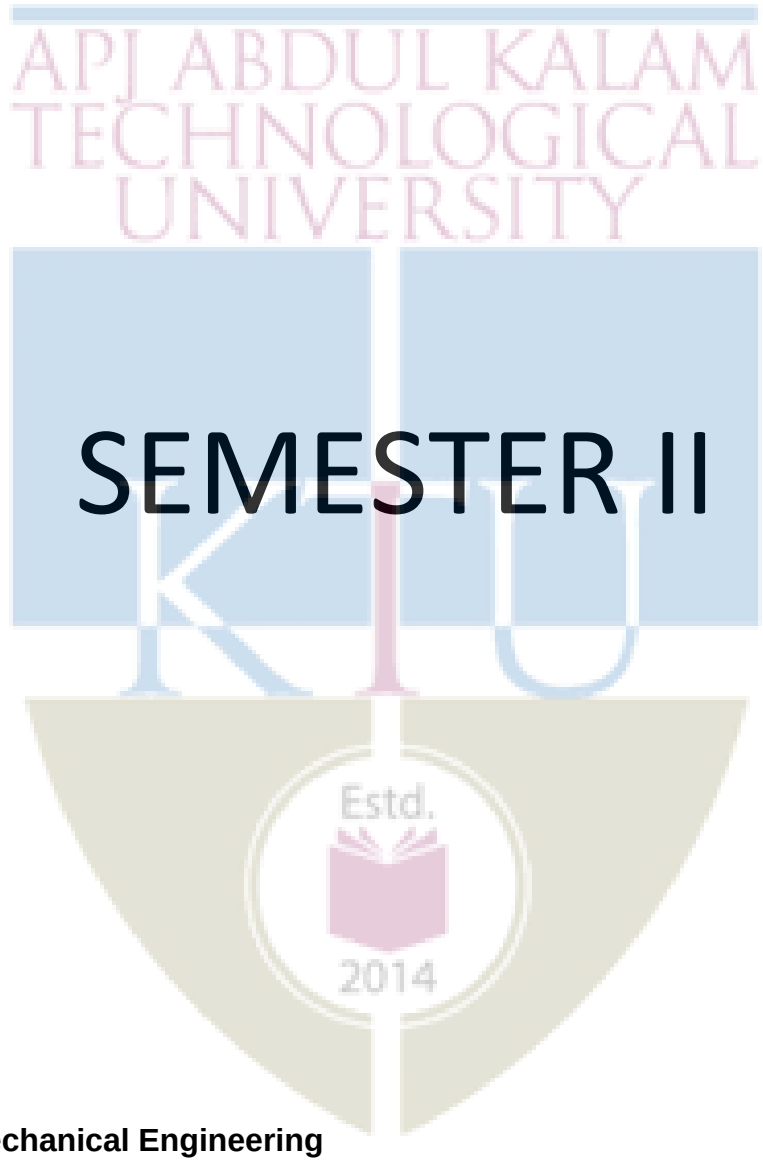


SEMESTER II

Discipline : Mechanical Engineering

Stream : ME4

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222TME100	DESIGN OF EXPERIMENTS	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 a 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. (3)

54, 60, 65, 66, 67, 69, 70, 72, 73, 75, 76

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)

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

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)

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 draw conclusions. Use $\alpha = 0.05$ (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

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 etch rate for silicon nitride. The data are given in the table below. Analyse the data to identify the significant factors and interactions. (7)

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 Temperature (405°C) Melting time (63 min)	1	79	
	2	78	
	3	76	
	4	79	
	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

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222TME004	Modern Manufacturing systems	PROGRAM CORE	3	0	0	3

Preamble: Nil

Course Outcomes:

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

CO 1	Analyse the fundamental machining principles
CO 2	Demonstrate the mechanisms in the non-traditional machining processes
CO 3	Understand various advanced metal cutting and forming operations
CO 4	Understand experimental methods using various computational methods
CO 5	Demonstrate the concept of Explosive forming Process.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	✓		✓	✓	✓	✓
CO 2	✓		✓	✓	✓	✓
CO 3	✓		✓	✓	✓	✓
CO 4	✓		✓	✓	✓	✓
CO 5	✓		✓	✓	✓	✓

Assessment Pattern

Bloom's Category	End Semester Examination (marks)
Apply	**20**
Analyse	**40**
Evaluate	
Create	

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

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

End Semester Examination Pattern:

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 one question from each module of which student shall answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

Model Question paper

222TME004 MODERN MANUFACTURING SYSTEMS

PART A

(Answer all the questions. Each question carries 5 Marks)

1. Explain the need and characteristics of non-traditional machining?
2. Mention the advantages and disadvantages of ultrasonic machining?
3. What are the process variables that affect the performance of water jet machining process?
4. What are the functions of dielectric fluid?
5. Explain the types of explosive forming?

PART B

(Answer any 5 questions. Each carry 7 Marks)

6 What are the advantages of non-traditional machining process?

7 With a neat sketch explain the working principle of ultrasonic machining process?

8 Explain the following variables that influence the metal removal and accuracy of machining in abrasive jet machining, carrier gas, types of abrasives and standoff distance?

9 Explain with neat sketch Electron beam machining process?

10 Explain flushing and explain any two methods of flushing in EDM process?

11 Explain with sketch, the mechanism of metal removal in laser beam machining process?

12 Explain the principle of plasma generation and mechanism of metal removal in plasma arc machining?

Syllabus

MODULE	CONTENT
I	Mechanical Processes: Ultrasonic Machining- Elements of process, cutting tool system design, effect of parameters, economic considerations, applications, limitations of the process, advantages and disadvantages. Abrasive Jet Machining- Variables in AJM, metal removal rate in AJM. Water Jet Machining- Jet cutting equipment, process details, advantages and applications
II	Electrochemical and Chemical Metal Removal Processes: Electrochemical Machining- Elements of ECM process, tool work gap, chemistry of the process, metal removal rate, accuracy, surface finish and other work material characteristics, economics, advantages, applications, limitations. Electrochemical Grinding– Material removal, surface finish, accuracy, advantages, applications
III	Thermal Metal Removal Processes: Electric Discharge Machining (EDM) or spark erosion machining processes, mechanism of metal removal, spark erosion generators; electrode feed control, dielectric fluids, flushing, electrodes for spark erosion, selection of electrode material, tool electrode design, surface finish, machining accuracy, machine tool selection, applications, Wire cut EDM. Laser beam machining (LBM)- Apparatus, material removal, cutting speed and accuracy of cut, metallurgical effects, advantages and limitations
IV	Plasma Arc Machining (PAM): Plasma, non-thermal generation of plasma, mechanism of metal removal, PAM parameters, equipment for D.C. plasma torch unit, safety precautions, economics, other applications of plasma jets, Electron Beam Machining (EBM) – Generation and control of electron beam, theory of electron beam machining, process capabilities and limitations. High Velocity Forming Processes: - Conventional versus High velocity forming methods – Material behaviour – stress waves and deformation in solids – Stress wave

	induced fractures – Applications
V	Explosive Forming Processes: - Principles – Explosives – Length of reactions – Energy in plastic deformations – Expression for change in size required for deforming a flat disc into a bulged form – Effect of process in material properties – Types of Explosives forming – die construction. Magnetic Pulse Forming Processes: - General principles – Applications

