat pump operates between the same temperatures as the above refrigeration cycle, what is the coefficient of performance.

   (d) How many kJ/min will the heat pump deliver at 300 K if it absorbs 1130 kJ/min at 270 K.

7) A cold storage plant is required to store 20 tonnes of fish. The fish is supplied at a temperature of 30°C. The specific heat of fish above freezing point is 2.93 kJ/kg K. The specific heat offish below freezing point is 1.26 kJ/kg K. The fish is stored in cold storage which is maintained at – 8°C. The freezing point of fish is – 4°C. The latent heat of fish is 235 kJ/kg. If the plant requires 75 kW to drive it, find

   (a) The capacity of the plant, and

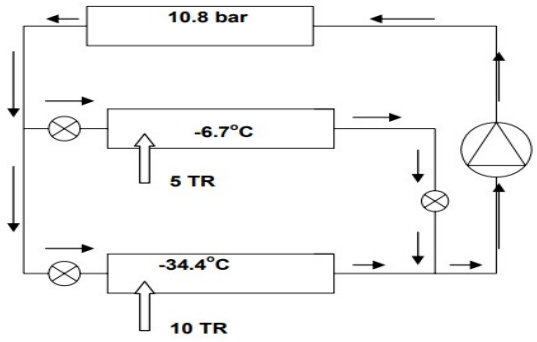
(b) Time taken to achieve cooling.

Assume actual C.O.P. of the plant as 0.3 of the Carnot C.O.P.

8) A refrigeration machine using R-12 as refrigerant operates between the pressures 2.5 bar and 9 bar. The compression is isentropic and there is no undercooling in the condenser. The vapour is in dry saturated condition at the beginning of the compression. Estimate the theoretical coefficient of performance. If the actual coefficient of performance is 0.65 of theoretical value, calculate the net cooling produced per hour. The refrigerant flow is 5 kg per minute.

9) A water cooler using R-12 works on the condensing and evaporating temperatures of 26°C and 2°C respectively. The vapour leaves the evaporator saturated and dry. The average output of cold water is 100 kg /hr cooled from 26°C to 6°C. Allowing 20% of useful heat into water cooler and the volumetric efficiency of the compressor as 80% and mechanical efficiency of the compressor and the electric motor as 85% and 95% respectively, find: (i) volumetric displacement of the compressor; and (ii) power of the motor.

10) The figure given below shows a multi-evaporator, vapour compression refrigeration system working with ammonia. The refrigeration capacity of the high temperature evaporator operates at –6.7o C is 5 TR, while it is 10 TR for the low temperature evaporator operating at –34.4o C. The condenser pressure is 10.8 bar. Assuming saturated conditions at the exit of evaporators and condenser, ammonia vapour to behave as an ideal gas with a gas constant of 0.4882 kJ/kg.K and isentropic index (cp/cv) of 1.29, and isentropic compression: a) Find the required power input to compressor in kW b) Find the required power input if instead of using a single compressor, individual compressors are used for low and high temperature evaporators.



Use the data given in the table:

T,°C	P_{sat} (kPa)	h_f (kJ/kg) (sat.liquid)	h_g(kJ/kg) sat. vapour
-34.4	95.98	44.0	1417
-6.7	331.8	169.1	1455
27.7	1080.0	330.4	1485

11) Discuss in detail the desirable properties of refrigerants.

12) With a neat sketch explain the magnetic refrigeration cycle.

(5 x 7 =35 marks)

Syllabus

Module	Content	Hours
1	Introduction to refrigeration systems, methods of refrigeration, units of refrigeration, COP, Carnot Refrigerator – Limitations of Carnot Cycle using Vapour as Refrigerant- Wet compression Vs. Dry compression.	8
2	Vapour compression refrigeration cycle, methods for improving the COP of Vapour compression refrigeration system – Sub cooling by external cooling medium - Sub cooling by liquid vapour heat exchange – Increasing refrigeration effect by flash chamber – de-superheating between stages to decrease work of compression.	8
3	Multi Evaporator Systems – Three evaporators with individual expansion valve and single compressor - Three evaporators, multiple expansion valve and Individual compressors compressor – Three evaporators with multiple expansion valve, compound compression and Flash intercooling .	8
4	Refrigerants – Classification – Halocarbons, Inorganic, and Hydrocarbons - Designation – Desirable properties – Thermodynamic, Chemical, and Physical properties – Secondary refrigerants.	8
5	Vapour absorption refrigeration systems -Ammonia – water, Electrolux, Steam Jet refrigeration. Air Cycle refrigeration – Necessity – application. Introduction to Magnetic refrigeration, magneto-caloric effect, Magnetic Refrigeration Cycle - advantages	8

Course Plan

No	Topic	No. of Lectures
1	**Introduction to Refrigeration**	
1.1	Types of refrigeration systems – unit of refrigeration	3
1.2	Reversed Carnot Cycle – analysis	3
1.3	Limitations of Carnot Cycle using Vapour as Refrigerant-Wet compression Vs. Dry compression.	2
2	**Vapour compression refrigeration cycle**	
2.1	Vapour compression refrigeration cycle - analysis	3
2.2	Methods for improving performance - Sub cooling by external cooling medium - Sub cooling by liquid vapour heat exchange –	3
	Increasing refrigeration effect by flash chamber – de-superheating between stages to decrease work of compression.	2
3	**Multi Evaporator Systems**	
3.1	Need for multistage refrigeration - Three evaporators with individual expansion valve and single compressor -	3
3.2	Three evaporators, multiple expansion valve and Individual compressors compressor	3
3.3	Three evaporators with multiple expansion valve, compound compression and Flash intercooling.	2
4	**Refrigerants**	
4.1	Classification and types	2
4.2	Designation of refrigerants	3
4.3	Desirable properties – Thermodynamic, Chemical, and Physical properties – Secondary refrigerants.	3
5	**Vapour absorption, air and Magnetic Refrigeration**	
5.1	Vapour absorption refrigeration systems -Ammonia – water, Electrolux, Steam Jet refrigeration.	3
5.2	Air Cycle refrigeration – Necessity – application.	2
5.3	Introduction to Magnetic refrigeration, magneto-caloric	3

	effect, Magnetic Refrigeration Cycle – advantages	

Reference Books

1) Arora C.P "Refrigeration and Air conditioning"-Tata Mc Graw Hill, 2021
2) Stoecker W.F "Refrigeration and Air conditioning"-Tata Mc Graw Hill, 2017
3) Gosney W. B "Principles of Refrigeration", Cambridge University Press, 1983
4) Stanley W Angrist "Direct Energy conversions", Allyn & Bacon, 1982
5) HJ Goldsmid, "Thermoelectric Refrigeration", Springer, 1st Ed. 1995

222EME014	POWER SYSTEM MODELING	CATEGORY	L	T	P	CREDIT
		PROGRAM ELECTIVE 3	3	0	0	3

Preamble:

To impart knowledge about the power system components and their control methods.

Course Outcomes:

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

CO 1	Develop the classical model representation of a Synchronous machine.
CO 2	Analyse the performance of Induction machines.
CO 3	Develop the model of Exciter and Prime mover.
CO 4	Model LFC, AGC and AVR for single and two area power systems.
CO 5	Analyse the steady state and transient stability of power system networks.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1		2	2	3	2	2	
CO 2		2	2	3	2	2	
CO 3		2	2	3		2	
CO 4			3	3		2	
CO 5			3	3		2	

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	40%
Analyse	60%
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred)	**15 marks**
Course based task/Seminar/Data collection and interpretation	**15 marks**
Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus)	**10 marks**

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question paper

QP CODE:
Reg. No:_____
Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY SECOND SEMESTER
M.TECH DEGREE EXAMINATION, MONTH & YEAR
Course Code: 222EME014
Course Name: POWER SYSTEM MODELING

Max. Marks: 60 Duration: 2.5 Hrs

PART A

Answer all questions. Each Question Carries 5 marks **Marks**

1. Draw the phasor diagram of a salient pole alternator working at a lagging power factor and derive an expression for the regulation. (5)
2. Derive the expression of induced emf of an induction machine. (5)
3. With necessary figure explain DC1A type exciter. (5)
4. Derive the block diagram representation of generator-load model. (5)
5. Derive the expression for swing equation for a synchronous machine connected to an infinite bus. (5)

PART B

Answer any Five full questions. Each question carries 7 marks

6. Develop the classical model of a synchronous machine. (7)
7. A 6-pole, 50Hz, 3 phase induction motor running on full load develops a useful torque of 150Nm at a rotor frequency of 1.5Hz. Calculate the shaft power output. If the mechanical torque lost in friction is 10Nm, determine a) rotor copper loss b) input to the motor c) the efficiency. The total stator loss is 700W. (7)
8. Develop the classical model of a synchronous machine. (7)
9. Develop the transfer function model of a steam turbine. (7)
10. a) A 100MVA synchronous generator operates on full load at a frequency of 50Hz. The load is suddenly reduced by 50MW. Due to time lag in governor system, the steam valve begins to close after 0.4s. Determine the change in frequency that occurs in this time. Given H = 5kW-s/kVA. (3)

b) Develop the block diagram representation of Load Frequency Control of a single area system. (4)

11. Prove that the maximum permissible sudden increase in load is 72.5% of the steady state limit if the machine is initially at no load. (7)

12. Explain how Equal Area Criterion is used in determining the stability when there is a sudden change in mechanical power input. (7)

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**Synchronous Machine Modelling**	
1.1	Synchronous Machines: basic principles, construction, speed and frequency, synchronous reactance, regulation, induced EMF, basic vector diagram	3
1.2	Basic equations of a synchronous machine, Mathematical description, dq0 transformation, per unit representation	3
1.3	voltage-current and flux linkage equations, Equivalent Circuits for direct and quadrature axes, Classical model	4
2	**Induction Machines**	
2.1	Introduction to Induction Machines: principle of operation, construction, classification	2
2.2	Expression for induced EMF, Torque/slip characteristics, Vector diagram	3
2.3	Losses and efficiency of the machine, related problems.	2
3	**Modelling of Excitation and Prime Mover**	
3.1	Excitation System Requirements, Elements of an Excitation System	2
3.2	Types of Excitation System – IEEE (1992) Type DC1A, AC1A, and ST1A models.	2
3.3	Modelling of Prime movers – Hydraulic turbine transfer function, modelling of steam turbine	2
4	**Load Frequency Control**	
4.1	Turbines and speed governors-inertia	2
4.2	Automatic Generation Control: Load frequency control: single area and two area systems-Numerical Problems	4
4.3	Automatic voltage control -Exciter Control	2
5	**Power System Stability**	
5.1	Power system stability steady state, dynamic and transient stability, power angle curve, steady state stability limit	3
5.2	Mechanics of angular motion - swing equation, Solution of swing equation	3
5.3	Equal area criterion - application, Methods of improving stability limits	3

Reference Books

1. Bimbra P S, Electric Machines, Khanna Publishers, 2ndedition, 2017.
2. Kothari D. P., Nagrath I. J., Electric Machines, Tata McGraw Hill, 5thedition.2017
3. Alexander SLangsdorf, “Theory of Alternating Current Machinery”, Tata McGraw Hill, 2nd revised edition, 2001.
4. Gupta J B, “Theory and Performance of Electrical Machines”, S K Kataria& Sons, 14thedition, 2013.
5. Kundur P., Power system Stability and Control, McGraw Hill, 2006
6. D. P. Kothari and I. J. Nagrath, Modern Power System Analysis, 2/e, TMH, 2009.
7. Soni, M.L., P. V. Gupta and U. S. Bhatnagar, A Course in Electrical Power, Dhanpat Rai& Sons, New Delhi, 1984.
8. Hadi Saadat, Power System Analysis, 2/e, McGraw Hill, 2002.

222EME015	INDUSTRIAL NOISE CONTROL	CATEGORY	L	T	P	CREDIT
		PROGRAM ELECTIVE 3	3	0	0	3

Preamble:

This course covers all aspects of acoustics and noise control right from the very basics. It helps to get an in-depth knowledge about sound measurement techniques, related instruments and existing noise regulations which have a lot of applications in industries.

