



SEMESTER -4

CET202	Engineering Geology	Category	L	T	P	Credits	Year of Introduction
		PCC	3	0	1		

Preamble: Goal of this course is to introduce to the students the basics of earth processes, materials, groundwater and the geological characteristics of such processes and materials which are relevant to the Civil Engineering applications.

Prerequisites: Nil

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

CO1	Recall the fundamental concepts of surface processes, subsurface process, minerals, rocks, groundwater and geological factors in civil engineering constructions.
CO2	Identify and describe the surface processes, subsurface process, earth materials, groundwater and geological factors in civil engineering constructions.
CO3	Apply the basic concepts of surface and subsurface processes, minerals, rocks, groundwater and geological characteristics in civil engineering constructions.
CO4	Analyze and classify geological processes, earth materials and groundwater.
CO5	Evaluation of geological factors in civil engineering constructions.

Mapping of course outcomes with program outcomes (Minimum requirement)

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

Assessment pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination (Marks)
	Test 1 (Marks)	Test 2 (Marks)	
Remember	9 (3 marks for each question in which one question from third module)	6	15
Understand	6	9 (3 marks for each question in which one question from third module)	15
Apply	14 +14 + 7 (Question for 7 marks is from third module)	14 +14 + 7 (Question for 7 marks is from third module)	70
Analyse			
Evaluate			

Mark distribution

Total Marks	CIE marks	ESE marks	Test 1 &2 Duration	ESE Duration
150	50	100	1.5 hours	3 hours

Continuous Internal Evaluation Pattern:

Attendance: 10marks

Continuous Assessment Test (2 numbers): 25 marks

Assignment/Quiz/Courseproject: 15 marks

End Semester ExaminationPattern:

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

Course Level Assessment Questions:**Part A**

Course Outcome 1 (CO1): (One question from each module to meet the course objective 1: To recall the fundamental concepts of surface processes, subsurface process, minerals, rocks, groundwater and geological factors in civil engineering constructions).

1. Define weathering of rocks

Course Outcome 2 (CO2) (One question from each module to meet the course objective 2: To identify and describe the surface processes, subsurface process, earth materials, groundwater and geological factors in civil engineering constructions.)

1. Explain the classification of soil

Part B

All the questions under this section shall assess the learning levels corresponding to the course outcomes 3, 4 and 5.

1. a) Classify weathering and discuss the engineering classification of weathered rock masses (7 marks)
- b) Write your comments on the relevance of geology in civil engineering constructions (7 marks)

Model Question Paper

QP CODE:

RegNo.: _____

Name: _____

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

Course Code: CET 202

ENGINEERING GEOLOGY

Max.Marks: 100

Duration: 3hours

Part A

(Answer all questions; each question carries 3 marks)

1. Define weathering of rocks
2. Explain soil erosion and classification of soils
3. Describe earthquakes and write notes on seismograph and seismogram
4. Illustrate the elastic rebound theory with a diagram
5. Define Ghyben Herzberg relation in sea water intrusion
6. Explain Darcy's Law with a neat diagram
7. Write down the physical properties and chemical composition of given minerals
 - a. Calcite
 - b. Gypsum
8. Describe the different types of igneous rocks based on their origin
9. Illustrate the major parts of the fold with a neat diagram
10. Distinguish between clinometer compass and Brunton compass

PART B

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

Module -1

11. **a)** Discuss the relevance of geology in civil engineering constructions (7marks)
b) Give an account on classification of weathering with suitable diagrams and examples (7 marks)
12. Describe the geological work of rivers. Discuss different landform features produced by weathering and river action with suitable diagrams. (14 marks)

Module -2

13. Comment on the relation of earthquakes with plate tectonics. Give an account on different plates with earthquake prone area (14 marks)

14. Discuss the various types of seismic waves and their relevance in the study of internal structure of earth. (14marks)

Module -3

15. Discuss the vertical distribution of groundwater. Give an account of the water bearing properties of rocks and hydrological cycle with neat diagrams. (14marks)
16. a) Elucidate application of electrical resistivity survey in ground water exploration. (8 marks)
- b) Give a brief account on different ground water recharge methods (6 marks)

Module -4

17. Distinguish between metamorphic and sedimentary rocks with respect to their structure with diagrams (14marks)
18. a) Elucidate various physical properties of minerals for their identification. (9marks)
- b) Give an account on hardness of minerals with Moh's hardness scale (5 marks)

Module -5

19. a) Enumerate the geological factors to be considered for selecting a dam site (9 marks)
- b) Discuss the geological conditions suitable and unsuitable for construction of tunnels (5marks)
20. Distinguish between folds and faults. Give an account on classification of folds with neat diagrams (14 marks)



ENGINEERING GEOLOGY

Syllabus

Module	Contents	Hours
Module 1 External Earth Processes	Relevance of Geology in Civil Engineering, Surface Processes of the earth- a) Weathering of rocks-Types of weathering, Processes of Origin of Products of weathering like sand, clay, laterite and soil, soil profile, Soil erosion and soil conservation measures. Engineering significance of weathering. b) Geological processes by rivers. c) Landslides-types, causes and controlling measures, Coastal Processes-Geological work by waves and currents and coastal protection measures	9
Module 2 Internal Earth Processes	Internal Processes of the earth- a) Earthquakes- Plate Tectonics, Origin of earthquakes, Seismic waves, Rating of earthquakes, types of earthquakes, Seismic zones of India. Basics of seismic safety factor, Interior of the earth as revealed by propagation of seismic waves.	9
Module 3 Groundwater	Hydrogeology- Occurrence of groundwater, aquifers and types of aquifers, confining beds, porosity and vertical distribution of groundwater. Darcy's Law. Permeability/hydraulic conductivity. Problems created by groundwater to civil engineering structures, Methods to control groundwater problems, Electrical resistivity survey for groundwater exploration. Seawater intrusion in Coastal area. Ghyben Herzberg relation.	9
Module 4 Earth Materials	Mineralogy- Physical properties of minerals, physical properties and chemical composition of minerals like quartz, orthoclase, plagioclase, biotite, muscovite, hornblende, augite, hypersthene, calcite, gypsum. Petrology- Igneous, sedimentary and metamorphic rocks, Igneous rocks-Chemical and mineralogical classification and structure. Sedimentary rocks-types based on mode of formation and structures Metamorphic rocks-structures only. Megascopic study of granite, dolerite, basalt, sandstone, limestone, shale, gneiss, marble and charnockite. Rock types of Kerala. Rock cycle	9
Module 5 Secondary Structures of Rocks	Structural Geology- Attitude of rocks – Dip and Strike. Terminology, brief classification and engineering significance of folds, faults and joints. Geological part of site investigation for the construction of dams, reservoirs and tunnels. Toposheet. Structural mapping. Clinometer compass and Brunton compass.	9

Textbooks

1. Duggal S.K, Pandey H.K and Rawat N (2014) Engineering Geology, Mcgraw Hill Education NewDelhi
2. Gokhale KVGK (2015) Principles of Engineering Geology, BS Publications, Hyderabad

3. Singh P (2014) Engineering and General Geology, SK Kataria and sons, NewDelhi
4. SubinoyGangopadhyay (2017) Engineering Geology, OxfordUniversity

References

1. David K Todd & Larry W Mays (2011) Groundwater Hydrogeology, Wiley India Pvt Ltd.
2. Gokhale N.W. (2015) Manual of Geological Maps, CBS Publishers, NewDelhi
3. Gribble CD (2005) Rutleys Elements of Mineralogy, Springer
4. Marland P Billings (2016), Structural Geology, Pearson education