Course Plan

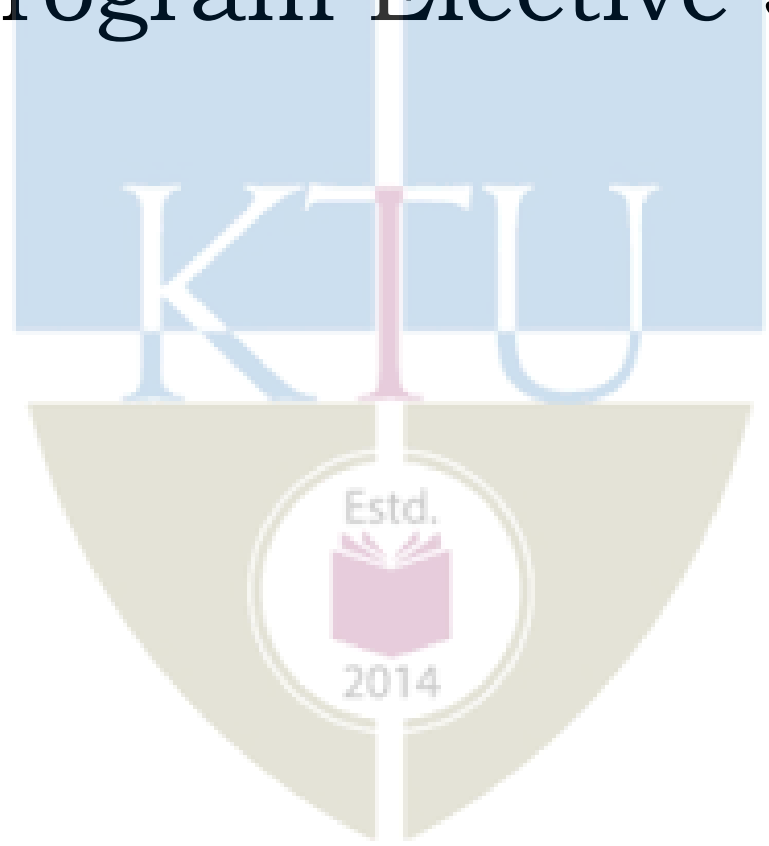
No	Topic	No. of Lectures
1	**Introduction to mechanical processes**	
1.1	Mechanical Processes: Ultrasonic Machining- Elements of process	1
1.2	Cutting tool system design, effect of parameters, economic considerations	1
1.3	Applications, limitations of the process, advantages and disadvantages	1
1.4	Abrasive Jet Machining- Variables in AJM, metal removal rate in AJM	1
1.5	Water Jet Machining- Jet cutting equipment, process details, advantages and applications	2
2	**Electrochemical and Chemical Metal Removal Processes**	
2.1	Electrochemical and Chemical Metal Removal Processes: Electrochemical Machining	2
2.2	Elements of ECM process, tool work gap, chemistry of the process, metal removal rate	2
2.3	accuracy, surface finish and other work material characteristics, economics, advantages, applications, limitations	2
2.4	Electrochemical Grinding– Material removal, surface finish, accuracy, advantages, applications	2
3	**Thermal Metal Removal Processes**	
3.1	Thermal Metal Removal Processes: Electric Discharge Machining (EDM) or spark erosion machining processes	2
3.2	Mechanism of metal removal, spark erosion generators; electrode feed control, dielectric fluids	1
3.3	Flushing, electrodes for spark erosion, selection of electrode material, tool electrode design, surface finish	2
3.4	Machining accuracy, machine tool selection, applications, Wire cut EDM	1
3.5	Laser beam machining (LBM)- Apparatus, material removal, cutting speed and accuracy of cut, metallurgical effects, advantages and limitations	2
4	**Plasma Arc Machining (PAM), Electron Beam Machining (EBM) and High Velocity Forming Processes**	

4.1	Plasma Arc Machining (PAM): Plasma, non-thermal generation of plasma, mechanism of metal removal	2
4.2	PAM parameters, equipment for D.C. plasma torch unit, safety precautions, economics, other applications of plasma jets	2
4.3	Electron Beam Machining (EBM) – Generation and control of electron beam, theory of electron beam machining, process capabilities and limitations	2
4.4	High Velocity Forming Processes: - Conventional versus High velocity forming methods – Material behaviour – stress waves and deformation in solids	2
4.5	Stress wave induced fractures – Applications	1
5	**Explosive Forming Processes**	
5.1	Explosive Forming Processes: - Principles – Explosives – Length of reactions	1
5.2	Energy in plastic deformations – Expression for change in size required for deforming a flat disc into a bulged form	2
5.3	Effect of process in material properties, Types of Explosives forming – die construction	2
5.4	Magnetic Pulse Forming Processes: - General principles – Applications	2

Reference Books

1. J. Ghosh and Mallik, Manufacturing Science, East West Press, (2006)
2. HMT, Production Technology, Tata McGraw Hill, New Delhi. (2005)
3. C. Pandey, H.S. Shan, Modern Machining Processes, Tata McGraw Hill, (2008)
4. Mc Geongh J. A., Advanced Methods of Machining, Chapman and Hall, (2006)

Program Elective 3



CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EME035	CELLULAR MANUFACTURING AND GROUP TECHNOLOGY	PROGRAMME ELECTIVE - 3	3	0	0	3

Preamble: Nil

Course Outcomes:

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

CO 1	Develop an understanding about Group Technology and part classification and coding
CO 2	Understand the algorithms and methods for part grouping
CO 3	Understand the concepts of cellular manufacturing
CO 4	Understand about the design methods of Cellular manufacturing systems
CO 5	Understand about quantitative analysis of cellular manufacturing

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	**20**
Analyse	**40**
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

222EME035 CELLULAR MANUFACTURING AND GROUP TECHNOLOGY

PART A

(Answer all the questions. Each question carries 5 Marks)

1. Justify the need of Group Technology citing the limitations in traditional manufacturing systems.
2. Explain about methods for cell formation.
3. Describe key machine concept in cellular manufacturing
4. Explain about machine component group analysis.
5. Explain briefly about the parametric analysis of GT.

PART B

(Answer any 5 questions. Each carries 7 Marks)

6 Explain in detail about the OPITZ multiclass coding system citing an example.

7 Explain in detail about part classification based on design attributes and manufacturing attributes citing relevant examples.

8 Explain in detail about the different machine cell layouts in cellular manufacturing systems.

9 Explain how the concepts of genetic algorithms can be implemented for design and modelling of a cellular manufacturing system.