Course Outcomes:

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

CO 1	Define the fundamental parameters of acoustics.
CO 2	Derive wave equations and find their solutions.
CO 3	Measure sound absorption coefficient and sound transmission loss using impedance tube.
CO 4	Design different types of mufflers.
CO 5	Estimate the noise levels in industries and know different noise criteria and regulations.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3						
CO 2	3						
CO 3	3		3		3		
CO 4	3		3	3	3	3	
CO 5	3		3		3		

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30
Analyse	30
Evaluate	30
Create	10

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) **15 marks**

Course based task/Seminar/Data collection and interpretation **15 marks**

Test paper, 1 no. **10 marks**

(Test paper shall include minimum 80% of the syllabus)

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question Paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SECOND SEMESTER M.TECH. DEGREE EXAMINATION

222EME015 INDUSTRIAL NOISE CONTROL

Maximum Marks: 60 **Duration: 2.5 Hours**

Part – A

Answer all questions, each question carries 5 marks

1. Define acoustic pressure, particle velocity and acoustic intensity
2. Find the directivity factor and directivity index (in the direction $\theta = 0$) of a source of sound that radiates symmetrically with the following pressure distribution $H(\theta) = \sin\theta$
3. Explain the functions of the following instruments: (i) intensity level meter, (ii) dosimeter and (iii) impedance tube
4. What are the design requirements of a muffler?
5. List the various sources of noise in industries.

Part B

Answer any 5 questions, each question carries 7 marks

6. The sound pressure level spectrum around a machine unit is given below.
   Determine the (a) overall sound pressure level and (b) A-weighted sound level

p (Pa)	0.12	0.15	0.16	0.18	0.14	0.16	0.14	0.11
f (Hz)	63	125	250	500	1000	2000	4000	8000
CFA	-26.2	-16.1	-8.9	-3.2	0	+1.2	+1.0	-1.1

7. Derive spherical wave equation from the equation $\frac{\partial^2 p}{\partial x^2}+\frac{\partial^2 p}{\partial x^2}+\frac{\partial^2 p}{\partial x^2}=\frac{1}{c^2}\frac{\partial^2 p}{\partial t^2}$

8. A Helmholtz resonator is constructed of a thin-walled sphere, having an inside diameter of 101.6 mm. The effect of the thickness of the sphere on the acoustic mass may be neglected. What diameter hole should be drilled in the sphere if it is to resonate at a frequency of 320 Hz? The gas in the resonator is air at 300K and 101.3 kPa (density, 1.177 kg/m3; sonic velocity; specific heat ratio, 1.400). What would be the resonant frequency if a hole of twice the diameter as in the previous case were used, instead of the original hole?

9. For a single expansion chamber muffler having the same inlet and outlet tube cross-sectional areas, show that the transmission loss (TL) is given by $TL = 10\ log_{10}\left(1+\frac{1}{4}\left(m+\frac{1}{m}\right)^2 \sin^2 kL\right)$ where k is the wave number, L is the expansion length and m is the area ratio.

10. A propeller fan delivers 297.8 dm3 /s of air against a pressure head of 62.5 Pa (0.25 in H_2O). The fan has 4 blades and operates at 2400 rpm. The blade tone component of the noise from the fan is BT = 6 dB. Noise is radiated from the fan inlet to the outdoors, and there is negligible sound transmitted through the housing. The directivity factor for the fan is Q = 2.455. Determine the octave band sound pressure levels at a distance of 3.162 m from the fan inlet (outdoors). Attenuation by atmospheric air is negligible.

11. A barrier is placed between a transformer (noise source) and the personnel (receiver). The height of the barrier is 3m. The distance between the source and the receiver is 37 m and the receiver is at 27m from the barrier. Following table gives the sound power spectrum

and TL of the transformer. Find the SPL with and without the barrier

f (Hz)	63	125	250	500	1000	2000	4000	8000
Lw (dB)	112	116	110	106	106	100	95	90
TL (dB)	36	38	38	38	38	44	50	56

at the frequency of 500 Hz and 4000 Hz.

12. a) 12. Distinguish between insertion loss and transmission loss
    b) Differentiate between personnel enclosure and source enclosure.

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**Fundamentals of acoustics** Acoustic pressure, acoustic intensity, acoustic energy density, impedance, levels and decibels, combination of decibels, octave bands, weighted sound levels.	
1.1	Acoustic pressure, acoustic intensity, acoustic energy density	2
1.2	Impedance, levels, decibels, combination of decibels	2
1.3	Octave bands	1
1.4	Weighted sound levels	2
2	**Wave equations & solutions** Plane waves, spherical waves, solution, near field, far field, direct field, reverberant field, standing waves, directivity factor and directivity index.	
2.1	Wave equation, plane waves	2
2.2	Spherical waves, solution	2
2.3	Near field, far field, direct field, reverberant field, standing waves	2
2.4	Directivity factor and directivity index	2
3	**Measurements** Microphones, sound level meter, intensity level meter, octave band filters, acoustic analysers, dosimeter, measurement of sound power, measurement in reverberant room, sound transmission and absorption, measurement using impedance tube, acoustic enclosures, acoustic barriers.	
3.1	Microphones, sound level meter, intensity level meter	1
3.2	Octave band filters, acoustic analysers, dosimeter	1
3.3	Measurement of sound power, measurement in reverberant room, sound transmission and absorption, measurement using impedance tube	2
3.4	Acoustic enclosures, acoustic barriers.	1
4	**Mufflers** Design requirements, lumped parameter analysis, Helmholtz resonator, side branch mufflers, expansion chamber mufflers, dissipative mufflers, estimation of attenuation coefficient.	
4.1	Design requirements, lumped parameter analysis	2
4.2	Helmholtz resonator, side branch mufflers	2
4.3	Side branch mufflers, expansion chamber mufflers,	3

	dissipative mufflers	
4.4	Estimation of attenuation coefficient	1
5	**Noise sources & regulations** Fan noise, electric motor noise, noise from gears, pump noise, gas compressor noise, transformer noise, cooling tower noise, valve noise, air distribution system noise, traffic noise, train noise-Noise criteria for interior spaces, day-night level, EPA criteria, HUD criteria, aircraft noise criteria, OSHA regulations.	
5.1	Fan noise, electric motor noise, noise from gears	2
5.2	Pump noise, gas compressor noise, transformer noise, cooling tower noise	2
5.3	Air distribution system noise, traffic noise, train noise	1
5.4	Noise criteria for interior spaces, day-night level, EPA criteria, HUD criteria, aircraft noise criteria, OSHA regulations.	2

Reference Books

1. Barron, Randall F. *Industrial noise control and acoustics*. CRC Press, 2002.
2. Crocker, Malcolm J., ed. *Handbook of noise and vibration control*. John Wiley & Sons, 2007.
3. Williams, Earl G., and J. Adin Mann III. "Fourier acoustics: sound radiation and nearfield acoustical holography." (2000): 1373-1373.

222EME016	ENERGY EFFICIENT BUILDINGS	CATEGORY	L	T	P	CREDIT
		PROGRAM ELECTIVE 3	3	0	0	3

Preamble: Energy management and methods of developing energy efficient buildings

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

CO 1	Develop the methods for establishing energy-efficient buildings.
CO 2	Design green buildings for maximum human comfort
CO 3	Summarize different climatic zones in establishing energy-efficient buildings
CO 4	Describe the concept of energy management in buildings

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1			3		2		
CO 2			3		2		
CO 3			3		2		
CO 4			3		2		

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	40%
Analyse	30%
Evaluate	30%
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred)	**15 marks**
Course based task/Seminar/Data collection and interpretation	**15 marks**
Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus)	**10 marks**

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question paper

QP CODE:

Reg. No:_____

Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SECOND SEMESTER M. TECH DEGREE EXAMINATION, MONTH & YEAR

222EME016 ENERGY EFFICIENT BUILDINGS

Max. Marks: 60 Duration: 2.5 Hrs

Part A

Answer all questions. Each question carries 5 marks

1. Explain the need of modern architectures.
2. Explain the principles of energy conscious building design
3. What are the advances in thermal insulation of buildings? Mention some materials
4. Explain wind tower induced ventilation principle
5. Give some features of building rating procedures in India

Part B

Answer any 5 full questions. Each question carries 7 Marks

6. Mention the methods to provide comfortness in a building exists at Hot and humid climate
7. Explain any two types of day lighting devices
8. A roof slab is made of concrete have size 5mx5m.The heat gain through the slab is 300 W/m^2.Thermal conductivity of concrete is 2.25 W/mK. Thickness of slab is 10 cm. Find the temperature at the bottom of the slab. If the top of the slab is covered with the insulation material having

thermal conductivity 0.023 W/mK and thickness 25 mm. What will be the temperature at the bottom of the slab.

9. With schematic diagram explain passive cooling for thermal comfort
10. With schematic diagram explain earth air tunnel cooling
11. With schematic diagram explain the working principle of nocturnal radiation cooling method
12. Explain the features of acoustical and olfactory comfort

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**MODULE 1**	**8**
1.1	Climate and shelter-historic buildings-Examples from different climate zones	2
1.2	Solar geometry and shading	2
1.3	Conventional building materials and alternatives-future building design aspects	2
1.4	Criticality of resources and needs of modern architecture	2
2	**MODULE 2**	**8**
2.1	Human comfort-Thermal, visual, acoustical and olfactory comfort	2
2.2	Principles of energy conscious building design-building envelope, wall and windows	2
2.3	Energy conservation in buildings-ventilation and its significance	2
2.4	Day lighting devices-water heating systems-photo voltaic systems	2
3	**MODULE 3**	**8**
3.1	Advances in thermal insulation-types of insulation materials-insulation methods-in door and out door	3
3.2	Heat gain and loss through building components-conduction, convection and radiation	3
3.3	Heat transfer due to ventilation and infiltration-internal heat transfer	2
4	**MODULE 4**	**8**
4.1	Passive solar heating-Direct gain-Thermal storage wall-solarium	3
4.2	Passive cooling-ventilation-wind tower-induced ventilation	3
4.3	Nocturnal cooling-evaporative cooling-Earth mass effect design	2
5	**MODULE 5**	**8**
5.1	Roof radiation traps-earth air tunnel-small wind turbines-hybrid system	2
5.2	Control systems for energy efficient buildings-building rating concepts in India and abroad	2
5.3	Case studies on energy conscious buildings	2
5.4	Computer packages for carrying out thermal design of buildings and predicting performance	2

Text Books

1. Clarke, J.A. , Energy Simulation in Building Design ,(2e), Butterworth, 2001.

2. Nayak, J.K. and Prajapati, J.A. , Handbook on Energy Conscious Buildings, Solar Energy Control MNES, 2006.

Reference Books

1. Energy Conservation Building Codes 2006, Bureau of Energy Efficiency.

2. Williams, J.R., Passive Solar Heating, Ann Arbar Science, 1983

3. Jones, R.W. , Balcomb, J.D., Kosiewiez, C.E. , Lazarus, G.S. , McFarland, R.D., and Wray, W.O., Passive Solar Design Handbook, Vol.3, Report of U.S. Department of Energy (DOE/CS0127/3),1982.

4. Sodha, M.S. , Bansal, N.K., Bansal, P.K. ,Kumar, A and Malik, M.A.S., Solar Passive Building, Science and Design, Pergamon Press, 1986

5. Threlkeld, J.L. , Thermal Environmental Engineering, Prentice Hall, 1970.

222EME017	NANOMATERIALS FOR ENERGY APPLICATIONS	CATEGORY	L	T	P	CREDIT
		PROGRAM ELECTIVE 3	3	0	0	3

Preamble:

This course aims to understand the application of nanomaterials in energy application.

Course Outcomes:

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

CO 1	To understand the semiconductor physics behind the nanomaterials
CO 2	To explain the application of nanomaterials for energy applications.
CO 3	To illustrate the use of nano-materials in fuel cell applications.
CO 4	To explain the Synthesis and preparation of nano-materials.
CO 5	To summarize the concepts of nano-materials for solar cells.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	3	2	2			
CO 2	3	3	3	3			
CO 3	3	3	3	2			
CO 4	3	3	2	2		2	
CO 5	3	3	2	2			

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	60
Analyse	30
Evaluate	10
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) **15 marks**

Course based task/Seminar/Data collection and interpretation **15 marks**

Test paper, 1 no. **10 marks**

(Test paper shall include minimum 80% of the syllabus)

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

222EME017 NANO MATERIALS FOR ENERGY APPLICATION

Time: 2.5 hours Max. Marks: 60

PART-A

Answer *all* questions. Each question carries *5 marks*.