Course Contents and Lecture Schedule:

Module	Topic	No. of hours
Module 1	Weathering of rocks-Types of weathering, Processes of Origin of Products of weathering like sand, clay, laterite and soil	3
	Soil profile, Soil erosion and soil conservation measures. Engineering significance of weathering.	2
	Geological processes by rivers. Landslides-types, causes and controlling measures	2
	Coastal Processes-Geological work by waves and currents and coastal protection measures	2
Module 2	Earthquakes- Plate Tectonics, Origin of earthquakes, Seismic waves, Rating of earthquakes, types of earthquakes	4
	Seismic zones of India. Basics of seismic safety factor	2
	Interior of the earth as revealed by propagation of seismic waves.	3
Module 3	Occurrence of groundwater, aquifers and types of aquifers, confining beds, porosity and vertical distribution of groundwater.	2
	Darcy's Law.Permeability/hydraulic conductivity. Problems created by groundwater to civil engineering structures	3
	Methods to control groundwater problems	1
	Electrical resistivity survey for groundwater exploration.	2
	Seawater intrusion in Coastal area. Ghyben Herzberg relation.	1
Module 4	Physical properties of minerals, physical properties and chemical composition of minerals like quartz, orthoclase, plagioclase, biotite, muscovite, hornblende, augite, hypersthene, calcite, gypsum	4

	Igneous, sedimentary and metamorphic rocks, Igneous rocks-Chemical and mineralogical classification and structure. Sedimentary rocks-types based on mode of formation and structures Metamorphic rocks-structures only. Megascopic study of granite, dolerite, basalt, sandstone, limestone, shale, gneiss, marble and charnockite. Rock types of Kerala. Rock cycle	5
Module 5	Attitude of rocks – Dip and Strike. Terminology	1
	Brief classification and engineering significance of folds, faults and joints	3
	Geological part of site investigation for the construction of dams, reservoirs and tunnels	3
	Toposheet, Structural mapping. Clinometer compass and Brunton compass	2



CET 204	GEOTECHNICAL ENGINEERING - I	CATEGORY	L	T	P	CREDIT	Year of Introduction
		PCC	4	0	0	4	2019

Preamble: Goal of this course is to expose the students to the fundamental concepts of soil mechanics and laboratory tests to determine the basic, index and engineering properties of soils. After this course, students will be able to identify and classify the soil and to recognize practical problems in real-world situations and respond accordingly.

Prerequisite : Nil

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

CO 1	Explain the fundamental concepts of basic and engineering properties of soil
CO 2	Describe the laboratory testing methods for determining soil parameters
CO 3	Solve the basic properties of soil by applying functional relationships
CO 4	Calculate the engineering properties of soil by applying the laboratory test results and the fundamental concepts of soil mechanics
CO 5	Analyze the soil properties to identify and classify the soil

Mapping of course outcomes with program outcomes (Minimum requirement)

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination (Marks)
	Test 1 (Marks)	Test 2 (Marks)	
Remember	10	10	20
Understand	10	15	20
Apply	25	25	50
Analyse	5		10
Evaluate			
Create			

Mark Distribution

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

Continuous Internal Evaluation (CIE) Pattern :

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

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

Course Level Assessment Questions

(Questions may be framed based on the outline given under each course outcome)

Course Outcome 1 (CO1):

1. The fundamental concepts of basic properties and index properties of soil
2. The fundamental concepts of engineering properties of soils related to Permeability, consolidation, compaction & shear strength
3. Concepts of Total, neutral and effective stress; and vertical stress below loaded areas
4. Concepts of Slope stability

Course Outcome 2 (CO2):

1. The laboratory testing methods for determining basic and index soil properties
2. The laboratory testing methods for determining engineering properties related to Permeability, consolidation, compaction & shear strength

Course Outcome 3 (CO3):

1. Solve the basic properties of soil by applying functional relationships

Course Outcome 4 (CO4):

1. Calculate the engineering properties of soil related to Permeability, consolidation, compaction & shear strength by applying the laboratory test results
2. Calculate the settlement of footings due to consolidation and application of time rate of consolidation settlement
3. Calculate the engineering properties of soil by applying the concepts of soil mechanics related to total, neutral and effective stress; and vertical stress below loaded areas
4. Calculate the stability of slopes

Course Outcome 5 (CO5):

1. Identify and classify the soil by analysing the basic and index properties of soil

Model Question Paper

QP CODE:

Reg No.: _____

Name: _____

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

Course Code: CET 204

Course Name : GEOTECHNICAL ENGINEERING - I

Max. Marks: 100

Duration: 3 hours

Part A*(Answer all questions; each question carries 3 marks)*

1. Draw a three phase block diagram and define (i) Void Ratio, (ii) Water Content and (iii) Degree of saturation
2. Explain the procedure for Specific Gravity test using Pycnometer.
3. Define (i) Liquid Limit, (ii) Plastic Limit & (iii) Shrinkage Limit
4. Differentiate between Coefficient of Permeability and Coefficient of Percolation.
5. Explain Total Stress, Neutral Stress and Effective Stress.
6. List the assumptions of Boussinesq's theory.
7. Define pre consolidation pressure. Explain the method for the estimation of pre consolidation pressure.
8. Differentiate between Consolidation and Compaction.
9. Explain Mohr Coulomb shear strength theory.
10. What are the different types of slope failures?

PART B*(Answer one full question from each module, each question carries 14 marks)***Module – 1**

11. (a) Derive the relation between bulk unit weight, specific gravity, void ratio and degree of saturation from the fundamentals. (5 Marks)
- (b) A sample of wet silty clay soil weighs 1.26 kN. The following data were found from lab tests on the sample. Density $\gamma = 21 \text{ kN/m}^3$, Water content $w = 15\%$, Specific Gravity $G = 2.7$. Determine (i) Dry density, (ii) Void Ratio, (iii) Porosity (iv) Degree of Saturation, (v) Saturated unit weight (vi) Submerged unit weight and (vii) Volume of soil. (9 Marks)

12. (a) Explain different types of soil structures. (5 Marks)
- (b) 1000 cm³ core cutter weighing 9.46 N was used to find out the in-situ unit weight of soil in an embankment. The weight of core cutter with in-situ soil was noted to be 27.7 N. Laboratory tests on the sample indicated water content of 10% and specific gravity of solids of 2.63. Determine the bulk unit weight, dry unit weight, void ratio and degree of saturation. Also calculate the saturated unit weight and the corresponding water content if the embankment is saturated during rain without change in volume. (9 Marks)

Module – 2

13. (a) What is the use of particle size distribution curve? With the help of particle size distribution curve define the following terms (i) well graded soil (ii) poorly graded soil and (iii) gap graded soil. (5 Marks)
- (b) Tests on a fined grained soil sample indicated the following properties:
Liquid Limit = 52%, Plastic Limit = 32% and Shrinkage Limit = 17%. Classify the soil as per IS Code. If the specimen of this soil shrinks from a volume of 10 cm³ at Liquid Limit to 6 cm³ at the shrinkage limit, calculate the specific gravity of solids. (9 Marks)
14. (a) Explain the factors affecting permeability of soil. (5 Marks)
- (b) A soil sample of height 6 cm and area of cross section 100 cm² was subjected to constant head permeability test with head of 36 cm and 90 cc of water passes through the specimen during a test interval of 5 min. Compute the coefficient of permeability of the soil sample.
If the same sample is subjected to falling head permeability test and found that head drops from 60 cm to 20 cm in 4 min. Determine the cross sectional area of the stand pipe. (9 Marks)