10 Explain the Application of Genetic algorithm in CMS

11 Explain various life cycle issues in GT/CMS.

12 Describe the following terms Inter and Intra cell layout, cost and non-cost-based models,

Syllabus

MODULE	CONTENT	HOURS	SEMESTER EXAM MARKS (%)
I	Limitations of traditional manufacturing systems, Introduction to Group Technology, GT concepts, Advantages of GT, Part family formation –Part classification and coding systems. GT and Economics of GT. Features of part classification and coding- examples- OPITZ multiclass coding system, Benefits of GT and issues in GT.	8	20
II	Design attributes, manufacturing attributes, characteristics, and design of groups, PFA, FFA. Part machine group analysis, Methods for cell formation, Use of different algorithms, mathematical programming, and graph theoretic model approach for part grouping.	8	20

III	Cellular Manufacturing- composite part concept- examples machine cell design- types of machine cell and layout, Types of manufacturing cell, Design of cellular manufacturing systems, determination of best cell arrangement, key machine concept.	**8**	**20**
IV	Cell formation approach- Machine component group analysis, similarity coefficient-based approach, exceptional parts and bottleneck machines, Problems in GT/CMS - Design of CMS - Models, traditional approaches and non-traditional approaches - Genetic Algorithms, Simulated Annealing, Neural networks	**8**	**20**
V	Quantitative analysis in cellular manufacturing- arranging machines in GT cell- examples. Inter and Intra cell layout, cost and non-cost-based models, batch sequencing and sizing, life cycle issues in GT/CMS. Measuring CMS performance - Parametric analysis - PBC in GT/CMS, Human aspects of GT/CMS	**8**	**20**

Corse Plan

No	Topic	No. of Lectures
1	**Introduction to group technology and basics of part classification and coding**	
1.1	Limitations of traditional manufacturing systems, Introduction to Group Technology	1
1.2	GT concepts, Advantages of GT, Part classification and coding systems	2
1.3	GT and Economics of GT	1
1.4	OPITZ multiclass coding system	2
1.5	Benefits of GT and issues in GT.	2
2	**Part grouping analysis**	
2.1	Design attributes, manufacturing attributes	1
2.2	Characteristics, and design of groups	2
2.3	Production flow analysis and factory flow analysis	1
2.3	Methods for cell formation, Use of different algorithms	2
2.4	Mathematical programming, and graph theoretic model approach for part grouping.	2
3	**Concepts of cellular manufacturing**	
3.1	Composite part concept in cellular manufacturing and examples	2
3.2	Types of machine cell and layout	1
3.3	Types of manufacturing cell	1

3.4	Design of cellular manufacturing systems, determination of best cell arrangement,	2
3.5	Key machine concept	2
4	**Methods of cell formation, problems in GT/CMS, Design of CMS**	
4.1	Cell formation approach- Machine component group analysis	1
4.2	similarity coefficient-based approach, exceptional parts and bottleneck machines	2
4.3	Problems in GT/CMS	1
4.4	Design and Modelling of CMS-traditional approaches and non-traditional approaches	2
4.5	Use of Genetic Algorithms, Simulated Annealing, Neural networks in CMS design	2
5	**Quantitative analysis in cellular manufacturing**	
5.1	arranging machines in GT cell- examples	1
5.2	Inter and Intra cell layout, cost and non-cost based models	2
5.3	batch sequencing and sizing	1
5.4	life cycle issues in GT/CMS.	2
5.5	Parametric analysis - PBC in GT/CMS,	1
5.6	Human aspects of GT/CMS	1

Reference Books

1. Mikell P. Groover, "Automation, Production systems and Computer integrated manufacturing", Prentice hall of India private limited.

2. Ali Kamrani, Hamid R Parsaei, Donald H Liles, "Planning, Design and Analysis of cellular manufacturing system", Elsevier, 1995

3. Manua Singh, "Systems approach to Computer Integrated Design and Manufacturing", John Wiley & Sons Inc, 1996

4. Irani.S.A, "Cellular Manufacturing Systems", Hand Book 5. Kamrani, A.K, and Nasr, E.A. (Eds), "Collaborative Engineering: Theory and Practice Springer science, business media, 2008.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EME036	ENTERPRISE RESOURCE PLANNING	PROGRAMME ELECTIVE - 3	3	0	0	3

Preamble: Nil

Course Outcomes:

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

CO 1	Understand the fundamental concepts of enterprise resource planning
CO 2	Apply the basic knowledge of the subject to design various modules as well as an integrated ERP system for an enterprise.
CO 3	Design and implement the various ERP modules as per the requirements of the clients
CO 4	Analyse the fitting requirements of ERP packages in different industrial domains.
CO 5	Understand how companies have implemented ERP successfully.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20
Analyse	40
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

222EME036 Enterprise Resource Planning

PART A

(Answer all the questions. Each question carries 5 Marks)

1. Explain the role of enterprise in business modelling.
2. Illustrate Business Process Reengineering.
3. Write shote notes on Basic modules of ERP Package.
4. Write shot note on ERP in manufacturing industry.
5. What are the implementation methodologies of ERP software?

PART B

(Answer any 5 questions. Each carry 7 Marks)

6. Explain the conceptual model of ERP.

7. Explain in detail about following terms in ERP environment i) Data Warehousing and Data mining ii) Data extraction and transformation

8. Explain the various performance measures of ERP

9. Describe about the ERP functional modules i) Human capital Management ii) Financial management iii) Supply chain planning iv) Sales and service.

10. Explain in detail about application of ERP in service industries

11. Explain the terms in ERP Related technology

(i)Data base Management System (ii) Decision Support Systems

12. Explain in detail about ERP implementation methodology.

Syllabus

MODULE	CONTENT	HOURS	SEMESTER EXAM MARKS (%)
I	Introduction of ERP: Concept of Enterprise, ERP Overview, Integrated information system, The role of Enterprise, Business Modelling, Myths about ERP, Basic ERP Concepts. Enabling Technologies, Conceptual Model of ERP, Structure of ERP, Intangible benefits of ERP, Justifying ERP investment, Risks of ERP, Benefits of ERP.	8	20
II	ERP and related Technology: Business Process Reengineering (BPR), Management Information System (MIS), Data base Management System (DBMS), Decision Support Systems (DSS), Executive Support Systems (ESS), Data Warehousing and Data Mining, Online Analytical Processing (OLTP), Supply Chain Management (SCM), Customer Relationship	8	20

	Management (CRM).		
III	Modules of ERP: Basic modules of ERP Package-Human Resources Management, Financial Management, Inventory Management, Quality Management, Sales and Distribution.	**8**	**20**
IV	ERP packages and Cases: ERP for manufacturing Industries, ERP for Service Industries. Performance measures for ERP, Cloud ERP.	**8**	**20**
V	ERP Implementation: ERP Implementation Strategies, ERP Implementation Life Cycle, Implementation Methodologies, ERP package selection, ERP Projects Teams, Vendors and Consultants, Reasons for failure and reasons for success of ERP implementation, Dealing with employee resistance, Training and Education, data migration, Project Management and monitoring, Post Implementation activities.	**8**	**20**

Corse Plan

No	Topic	No. of Lectures
1	**Introduction of ERP**	
1.1	Concept of Enterprise, ERP Overview, Integrated information system	1
1.2	The role of Enterprise, Business Modelling	1
1.3	Myths about ERP	1
1.4	Basic ERP Concepts.	1
1.5	Enabling Technologies	1
1.6	Conceptual Model of ERP& Structure of ERP	1
1.7	Intangible benefits of ERP	1
1.8	Justifying ERP investment, Risks of ERP, Benefits of ERP	1
2	**ERP and related Technology**	
2.1	Business Process Reengineering (BPR), Management Information System (MIS).	2
2.2	Data base Management System (DBMS), Decision Support Systems (DSS).	2
2.3	Executive Support Systems (ESS), Data Warehousing and Data Mining, Online Analytical Processing (OLTP).	2
2.4	Supply Chain Management (SCM), Customer Relationship Management (CRM).	2
3	**Modules of ERP**	