1. Explain the operation of solar cell structure with neat sketch.
2. How do thin film solar cells work?
3. What are the types of nano-materials employed in solar cells?
4. How nanoscale catalysts are used to save energy and to increase the industrial productivity?
5. What is nano grinding? How nano-particles are made by grinding?

PART-B

Answer *any five* questions. Each question carries 7 marks

6. Explain in detail about the formation of semiconductor nano structures with neat sketch?
7. With neat sketch explain the structure of amorphous silicon solar cell.
8. Explain the relationship between current density and voltage (J-V) in the solar cells under illumination?
9. Explain in detail about organic-inorganic hybrid solar cells?
10. What is principle behind in Dye Sensitized solar cells? Compare the performance of the same with p-n junction photo voltaic devices?
11. How electrical energy is released from the Acid and Alkaline Electrolyte fuel cells? Explain with necessary chemical equations?
12. Explain the schematic of different stages of sol-gel process.

SYLLABUS

MODULE-I – Semiconductor Physics for Nano-materials

Renewable Energy: Energy conversion process. Introduction to Semiconductor physics, conducting and semiconducting materials, Semiconductor nanostructures, Electronic structure and physical process, material aspect of solar cells

MODULE-II – Solar Cells

Thin film solar cells, Solar cell characteristics and characterization techniques. Nano-, micro-, and poly crystalline and amorphous Si for solar cells, Si deposition techniques.

MODUE-III – Plastic/flexible solar cells

Organic solar cells, Polymer composites for solar cells, p-n junction, Device fabrication and characterization, Nano-materials for solar cells, Dye-sensitized solar cells, Organic-inorganic hybrid solar cells, Current status and future prospects.

MODULE-IV – Fuel Cells

Polymer membranes for fuel cells, Acid/ alkaline fuel cells, design of fuel cells, Carbon Nano-tubes for energy storage, Hydrogen Storage in Carbon Nano-tubes, Use of nano-scale catalysts to save energy and increase the industrial productivity.

MODULE-V – Synthesis and preparation of Nano-materials

Synthesis of bulk nano-structured materials - SolGel processing- bulk and nano composite materials - Grinding - high energy ball milling –injection moulding - extrusion - melt quenching and annealing.

Course Plan

No	Topic	No. of Lectures
1	**Semiconductor Physics for Nano-materials**	
1.1	Energy conversion process.	1
1.2	Introduction to Semiconductor physics	1
1.3	Conducting and semiconducting materials	1
1.4	Semiconductor nanostructures	1
1.5	Electronic structure and physical process	1
1.6	Material aspect of solar cells	1
2	**Solar Cells**	
2.1	Thin film solar cells	1
2.2	Solar cell characteristics and characterization techniques	2
2.3	Nano-, micro-, and poly crystalline and amorphous Si for solar cells	2
2.4	Si deposition techniques	2
3	**Plastic/flexible solar cells**	
3.1	Organic solar cells	1
3.2	Polymer composites for solar cells	1
3.3	p-n junction	1
3.4	Device fabrication and characterization	1
3.5	Nano-materials for solar cells	1
3.6	Dye-sensitized solar cells	1
3.7	Organic-inorganic hybrid solar cells	1
3.8	Current status and future prospects	1
4	**Fuel Cells**	
4.1	Polymer membranes for fuel cells	1
4.2	Acid/ alkaline fuel cells	1
4.3	Design of fuel cells	2
4.4	Carbon Nano-tubes for energy storage	1
4.5	Hydrogen Storage in Carbon Nano-tubes	1
4.6	Use of nano-scale catalysts to save energy and increase the industrial productivity	2
5	**Synthesis and preparation of Nano-materials**	
5.1	Synthesis of bulk nano-structured materials	2
5.2	SolGel processing	2
5.3	Bulk and Nano composite materials	2
5.4	Grinding	1
5.5	High Energy Ball Milling	1
5.6	Injection Moulding	1

5.7	Extrusion	1
5.8	Melt Quenching and Annealing	2

Text Books:

1. Hand book of Batteries and fuel cells, Linden, McGraw Hill, 1984.
2. Organic Photovoltaics – Materials, Device Physics and Manufacturing Technologies, (eds. C. Brabec, V. Dyakonov, U. Scherf), 2nd Ed., Wiley-VCH, Germany, 2014.
3. C. N. R. Rao, A. Muller, A. K. Cheetham (Eds), The chemistry of nanomaterials: Synthesis,properties and applications, Wiley VCH VerlagGmbh& Co, Weinheim, 2004.

References:

1. Solar cells: Operating principles, technology and system applications by Martin A Green,Prentice Hall Inc, Englewood Cliffs, NJ, USA, 1981.
2. Semiconductor for solar cells, H J Moller, Artech House Inc, MA, USA, 1993.
3. Solid state electronic device, Ben G Streetman, Prentice Hall of India Pvt Ltd., New Delhi 1995
4. Hand book of Batteries and fuel cells, Linden, McGraw Hill, 1984.
5. W. Gaddand, D. Brenner, S. Lysherski and G. J. Infrate (Eds), Handbook of nanoscience, Engg. and Technology, CRC Press, 2002.
6. G. Cao, Naostructures and Nanomaterials: Synthesis, properties and applications, Imperical College Press, 2004.
7. Jingbiolouise Liu, Sajid Bashir, Advanced Nanomaterials and their applications inRenewable energy, Elsevier, 2015.
8. Tetsuo Soga, Nanostructured Materials for Solar Energy Conversion, Elsevier, 2006.
9. G.A. Nazri and G. Pistoia, Lithium Batteries: Science and Technology, Kluwer Academic Publishers, Dordrecht, Netherlands, 2004.

PROGRAM ELECTIVE IV

222EME018	HEATING VENTILATION AND AIR CONDITIONING	CATEGORY	L	T	P	CREDIT
		PROGRAM ELECTIVE 4	3	0	0	3

Preamble:

Air conditioning and refrigeration is highly significant in the field of technology as it has great impact on the quality of life. Providing a comfortable and healthy indoor environment is a major factor in life today. Air conditioning systems provide year-round control of several air conditions. Hence, they are usually called heating, ventilation and air conditioning. The focus of the Heating, ventilation and air conditioning course is to provide an intensive introduction to HVAC systems and different air conditioning equipment. The content of the course is prepared in conjunction with the ASHRAE standards. It also emphasis to develop student's skills in design of HVAC system.

Course Outcomes:

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

CO 1	Analyse the basic processes in HVAC
CO 2	Understand the functioning of HVAC system
CO 3	Select and design the components of HVAC system.
CO 4	Estimate heating & cooling loads utilizing accepted industry-standard engineering methods.
CO 5	Perform psychrometric analyses to determine loads for heating & cooling systems.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1						2	
CO 2						2	
CO 3						2	
CO 4						3	
CO 5						2	

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	25% (roughly)
Analyse	25% (roughly)
Evaluate	50% (roughly)
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) **15 marks**

Course based task/Seminar/Data collection and interpretation **15 marks**

Test paper, 1 no. **10 marks**

(Test paper shall include minimum 80% of the syllabus)

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question Paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SECOND SEMESTER M.TECH. DEGREE EXAMINATION

222 EME018 – HEATING VENTILLATION AND AIR CONDITIONING

Max. Marks: 60 **Duration: 2.5 Hours**

Part A

(Answer *all* questions – each question carries 5 marks)

1) Illustrate the principle of Winter air conditioning using psychrometric chart.
2) Show the components of an open circuit water cooled HVAC system.
3) What is air distribution performance index? What are the criteria for developing air distribution performance index
4) What is NPSHA for pumps? What is its significance?
5) How the energy input and capacity can be normalized for chiller modelling?

(5 x 5 =25 marks)

Part B

(Answer *any* 5 questions – each question carries 7 marks)

6) In a cooling application moist air enters a refrigerator coil at the rate of 100 kg of dry air per minute at 35^0C and 50% relative humidity. The apparatus dew point of coil is 5^0C and a bypass factor of 0.15. Determine outlet state of moist air.
7) Determine the specific volume, enthalpy, and entropy of 1 kg of R-134a at a saturation temperature of –5°C and a quality of 14%.
8) Explain in detail the procedure for selection and location of supply air

outlets in centralized air conditioning system

9) Explain schematically, different types of valves used in HVAC applications

10) What are the different impeller designs for centrifugal fans in air handling system ? Identify the area of application of each type.

11) In a water-cooled condenser water flows at the rate of 0.5 litres /sec with a temperature rise of 70^0 C. Determine the length of the steel tube required for the counter flow condenser (k= 50 W/m.^{0}C). The inside and outside diameters of the tube are 0.0381m and 0.0444 m respectively. The value of U may be taken as 8.5 W/m^2.^{0}C. The entering temperature of the refrigerant in the condenser is 43^0C and the leaving temperature is 35^0C.

12) . A house has a pitched roof with an area of 159 m2 and a U of 1.6W/(m2·K). The ceiling beneath the roof has an area of 133 m2 and a U of 0.42 W/(m2·K). The attic is unvented in winter for which the design conditions are –19°C outside and 22°C inside. Determine the heat loss through the ceiling.

(5 x 7 =35 marks)

Syllabus

Module	Content	Hours
1	Fundamentals of thermodynamics, , Psychrometry, Psychrometric processes, Psychrometry of air conditioning systems, Indoor air quality, thermal comfort, and weather data . Refrigeration and air-conditioning, Thermodynamics applied to refrigeration systems , Air-conditioning system concepts, Room air conditioners, Centralized air conditioning , Background of HVAC	8
2	Fundamentals of HVAC- Components of HVAC .Types of systems used in HVAC- All air systems, Air and water systems, All water systems, Heat pump systems, Heat recovery systems. Heat pumps, Cogeneration and heat recovery systems,	8
3	Air handling systems- Air handling components, Fans, Selection of fans, Fan performance. Diffusers-Types and Selection. Space air diffusion and duct design.	8
4	Chilled water systems, Types and application of chillers, open loop and closed loop systems, ASHRE standards, Heat exchangers. Hydraulic calculations for pump selection, Valves, pipe design.	8
5	Load estimating fundamentals, Solar Radiations, Infiltration and ventilation, Heating and cooling load calculations in residential and commercial buildings, Hourly analysis program, building energy calculations, Energy auditing for HVAC systems, costing of HVAC systems. Design, analysis and problem solving of HVAC systems using software.	8

Course Plan

No	Topic	No. of Lectures
1	Thermodynamics and pshychrometrics	
1.1	Fundamental concepts and principles, property equations of ideal gas, Different processes- isobaric or constant pressure, isothermal, isochoric, adiabatic and isentropic processes- P-v- t relationships heat transferred and work done, properties -enthalpy, entropy, specific vol;ume, density. Pressure measurement, analysis of mixtures law of additive volumes.	3
1.2	Flow equations- SFEE, SFEE- Heat exchanger, Nozzle- Problems. Moist Air Properties and Conditioning Processes- fundamental parameters- Humidity ratio, relative humidity, degree of saturation, DPT, DBT, WBT, Enthalpy of moist air Problems using psychrometric chart. Psychrometric processes- Adiabatic saturation, Heating, cooling, Cooling and dehumidification, Heating and humidification, analysis of cooling and heating coil- by pass factor, adiabatic humidification, mixing of air streams.	3
1.3	Vapor compression and vapour absorption refrigeration systems, Split and window air conditioners.	2
2	Fundamentals of HVAC.	
2.1	Components and configurations of HVAC. Types of all air systems- Single zone system, Reheat system, Variable volume system, Dual duct system, Multizone system,.	3
2.2	Air and water systems- Air–Water Induction System, Fan–Coil Conditioner System.	2
2.3	All water systems. Decentralized cooling and heating, Heat pump systems, Heat pump types, Heat recovery systems.	3