Module – 3

15. (a) Explain Quick Sand Condition and Critical Hydraulic Gradient. (5 Marks)
- (b) A sand deposit of 8 m thick was loaded with a uniform surcharge of 10 kN/m². Water table (WT) is at 3 m below GL. Density of sand is 18 kN/m³ above WT and 19 kN/m³ below WT. Draw Total, Neutral and Effective Stress Diagrams up to 8 m below GL. Take $\gamma_w = 10 \text{ kN/m}^3$. (9 Marks)
16. (a) A concentrated load of 500 kN is applied at ground surface. Compute the vertical pressure (i) at a depth of 5m below the load, (ii) at a distance of 3m at the same depth. Use Boussinesq's theory. (7 Marks)
- (b) A water tank is founded on a circular ring type of foundation. The ring is of 2.5m width and its external diameter is 10m. Compute the vertical stress at 4m depth beneath the centre of the foundation, if pressure on the foundation is 100kPa. (7 Marks)

Module – 4

17. (a) A 8 m thick clay layer with double drainage settles by 120 mm in 2 years. $C_v = 1.5 \times 10^{-3} \text{ cm}^2/\text{sec}$. Calculate the likely ultimate consolidation settlement and find out how long it will take to undergo 90% of this settlement. (5 Marks)
- (b) A 3m square footing at a depth of 2m from ground level carries a net load intensity of 150 kN/m². If a compressible clay layer 3m thick exists at a depth of 5m below the footing, determine the settlement of the footing due to consolidation of clay layer. Assume the water table at a depth of 3m below GL. For sand, density = 18 kN/m³ above water table and

19 kN/m³ below water table. For clay layer, LL = 65%, w_n = 40% and G = 2.7. Take $\gamma_w = 10 \text{ kN/m}^3$. (9 Marks)

18. (a) Explain the field compaction methods. (5 Marks)

(b) The following are results of a standards proctor compaction test performed on a sample of soil

Water Content %	6	8	10	12	14	16
Bulk Density (kN/m ³)	17.7	19.8	21	21.3	20.9	20.2

Plot the water content – dry density curve and obtain Moisture content and Maximum dry density. Also plot the zero air voids curve. Take G = 2.65. (9 Marks)

Module – 5

19. (a) A cylindrical specimen of soil fails under axial vertical stress of 150 kN/m², when it is laterally unconfined. Failure plane makes an angle of 53° with the horizontal. Determine shear strength parameters c & ϕ . (5 Marks)

(b) Determine the shear strength parameters using the following data using graphical method:

Sample	Confining Pressure σ_c (kN/m ²)	Deviator Stress σ_d (kN/m ²)
1	100	600
2	200	750
3	300	900

(9 Marks)

20. (a) Explain the Swedish circle method for the analysis of slopes for a c- ϕ soil. (5 Marks)

(b) Determine factor of safety of vertical foundation trench 5m deep if c = 50 kN/m², $\phi = 25^\circ$, $\gamma = 17 \text{ kN/m}^3$. Assume Taylor's stability no. Sn = 0.166. (9 Marks)

SYLLABUS**Module 1**

Nature of soil and functional relationships : Introduction to soil mechanics – Soil types – Major soil deposits of India - 3 phase system – Basic soil properties : Void ratio, porosity, degree of saturation, air content, water content, specific gravity, unit weight - Relationship between basic soil properties - Numerical problems

Determination of Water content by oven drying, Specific gravity using pycnometer & specific gravity bottle - Determination of Field density by sand replacement method & Core Cutter method - Numerical problems

Soil Structure and their effects on the basic soil properties – Sensitivity and Thixotropy

Module 2

Index properties : Sieve analysis – Well graded, poorly graded and gap graded soils - Stoke's law – Hydrometer analysis [no derivation required for percentage finer and diameter] – Relative Density - Numerical problems - Consistency – Atterberg Limits and indices – Plasticity charts - laboratory tests for Liquid Limit, Plastic Limit & Shrinkage Limit - Numerical problems

IS classification of soil - Numerical problems

Permeability of soils : Darcy's law – Factors affecting permeability – Laboratory tests: Constant head and falling head permeability tests - Numerical problems - Average permeability of stratified deposits - numerical problems

Module 3

Principle of effective stress - Total, neutral and effective stress – Pressure diagrams - Numerical problems - Pressure diagrams in soils saturated by capillary action – Quick sand condition – Critical hydraulic gradient

Stress distribution : Introduction - Boussinesq's equations for vertical pressure due to point loads and line loads – Assumptions and Limitations - Numerical problems - Vertical pressure due to uniformly distributed loads beneath strip, circular and rectangular shapes [no derivation required] - Numerical problems

Approximate methods for vertical stress-distribution of contact pressure beneath footings : Equivalent Point Load method & 2:1 Distribution Method - Numerical problems - Pressure Isobars - Pressure bulbs – Newmark's charts (Construction procedure not required) and their use.

Module 4

Consolidation - Definition – Concepts of Coefficient of compressibility and volume compressibility - e-log p curve - Compression index, Recompression index and Pre consolidation Pressure - Normally consolidated, over consolidated and under consolidated soils - Estimation of magnitude of settlement of normally consolidated clays - Numerical problems

Terzaghi's theory of one-dimensional consolidation (no derivation required) - average degree of consolidation – Time factor - Coefficient of consolidation - Numerical problems - Laboratory consolidation test – Determination of Coefficient of Consolidation - Practical Applications

Compaction of soils - Difference between consolidation and compaction - IS Light & Heavy Compaction Tests – OMC and MDD - Zero Air voids line - Numerical problems - Control of

compaction - Field compaction methods - Proctor needle for field control

Module 5

Shear strength of soils- Practical Applications - Mohr-Coulomb failure criterion - Mohr circle method for determination of principal planes and stresses– relationship between shear parameters and principal stresses - Numerical problems

Brief discussion of Laboratory tests - Triaxial compression test - UU, CU and CD tests - Total and effective stress strength parameters - Unconfined compression test, Direct shear test and vane shear test – Applicability - Numerical problems

Stability of finite slopes - Toe failure, base failure, slip failure - Swedish Circle Method : $\phi=0$ analysis and $c-\phi$ analysis - Friction circle method - Taylor's Stability number - Stability charts - Numerical Problems

Text Books:

1. Ranjan G. and A. S. R. Rao, Basic and Applied Soil Mechanics, New Age International, 2002.
2. Arora K. R., Geotechnical Engineering, Standard Publishers, 2006.

References:

1. Das B. M., Principles of Geotechnical Engineering, Cengage India Pvt. Ltd., 2010.
2. Venkatramaiah, Geotechnical Engg, Universities Press, 2000.
3. Terzaghi K. and R. B. Peck, Soil Mechanics in Engineering Practice, John Wiley, 1967.
4. A V Narasimha Rao and C Venkatramaiah, Numerical Problems, Examples and Objective questions in Geotechnical Engineering, Universities Press (India) Ltd., 2000
5. Purushothamaraj P., Soil Mechanics and Foundation Engineering, Dorling Indersley (India) Pvt. Ltd., 2013
6. Taylor D.W., Fundamentals of Soil Mechanics, Asia Publishing House, 1948.