3.1	Basic modules of ERP Package, Human Resources Management.	2
3.2	Financial Management, Inventory Management.	2
3.3	Quality Management.	2
3.4	Sales and Distribution.	2
4	**ERP packages and Cases**	
4.1	ERP for manufacturing Industries.	2
4.2	ERP for Service Industries.	2
4.3	Performance measures for ERP	2
4.4	Cloud ERP.	2
5	**ERP Implementation**	
5.1	ERP Implementation Strategies, ERP Implementation Life Cycle.	1
5.2	Implementation Methodologies, ERP package selection, ERP Projects Teams.	2
5.3	ERP Projects Teams, Vendors and Consultants, Reasons for failure and reasons for success of ERP implementation.	1
5.4	Dealing with employee resistance, Training and Education, data migration.	2
5.5	Project Management and monitoring, Post Implementation activities.	2

Reference Books

1. Rajesh Ray "Enterprise Resource Planning'', Tata McGraw Hill Education Private Limited, New Delhi.
2. Vinod Kumar Garg and Venkitakrishnan N K,"Enterprise Resource Planning-Concepts and Practice". PHI, 2006
3. David L. Olson, "Managerial issues of Enterprise Resource Planning systems" TMH Edition 2008.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EME037	FLEXIBLE MANUFACTURING SYSTEMS	PROGRAMME ELECTIVE - 3	3	0	0	3

Course Outcomes:

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

CO 1	Demonstrate in detail about FMS, types and equipment
CO 2	Understand some of the flexibility achievements and economic justification and functional requirements for FMS
CO 3	Understand the concept of FMS processing and QA equipment
CO 4	Evaluate the types of storage systems and cutting tool management
CO 5	Analyse various work holding considerations in FMS environment

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	**20**
Analyse	**40**
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

222EME037 FLEXIBLE MANUFACTURING SYSTEMS

PART A

(Answer all the questions. Each question carries 5 Marks)

1. What is the need for FMS? Explain in the context of evolution of FMS?
2. Enumerate the economic justification for FMS and functional requirements for FMS equipment?
3. Describe material handling principles in FMS?
4. Differentiate Conventional and Automated storage systems
5. Describe the fixture considerations in FMS environment?

PART B

(Answer any 5 questions. Each carry 7 Marks)

6 What are the different types of flexibilities. Mention its measurement?

7 Define a flexible manufacturing system. Also, explain its evolution from mechanized machine to a contemporary flexible manufacturing system?

8 Enumerate components structure of FMS and their functions with neat sketch?

9 Explain AGV and its types in detail with a neat sketch?

10 Discuss the problems involved in implantation of FMS?

11 Describe the use of deterministic models for quantitative analysis of FMS?

12 List out the typical data handled by an FMS. Explain their role in detail

Syllabus

MODULE	CONTENT	HOURS	SEMESTER EXAM MARKS (%)
I	Introduction: Introduction to FMS, FMS definition, evolution, equipment, and classification of FMS - configuration of FMS-application of FMS, Automated production cycle, Need of flexibility, Concept of flexibility, Types of flexibilities and its measurement. FMS Equipment: Why FMS, Factors responsible for the growth of FMS	9	20
II	FMS types and applications, user- host supplier flexibilities- flexibility achievement-how to develop FMS, Economic justification for FMS, Functional requirements for FMS equipments	8	20
III	FMS processing and QA equipment, e.g., turning and machining centers, Coordinate measuring machines, Cleaning and deburring machines, FMS system support equipment, Material handling principles- transport system-industrial truck, Automated material handling, AGV- monorail and other guided vehicle-conveyor-crane- hoist	9	20
IV	Storage system- performance- location strategies-conventional and automated storage systems- equipment	7	20

	used for storage, engineering analysis. Cutting tool and tool management		
V	Work holding considerations, Fixture considerations in FMS environment, FMS production, and its importance, Manufacturing support system- process planning for parts and assemblies- CAPP retrieval and generative	**7**	**20**