3	Air handling systems. Diffusers-Types and Selection. Space air diffusion and duct design. Compressors.	
3.1	Components of air handling unit. Different types of fans. Fan law equations, Fan performance. Variable speed control of fans.	3
3.2	Air movement parameters. - Induction ratio, Entrainment, Throw, Drop. Diffusers- Different types and selection. Dampers.	2
3.3	Space air diffusion and duct design. - Pressure changes and losses in ducts. Equivalent diameter. Familiarization of air friction chart. Duct materials.	3
4	Chilled water systems.	
4.1	Chilled water-cooling loop, Open loop and closed loop systems, ASHRE standards. Chilled water-cooling systems- Air cooled and water-cooled chillers. Vapor Compression chillers and absorption chillers, Different types of absorption chillers- Indirect-fired, single-effect absorption chillers , Indirect-fired, double-effect absorption chillers, The direct-fired absorption chiller (Elementary idea only)	3
4.2	Heat exchangers – Classification, Parallel flow, counter flow, cross flow types. Energy balance equation for Heat exchangers LMTD, ASME standards for heat exchangers. Air cooled and water-cooled condenser. - Mass flow rate.	2
4.3	Selection of pumps, Types of pupms. Suction characteristics-NPSHA and NPSHR. Pump performance curves. Series and parallel configuration of pumps- Hydraulic calculation. Pipe materials, pipe fittings, different types of valves.	3
5	Load estimating fundamentals	
5.1	Heat transmission in building structures- Modes of heat transfer- Thermal conduction, R Factor, Thermal properties of building materials (Overview only). Convective heat transfer, ASHRAE standards- Concept of thermal bridge. Heating versus cooling load calculations, Externally and internally loaded buildings, Estimation of external loads-	3

	Heat transfer through opaque surfaces,	
5.2	Heat transfer through fenestration, Heat transfers due to infiltration, Infiltration rate- Air change method, Infiltration rate-crack method. Misc. External loads, Heating vs cooling load calculations,	2
5.3	Internal loads- Load due to occupants, Load due to lighting Load due to equipment and appliances, Estimation of cooling capacity: Load on the system due to ventilated air: Total load on cooling coil.	3

Reference Books

1. Ronald H. Howell William J. Coad Harry J. Sauer, Jr.: Principles of heating ventilating and air conditioning, ASHRAE, 2013.
2. Faye C. McQuiston, Jerald D. Parker, Jeffrey D. Spitler. Heating, Ventilating, and
3. Air Conditioning- Analysis and Design, Sixth Edition, John Wiley & Sons, Inc.
4. Roy J. Dossat and Thomas J. Horan, Principles of Refrigeration, Pearson
5. Croome, D.J. and Roberts, B.M., Air conditioning and ventilation of buildings, Pergamon.

Additional reading:

1. ASHRAE Handbook – HVAC Applications, American Society of Heating, Refrigerating and Air-Conditioning Engineers Inc., Atlanta, USA, 2007.
2. ASHRAE Handbook – HVAC Systems and Equiplents, American Society of Heating, Refrigerating and Air-Conditioning Engineers Inc., Atlanta, USA, 2008.
3. Haines, W.R. and Wilson, C.L., HVAC Systems Design Handbook, McGraw Hill, 2nd Ed., New Delhi, 1994.

4. Legg, R.C., Air Conditioning Systems - Design, Commissioning and maintenance, Batsford Ltd, London 1991.

5. Abrams, D. W., Low Energy Cooling – A guide to the practical application of passive cooling and cooling energy conservation measures, Van Nostrand Reinhold Company, New York, 1985.

222EME019	SAFETY TECHNOLOGY AND MANAGEMENT	CATEGORY	L	T	P	CREDIT
		PROGRAM ELECTIVE 4	3	0	0	3

Preamble:

Industrial safety is important in preventing accidents and losses in industry. This course introduces safety management systems and principles. This course details a systematic approach for hazard identification and risk assessment, and procedures for controlling and monitoring them. Identifying, controlling, and addressing hazards and risk requires inspections and investigations, for which appropriate training and leadership are necessary. The course emphasizes the necessity of leadership involvement to set the tone for a safety-conscious work culture and provide training to develop and maintain this culture.

Course Outcomes:

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

CO 1	Understand and evaluate hazardous conditions and practices in the workplace
CO 2	Formulate hazard control designs, methods, procedures, and programs.
CO 3	Solve safety-related problems using mathematics, chemistry and life sciences, or management techniques.
CO 4	Understand the use of the techniques, skills, and modern scientific and technical tools necessary for professional practice.
CO 5	Apply management tools in implementing safety program in an industrial environment.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1						2	

CO 2						2	
CO 3						2	
CO 4						3	
CO 5						2	

Assessment Pattern

Bloom's Category	**End Semester Examination**
Apply	25% (roughly)
Analyse	25% (roughly)
Evaluate	50% (roughly)
Create	

Mark distribution

Total Marks	**CIE**	**ESE**	**ESE Duration**
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) **15 marks**

Course based task/Seminar/Data collection and interpretation **15 marks**

Test paper, 1 no. **10 marks**

(Test paper shall include minimum 80% of the syllabus)

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis,

evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question Paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SECOND SEMESTER M.TECH. DEGREE EXAMINATION

222EME019– SAFETY TECHNOLOGY AND MANAGEMENT

Max. Marks: 60 **Duration: 2.5 Hours**

Part A

(Answer *all* questions – each question carries 5 marks)

1) Define (i) Accident (ii) Unsafe Conditions (iii) Unsafe act
2) How safety performance indicators are used in safety management?
3) What is safety life cycle?
4) Where do you apply permit to work system?
5) List out the precautions to be taken while moving the materials mechanically?

(5 x 5 =25 marks)

Part B

(Answer *any* 5 questions – each question carries 7 marks)

6) Discuss various approaches to analyse the causation of accidents.
7) Explain the significance of SHE plan. Who is responsible for the preparation of SHE plan? Illustrate the management responsibility clauses in a SHE plan.
8) Explain in detail the procedure for selection and location of supply air outlets in centralized air conditioning system

9) Prepare a plant safety inspection chekist in a gas storage area with appropriate assumptions.

10) Prepare a JSA for lifting a steel column using crane.

11) Classify fire. Explain the methods used for fire detection.

12) What is HAZOP? Explain the phases in a HAZOP study. Prepare a template for a HAZOP study in a computer lab

(5 x 7 =35 marks)

Syllabus

Module	Content	Hours
1	Need for safety - Goals of safety engineering – basic definitions of accident, injury, unsafe act, unsafe condition, dangerous occurrence, reportable accidents - theories and principles of accident causation -cost of accidents	8
2	Indices of safety performance - plant safety inspection - inspection procedures - safety sampling techniques - potential Risk assessment- SHE Plan-product safety – material safety data sheet-total loss control - fire prevention and catastrophe control – fire extinguishers-protective equipments.	8
3	Aims and objectives of first aid - introduction to the body – basic anatomical terms –body cavities – head-cranium – thorax – abdomen and pelvis - management of unconsciousness and shock. Product safety – Cost analysis – Human factors in safety management – Behaviour-based safety. Health and safety management: Safety organization – Safety in System life cycle – HSE policy – Risk management: techniques, strategies and programmes.	8
4	Safety in engineering industry – safe work practice of shop equipment and hand tools - safety in welding – safe use of material handling equipment, excavation safety-work permit system, lifting procedure, work place environmental standards. Construction safety.	8

	Job safety analysis, Permit to work,	
5	Hazard and risk, Hazard identification and quantifications:- Preliminary hazard analysis ,Dow index, Mond's index, HAZOP, Failure mode and effect analysis – FMEA - FMECA – Fault tree analysis- Event tree analysis Bow tie analysis, Risk estimation, Presentation and perception; Individual risk, societal risk, risk estimation, risk representations, Risk targets, tolerability and acceptability, risk perception, risk reduction method	**8**

Course Plan

No	Topic	No. of Lectures
1	Introduction to Safety	
1.1	Need for safety - Goals of safety engineering – basic definitions of accident, injury, unsafe act, unsafe condition, dangerous occurrence. occupational and work-related diseases- levels of prevention of diseases. Methods of Controlling the Work Environment. Causes of unsafe acts.	3
1.2	Reportable accidents, accident reporting. Theories and principles of accident causation - Heinrich's Domino theory, Human Factors Theory, cost of accidents. Prevention and mitigation of accidental chemical releases, General methods for the control of airborne hazards. Personal protective clothing, Respiratory protection	3
1.3	Roles of Stake holders in safety: management, supervisors, workmen, trade unions, government, voluntary organizations etc. – Workers' participation in safety management – Engineering, education and enforcement	2
2	Safety- Planning and procedures	
2.1	Safety indices, Safety performance indicators. Plant safety Inspection- procedures, preparation of check lists. Types of safety inspection- Safety Checklist Inspections, General Knowledge Safety Inspections, Risk mapping safety inspections. safety sampling techniques.	2
2.2	Potential Risk assessment- SHE Plan-responsibility of stake holders. product safety –material safety data sheet-total loss control - fire prevention and catastrophe control –Combustion, Fire resistance, Escape route, classification of gases. Fire extinction, Methods of fire extinguishment. Classification of fires. Triangle and tetrahedron of fire. fire extinguishing agents.	3
2.3	Fire suppression equipment and installation- Fire Detection and Alarm Systems (Automatic Fire Alarm Systems), Fixed Fire Extinguishing Systems, First Aid	3

	Fire Fighting Equipment. Fire extinguishers, Different types of fire extinguishers. Personal protective equipment.	
3	Health and safety management	
3.1	Aims and objectives of first aid - first aid principles - role of the first aider – sequence of action on arrival at scene - vital scenes- breathing – pulse - introduction to the body – basic anatomical terms –body cavities – head-cranium – thorax – abdomen and pelvis - management of unconsciousness and shock.	3
3.2	Product safety – Cost analysis – Human factors in safety management – Behaviour-based safety. Waste product handling, Strategy for waste disposal – Planning the survey – Solid waste disposal – Liquid waste disposal	2
3.3	Health and safety management: Safety organization – Organisational management – Employee awareness Organisational management – Safety in System life cycle – Developing a system safety programme – Closed-loop process – Benchmarking – HSE policy – Risk management: techniques, strategies and programmes.	3
4	Safety in Industry	
4.1	Safety engineering in industry –. safe work practice of shop equipment and hand tools. Safety in materials handling and storage- Potential hazards in Material handling, precautions- manual and mechanical, Precaution- storage hazards, stalking materials, Safety measures for conveyors, cranes, Lifting procedure- Managing lifting procedure, Excavation- definition, types- Open, potholing, pit excavations, trenches and retaining walls, shafts and drives	3
4.2	Safety in welding- Different types of welding- Fusion and pressure welding. Welding hazards- Fires and explosion, Fumes, Electric shock, Gases etc. fumes generated during welding and their effect – WPS and PQR- standards.	2

4.3	Construction safety- Framing of contract conditions on safety, and related matters. Ergonomics in construction safety. working in confined space, Safety in erection and using of scaffold Safety in operation and maintenance of equipment at construction site- vehicles, mobile cranes, tower cranes, lifting gears, hoists & lifts, wire ropes, pulley blocks, mixers, pneumatic and hydraulic tools and heavy equipment. Job safety analysis, permit to work	3
5	Hazard and risk management	
5.1	Hazard and risk, Hazard identification and quantifications: - Preliminary hazard analysis, Dow index, Mond's index, HAZOP,	3
5.2	Failure mode and effect analysis – FMEA - FMECA – Fault tree analysis- Event tree analysis.	2
5.3	Bow tie analysis, Risk estimation, Presentation and perception; Individual risk, societal risk, risk estimation, risk representations, Risk targets, tolerability and acceptability, risk perception, risk reduction method	3

Reference Books

1. Grose,V.L and Englewood Cliffs. "Managing Risk : Systematic Loss Prevention for Executives" , Prentice – Hall, Inc.
2. Russell Dereamer. "Modern Safety and Health Technology", John Wiley,1980.
3. Schilling. "Occupational Health Practice" R.S.F(ed) Boston : Butterworth, 1981.
4. McCormick, E.J. "Human Factors in Engineering and Design",McGraw Hill, 1982.
5. Sam Mannan, Lees' Loss Prevention in Process Industries: Hazard Identification, Assessment and Control (3 Volumes), 4 th Edition, Butterworth-Heinemann, 2012.