Course Contents and Lecture Schedule:

Module	Contents	Outcomes Addressed	Hours
1	Module 1		9
1.1	Nature of soil and functional relationships : Introduction to soil mechanics – Soil types – Major soil deposits of India	CO 1	1
1.2	3 phase system – Basic soil properties : Void ratio, porosity, degree of saturation, air content, water content, specific gravity, unit weight	CO 1	1
1.3	Relationship between basic soil properties	CO 1 & CO 3	1
1.4	Numerical problems	CO 3	2
1.5	Determination of Water content by oven drying, Specific gravity using pycnometer & specific gravity bottle	CO 2	1
1.6	Determination of Field density by sand replacement method & Core Cutter method	CO 2	1
1.7	Numerical problems	CO 3 & CO 4	1
1.8	Soil Structure and their effects on the basic soil properties – Sensitivity and Thixotropy	CO 1 & CO 5	1
2	Module 2		9
2.1	Index properties : Sieve analysis – Well graded, poorly graded and gap graded soils	CO 1 & CO 2	1
2.2	Stoke's law – Hydrometer analysis [no derivation required for percentage finer and diameter] – Relative Density	CO 1 & CO 2	1
2.3	Numerical problems	CO 4	1
2.4	Consistency – Atterberg Limits and indices – Plasticity charts - laboratory tests for Liquid Limit, Plastic Limit & Shrinkage Limit	CO 1 & CO 2	1
2.5	Numerical problems	CO 4	1
2.6	IS classification of soil - Numerical problems	CO 1 & CO 5	1
2.7	Permeability of soils : Darcy's law – Factors affecting permeability – Laboratory tests: Constant head and falling head permeability tests	CO 1 & CO 4	1
2.8	Numerical problems	CO 4	1
2.9	Average permeability of stratified deposits - numerical problems	CO 1 & CO 4	1
3	Module 3		9
3.1	Principle of effective stress - Total, neutral and effective stress – Pressure diagrams	CO 1	1
3.2	Numerical problems	CO 4	1
3.3	Pressure diagrams in soils saturated by capillary action – Quick sand condition – Critical hydraulic gradient	CO 1	1
3.4	Stress distribution : Introduction - Boussinesq's equations for vertical pressure due to point loads and line loads – Assumptions and Limitations	CO 1	1

3.5	Numerical problems	CO 4	1
3.6	Vertical pressure due to uniformly distributed loads beneath strip, circular and rectangular shapes [no derivation required]	CO 1	1
3.7	Numerical problems	CO 4	1
3.8	Approximate methods for vertical stress-distribution of contact pressure beneath footings : Equivalent Point Load method & 2:1 Distribution Method - Numerical problems	CO 1 & CO 4	1
3.9	Pressure Isobars - Pressure bulbs – Newmark’s charts (Construction procedure not required) and their use.	CO 1	1
4	Module 4		9
4.1	Consolidation - Definition – Concepts of Coefficient of compressibility and volume compressibility - e-log p curve - Compression index, Recompression index and Pre consolidation Pressure	CO 1	1
4.2	Normally consolidated, over consolidated and under consolidated soils - Estimation of magnitude of settlement of normally consolidated clays	CO 1 & CO 4	1
4.3	Numerical problems	CO 4	1
4.4	Terzaghi’s theory of one-dimensional consolidation (no derivation required) - average degree of consolidation – Time factor - Coefficient of consolidation	CO 1 & CO 4	1
4.5	Numerical problems	CO 4	1
4.6	Laboratory consolidation test – Determination of Coefficient of Consolidation - Practical Applications	CO 2 & CO 4	1
4.7	Compaction of soils - Difference between consolidation and compaction - IS Light & Heavy Compaction Tests – OMC and MDD - Zero Air voids line	CO 1, CO2 & CO 4	1
4.8	Numerical problems	CO 4	1
4.9	Control of compaction - Field compaction methods - Proctor needle for field control	CO 1	1
5	Module 5		9
5.1	Shear strength of soils- Practical Applications - Mohr-Coulomb failure criterion	CO 1	1
5.2	Mohr circle method for determination of principal planes and stresses– relationship between shear parameters and principal stresses	CO 1 & CO 4	1
5.3	Numerical problems	CO 4	1
5.4	Brief discussion of Laboratory tests - Triaxial compression test - UU, CU and CD tests - Total and effective stress strength parameters	CO 2 & CO 4	1
5.5	Unconfined compression test, Direct shear test and vane shear test – Applicability	CO 2 & CO 4	1
5.6	Numerical problems	CO 4	1
5.7	Stability of finite slopes - Toe failure, base failure, slip failure	CO 1	1
5.8	Swedish Circle Method : $\phi=0$ analysis and $c-\phi$ analysis - Friction circle method	CO 1 & CO 4	1

5.9	Taylor's Stability number - Stability charts - Numerical Problems	CO 1 & CO 4	1
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CIVIL ENGINEERING

CET206	TRANSPORTATION ENGINEERING	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		PCC	4	0	0	4	2019

Preamble

Objective of the course is to introduce the principles and practice of Highway, Railway, Harbour and dock, Tunnel and Airport Engineering.

Prerequisite: Nil

Course Outcomes:

	Description
CO No.	At the end of the course, students will be able to:
CO 1	Apply the basic principles of Highway planning and design highway geometric elements
CO 2	Apply standard code specifications in judging the quality of highway materials; designing of flexible pavements
CO 3	Explain phenomena in road traffic by collection, analysis and interpretation of traffic data through surveys; creative design of traffic control facilities
CO 4	Understand about railway systems, tunnel, harbour and docks
CO 5	Express basics of airport engineering and design airport elements

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (marks)
	Test 1 Marks	Test 2 Marks	
Remember	7.5	7.5	30
Understand	7.5	7.5	30
Apply	5	5	20
Analyse	5	5	20
Evaluate			
Create			

Mark Distribution

Total Marks	CIE (Marks)	ESE (Marks)	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

End Semester Examination Pattern:

The question consists of two parts- Part A and Part B. Part A consists of 10 questions with 3 marks for each (two questions from each module). Part B consists of two questions from each module, out of which one has to be answered. Each question carries 14 marks and can have maximum 2 subdivisions.

Sample Course Level Assessment Questions:

1 Course Outcome 1 (CO1): While aligning a highway in a built up area, it was necessary to provide a horizontal curve of radius 300 m for a design speed 65Km/hr, length of wheel base-6m and pavement width 10.5m. Assume rate of introduction of super elevation as 1 in 100 and super elevation is provided by rotating about centre line. Design super elevation, extra widening of pavement and length of transition curve.

2 Course Outcome 2 (CO2): Design a flexible pavement for two lane single carriage way for present traffic 1200 commercial vehicles per day, period of construction= 3 yrs, annual traffic growth = 7.5%, Design CBR = 7%, Design life = 15 yrs. Use IRC method.

3 Course Outcome 3 (CO3): Traffic in a congested multilane highway lane is observed to have an average spacing of 200 ft, and an average headway of 3.8s. Estimate the rate of flow, density and speed of traffic in this lane.

4 Course Outcome 4 (CO4):

Sketch the component parts of a permanent way and mark the salient points

5 Course Outcome 5 (CO5): The total length of a runway is 1000 m. The elevation at distance 0, 200 m, 400 m, 600 m, 800 m and 1000 m are 100.0 m, 99.2 m, 101.0 m, 101.8 m, 101.4 m and 101.0 m respectively. What will be the effective gradient of runway?