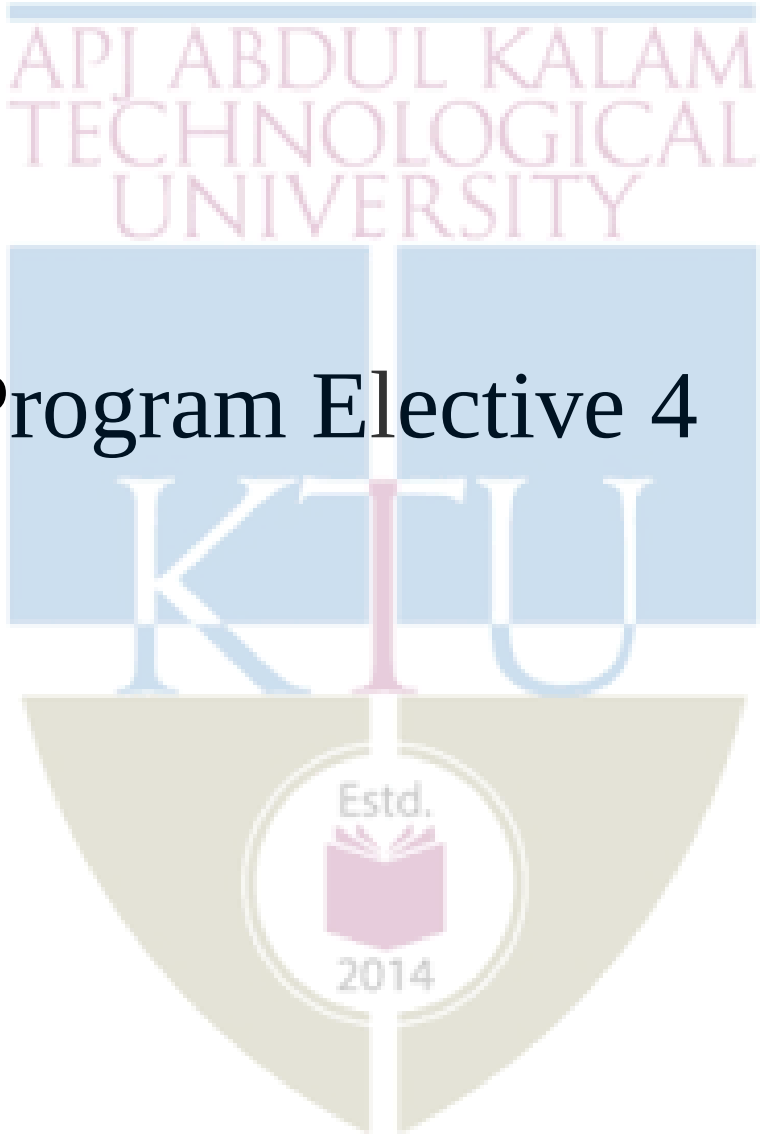
Corse Plan

No	Topic	No. of Lectures
1	**Introduction: Introduction to FMS, FMS definition, evolution, equipment and classification of FMS**	
1.1	Introduction: Introduction to FMS, FMS definition, evolution, equipment and classification of FMS	2
1.2	Configuration of FMS	1
1.3	Application of FMS Automated production cycle	2
1.4	Need of flexibility, Concept of flexibility, Types of flexibilities and its measurement	2
1.5	FMS Equipment: Why FMS, Factors responsible for the growth of FMS	2
2	**FMS types, applications and equipment**	
2.1	FMS types and applications	2
2.2	User- host supplier flexibilities	2
2.3	Flexibility achievement-how to develop FMS	2
2.4	Economic justification for FMS, Functional requirements for FMS equipment	2
3	**FMS processing and QA equipment and AGV**	
3.1	FMS processing and QA equipment, e.g., turning and machining centres	2
3.2	Coordinate measuring machines, Cleaning and deburring machines	2
3.3	FMS system support equipment	1
3.4	Material handling-principles- transport system-industrial truck Automated material handling	2
3.5	AGV- monorail and other guided vehicle-conveyor- crane- hoist	2
4	**Storage system and Cutting tool, equipment and management**	
4.1	Storage system- performance- location strategies	2
4.2	Conventional and automated storage systems	2
4.3	Equipments used for storage, engineering analysis	1
4.4	Cutting tool and tool management	2
5	Work holding considerations, Manufacturing support systems and CAPP retrieval	
5.1	Work holding considerations	1

5.2	Fixture considerations in FMS environment	1
5.3	FMS production and its importance	1
5.4	Manufacturing support system	1
5.5	process planning for parts and assemblies	1
5.6	CAPP retrieval and generative	2

Reference Books

1. D. J. Parrish. Butterworth Heinmann; Flexible manufacturing systems
2. Groover, M.P., "Automation, Production System and CIM", Prentice-Hall of India, 2006.3. V. K. Jain, Introduction to micro machining, Narosa publishing house, 2014
3. David Bedworth, "Computer Integrated Design and Manufacturing", TMH, New Delhi, III Edition 2005



Program Elective 4

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EME041	COMPUTER AIDED MEASUREMENTS	PROGRAME ELECTIVE - 4	3	0	0	3

Preamble: Nil

Course Outcomes:

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

CO 1	Under stand the fundamentals of measurements and its dynamics
CO 2	Identify the use of sensors and transducers in measurement.
CO 3	Evaluate the basic concepts for measuring the displacement and pressure,
CO 4	Analyse the importance of temperature and flow measurement.
CO 5	Knowledge and skills in using sensors with conditioning circuits for automation systems which has applications in diverse areas of process and manufacturing automation

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20%
Analyse	60%
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

222EME041 COMPUTER AIDED MEASUREMENTS

PART A

(Answer all the questions. Each question carries 5 Marks)

1. What is measurement? State and explain the requirements to be satisfied in the act of measurement.
2. What is a passive transducer? Give examples. How does it differ from an active transducer.
3. Describe, in brief, a variable resistance transducer used for measurement of small displacements.
4. Suggest and explain about an instrumentation circuit which will produce a linear output with temperature.

5. Explain the basic working principle of any one magnetic sensor with a neat diagram.

PART B

(Answer any 5 questions. Each carry 7 Marks)

6 Define dynamic system response of a measuring system and explain. (i) Amplitude response (ii) phase response (iii) delay or rise time (iv) bandwidth of frequency response

7 With the aid of a block diagram explain the generalised measuring system.

8 Define what is meant by a transducer and state their desirable operational characteristics. Explain why all transducers are designed to give electrical output by linking primary mechanical detectors to electrical secondary sensors give reasons.

9 What are the three major classes of digital displacement transducers? Draw diagrams of each of them. Discuss their relative merits and demerits.

10 What is process loading? If a potentiometer is used as displacement sensor, then prove that the relation ship between load voltage and fractional displacement of wiper is nonlinear.

11 Describe the principle of operation of a head -type flowmeter based on differential pressure measurement. what is Reynolds number?

12 With the aid of neat sketches explain briefly any two radiation sensors used for measurement.

Syllabus

MODULE	CONTENT	HOURS	SEMESTER EXAM MARKS (%)
I	Introduction to Measurement: Significance of measurement, Different methods of measurement, Classification of measuring instruments, Application of measurement systems, typical measurement schemes. Dynamic Characteristics: Dynamic response; Transient response; speed of response, fidelity, measuring lag etc, Linear approximation, Introduction to compensation techniques. Significance of testing and calibration, Calibration curve, Standards for calibration, Different calibration procedures-primary, secondary, direct, indirect, routine calibration, Calibration setup: pressure gauge, level etc.	8	20
II	Introduction to Sensors: Definition and differences of sensors and transducers, Classification, static and dynamic characteristics, electrical characterization, mechanical and thermal characterization including bathtub curve. Introduction to Transducers: Transducer classification, Active and Passive Transducers, Potentiometric Transducers, Linear and non-linear potentiometer, Feedback transducer system, Inverse transducer, Self-balancing transducer, Servo- operated manometer, Feedback pneumatic load cell, integrating servo.	8	20
III	Displacement Measurement: Linear /Angular displacement, Pneumatic/Electric/ Optical/ Ultrasonic/Electronic Displacement Transducers, Tactile and Proximity Sensors, Typical application schemes, Tacho-generators. Pressure Measurement: Pressure Units, Force Summing Devices, Secondary Transducers, Vacuum Measurement, Torque Measurement, Resistance/Bonded Type Strain Gauge.	8	20
IV	Temperature Measurement: Electric Method, Change in Electrical Properties, RTD, Thermocouples, Thermistors,	8	20

	Thermowells. Nuclear thermometers, resistance change type thermometric sensors. Flow Measurement: Reynold Number, Head type flowmeters, Velocity measurement type flowmeters, Mass flow measurement type flow meters.		
V	Magnetic sensors: Basic working principles, Magneto-strictive, Hall effect, Eddy current type. Radiation sensors: Photo-detectors, Photo-emissive, photomultiplier, scintillation detectors. Electroanalytical sensors: Electrochemical cell, SHE, Polarization, Reference electrode, Metal electrodes, Membrane electrodes.	**8**	**20**

Corse Plan

No	Topic	No. of Lectures
1	**Introduction to Measurement & Dynamic Characteristics**	
1.1	Significance of measurement, Different methods of measurement, Classification of measuring instruments, Application of measurement systems, typical measurement schemes.	2
1.2	Dynamic response; Transient response; speed of response, fidelity, measuring lag etc,	2
1.3	Linear approximation, Introduction to compensation techniques.	1
1.4	Significance of testing and calibration, Calibration curve, Standards for calibration, Different calibration procedures-primary, secondary, direct, indirect, routine calibration, Calibration setup: pressure gauge, level etc.	3
2	**Introduction to Sensors and Transducers**	
2.1	Definition and differences of sensors and transducers, Classification.	2
2.2	Static and dynamic characteristics, electrical characterization, mechanical and thermal characterization including bathtub curve.	2
2.3	Introduction to Transducers: Transducer classification, Active and Passive Transducers, Potentiometric Transducers, Linear and non-linear potentiometer, Feedback transducer system, Inverse transducer, Self-balancing transducer.	2
2.4	Servo- operated manometer, Feedback pneumatic load cell, integrating servo.	2
3	**Displacement and Pressure Measurements**	