Additional reading:

1. Nicholas J. Bahr. System Safety Engineering And Risk Assessment – A Practical Approach: Taylor & Francis, 1997.
2. Jeremy Stanks. The Manager's Guide to Health & Safety at Work, 8 th Edition, Kogan Page Ltd., UK, 2006.
3. K.N. Vaid, Construction Safety Management, NICMAR, Bombay.
4. V.J. Davies and K. Tomasin, Construction Safety Handbook, 2 nd Revised edition, Thomas Telford Ltd.,1996.

221EME020	HYDROGEN AND FUEL CELL TECHNOLOGIES	CATEGORY	L	T	P	CREDIT
		PROGRAM ELECTIVE 4	3	0	0	3

Preamble:

This course provides an in-depth knowledge about the potential of hydrogen as a new source of renewable energy, various methods of production and storage of hydrogen, applications of hydrogen energy in various fields and the working, classification and uses of various types of fuel cells.

Course Outcomes:

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

CO 1	Discuss the properties of hydrogen and its applications
CO 2	Describe various methods of hydrogen production
CO 3	Explain the different methods of hydrogen storage and the safety aspects of hydrogen
CO 4	Explain the working of different types of fuel cells and identify their relative advantages and disadvantages.
CO 5	Discuss the applications of fuel cells

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3		3	2		2	
CO 2	3		3	2		2	
CO 3	3		3	2		2	
CO 4	3		3	2		2	
CO 5	3		3	2		2	
CO 6	3		3	2		2	

Assessment Pattern

Bloom's Category	End Semester Examination (%)
Apply	30
Analyse	30
Evaluate	30
Create	10

Mark distribution

Total Marks	CIE	ESE	ESE Duration

100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred)	**15 marks**
Course based task/Seminar/Data collection and interpretation	**15 marks**
Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus)	**10 marks**

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %.

Model Question paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SECOND SEMESTER M.TECH. DEGREE EXAMINATION

221EME020 HYDROGEN AND FUEL CELL TECHNOLOGIES

Maximum Marks: 60 **Duration: 2.5 Hours**

Part – A

Answer all questions, each question carries 5 marks

1. Discuss the various factors which makes hydrogen an ideal fuel for combustion engine
2. Explain the pyrolysis method of hydrogen production.
3. How liquid state hydrogen can be stored?
4. With the help of a schematic diagram, describe the operation of a fuel cell.
5. Discuss the applications of fuel cells in automobiles.

Part B

Answer any 5 questions, each question carries 7 marks

6. Explain hydrogen sensing using Gas chromatography.
7. How nuclear thermal catalytic method is used for hydrogen production?
8. With the help of a diagram explain how pressure swing adsorption is used for hydrogen separation and purification?
9. How metal hydrides and chemical hydrides are used for hydrogen storage?
10. Explain the working of direct methanol fuel cell.
11. What is electrochemical potential? Compare the performance of a battery and fuel cell.
12. Explain the application of Fuel cell Technology for domestic power systems.

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**Introduction of hydrogen energy systems** Introduction to hydrogen as an element, Physical and chemical properties of hydrogen, Properties of hydrogen as fuel, Hydrogen pathways introduction-current uses, general introduction to infrastructure requirement for hydrogen production, storage, dispensing and utilization, and hydrogen production plants	
1.1	Introduction to hydrogen as an element, Physical and chemical properties of hydrogen	2
1.2	Properties of hydrogen as fuel	2
1.3	Hydrogen pathways: introduction, current uses of hydrogen	2
1.4	General introduction to infrastructure requirement for hydrogen production, storage, dispensing and utilization and hydrogen production plants	2
2	**Hydrogen production processes** Thermal-Steam reformation, thermo chemical water splitting, gasification-pyrolysis, nuclear, thermal catalytic and partial oxidation methods. Electrochemical-Electrolysis, photo electro chemical method.	
2.1	Thermal-Steam reformation	2
2.2	Thermo chemical water splitting	1
2.3	Gasification-pyrolysis	1
2.4	Nuclear, thermal catalytic and partial oxidation methods	2
2.5	Electrochemical-Electrolysis, photo electro chemical method	2
3	**Hydrogen storage and safety** Hydrogen separation and purification-pressure swing adsorption, solvent-based adsorption, membrane separations, cryogenic separation General storage methods, Liquid Hydrogen (LH_2),compressed gaseous hydrogen-composite cylinders, metal hydride storage, carbon based materials for hydrogen storage. Hydrogen safety aspects, backfire, pre-ignition, hydrogen emission NOx control techniques and strategies, Hydrogen powered vehicles	
3.1	Hydrogen separation and purification-pressure swing adsorption, solvent-based adsorption, membrane separations, cryogenic separation	2

3.2	General storage methods, Liquid Hydrogen (LH2), compressed gaseous storage-composite cylinders, metal hydride storage, carbon-based materials for hydrogen storage	2
3.3	Hydrogen safety aspects, backfire, pre-ignition	2
3.4	Hydrogen emission: NOx control techniques and strategies	1
3.5	Hydrogen powered vehicles	1
4	**Fuel Cells** History, Working principle of fuel cells, thermodynamics and kinetics of fuel cell process, performance evaluation of fuel cells, Types of Fuel Cells: AFC, PAFC, SOFC, MCFC, DMFC, relative merits and demerits.	
4.1	History and working principle of fuel cells	2
4.2	Thermodynamics and kinetics of fuel cell process.	2
4.3	Performance evaluation of fuel cells	1
4.4	Types of Fuel Cells: AFC, PAFC, SOFC, MCFC, DMFC	2
4.5	Relative merits and demerits of various types of fuel cells.	1
5	**Application of Fuel Cells** Fuel Cell usage for domestic power systems, large scale power generation, Automobile, environmental analysis. Future trends in fuel cells, portable fuel cells, laptops, mobiles, submarines	
5.1	Fuel Cell usage for domestic power systems, large scale power generation, Automobile and space	3
5.2	Environmental analysis of fuel cell	1
5.3	Future trends in fuel cells	1
5.4	Portable fuel cells, fuel cell for laptops, mobiles and submarines	3

Reference Books

1. Bent Sorensen (Sørensen), Hydrogen and Fuel Cells: Emerging Technologies and Applications, Elsevier, UK (2005).
2. Yurum Yuda, Hydrogen Energy Systems, NATO ASI Series, London
3. Ball M. and Wietschel M., The Hydrogen Economy Opportunities and Challenges, Cambridge University Press (2009).
4. Ryan O'Hayre, SW Cha, W Colella and FB Prinz Fuel Cell Fundamentals, Wiley (2016).
5. Xianguo Li, Principles of Fuel Cells, Taylor & Francis (2005).

221EME021	WASTE MANAGEMENT AND ENERGY RECOVERY	CATEGORY	L	T	P	CREDIT
		PROGRAM ELECTIVE 4	3	0	0	3

Preamble:

This course provides an in-depth knowledge about solid waste and hazardous waste management and various technologies for energy generation from waste.

Course Outcomes:

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

CO 1	Explain the various sources of waste and waste management methods
CO 2	Discuss technologies of waste handling and disposal
CO 3	Describe the potential sources of hazardous wastes and its impact on environment.
CO 4	Explain technologies of energy generation from wastes

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3		2	2	1		
CO 2	3		2	2	1		
CO 3	3		2	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	End Semester Examination (%)
Apply	30
Analyse	30
Evaluate	30
Create	10

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) **15 marks**

Course based task/Seminar/Data collection and interpretation **15 marks**

Test paper, 1 no. **10 marks**

(Test paper shall include minimum 80% of the syllabus)

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %.

Model Question paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SECOND SEMESTER M.TECH. DEGREE EXAMINATION

221EME021 WASTE MANAGEMENT AND ENERGY RECOVERY

Max. Marks: 60 **Duration: 2.5 Hours**

PART A

Answer all questions

Each question carries 5 marks

1. Explain the important characteristics of MSW
2. What is the 3R principle
3. What are the different methods for disposal of solid waste
4. What are the major characteristics of hazardous wastes
5. Explain different methods for thermal conversion of waste

PART B

Answer any five questions

Each question carries 7 mark

6. a) Explain the stages in the decomposition of biodegradable wastes (4 marks)

   b) Explain the integrated solid waste management (3 marks)

7. a) Explain on the volume and size reduction of MSW (3 marks)

   b) What are the major challenges in the aerobic decomposition of MSW (4 marks)

8. a) Explain the guidelines on the site selection for a landfill (4 marks)

   b) What is the function of liners in landfills (3 marks)

9. a) What are the major characteristics of hazardous wastes(3 marks)

   b) Explain the waste to energy concept with examples (4 marks)

10. a) What are the different components of a landfill(4 marks)

b) Explain the landfill closure (3 marks)

11. Explain the combustion technologies for MSW (7 marks)

12. What are the draw backs in combustion technologies for MSW (7 marks)

Syllabus and Course Plan

No	Topic	No. of Lectures
1	Solid Waste-Characteristics and perspectives:-Sources, generation and estimation, types, compositions, Properties - physical, chemical and biological. Collection, Transfer stations, waste minimization, Recycling of municipal wastes, regulations.	
1.1	Solid Waste-Characteristics and perspectives:- Sources, generation and estimation, types, compositions	2
1.2	Solid waste properties - physical, chemical and biological	2
1.3	Collection, Transfer stations, waste minimization, Recycling of municipal wastes, regulations.	3
2	Collection, Transportation and Processing Techniques: - onsite handling, storage, processing, types of waste collection mechanisms, Transfer stations - types and location, Manual component separation and other separation techniques	
2.1	Collection, Transportation and Processing Techniques: - onsite handling, storage, processing	2
2.2	Types of waste collection mechanisms, Transfer stations - types and location	2
2.3	Manual component separation and other separation techniques	2
3	Size Reduction - Aerobic Composting, Incineration for Medical /Pharmaceutical Waste. Land Fill Method- Types, Methods & siting consideration. Composition, characteristics, generation. Control of landfill leachate & gases, an environmental monitoring system for landfill gases.	
3.1	Size Reduction - Aerobic Composting, Incineration for Medical /Pharmaceutical Waste	2
3.2	Land Fill Method- Types, Methods & siting consideration. Composition, characteristics,	2

	generation	
3.3	Control of landfill leachate & gases, an environmental monitoring system for landfill gases.	2
4	Hazardous Waste – definition, potential sources, impact on the environment, transportation regulations, risk assessment, remediation technologies. Private-public partnership, Government initiatives. Disposal of Hazardous Waste -Underground Storage Tanks Construction, Installation and Closure.	
4.1	Hazardous Waste – definition, potential sources, impact on the environment	2
4.2	Transportation regulations, risk assessment, remediation technologies	2
4.3	Private-public partnership, Government initiatives	1
4.4	Disposal of Hazardous Waste -Underground Storage Tanks Construction, Installation and Closure.	2
5	Energy generation from wastes - Basics, types, working and typical conversion efficiencies of composting, anaerobic digestion, combustion, incineration, gasification, pyrolysis.	
5.1	Energy generation from wastes - Basics, types, working and typical conversion efficiencies of composting	2
5.2	Energy generation from wastes - Basics, types, working and typical conversion efficiencies of anaerobic digestion	2
5.3	Energy generation from wastes - Basics, types, working and typical conversion efficiencies of combustion, incineration, gasification and pyrolysis.	3

Reference Books

1. John Pichtel ., Waste management and Practices: Municipal, Hazardous and Industrial, Second Edition, CRC Press, 2014.
2. Shah, Kanti L., Basics of Solid & Hazardous Waste Management Technology, Prentice Hall,1999.
3. Parker, Colin, & Roberts, Energy from Waste - An Evaluation of Conversion Technologies, Elsevier Applied Science, London, 1985
4. Cliff V. G., Hazardous Waste Management, Mercurary Learning and Information, 2012.
5. Paul R., Lydia F., Risks of Hazardous Wastes, Elsevier, 2011.