Syllabus

Module	Contents	Hours
1	Introduction to Transportation Engineering, Classification of roads, Typical cross sections of roads in urban and rural area, Requirements and factors controlling alignment of roads Introduction to geometric design of highways, Design controls and criteria, Design of highway cross section elements, Design of horizontal alignment - Stopping sight distance, Overtaking sight distance, super elevation, transition curve, length and shift of transition curve, extra widening. Vertical alignment (introduction only)	10
2	Introduction to highway materials, Desirable properties and testing of road aggregates, bituminous materials and sub grade soil. Introduction of flexible and rigid pavements, Factors influencing the design of flexible pavements, Design of flexible pavements by CBR method and IRC 37: 2018. Construction of bituminous pavements	9
3	Introduction to traffic engineering, Traffic characteristics, Capacity and Level of Service, Design Speed, Traffic surveys, Types of road intersections, Traffic control devices (introduction only), Design of isolated signals by Webster’s method.	7
4	Railway Engineering - Component parts of a railway track - functions, concept of Gauges, coning of wheels, cant deficiency, compensation of gradients Tunnel Engineering: Tunnel – sections, tunnel surveying - alignment, transferring centre grade into tunnel. Harbours – classification, features, requirements. Break waters - necessity and functions, classification. Docks – Functions and types - dry docks, wet docks (Introduction only)	8
5	Introduction to Airport Engineering, Components of airport, selection of site for airport. Runway orientation, basic runway length and corrections required, Taxiways and aprons.	8

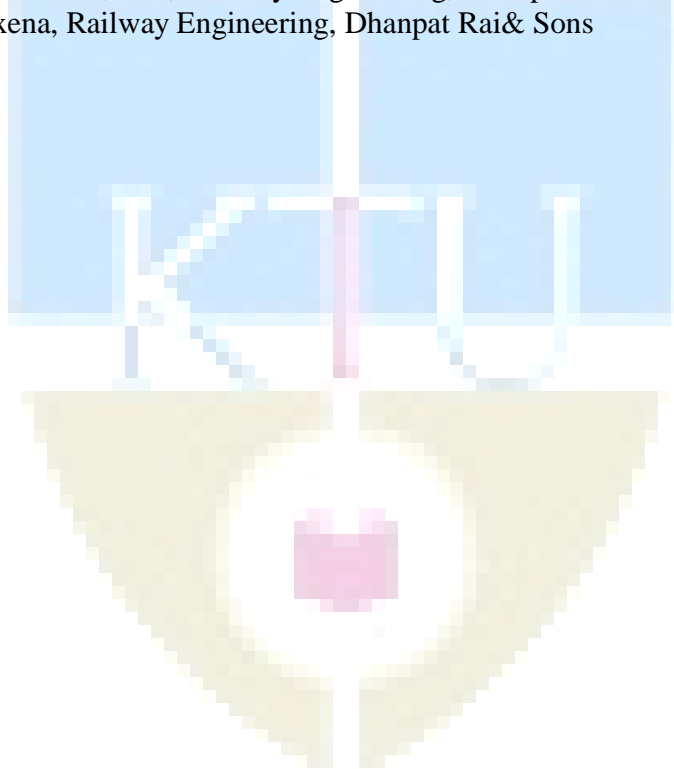
Text Books

1. Khanna, S.K. and Justo C.E.G., Highway Engineering, Nem Chand & Bros., 2015
2. Kadiyali, L. R. and N.B Lal, Principles and Practices of Highway Engineering, Khanna Publishers, 2013
3. Khanna, S. K. and Arora. M. G., Airport Planning and Design, Nemchand& Bros
4. Mundrey J. S, Railway Track Engineering, Tata McGraw Hill, 2009

5. Rangawala, S.C. , Railway Engineering, Charotar Publishing House
6. Rao G. V, Principles of Transportation and Highway Engineering, Tata McGrawHill, 1996
7. Srinivasan,R., Harbour, Dock & Tunnel Engineering, Charotor Publishing House, 28e, 2016

References

1. Horonjeff R. and McKelvy, F., Planning and Design of Airports, McGraw Hill, 5e, 2010
2. IRC: 37-2018, Guidelines for the Design of Flexible Pavements, IRC 2018, New Delhi
3. O' Flaherty, C.A (Ed.), Transport Planning and Traffic Engineering, Elsevier, 1997
4. Rangwala, S. C., Airport Engg. Charotar Publishing Co., 16e, 2016
5. Yoder, E. J and Witczak, M. W, Principles of Pavement Design, John Wiley & Sons, 1991
6. Bindra, S.P., A course in Docks and Harbour Engineering, Dhanpat Rai& Sons
7. Chandra, S. and Agarwal, M.M., Railway Engineering, Oxford University Press, New Delhi, 2008
8. Saxena, S. C and Arora, S. P, Railway Engineering, Dhanpat Rai& Sons, 7e, 2010
9. Subhash C. Saxena, Railway Engineering, Dhanpat Rai& Sons



Course Content and lecture Schedule:

No.	Topic	Course Outcome	No. of Hrs
1	Module 1		Total: 10
1.1	Introduction to Transportation Engineering, Classification of roads, Typical cross sections of roads in urban and rural area, Requirements and factors controlling alignment of roads.	CO1	2
1.2	Introduction to geometric design of highways, Design controls and criteria, Design of highway cross section elements	CO1	2
1.3	Design of horizontal alignment - Stopping sight distance, Overtaking sight distance, super elevation, transition curve, length and shift of transition curve, extra widening. Vertical alignment (introduction only)	CO1	6
2	Module 2		Total: 9
2.1	Introduction to highway materials, Desirable properties and testing of road aggregates, bituminous materials and sub grade soil.	CO2	3
2.2	Introduction of flexible and rigid pavements, Factors influencing the design of flexible pavements, Design of flexible pavements by CBR method and IRC 37 : 2018	CO2	3
2.3	Construction of bituminous pavements	CO2	3
3	Module 3		Total: 7
3.1	Introduction to traffic engineering, Traffic characteristics, Capacity and Level of Service, Design Speed, Traffic surveys, Types of road intersections,	CO3	4
3.2	Traffic control devices (introduction only), Design of isolated signals by Webster's method.	CO3	3
4	Module 4		Total: 8
4.1	Railway Engineering - Component parts of a railway track - functions, concept of Gauges, coning of wheels, cant deficiency, compensation of gradients	CO4	4
4.2	Tunnel Engineering: Tunnel – sections, tunnel surveying - alignment, transferring centre grade into tunnel.	CO4	2
4.3	Harbours – classification, features, requirements. Break waters - necessity and functions, classification. Docks – Functions and types - dry docks, wet docks (Introduction only)	CO4	2
5	Module 5		Total: 8
5.1	Introduction to Airport Engineering, Components of airport, selection of site for airport.	CO5	3
5.2	Runway orientation, basic runway length and corrections required, Taxiways and aprons.	CO5	5

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

Course Code: **CET 206**

Course Name: **TRANSPORTATION ENGINEERING**

Model Question Paper

Marks:100

Duration: 3 hrs

PART A

(Answer all questions. Each question carry three marks)

1. With a sketch, explain typical cross sectional layout of a two lane road in urban areas.
2. What is meant by reaction time? What is its role in Geometric design of highways?
3. Outline the IRC 37- 2018 recommendations for determining the thickness of Flexible pavements.
4. Differentiate flexible and rigid pavements
5. How would you draw the fundamental diagram of traffic flow
6. Explain grade separated intersections and discuss the advantages and limitations
7. Analyse the concept of cant deficiency with suitable explanations
8. Write short note on Littoral Drift
9. Enumerate the various factors which would be kept in view while selecting suitable site for an airport.
10. What are taxiways?