3.1	Linear /Angular displacement, Pneumatic/Electric/ Optical/ Ultrasonic/Electronic Displacement Transducers.	2
3.2	Tactile and Proximity Sensors, Typical application schemes, Tacho-generators.	2
3.3	Pressure Units, Force Summing Devices, Secondary Transducers.	2
3.4	Vacuum Measurement, Torque Measurement, Resistance/Bonded Type Strain Gauge.	2
4	**Temperature and flow Measurements**	
4.1	Electric Method, Change in Electrical Properties, RTD, Thermocouples, Thermistors, Thermowells.	3
4.2	Nuclear thermometers, resistance change type thermometric sensors	2
4.3	Reynold Number, Head type flowmeters, Velocity measurement type flowmeters, Mass flow measurement type flow meters.	2
5	**Magnetic, Radiation and Electroanalytical sensors**	
5.1	Basic working principles, Magneto-strictive, Hall effect, Eddy current type.	2
5.2	Photo-detectors, Photo-emissive, photomultiplier, scintillation detectors	2
5.3	Electrochemical cell, SHE, Polarization, Reference electrode, Metal electrodes, Membrane electrodes.	4

Reference Books

1. K.L. Kishore, Electronic Measurement and Instrumentation, Pearson.
2. D. Patranabis, Sensors and Transducers, PHI Learning Pvt. Ltd., 2nd Edition
3. A. K. Ghosh, Introduction to Measurements and Instrumentation, 4th Edition, PHI.
4. D V S Murty, Transducers and Instrumentation, PHI Learning Pvt. Ltd.
5. B. C. Nakra, K. K. Chaudhry, Instrumentation, Measurement and Analysis, 4th Edition, Tata McGraw Hill.
6. W. D. Cooper, Modern Electronics Instrumentation & Measurement Techniques, PHI.
7. John. P. Bentley, Principles of Measurement Systems, Pearson
8. E. O. Doebelin, Dhanesh N Manik, Measurement Systems, 6th Edition, McGraw Hill.
9. Bolton W, Mechatronics- Electronic Control Systems in Mechanical & Electrical Engineering, 2nd Edition, Longman Publishers, 2002.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EME042	MODELING AND SIMULATION OF ENGINEERING SYSTEM	Program Elective 4	3	0	0	3

Preamble: Nil

Course Outcomes:

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

CO 1	Understand in detail about fundamental concepts in mathematical modeling
CO 2	Demonstrate some of the lumped element modeling
CO 3	Understand the modelling of first order and second order systems
CO 4	Analyse the frequency response of linear and time invariant systems
CO 5	Understand various feedback systems

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	**20**
Analyse	**40**
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

222EME042 -MODELING AND SIMULATION OF ENGINEERING SYSTEM

PART A

(Answer all the questions. Each question carries 5 Marks)

1. Explain the fundamental concepts in Mathematical modeling?
2. Explain the thermal systems and hydraulic systems in lumped element modelling?
3. Describe time domain and frequency domain?
4. Explain Conventional and Automated storage systems in detail?
5. Explain the phase and gain margins?

PART B

(Answer any 5 questions. Each carries 7 Marks)

6 Explain balance and conservation laws and system boundary approach?

7 Explain various lumped element modelling techniques?

8 Derive the governing equation for first order free responses?

9 Derive the governing equations for forced responses?

10 Derive the equations for frequency response of the first order system?

11 Derive the equations for frequency response of the second order system?

12 Discuss feedback systems with block diagram?

Syllabus

MODULE	CONTENT	HOURS	SEMESTER EXAM MARKS (%)
I	Fundamental Concepts in Mathematical Modelling: Abstraction – linearity and superposition – balance and conservation laws and the system – boundary approach.	8	20
II	Lumped – Element Modeling: Mechanical systems – Translational, rotational. Hydraulic systems. Thermal systems. RLC Electrical Systems.	7	20
III	Modeling of First–order and Second–order Systems: Governing equations for free and forced responses – transient response specifications – experimental determination – Laplace transform. Time Domain, Frequency Domain and State Space.	9	20
IV	Frequency response of Linear, Time invariant systems – frequency response of first–order and second–order systems – state space formulations of systems problems relating frequency response to pole location – transient	9	20

	response-poles and frequency response.		
V	Feedback systems: Systems with feedback – block diagrams – properties of feedback systems – relative stability – phase and gain margins.	7	20

Corse Plan

No	Topic	No. of Lectures
1	**Fundamental Concepts in Mathematical Modelling:**	
1.1	Fundamental Concepts in Mathematical Modelling	1
1.2	Fundamental Concepts in Mathematical Modelling: Abstraction	1
1.3	Linearity and superposition	2
1.4	Balance and conservation laws and the system	2
1.5	Boundary approach	2
2	**Mechanical, Hydraulic, Thermal & Electrical systems**	
2.1	Lumped – Element Modeling	2
2.2	Mechanical systems – Translational, rotational	2
2.3	Hydraulic systems	1
2.4	Thermal systems. RLC Electrical Systems	2
3	**Modeling of First–order and Second–order Systems**	
3.1	Modeling of First–order and Second–order Systems	2
3.2	Governing equations for free and forced responses	2
3.3	Transient response specifications – experimental determination	2
3.4	Laplace transform	1
3.5	Time Domain, Frequency Domain and State Space.	2
4	**Frequency response**	
4.1	Frequency response of Linear, Time invariant systems	2
4.2	Frequency response of first–order and second–order systems	2
4.3	State space formulations of systems	1
4.4	Problems relating frequency response to pole location	2
4.5	Transient response-poles and frequency response	2
5	**Feedback systems**	
5.1	Feedback systems	1
5.2	Systems with feedback – block diagrams	1
5.3	Systems with feedback – block diagrams	1
5.4	properties of feedback systems	1
5.5	relative stability	1
5.6	phase and gain margins	2

Reference Books

1. Cha P. D., Rosenberg J. J. and Dym C. L. – 'Fundamentals of Modeling and Analyzing Engineering Systems'- Cambridge University – 2000
2. Woods Robert L. and Kent L.- 'Modeling and Simulation of Dynamic Systems'- Prentice Hall – 1997
3. Mukherjee A. and Karmakar R. – 'Modeling and Simulation of Engineering Systems through Bondgraphs' – Narosa – 2000
4. Frederick C. – 'Modeling and Analysis of Dynamic Systems' – Wiley – 2001 – 3rd Edition

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EME043	OPTIMIZATION TECHNIQUES	PROGRAMME ELECTIVE - 4	3	0	0	3

Preamble: Nil

Course Outcomes:

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

CO 1	Understand the theory of simplex method
CO 2	Understand the concepts of non-linear programming in manufacturing process
CO 3	Identify algorithms for unconstrained optimization.
CO 4	Understand the basic concepts of multi-objective decision making and sequential decision making.
CO 5	Solve a multi-variable single objective optimization problem using Metaheuristics.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	**20**
Analyse	**40**
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

222EME043 OPTIMIZATION TECHNIQUES

PART A

(Answer all the questions. Each question carries 5 Marks)

1. Explain various theorems of duality.
2. Explain the necessity conditions for constrained multivariable optimization with equality and inequality constraints.
3. Explain the various step by step procedure for Fibonacci search for find the maximum and minimum of a unimodal univariate objective function.
4. Explain the various steps involved in goal programming.