221EME022	DESIGN OF HEAT TRANSFER EQUIPMENT	CATEGORY	L	T	P	CREDIT
		PROGRAM ELECTIVE 4	3	0	0	3

Preamble:

Make the students to design heat transfer equipment by integrating heat transfer physics design concepts.

Course Outcomes:

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

CO 1	Justify the performance of various heat exchangers
CO 2	Design a shell and tube heat exchanger
CO 3	Design a plate and frame heat exchanger
CO 4	Compute the performance of regenerator
CO 5	Compute the performance of compact heat exchangers.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	2		3				
CO 2	2		3				
CO 3	2		3				
CO 4	2		3				
CO 5	2		3				

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30%
Analyse	30%
Evaluate	30%
Create	10%

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred)	**15 marks**
Course based task/Seminar/Data collection and interpretation	**15 marks**
Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus)	**10 marks**

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %.

Model Question paper

Reg. No:_____

Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
M. TECH DEGREE EXAMINATION, MONTH & YEAR
SECOND SEMESTER

221EME022 DESIGN OF HEAT TRANSFER EQUIPMENT

Time: 2.5 hrs
Marks: 60

Part A (5 x 5 = 25 Marks)
Answer all questions. Each question carries 5 marks.

1. Why is the maximum possible heat rate for a heat exchanger not equal to $C_{\max}(T_{hi} - T_{ci})$? Can the outlet temperature of the cold fluid ever exceed the inlet temperature of the hot fluid?
2. What is the role of baffles in a shell and tube heat exchanger? How does the presence of baffles affect the heat transfer and the pumping power requirements?
3. What are the advantages and limitations of plate heat exchanger?
4. What are the advantages and disadvantages of regenerators?
5. Why laminar flow is important in plate fin heat exchangers?

Part B (5 x 7 = 35 Marks)
Answer any five questions. Each question carries 7 marks

6. In an open heart surgery under hypothermic conditions, the patient's blood is cooled before surgery and warmed afterwards. It is proposed that a concentric tube counter-flow heat exchanger is used having a length of 0.5 m and tube ID = 55 mm. If water at 60°C and 0.1 kg/s is used to heat the blood entering at 18°C and 0.05 kg/sec, what is the exit temperature of the blood? The overall heat transfer coefficient is 500 W/m^{2}K and C_p ofblood = 3500 J/kgK.
7. Two identical counter flow heat exchangers are available. Water at the rate of 3600 kg/h and at 30°C (Cp = 4.2 kJ/kgK) is to be heated by cooling an oil (Cp= 2.1 kJ/kgK) at 90°C. The oil flow rate is 2700 kg/h. The heat exchanger area in each heat exchanger is 4 m^2. The

heat exchangers are connected in series on the water side and in parallel on the oil side. The oil flow rate is split in the ratio of 2 to 1. 1800 kg/h in the first and 900 kg/h in the second heat exchanger. Water enters the first heat exchanger at 30°C. Find the final water and oil exit temperatures. Overall heat transfer coefficient in each heat exchanger is 300 W/m^{2}K.

8. A shell and tube heat exchanger is to be designed to sub-cool the condensate of a methanol condenser from 90°C to 40°C. The flow rate of methanol is 120000 kg/h. Water will be used as the coolant, with a temperature rise from 30°C to 50°C Kern's method should be used for the shell side design.
9. A shell and tube heat exchanger having the following specifications. Length of shell = 5.4 m, shell diameter = 900 mm, Outside diameter of tube =30 mm,Tube pitch(square) = 40 mm, baffle spacing = 150 mm, number of tubes = 120, shell to baffle clearance = 5 mm, tube to baffle clearance = 0.8 mm, Bundle to shell diametral clearance = 40 mm, number of sealing strips per cross flow = 1/5, thickness of baffles = 6.2 mm. The specification of the fluid are, mass flow rate = 7 kg/s, density= 780 kg/m^3. Specific heat = 2.58 kJ/kg K, dynamic viscosity = 0.385x10^{-3} Pas, thermal conductivity = 0.2 W/mK. Find the shell side heat transfer coefficient and pressure drop by the Bell- Delaware method.
10. A one pass counter current flow heat exchanger has 199 plates each 2 m high and 0.5m wide, with a gap between them of 5 mm. The plates have the heat transfer characteristic given by $Nu = 0.54\,\mathrm{Re}^{0.66}\,\mathrm{Pr}^{0.4}$. Cold water with an inlet temperature of 15°C is fed to the heat exchanger at a rate of 20 kg/s and hot water with an inlet temperature of 95°C is fed at 40 kg/s. What are the fluid outlet temperatures? What would be the effect of reducing the number of plates to 99 in this problem?
11. A fixed bed regenerator consists of two vessels containing slabs of a refractory material, each 19 m high, 2 m wide and 18 cm thick, and having 7 cm of gap between the slabs. Air at 20°C is to be preheated

using waste gas at 1100^{o}C. The flow velocity is 20 m/s and flow rate is assumed to be same on both heating and cooling stages. What is the air/gas outlet temperature for cooling period of 60 minutes?

12. A finned tube compact heat exchanger having the core configuration CF7.0-5/8 J. The core is fabricated from aluminum and the tubes have an inside diameter of 14 mm. In a waste heat recovery application, water flow through the tubes provides an inside convection coefficient of 1400 W/m^{2}K, while combustion gasesat 1 atm and 800 K are in cross flow over the tubes. If the gas flow rate is 1.5 kg/s and the frontal area is 0.25 m^2, what is the gas side overall heat transfer coefficient? If a water flow rate of 1 kg/s is to be heated from 300 to 400 K, what is the required heat exchanger volume?

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**Classification and selection of heat exchangers**	
1.1	Heat transfer and flow friction characteristics – pressure drop analysis	2
1.2	Basic thermal design – theory of heat exchangers –	2
1.3	E-NTU, P-NTU and MTD method -F-factor for various configurations.	3
2	**Shell and tube heat exchanger**	
2.1	Construction and thermal features	2
2.2	Thermal design procedure – Kern method	4
2.3	Bell Delaware method.	3
3	**Plate and frame heat exchanger**	
3.1	Construction and thermal features	2
3.2	Analysis of plate heat exchangers	4
3.3	Rating and sizing of plate heat exchanger	3
4	**Thermal design of regenerators**	
4.1	Classifications	2
4.2	Governing equations	3
4.3	Design parameters	3
5	**Compact heat exchangers**	
5.1	Classifications and selection	2
5.2	Design of plate fin heat exchanger	3
5.3	Design of tube fin heat exchanger	2

Reference Books

1. Kern, D. Q., Process Heat Transfer, Tata McGraw-Hill, 2000.
2. Fraas, A. P., Heat Exchanger Design, Second Edition, John Wiley & Sons, 1989
3. Hewitt , Process heat transfer
4. Das, S.K., Prosess heat transfer, Narosa publishing house.2005.

221EME023	ENERGY FORECASTING AND MODELLING	CATEGORY	L	T	P	CREDIT
		PROGRAM ELECTIVE 4	3	0	0	3

Preamble:

Objective of this course is to provide an understanding on the energy scenario and national and state energy policies and an insight in to developing forecasting models and optimization models for energy planning.

Course Outcomes:

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

CO 1	Apply their knowledge in Energy prediction using various forecasting techniques.
CO 2	Use forecasting models and optimisation models for energy planning and Energy prediction.
CO 3	Identify the role of energy in economic development and social transformation.
CO 4	Prepare detailed project reports with feasibility study and cost estimation.
CO 5	Evaluate the limit cost of energy for various renewable energy systems.
CO 6	Identify the present state and future promise of energy sources, demand and consumption globally.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	2	-	-	-	2	-	-
CO 2	2	-	-	-	2	-	-
CO 3	1	-	2	-	-	-	-
CO 4	2	3	-	-	-	-	1
CO 5	2	-	-	-	-	-	1

CO 6	1	-	-	-	-	1	-

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	25
Analyse	28
Evaluate	7
Create	0

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) **15 marks**

Course based task/Seminar/Data collection and interpretation **15 marks**

Test paper, 1 no. **10 marks**

(Test paper shall include minimum 80% of the syllabus)

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5

marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %.

Model Question paper

221EME023 Reg. Number……

Name……

A P J ABDUL KALAM TECHNOLOGICAL UNIVERSITY
M.TECH DEGREE EXAMINATION, May/June 2023

SECOND SEMESTER
Renewable Energy
ENERGY FORECASTING AND MODELING

Time: 2.5 Hours
Max. Marks: 60

PART A
Answer All Questions

1. India has promising renewable energy potential. Justify.
2. Describe the methods available for demand forecasting?
3. Explain Pareto optimality situation with a suitable example.
4. Describe briefly the various means of financing a project.
5. Differentiate between Energy Conservation and Energy Efficiency.

5 x 5 marks = 25 marks

PART B
Answer any five Questions

6. Compare and contrast the long term effect of Nuclear energy over Renewable Energy.
7. Explain the importance of renewable energy sources in current scenario of world energy consumption.
8. Fit a straight line trend to the following data on demand of power in MW to be produced and project the power demand for the year 2022.

Year	2015	2016	2017	2018	2019	2020	2021
Demand	80	84	90	93	98	100	104

9. Explain the concept of Neural Networks.
10. Describe briefly any two Mathematical Optimization Software.

11. Describe the principal stages in a typical Project Life Cycle.
12. Evaluate the various strategic measures for meeting energy security of a country.

5 x 7 marks = 35 marks

Syllabus and Course Plan

Role of energy in economic development and social transformation – Energy Sources, Overall Energy demand and Availability – Forecasting Techniques – Project Preparation and Appraisal – Principles of Optimization – Energy Security – Energy Policies.

No	Topic	No. of Lectures
1	**Module 1**	**7**
1.1	**Energy Scenario:** Role of energy in economic development and social transformation: Energy & GDP, GNP and its dynamics	3
1.2	Energy Sources and Overall Energy demand and Availability – Energy Consumption in various sectors and its changing pattern	2
1.3	Status of Nuclear and Renewable Energy: Present Status and future promise.	2
2	**Module 2**	**10**
2.1	**Forecasting Model:** Forecasting Techniques – Regression Analysis	2
2.2	Double Moving Average – Double Experimental Smoothing	2
2.3	Triple Exponential Smoothing – ARIMA model- Validation techniques	3
2.4	Qualitative forecasting – Delphi technique - Concept of Neural Net Works.	3
3	**Module 3**	**9**
3.1	**Optimization Model:** Principles of Optimization – Formulation of Objective Function – Constraints – Multi Objective Optimization	3
3.2	Mathematical Optimization Software – Development of Energy Optimization Model	3
3.3	Development of Scenarios – Sensitivity Analysis – Concept of Fuzzy Logic.	3
4	**Module 4**	**7**
4.1	**Project Preparation** – Feasibility Study – Detailed Project Report - Project Appraisal	3

4.2	Social-cost benefit Analysis - Project Cost Estimation – Project Risk Analysis	3
4.3	Project Financing – Financial Evaluation.	1
5	**Module 5**	**7**
5.1	**Energy Policy:** National & State Level Energy Issues – National & State Energy Policy	2
5.2	Energy Security – National solar mission – state solar energy policy	2
5.3	Framework of Central Electricity Authority (CEA), Central & States Electricity Regulatory Commissions (CERC & ERCs).	3

Reference Books

1. Spyros Makridakis, Steven C. Wheelwright and Rob J. Hyndman. Forecasting methods and applications. John Wiley & sons, 2008.
2. J. Scott Armstrong, Principles of Forecasting: A Handbook for Researchers and Practitioners, Vol. 30. Boston, MA: Kluwer Academic, 2001.
3. Rob J Hyndman and George Athanasopoulos, Forecasting: Principles and Practice, OTexts, 2018.
4. Draft National Energy Policy. National Institution for Transforming India (NITI Aayog), Government of India, New Delhi. 2017.
5. General Aspects of Energy Management and Energy Audit, Guide book for National Certification Examination for Energy Managers and Energy Auditors, Bureau of Energy Efficiency, New Delhi, India. 4th Ed, 2015.
6. Dhandapani Alagiri, Energy Security in India Current Scenario, The ICFAI University Press, 2006.
7. Fred Luthans, Organisational Behaviour, An evidence-based approach McGraw Hill, lnc, USA,12th Edition, 2011
8. Sukhvinder Kaur Multani, Energy Security in Asia Current Scenario, The ICFAI University Press
9. Yang X.S., Introduction to mathematical optimization: From linear programming to Metaheuristics, Cambridge, International Science Publishing, 2016
10. Nawneeth Vibhaw, Energy Law and Policy in India, 8th Edition, 2014.