PART B

(Answer one full question from each module)

11. a) Enumerate the factors governing the width of carriage way. State the IRC specifications for width of carriage way for various classes of roads. (10)
- b) Write a brief note on classification of highways in India. (4)

OR

12. a) Calculate the stopping sight distance on a highway for a design speed of 100 kmph. (6)
- b) What is super elevation? Explain the design steps of super elevation. (8)

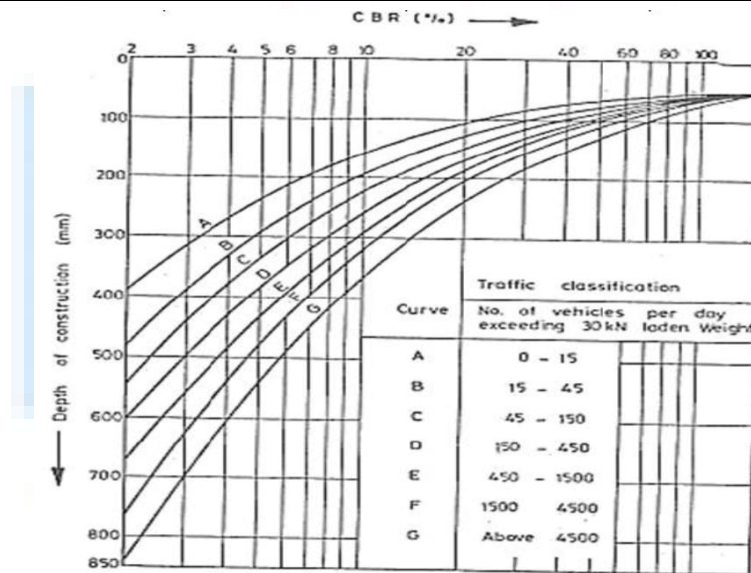
13a) Explain the construction practices of the following bituminous base courses.

- 1) Bituminous macadam
- 2) Penetration macadam (6)

b) The soil subgrade sample was obtained from the project site and the CBR tests conducted at field density gave the following readings. Draw the load penetration curve and determine the CBR value and find the total thickness of the pavement by CBR method as recommended by IRC for commercial vehicles 1500 per day, with 7% growth rate. The pavement construction is to be completed in three years after last traffic count. (Use the standard design chart provided)

(8)

Penetration (mm)	Load (kg)	Penetration (mm)	Load (kg)
0.0	0.0	3.0	60.0
0.5	6.0	4.0	70.0
1.0	17.0	5.0	77.0
1.5	30.0	7.5	89.0
2.0	42.0	10.0	100.0
2.5	55.0	12.5	115.0



OR

- 14 a) Explain in detail the various factors that influencing the design of flexible pavements? (10)
 b) List out the desirable properties of aggregates to be used in pavement construction. Also specify various tests for judging the suitability of aggregates. (4)

- 15 a) What are the advantages and disadvantages of traffic signals? (8)
 b) What is (i) Saturation flow, (ii) Lost time, and (iii) Phase in a signal design? (6)

OR

- 16 a) Define the basic terms basic capacity, possible capacity and practical capacity and analyze its importance in traffic engineering. (6)
 b) Evaluate the factors affecting level of service of a multilane highway. (8)

- 17 a) Analyse various types of gradient used on railway track. What is grade compensation and why is it necessary? (6)
 b) State the natural and meteorological phenomena a harbour engineer has to study and briefly mention the effects of these phenomena (8)

OR

- 18 a) Explain the functions of rails, sleepers and ballast. (8)
 b) What are the classifications of tunneling? (6)
- 19 a) Explain in detail about the functions of taxiways and aprons. (6)
 b) What are the factors to be considered in the orientation of runway? (8)

OR

- 20 a) What are the factors affecting selection of site for airport? (4)
 b) The length of a runway under standard conditions is 1500m. The airport is to be provided at an elevation of 110m above mean sea level. The airport reference temperature is 32°C. Following data refers to the proposed longitudinal section of runway. Determine the corrected length of runway. (10)

End to end of runway (m)	Grade (%)	End to end of runway (m)	Grade (%)
0 to 300	+1	1500 to 1800	+1
300 to 900	-0.2	1800 to 2100	-0.3
900 to 1500	+0.5		

CEL 202	MATERIAL TESTING LAB - I	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		PCC	0	0	3	2	2019

Preamble: The course aims to enrich the understanding of the fundamental concepts of mechanics of deformable bodies through systematic experimental techniques for the estimation of various mechanical properties of engineering materials.

Prerequisite: Engineering Physics, Mechanics of Materials. Knowledge in use of Vernier caliper and micrometer screw gauge expected.

General Instructions to Faculty:

1. Any 12 experiments out of 15 need to be performed mandatorily. Virtual Lab facility [11] cannot be used to substitute the conduct of these mandatory experiments.
2. The laboratory should have possession of modern testing equipment such as strain gauges, LVDTs, load cells and data acquisition systems at least for demonstration purposes
3. Periodic maintenance and calibration of various testing instruments needs to be made.
4. Use of data visualization packages needs to be promoted for making various plots.

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

Course Outcome	Course Outcome Description
CO 1	The understand the behaviour of engineering materials under various forms and stages of loading.
CO 2	Characterize the elastic properties of various materials.
CO3	Evaluate the strength and stiffness properties of engineering materials under various loading conditions.

Mapping of course outcomes with program outcomes:

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

Course Level Assessment Questions**Assessment Pattern****Mark distribution**

Total Marks	CIE	ESE	ESE Duration
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

Attendance	:	15 marks
Continuous Assessment	:	30 marks
Internal Test (Immediately before the second series test)	:	30 marks

End Semester Examination Pattern: The following guidelines should be followed regarding award of marks

(a) Preliminary work	:	15 Marks
(b) Implementing the work/Conducting the experiment	:	10 Marks
(c) Performance, result and inference (usage of equipment and trouble shooting)	:	25 Marks
(d) Viva voce	:	20 marks
(e) Record	:	5 Marks

General instructions:

Practical examination to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

References

1. S.P. Timoshenko, *History of Strength of Materials*, Dover publications, 1953
2. Egor P. Popov, *Engineering Mechanics of Solids*, Pearson, 1998.
3. IS 1608 (2005): *Metallic Materials – Tensile testing at Ambient temperature*, 3rd Revision, July 2008
4. IS 1598 (1977): *Method for Izod Impact test of Metals*, 2nd reprint, September 1986.
5. IS 1499 (1977) : *Method for Charpy Impact test (U-Notch) for metals*, 3rd reprint, March 1992.