5. Explain the difference between heuristics and Metaheuristics

PART B

(Answer any 5 questions. Each carry 7 Marks)

6 Find the values of basic variables for the following LPP if the optimum solution is having Basic variable set $X_B = [X_1, X_2]$ using revised simplex method. Also find the range of b_1 (right hand side value of the first constant) so that the solution set will have same optimum basic variables.

$$Max\ Z = 4X_1 + 6X_2 + 2X_3$$

Sub to

$$X_1 + X_2 + X_3 \leq 3$$

$$X_1 + 4X_2 + 7X_3 \leq 9$$

$$X_1, X2, X_3 \geq 0$$

7 Solve the following LPP by Duel Simplex method.

$$Min\ Z = 2X_1 + 4X_2$$

Sub to

$$2X_1 + X_2 \geq 4$$

$$X_1 + 2X_2 \geq 3$$

$$2X_1 + 2X_2 \leq 12$$

$$X_1, X_2 \geq 0$$

8 Determine the maximum or minimum point (if any) for the function

$f(X) = 2X_1^2 + X_2^2 + X_3^2 + 2X_1X_2 - 8X_1 - 4X_2 - 6X_3 + 37$

9 Market state of a product for the next month can be Strong Moderate or Weak (S, M, W) and depends only on the market condition of the current month. One step transient probabilities for the market states are given. The manufacturing company has to adopt one of the three marketing strategies namely Aggressive, Basic or Cautions (A , B, C).he returns per month for each of the strategies given a particular state of the market occurs in that month is also given , assuming the state f the product follows a Markov chain, determine the ideal long term marketing strategy to

adopt in order to maximize the expected returns per month.

One step Transient Probabilities

		Next month		
		S	M	W
Current Month	S	0.7	0.3	0.0
	M	0.0	0.6	0.4
	W	02	0.0	0.8

Returns per month in

Lakhs of Rs

		Market State		
		S	M	W
Marketing Strategy	A	43	32	25
	B	35	40	30
	C	20	28	32

10 Minimize

$f(x) = x^4 + 15x^3 + 7x^2 - 1135x$

Terminate when ,

$|f(x_n) - f(x_{(n-1)})| \leq 0.5$

Using Golden search method

11 Explain the principles of Simulated Annealing Algorithm used in optimization.

12 Explain the principles of Genetic Algorithm used in optimization

Syllabus

MODULE	CONTENT	HOURS	SEMESTER EXAM MARKS (%)
I	Theory of simplex method, Duality Theory, Duality theorems, Dual simplex method, Revised simplex method − Bounded variables algorithm, Sensitivity analysis, Parametric programming. Integer programming: Cutting plane method, Branch and bound method. Network models and solutions: Shortest route problems, Minimal spanning tree problems, Maximal flow problems.	8	20
II	Non-linear programming problems: General non-linear programming problems; Convex, Quasi-convex, Concave and uni-modal functions, Theory of unconstrained optimization − Necessary and sufficient conditions for extrema, Theory of constrained optimization −Lagrange multipliers and Lagrangian optimization, Inequality constraints, Kuhn-Tucker conditions.	8	20
III	Algorithms for unconstrained optimization: Fibonacci search method, Golden section search method, Cauchy's (steepest descent) method. Algorithms for constrained optimization: Quadratic programming, Separable convex programming.	8	20
IV	Multi-objective decision models: Introduction to multi-objective decision making, Concept of pareto-optimality, Goal programming formulation, The weighting method of	8	20

	solution, Analytic hierarchy process. Sequential decision making (stochastic case): Stochastic processes, Markov processes, Markov chains, Markov decision problems, Algorithms for solving Markov decision problems.		
V	Metaheuristics: Nature of metaheuristics, Tabu search, Simulated annealing, Genetic algorithm. Complexity of algorithms: Complexity of algorithms for combinatorial optimization problems.	**8**	**20**

Corse Plan (For 3 credit courses, the content can be for 40 hrs and for 2 credit courses, the content can be for 26 hrs. The audit course in third semester can have content for 30 hours).

No	Topic	No. of Lectures
1	**Parametric programming. Integer programming:**	
1.1	Theory of simplex method, Duality Theory, Duality theorems, Dual simplex method, Revised simplex method.	2
1.2	Bounded variables algorithm, Sensitivity analysis, Parametric programming.	2
1.3	Integer programming: Cutting plane method, Branch and bound method.	2
1.4	Network models and solutions: Shortest route problems, Minimal spanning tree problems, Maximal flow problems.	2
2	**Non-linear programming problems**	
2.1	General non-linear programming problems; Convex, Quasi-convex, Concave and uni-modal functions.	2
2.2	Theory of unconstrained optimization − Necessary and sufficient conditions for extrema.	2
2.3	Theory of constrained optimization −Lagrange multipliers and Lagrangian optimization, Inequality constraints, Kuhn-Tucker conditions.	4
3	**Algorithms for unconstrained optimization**	
3.1	Fibonacci search method.	2
3.2	Golden section search method.	2
3.3	Cauchy's (steepest descent) method.	2
3.4	Quadratic programming, Separable convex programming.	2
4	**Multi-objective decision models & Sequential decision making**	
4.1	Introduction to multi-objective decision making, Concept of pareto-optimality, Goal programming formulation, The weighting method of solution.	2

4.2	Analytic hierarchy process.	2
4.3	Stochastic processes, Markov processes, Markov chains, Markov decision problems.	2
4.4	Algorithms for solving Markov decision problems.	2
5	**Metaheuristics**	
5.1	Nature of metaheuristics.	1
5.2	Tabu search.	2
5.3	Simulated annealing.	1
5.4	Genetic algorithm.	2
5.5	Complexity of algorithms for combinatorial optimization problems	2

Reference Books

4. Rao S.S, Optimization: Theory and Applications, Wiley Eastern, Fourth edition, 2009.
5. Ravindran A., Philips D.T. and Solberg J.J., Operations Research: Principles and Practice, John Wiley & Sons, 4th Edition, 2009.
6. Taha H.A., Operations Research: An Introduction, Pearson Education, 9th Edition, 2013
7. Deb K., Optimization for Engineering Design: Algorithms and Examples, Prentice-Hall of India, 2nd 2012
8. Papadimitriou C.H. and Steghtz K., Combinatorial Optimization: Algorithms and Complexity, Dover Publications Inc, 2000 .
9. Hillier F.S. and Liberman G.J., Introduction to Operations Research, McGraw-Hill International, 10th edition, 2014
10. Reklatis G.V., Ravindran A. and Ragsdell K.M., Engineering Optimization: Methods and applications, John Wiley and Sons, 2nd Edition, 2006