INTER DISCIPLINARY ELECTIVE

222EME104	DIGITAL PRODUCT DESIGN AND MANUFACTURING	CATEGORY	L	T	P	CREDIT
		INTERDISCIPLINARY ELECTIVE	3	0	0	3

Preamble:

The focus of digital product design and manufacturing is the integration of digital technology in design and manufacturing functions in creating new products. It also envisages the use of digital tools such as virtual-augmented reality and additive manufacturing in product design and manufacturing.

Course Outcomes:

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

CO 1	Demonstrate the principles of product development process and the role of computers in it.
CO 2	Implement the principles of industrial design to develop new products
CO 3	Apply the innovative digital tools in product design and development
CO 4	Apply the innovative digital tools in simulation and analysis at the design stage
CO 5	Summarize the innovative prototyping techniques in design and understand the industrial practices.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1			3			
CO 2			3	2		
CO 3			3			
CO 4			3	2		
CO 5			3		2	

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	√
Analyse	√
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

ELECTIVE COURSES

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed
Original publications (minimum 10 publications shall be referred):15 marks
Course based task/Seminar/Data collection and interpretation: 15 marks
Test paper, 1 no.:10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern: (60 Marks)

The end semester examination will be conducted by the respective Colleges. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question paper

QP Code: **Total Pages:**

Reg No.:_____ **Name:**_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SECOND SEMESTER M.TECH DEGREE EXAMINATION, Month & Year

Stream: MACHINE DESIGN

Course Code: 222EME104

Course Name: DIGITAL PRODUCT DESIGN AND MANUFACTURING

Max. Marks: 60 **Duration: 2.5 Hours**

PART A

Answer all questions, each carries 5 marks. Marks

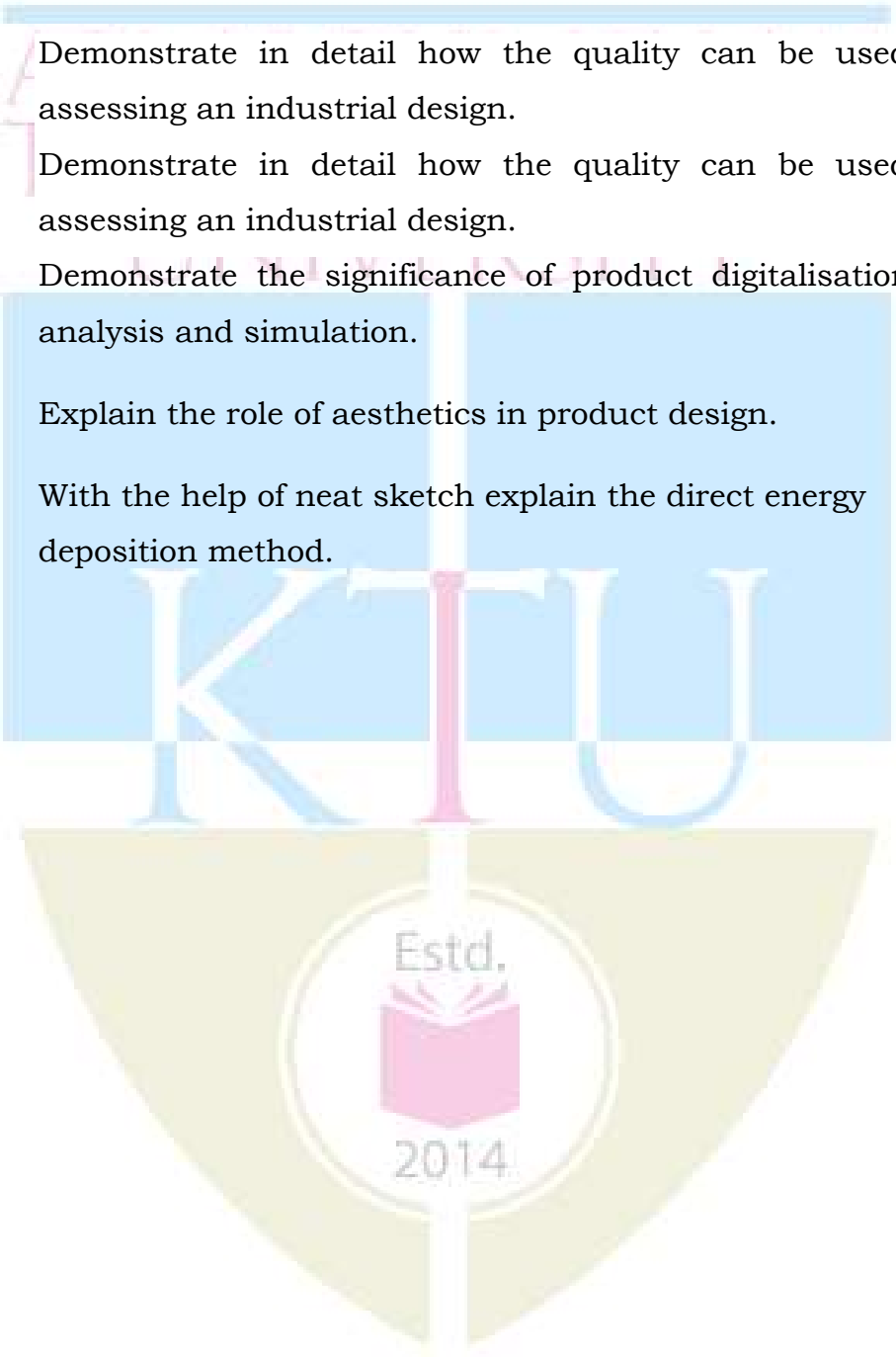
1	Elaborate different phases in design.	(5)
2	Explain the role of planning for product distribution.	(5)
3	Explain how VR can be utilised in product development.	(5)
4	Illustrate the role of virtual human in product development.	(5)
5	Differentiate between material extrusion and material jetting additive manufacturing techniques.	(5)

PART B

Answer any 5 full question, each question carries 7 marks.

6	Explain the concept of standardization in product design with the help of an example.	(7)
7	Explain the various aspects of human factors to be considered in product development.	(7)

8	Explain the importance of break-even analysis during design.	(7)
9	Illustrate with examples how VR and AR can be useful in product development.	(7)
10	Demonstrate in detail how the quality can be used in assessing an industrial design. Demonstrate in detail how the quality can be used in assessing an industrial design. Demonstrate the significance of product digitalisation in analysis and simulation.	(7)
11	Explain the role of aesthetics in product design.	(7)
12	With the help of neat sketch explain the direct energy deposition method.	(7)



SYLLABUS

Module 1

Concept of Product Design: Definition of engineering design, design constraints, different phases in design- conceptual design, embodiment design, detail design, planning for manufacture, planning for distribution, planning for use, Human factors design- ergonomics, anthropometry, comfort criteria, concepts of size, texture and colour, Introduction to product design, product design practices in industry.

Module 2

Tools for product design- drafting-modelling software CAE/CAD, computer aided styling, production process- CAM interface, product development-time and costs. Description of planning for product distribution, Economic factors affecting design.

Module 3

Digital tool enabled design -I: Evolution of digital tools for product design and manufacturing, 2D/3D models to digital mock-up and virtual prototyping (VP). Virtual reality (VR), augmented reality (AR) and Mixed reality, Implementation in product design and manufacturing. Interaction technology, Visualisation technology, Visual display-types- head mounted, organic LEDs, large volume displays, wall type, equipments, characteristics.

Module 4

Digital tool enabled design-II: AR-, tangible, collaborative; examples; AR tracking technology and devices; interaction techniques, haptic technology, olfactory technology. Product digitalization, analysis and simulation. Virtual humans (VH)- for clothing, for ergonomics analysis, biomechanical models.

Module 5

Digital manufacturing: 3D printing- additive manufacturing technology- Classification of additive manufacturing technologies: vat- photo polymerisation, powder bed fusion, material jetting, sheet lamination, material extrusion and direct energy deposition, infill lattice structures.

Course Plan

No	Topic	No. of lectures
1	**Product development process:**	
1.1	Concept of Product Design: Definition of engineering design, design constraints	2
1.2	Different phases in design- conceptual design, embodiment design, detail design, planning for manufacture, planning for distribution, planning for use	3
	Human factors design- ergonomics, anthropometry, comfort criteria, concepts of size, texture and colour	1
1.3	Introduction to product design, product design practices in industry.	2
2	**Embodiment design:**	
2.1	Tools for product design- drafting-modelling software CAE/CAD, computer aided styling, production process- CAM interface, product development- time and costs.	4
2.2	Description of planning for product distribution, economic factors affecting design.	4
3	**Digital tool enabled design-I**	
3.1	Evolution of digital tools for product design and manufacturing, 2D/3D models to digital mock-up, virtual prototyping (VP).	2
3.2	Virtual reality (VR), augmented reality (AR) and Mixed reality implementation in product design and manufacturing.	3
3.3	Interaction technology, VR- immersive, non-immersive, Visualisation technology, Visual display-types- head mounted, organic LEDs, large volume displays, wall type, equipments, characteristics.	3
4	**Digital tool enabled design-II**	
4.1	AR- tangible, collaborative; examples; AR tracking technology and devices; Interaction techniques, Haptic technology, Olfactory technology	3
4.2	Product digitalization, Analysis and simulation.	2
4.3	Virtual humans (VH)- for clothing, for ergonomics analysis, Biomechanical models.	2

5	**Digital manufacturing**	
5.1	3D printing- additive manufacturing technology- Classification of additive manufacturing technologies: Vat- photo polymerisation, powder bed fusion, material jetting, sheet lamination,	4
5.2	Material extrusion and direct energy deposition, Infill lattice structures	3

Reference Books

1. George Dieter and Linda C. Schmidt, Engineering Design, 4th Edition, Published by McGraw-Hill.
2. Monica Bordegoni and Caterina Rizzi, "Innovation In Product Design From CAD To Virtual Prototyping", Springer.
3. Karl T Ulrich and Steven D Eppinger, "Product Design & Development." Tata Mc- Graw Hill, 2003.
4. Ian Gibson, David Rosen and Brent Stucker, "Additive Manufacturing Technologies-3D Printing, Rapid Prototyping, and Direct Digital Manufacturing." Springer.
5. Fei Tao, Meng Zhang and A. Y. C. Nee, "Digital Twin Driven Smart Manufacturing", Academic Press, Elsevier.
6. D. T. Pham, S.S. Dimov, Rapid Manufacturing-The Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer – Verlag, London, 2001.
7. Kevin Otto & Kristin Wood Product Design: "Techniques in Reverse Engineering and New Product Development.", Pearson Education New Delhi, 2000.
8. N J M Roozenberg , J Ekels , N F M Roozenberg " Product Design Fundamentals and Methods". John Wiley & Sons.
9. AK Chitale & RC Gupta, "Product Design and Manufacturing", PHI, 2000.