6. IS 5242 (1979) Method of Test for determining Shear Strength of Metals, 1st revision, 2006.
7. IS 1500 (2005): Method for Brinell Hardness Test for Metallic Materials, 3rd revision, 2005.
8. IS 1501 (2002) : Method for Vickers hardness Test for Metallic Materials.
9. IS 1717 (2012): Metallic Materials – Wire – Simple Torsion Test, 3rd revision, 2012.
10. IS 883 (1994): Design of Structural Timber in Building- Code of Practice, Reaffirmed 2005)
11. www.vlab.co.in

SYLLABUS

- Exercise 1. Study on stress-strain characteristics of mild steel and by conducting uniaxial tension test on rod specimens
- Exercise 2. Study on stress-strain characteristics of tor steel by conducting uniaxial tension test on rod specimens
- Exercise 3. Study on estimation of shear capacity of mild steel specimen by conducting a double shear test on rod specimen.
- Exercise 4. Study on flexural behaviour of steel by conduction of test on RSJ (I cross section)
- Exercise 5. Study on torsional behaviour and estimation of modulus of rigidity of steel by conducting torsion test on rod specimens
- Exercise 6. Study on estimation of modulus of rigidity of steel and brass / copper materials utilizing the principles of torsional vibrations.
- Exercise 7. Study on estimation of toughness properties of steel specimens by conducting (a) Izod &(b) Charpy impact tests.
- Exercise 8. Study on estimation of hardness properties of engineering materials such as brass, aluminium, copper, steel etc.by performing Brinell hardness test
- Exercise 9. Study on estimation of Hardness properties of engineering materials such as brass, aluminium, copper, steel etc.by performing

9.1 Rockwell hardness test

9.2 Vicker's hardness test

Exercise 10. Study on estimation of modulus of rigidity of steel by performing tension tests on spring specimens.

Exercise 11. Study on estimation of modulus of rigidity of steel by performing compression tests on spring specimens

Exercise 12. Study on flexural behaviour of timber material by performing tests on beam specimens.

Exercise 13. Study on estimation of compression strength of timber specimen.

Exercise 14. Experiment on verification of Maxwell's reciprocal theorem

Exercise 15. Bend & rebend test on mild steel specimen

Optional Exercises:

Study/ demonstration of :

- Fatigue test on steel rod specimen
- Strain gauges and Load cells
- Elastic buckling modes of column under different boundary conditions

CEL 204	FLUID MECHANICS LAB	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		PCC	0	0	3	2	2019

Preamble: The course is designed to train the students to familiarize and understand the different flow measurement equipment's and their procedures. Students will be introduced to a team working environment where they develop the necessary skills of experimentation techniques for the study of flow phenomena in channels/pipes.

Prerequisite: Fluid Mechanics and Hydraulics

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

Course Outcome (CO)	Course Outcome Description
CO 1	Apply fundamental knowledge of Fluid Mechanics to corresponding experiments
CO 2	Apply theoretical concepts in Fluid Mechanics to respective experiments
CO 3	Analyse experimental data and interpret the results
CO 4	Document the experimentation in prescribed manner

Mapping of course outcomes (COs) with program outcomes (POs)

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

Course Level Assessment Questions

Assessment Pattern

Mark distribution

Total Marks	Continuous Internal Evaluation (CIE)	End Semester Examination (ESE)	End Semester Examination (ESE) Duration
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

Attendance	: 15 marks
Continuous Assessment	: 30 marks
Internal Test (Immediately before the second series test)	: 30 marks

End Semester Examination Pattern: The following guidelines should be followed regarding award of marks.

- | | |
|---|------------|
| a) Preliminary work | : 15 marks |
| b) Implementing the work/ Conducting the experiment | : 10 marks |
| c) Performance, result and inference (usage of equipments and trouble shooting) | : 25 marks |
| d) Viva voce | : 20 marks |
| e) Record | : 5 marks |

General Instructions:

Practical examination to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

Reference Books:

1. Modi P. N. and S. M. Seth, Hydraulics & Fluid Mechanics, S.B.H Publishers, New Delhi, 2002.
2. Subramanya K., Theory and Applications of Fluid Mechanics, Tata McGraw-Hill, 1993.
3. Subramanya K., Flow in Open channels, Tata McGraw-Hill, 2009.

List of Exercises/ Experiments (Any 12 experiments out of 15 need to be performed mandatorily. Lab experiments may be given considering 12 sessions of 3 hours each)

1. Study of taps, valves, pipe fittings, gauges, Pitot tubes, water meters and current meters.
2. Calibration of Pressure gauges
3. Determination of metacentric height and radius of gyration of floating bodies.
4. Verification of Bernoulli's theorem
5. Hydraulic coefficients of orifices and mouth pieces under constant head method and time of emptying method.
6. Calibration of Venturimeter

7. Calibration of Orifice meter
8. Calibration of water meter.
9. Calibration of rectangular notch
10. Calibration of triangular notch.
11. Time of Emptying through orifice
12. Plotting Specific Energy Curves in Open Channel flow
13. Study of Parameters of Hydraulic Jump in Open channel Flow.
14. Determination of friction co-efficient in pipes
15. Determination of loss co-efficient for pipe fittings



ATTA ABDUL KALAM
TECHNOLOGICAL
UNIVERSITY

SEMESTER -4
MINOR



Mark distribution

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

Continuous internal evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

Assignment/Quiz/Course Project : 15 marks

End Semester Examination Pattern: ESE will be of **3 hour** duration on A2 size answer booklet and will be for 100 marks. (only manual drafting for ESE). 5 descriptive type questions of 2 marks each, one from each module. 2 drawing questions of 45 marks each, with choice from 4, from any 4 modules.

Syllabus**Module 1**

General – Study of IS Codes of practice on building drawing – Scales- method of dimensioning.

Sectional plan, sectional elevation, front view and joint details of Panelled door and Glazed windows.

Module 2

Types of Roof- Roofing- Elevation and joint details-Roof truss in steel sections.

Types of Stairs- Plan and sectional elevation of reinforced concrete staircase.

Module 3

Building rules- Two storied and multi-storeyed building- Plan, section and elevation.

Public buildings like offices, bank, dispensary etc.

Module 4

Building rules -Industrial building- Plan, section and elevation.

Preparation of site plan and service plan.

Module 5

Preparation of Septic tank and soak pit -detailed drawing.

Course Content and lecturer Schedule:

No.	Course Plan	Course Outcome	No. ofHrs
	Module 1:		
1.1	General – Study of IS Codes of practice on building drawing	CO1	2
1.2	Scales- method of dimensioning		2
1.3	Sectional plan, sectional elevation, front view and joint details of	CO2	
1.4	(a) Panelled doors		2
1.5	(b) Glazed windows		2
	Module 2:		
2.1	Types of Roofs	CO2	2
2.2	Roof truss in steel sections		2
2.3	Types of Stairs	CO3	2
2.4	Reinforced concrete staircase		2
	Module 3:		
3.1	Building rules Plan, section and elevation of	CO4	2
3.2	(a) Two storied building		2
3.3	(b) multi-storeyed building		2
3.4	(c) Public building		2

	Module 4:		
4.1	Building rules and type of Industrial building	CO4	2
4.2	Plan elevation and section of industrial building		2
4.3	Preparation of site plan		2
4.4	service plan	CO5	2
	Module 5:		
5.1	Preparation of Septic tank and soak pit -detailed drawing	CO5	2

Reference Books

1. National Building Code of India.
2. Kerala Municipal Building Rules.
3. Dr. Balagopal T.S. Prabhu, Building Drawing and Detailing, Spades Publishers, Calicut.

Model Question Paper

QP CODE:

Reg No:-----

Name:-----

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIRST SEMESTER B.TECH
DEGREE EXAMINATION, MONTH & YEAR**Course Code: **CET282****BUILDING DRAWING**

Max. Marks: 100

Duration: 3 hours

Part A**(Answer all questions; each question carries 2 marks)**

1. Draw neat sketches for following lines; (a) Section line (b) Hidden line (c) Dimension line (d) Extension line
2. What are the major components of a steel truss?
3. What is the difference between waist slab and folded slab stair?
4. What is FAR and FSI?
5. State the importance of site plan and openings schedule in civil engineering drawing.