INTERDISCIPLINARY ELECTIVE

CODE 222EME103	Internet of Things	CATEGORY	L	T	P	CREDIT
		INTERDISCIPLINARY ELECTIVE	3	0	0	3

Preamble: Nil

Course Outcomes:

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

CO 1	Evaluate IoT enabling technologies
CO 2	Analyse protocols implemented for IoT connected devices.
CO 3	Design and develop Smart Devices using IoT
CO 4	Analyse the vulnerabilities for IoT and security requirements of IoT
CO 5	Apply IoT for various domains

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

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	80%
Analyse	10%
Evaluate	10%
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

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 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

Module 1

Introduction to Internet of Things: An overview; Definition, scope and characteristics of IoT; IoT enabling technologies; Structure of IoT; Major components. Sensor technology: sensor types and applications, Actuators: principles and properties. Basics of IoT Networking, Communication Protocols: MQTT, CoAP, AMQP

Module 2

Connectivity Technologies: Zigbee, Bluetooth, RFID. Wireless Sensor Network (WSN) technology- concepts and applications. Machine-to-Machine Communications, IoT and M2M, Interoperability in IoT.

Module 3

IoT device- definition and building blocks; Embedded platforms for prototyping, features and IoT applications; Connecting things to embedded devices. Introduction to Arduino Programming using an IDE (basics only), Integration of Sensors and Actuators with Arduino.

Module 4

Introduction to Raspberry Pi; Python programming; Interfacing Raspberry Pi with basic peripherals; Implementation of IoT with Raspberry Pi (basics only). Cloud platforms for IoT; Cloud security requirements

Module 5

Sensor-cloud, Industrial IoT(IIoT): Requirements of IIoT, applications. Case studies: Smart grid, Smart parking, Remote vehicle diagnostics, Smart Irrigation, Health and fitness monitoring.

Corse Plan

No	Topic	No. of Lectures
1	The Internet of Things: An overview	
1.1	Introduction to Internet of Things, Definition, scope and characteristics of IoT	1
1.2	IoT enabling technologies, Structure of IoT, Major components	2
1.3	Sensor technology, Actuators, principles and properties	2
1.4	Basics of IoT Networking, Communication Protocols	2
2	Architecture, design and connectivity principles	
2.1	Connectivity Technologies	2
2.2	Wireless Sensor Network (WSN) technology, concepts and applications	2
2.3	Machine-to-Machine Communications, IoT and M2M	2
2.4	Interoperability in IoT	1
3	Development of IoT platforms	
3.1	IoT device, definition and building blocks	1
3.2	Embedded platforms for prototyping, Connecting things to embedded devices	2
3.3	Introduction to Arduino Programming using an IDE	3
3.4	Integration of Sensors and Actuators with Arduino	3
4	IoT prototyping and security	
4.1	Introduction to Raspberry Pi, Python programming	2
4.2	Interfacing Raspberry Pi with basic peripherals	3
4.3	Implementation of IoT with Raspberry Pi	2
4.4	Cloud platforms for IoT, Cloud security requirements	2
5	Case studies	
5.1	Sensor-cloud	1
5.2	Industrial IoT(IIoT), Requirements of IIoT, applications	2
5.3	Case studies: Smart grid, Smart parking, Remote vehicle diagnostics	3
5.4	Case studies: Smart Irrigation, Health and fitness monitoring.	2

Reference Books

1. Internet of Things: A Hands-On Approach by Arshdeep Bahga, Vijay Madisetti. Universities press (India)
2. Internet of Things: Architecture and Design principles by Raj Kamal, Publisher: Mc Graw Hill Education
3. The Internet of Things: Enabling Technologies, Platforms, and Use Cases, by Pethuru Raj and Anupama C. Raman , CRC Press.
4. The Internet of Things by Samuel Greengard, The MIT Press Essential Knowledge series.

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.

	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 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.

Corse 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 Corse 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 MIL-217 standards	1
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

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.

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

COURSE CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222PME100	MINI PROJECT	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. Doing more projects increases 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	

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222LME003	ADVANCED MANUFACTURING LAB II	Laboratory	0	0	2	1

Preamble: Nil

Course Outcomes:

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

CO 1	To gather knowledge on CNC part programming
CO 2	To gather knowledge on CNC machine tool operations
CO 3	To impart knowledge on surface quality of machined parts
CO 4	To impart gather knowledge on measurement of tool wear and machine vision-based inspection
CO 5	To gather knowledge on software and hardware aspects of additive manufacturing
CO 6	To gather knowledge on programming of industrial robots

Mapping of course outcomes with program outcomes

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

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 Computer aided manufacturing: Part programming fundamentals – manual part programming and computer aided part programming -Simulations
2. Hands on training in computer controlled turning and milling operations - exercises on CNC lathe and machining centre /milling machines.
3. Practical study on surface quality of machined surfaces: Exercises on grinding /turning of components and measurement of surface finish and study of influence of cutting variables on surface quality
4. Study on thread angle measurements/Inspection of tool wear using tool makers microscope. Exercises on machine vision systems-– Machine vision – Computer imaging systems, Image Analysis, Preprocessing, Image model, Image enhancement, gray scale models, Image Transforms.
5. Additive manufacturing basics- Part Consolidation - Topology Optimization - CAD Modeling - Data Formats - Data Interfacing - Part Orientation - Support Structure Design and Support Structure Generation - Model Slicing - Tool Path Generation. Exercises on 3D printing
6. Exercises on Programming of industrial robots: Introduction to robotics - structure, workspace analysis and various components - hands on training on industrial robots - manual and programmed path planning

No	List of Exercise	Course Outcomes
1	Part programming to do basic turning operations	**CO 1**
2	Part programming to do basic milling operations	**CO 1**
3	Exercises on CNC Lathe/drilling machine operations	**CO 2**
4	Exercises on CNC milling operations	**CO 2**
5	Study on surface quality assessment using Talysurf/other surface metrology instruments	**CO 3**
6	Exercises on tool wear measurements and thread angle measurements	**CO 4**
7	Exercises on machine vision systems-part quality inspection	**CO 4**
8	Exercises on machine vision systems-image enhancement and analysis	**CO 4**
9	Exercises on additive manufacturing; CAD modelling and data formats	**CO 5**
10	Exercises on additive manufacturing; polymer/metal 3D printing	**CO 5**
11	Exercises on industrial robots- study of sensors and actuators	**CO 6**
12	Exercises on industrial robots- manual and programmed path planning	**CO 6**

(Minimum 8 experiments to be done)

References:

1. Chang T.C., Wysk, R.A. and Wang.H.P., “Computer Aided Manufacturing”, Pearson Prentice Hall, India ,2009, ISBN: 978-0131429192

2. Andreas Gebhardt and Jan-Steffen Hotter, “Additive Manufacturing:3D Printing for Prototyping and Manufacturing”, Hanser publications Munchen, Germany, 2016. ISBN:978-1-56990-582-1

3. P. Radhakrishnan, Computer Numerical Control and Computer Aided Manufacture, New Age International Publishers, 2012

4. Deb, S.R.” Robotics Technology and Flexible Automation”, Tata McGraw-Hill, 2009