CODE	RELIABILITY ENGINEERING	CATEGORY	L	T	P	CREDIT
222EME105		Inter Disciplinary Elective	3	0	0	3

Preamble:

Reliability engineering fundamentals and applications, Failure data analysis - Basics of Reliability Prediction Hazard models -System reliability models - Fault-tree analysis

Course Outcomes:

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

CO 1	Explain the tools of statistics and probability to determine the reliability of an item or a system.
CO 2	Discuss the methods of reliability prediction and maintenance strategies according to system characteristics and design transition programs to implement these strategies.
CO 3	Develop ability in formulating suitable strategies to enhance system reliability of a manufacturing system.
CO 4	Implement the concepts of RCM, FTA, FMEA and FMECA in managing the manufacturing organisation with highest possible levels of reliability/ availability.
CO 5	Differentiate various strategies adopted for life testing and maintenance.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	2		2	2	
CO 2			3	2	
CO 3			2		2
CO 4			2	3	2
CO 5			2		2

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	40%
Analyse	30%
Evaluate	30%
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks
Course based task/Seminar/Data collection and interpretation: 15 marks
Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus): 10 marks

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**Probability and reliability**	
1.1	Probability: Conditional probability, Bayes theorem	1
1.2	Probability distributions – Normal, Lognormal, Poisson, Exponential and Weibull distributions – relationship between them and their significance	2
1.3	Central tendency and dispersion of Normal, Lognormal, Poisson, Exponential and Weibull distributions	1
1.4	Reliability: Definitions, Importance, Quality and reliability,	1
1.5	Bath tub curve -Failure data analysis: Hazard rate, failure rate,	1
1.6	MTTF, MTBF, reliability functions, hazard functions,	1
1.7	Availability and Maintainability	1
2	**Hazard models and system reliability**	
2.1	Reliability hazard models: Parts stress model	1
2.2	Constant and linearly increasing models	1
2.3	Time dependent failure rates, Weibull model	1
2.4	Distribution functions and reliability analysis	1
2.5	System Reliability: Series system configuration	1
2.6	Parallel system configurations	1
2.7	Mixed configurations	1
2.8	k out of m system, standby systems	1
3	**Reliability evaluation and system analysis**	
3.1	Reliability evaluation using Markov model - Development of logic diagram	1
3.2	Set theory, optimal cut set and tie set methods, Markov analysis	2
3.3	Fault-tree analysis: Fault tree construction, calculation of reliability from fault tree	2
3.4	Event tree analysis	1
3.5	FMEA	1
3.6	FMECA	1
4	**Design for reliability**	
4.1	Load – strength interference - Distributed load and strength	1
4.2	Analysis of interference – Effect of safety margin	2
4.3	Software Reliability – software errors – fault tolerance – data reliability – hardware / software interfaces	2
4.4	Reliability prediction of equipments and systems using	1

	MIL-217 standards	
4.5	Reliability prediction of equipments and systems using and NSWC standards	1
4.6	Human Reliability	1
5	**Life testing and maintenance**	
5.1	Maintenance and reliability – Preventive and predictive maintenance	1
5.2	Reliability cantered maintenance	1
5.3	Life Testing – Objectives, Types - Censoring, replacement,	2
5.4	Accelerated life testing – Temperature stress and failure rates – stress combinations, accelerated cycling	2
5.5	HALT	1
5.6	HASS	1

Reference Books

1. Patrick O'Connor, Andre Kleyner, Practical Reliability Engineering, 5th Edition, Wiley India, 2012
2. A Birolini, Reliability Engineering, 8th edition Springer, 2017
3. Naikan V. N. A., Reliability Engineering and Life Testing, PHI, New Delhi, 2009
4. Ebling C. E., "An introduction to Reliability and Maintainability Engineering" Waveland Press, 2019.
5. Balagurusamy E., Reliability Engineering, McGraw Hill Education India P Ltd, 2017
6. Kapoor K. C., Pecht M., Reliability Engineering, Wiley, 2014
7. LS Srinath , Reliability Engineering, East West Press,2017

CODE 222EME106	INDUSTRIAL SAFETY IN ENGINEERING	CATEGORY	L	T	P	CREDIT
		Inter disciplinary Elective	3	0	0	3

Preamble:

The course is intended to give knowledge of various safety management systems, accident prevention techniques, various machine guarding devices, different types of hazards and fire prevention methods. Students will be able to understand the impact of safe industrial operations and become aware of safety responsibilities.

Course Outcomes:

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

CO 1	Discuss the basic concepts of Safety Management.
CO 2	Explain the factors contributing to accidents and how that can be controlled.
CO 3	Summarize general safety precautions and safe practices to be followed in Engineering Industries.
CO 4	Explain the occupational health hazards and the methods of control.
CO 5	Implement the firefighting techniques and understand the methods of pollution control.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1		2	3		
CO 2			3		
CO 3			3		
CO 4	2		3		
CO 5		2	3		

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	40%
Analyse	40%
Evaluate	20%
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks
Course based task/Seminar/Data collection and interpretation: 15 marks
Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus): 10 marks

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SECOND SEMESTER M.TECH DEGREE EXAMINATION
222EME106 Industrial Safety in Engineering

Time: 2.5 hrs Max. Marks: 60

Part A

(Answer all questions. Each question carries five marks)

1. Discuss the significance of a safety committee in improving the safety performance of an industry
2. What are the functions of safety professional
3. Which are five 'S' used in housekeeping?
4. Discuss the functions of occupational health services
5. Describe the importance of fire detection systems

Part B

(Answer any five questions. Each question carries seven marks)

6. Discuss the significance of safety policy in reducing the accidents.
7. Differentiate Hazard and Risk with examples
8. Which are the various types of machine guarding devices used industries.
9. Classify the personal protective equipment. List the suitability of at least ten types of PPEs.
10. Discuss the important types of ergonomic hazards associated with industries
11. Describe the selection of different types of fire extinguishers accordance to type of fire
12. Discuss about different types of chemical hazards

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**Module 1**	
1.1	Introduction to safety and safety management - Objectives and principles of safety management - Need for integration of safety, health and environment	2
1.2	Management's safety policy and Formulation – Safety auditing – Safety budget	2
1.3	Safety committees and its functions - Safety education and training - Motivation and communicating safety	2
1.4	Significance of health and safety culture - 4 E's in industrial safety - Role of management in Industrial Safety - Factors impeding safety.	2
2	**Module II**	
2.1	Accidents and Hazard control - Accident causation - Classification of accidents	2
2.2	Accident proneness - Cost of accidents - Accident investigation – Hazard control programme	2
2.3	Risk analysis - Quantitative risk assessment- Roles and functions of safety professional- Job safety analysis	3
3	**Module III**	
3.1	Machine Guarding - Types of guards	1
3.2	Housekeeping: Responsibility of management and employees. Advantages of good housekeeping. 5 s of housekeeping.	2
3.3	Personal protective equipments and personal safety	2
3.4	General safety considerations in material handling - Manual and mechanical - Safety in machine shop	2
3.5	Safety in sewage disposal and cleaning - Disaster management plan for industrial plant.	2

4	**Module IV**	
4.1	Occupational health and industrial hygiene - Functions of occupational health services	1
4.2	Occupational health risks - Functional units of OHS	1
4.3	Occupational diseases - Silicosis - Asbestosis - lead poisoning - Nickel toxicity - Chromium toxicity	2
4.4	Hearing conservation programme - First aid and CPR	1
4.5	Types of industrial hazards and their control - Physical, Mechanical, Electrical, Chemical and Ergonomic hazards	3
5	**Module V**	
5.1	Industrial fire prevention -Methods of extinguishing fire - Classification of fires	1
5.2	Factors contributing towards fire - Fire risk assessment - Fire load	1
5.3	Fire safety plan	1
5.4	Fire detection systems – Fire protection systems	1
5.5	Pollution control in engineering industry - Recent development of safety engineering approaches	2

Reference Books

1. R.K Jain (2000) Industrial Safety, Health and Environment management systems, Khanna Publications.
2. Ronald P. Blake. (1973). *Industrial safety.* Prentice Hall, New Delhi.
3. Krishnan, N.V. (1997). *Safety management in Industry.* Jaico Publishing House, New Delhi.
4. Frank P Lees, 'Loss prevention in process industries',Vol I, II, III, Butterworth, London 1980
5. Heinrich H.W, 'Industrial accident prevention', McGraw Hill Company, New York, 1980.

MECHANICAL ENGINEERING

MINIPROJECT

222PME100	MINI PROJECT	CATEGORY	L	T	P	CREDIT
		PROJECT	0	0	4	2

Mini project can help to strengthen the understanding of student's fundamentals through application of theoretical concepts and to boost their skills and widen the horizon of their thinking. The ultimate aim of an engineering student is to resolve a problem by applying theoretical knowledge. Exposure to more projects enhances problem solving skills.

The introduction of mini projects ensures preparedness of students to undertake dissertation. Students should identify a topic of interest in consultation with PG Programme Coordinator that should lead to their dissertation/research project. Demonstrate the novelty of the project through the results and outputs.

The progress of the mini project is evaluated based on three reviews, two interim reviews and a final review. A report is required at the end of the semester.

Evaluation Committee - Programme Coordinator, One Senior Professor and Guide.

Sl. No	Type of evaluations	Mark	Evaluation criteria
1	Interim evaluation 1	20	
2	Interim evaluation 2	20	

3	Final evaluation by a Committee	35	Will be evaluating the level of completion and demonstration of functionality/ specifications, clarity of presentation, oral examination, work knowledge and involvement
4	Report	15	the committee will be evaluating for the technical content, adequacy of references, templates Followed and permitted plagiarism level(not more than 25%)
5	Supervisor/Guide	10	
	Total Marks	100	

LABORATORY

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222LME001	COMPUTATIONAL AND MODELING LAB	Laboratory	0	0	2	1

Course Outcomes:

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

CO 1	Model conventional energy systems and evaluate their performance
CO 2	Model nonconventional/renewable energy systems and evaluate their performance
CO 3	Model and analyse the fluid flow and heat transfer in different surfaces
CO 4	Optimize and predict energy systems using suitable computational tools

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	-	3	3	3	3	-
CO 2	3	-	3	3	3	3	-
CO 3	3	-	3	3	3	3	-
CO 4	3	-	3	3	3	3	-

Continuous Internal Evaluation (CIE) Pattern:
Total Marks: 100

Attendance	15 marks
Regular class work/Modelling and Simulation Lab Record and Class Performance	60 marks
Continuous Assessment Test (Minimum 1 Test)	25 marks

Continuous Assessment Test Pattern

Bloom's Taxonomy	Continuous Assessment Test (Marks)
Apply	15
Analyse	10

Syllabus

1. Exercises on modelling of energy systems in cycle tempo-modelling of components like compressor, turbine, pump, combustor- input variables – analysing simulation results
2. Modeling of Brayton cycle in cycle tempo-input variables-analysing simulation results- Parametric variations
3. Modeling of Rankine cycle-reheat cycle- regenerative cycle- input variables-analysing simulation results- Parametric variations
4. Modeling of gasifier – Fuel Cell- Geothermal plant- input variables-analysing simulation results- Parametric variations
5. Modeling of geometry in CAD – Meshing- Initial and boundary conditions in ANSYS- analysing simulation result
6. Modeling of energy system using input and output variables in ANN MATLAB- training – prediction- Optimization using Genetic algorithm

No	List of Exercise	Course Outcomes
1	Modeling of a gas turbine powerplant (Brayton cycle) and performance evaluation using Cycle Tempo software	**CO 1**
2	Modeling of a steam turbine powerplant (Rankine cycle) and performance evaluation using Cycle Tempo software	**CO 1**
3	Modeling of a reheat steam turbine powerplant and performance evaluation using Cycle Tempo software	**CO 1**
4	Modeling of a regenerative steam turbine powerplant and performance evaluation using Cycle Tempo software	**CO 1**
5	Modeling of a Combined Cycle powerplant and performance evaluation using Cycle Tempo software	**CO 1**
6	Modeling of vapour compression refrigeration system and performance evaluation using Cycle Tempo software	**CO 1**
7	Modeling of gasifier and performance evaluation using Cycle Tempo software	**CO 2**
8	Modeling of geothermal power plant and performance evaluation using Cycle tempo software	**CO 2**
9	Modeling of fuel cell and performance evaluation using Cycle Tempo software	**CO 2**
10	Flow and heat transfer analysis of fluid flow over a plate using ANSYS	**CO 3**
11	Flow and heat transfer analysis of pipe flow using	**CO 3**

	ANSYS	
12	Exercises on data prediction of energy systems using ANN	**CO 4**
13	Exercises on optimization of energy system using Genetic algorithm	**CO 4**

(Minimum 8 experiments to be done)