PART B**(Answer Two full question, each question carries 45 marks)**

6. (a) Draw the elevation and sectional view of a double leaf and six paneled door of size 2000x1200 mm

OR

(b) Plan a RCC stair case for a room dimension 450 cm x 300 cm. Draw plan view and sectional view. Take floor height = 3m.

7. (a) a single stored residential house with the following requirements & draw plan, elevation and section.

(i) Verandah (ii) Bed room (3 no's), one with attached toilet (iii) living hall (iv) kitchen (v) work area (vi) common toilet

OR

- (b) Draw the plan and elevation of a small hospital for the following requirements;

(i) Doctor's room (2) (ii) casualty
 (iii) Dressing area (iv) Pharmacy
 (v) Laboratory (vi) Store room
 (vii) Toilets (vii) ward (5 bed)

CET284	INTRODUCTION TO TRANSPORTATION ENGINEERING	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		VAC	4	0	0	4	2019

Preamble

Objective of the course is to introduce the principles and practice of Highway, Traffic Engineering and Transportation Planning.

Prerequisite: Nil

Course Outcomes:

	Description
CO No.	At the end of the course, students will be able to:
1	Discuss the basic characteristics of Highways and basics of geometric design.
2	Analyse the features of highway materials , various types of pavements, and construction techniques
3	Interpret the basics of traffic characteristics, describe how to conduct traffic surveys and interpret data, understand the various traffic control devices
4	Establish the basics of different modes of transportation and their characteristics including rail, water and air.
5	Appraise Travel Demand Estimation process and the sustainable transportation measures and its application through promoting public transportation modes.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (marks)
	Test 1 Marks	Test 2 Marks	
Remember	10	10	30
Understand	10	10	30
Apply	5	5	40
Analyse			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE (Marks)	ESE (Marks)	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

End Semester Examination Pattern:

The question consists of two parts- Part A and Part B. Part A consists of 5 questions with 5 marks for each (one questions from each module). Part B consists of two questions from each module, out of which one has to be answered. Each question carries 15 marks and can have maximum 3 subdivisions.

Course Level Assessment Questions:

Course Outcome 1 (CO1):What are the basic requirements for an ideal highway alignment? Describe the factors considered in finalising the alignment.

Course Outcome 2 (CO2):Describe the specifications of materials and construction steps of bituminous concrete pavements.

Course Outcome 3 (CO3):Explain the effect of various vehicular characteristics on traffic stream behaviour.

Course Outcome 4 (CO4): Sketch the typical layout of an airport showing the location of taxiways, runways, apron and terminal building for a two open parallel runways.

Course Outcome 5 (CO5): What are the options available in present day society to make transportation sustainable? What are the steps to be adopted by the stakeholders to implement it in India?

SYLLABUS

Mod	Contents	Hrs
1	Introduction to Transportation Engineering, Role of transportation in the development of a society, Classification of roads, Typical cross sections of roads in urban and rural area, Introduction to geometric design of highways, highway cross section elements	9
2	Introduction of flexible and rigid pavements. Introduction to highway materials, Desirable properties and testing of road aggregates, bituminous materials and sub grade soil. Construction of bituminous pavements and rigid pavements (Basics only)	9
3	Introduction to traffic engineering, Traffic characteristics, Capacity and Level of Service, Design Speed, Traffic signals and markings, Types of road intersections, Traffic control devices (introduction only)	8
4	Railway Engineering - Component parts of a railway track - functions, concept of Gauges, coning of wheels Harbours – classification, features, requirements. Break waters - necessity and functions, classification. Docks – Functions and types - dry docks, wet docks (Introduction only) Airport Engineering:- Components of airport and airport layout, Runway orientation, Taxiways, aprons. and Terminal Building (Introduction only)	12
5	Transportation Planning:-Need for Transportation planning, Transport- land use interaction, Travel Demand Estimation –(Introduction only) Sustainable urban transport; issues and challenges, Emerging concepts in sustainable transportation: green vehicles and green roads, green and alternate fuels;	7

Text Books

1. Khanna, S.K. & Justo E.G., Highway Engineering, Nem Chand & Bros., 2000
2. Kadiyali, L. R., Traffic Engineering& Transportation Planning, Khanna Publishers, 2017
3. Khanna, S. K. and Arora. M. G., Airport Planning and Design, Nemchand& Bros
4. Rangawala, S.C. , Railway Engineering, Charotar Publishing House
5. Rao G. V, Principles of Transportation and Highway Engineering, Tata McGrawHill, 1996
6. Srinivasan,R., Harbour, Dock & Tunnel Engineering, Charotar Publishing House, 28e, 2016

References

1. Partho Chakraborty and Animesh Das, Principles of Transportation Engineering,
2. IRC: 37-2001, Guidelines for the Design of Flexible Pavements, IRC 2001, New Delhi
3. IRC:37-2012, Tentative Guidelines for the Design of Flexible Pavements , PHI, 2017
4. O' Flaherty, C.A (Ed.), Transport Planning and Traffic Engineering, Elsevier, 1997
5. C S Papacostas and P D Prevedouros, Transportation Engineering and Planning, 2007
6. Yoder, E. J & Witezak, M. W, Principles of Pavement Design, John Wiley & Sons, 1991
7. Sustainable Urban Transport Shanghai Manual – A Guide for Sustainable Urban Development in the 21st Century

Course Content and lecture Schedule:			
No.	Topic	Course Outcome	No. of Hrs
1	Module 1		Total: 9
1.1	Introduction to Transportation Engineering, Role of transportation in the development of a society, Various fields of Transportation Engineering	CO1	2
1.2	Classification of roads, Typical cross sections of roads in urban and rural area,	CO1	3
1.3	Introduction to geometric design of highways, highway cross section elements, Horizontal alignment and Vertical alignment (introduction only)	CO1	4
2	Module 2		Total:9
2.1	Introduction of flexible and rigid pavements	CO2	2
2.2	Introduction to highway materials, Desirable properties and testing of road aggregates	CO2	4
2.3	Construction of bituminous pavement sand rigid pavements (Basics only)	CO2	3
3	Module 3		Total: 8
3.1	Introduction to traffic engineering, Traffic characteristics	CO3	2
3.2	Capacity and Level of Service, Design Speed	CO3	2
3.3	Traffic signals and markings	CO3	2
3.4	Types of road intersections, Traffic control devices (introduction only)	CO3	2
4	Module 4		Total: 12
4.1	Railway Engineering - Component parts of a railway track functions, concept of Gauges, coning of wheels	CO4	4
4.2	Harbours – classification, features, requirements. Break waters - necessity and functions, classification. Docks – Functions and types - dry docks, wet docks (Introduction only)	CO4	4
4.3	Introduction to Airport Engineering, Components of airport, Runway orientation, Taxiways and aprons and Terminal Building	CO4	4
5	Module 5		Total: 7
5.1	Need for Transportation planning, Transport- land use interaction	CO5	1
5.2	Travel Demand Estimation - Steps in 4 stage planning process	CO5	2
5.3	Sustainable urban transport; issues and challenges	CO5	1
5.4	Policy options for urban transport- Push and pull approach, NMT planning, Transit oriented development	CO5	2
5.5	Emerging concepts in sustainable transportation: green vehicles and green roads, green and alternate fuels;	CO5	1

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

Course Code: **CET284**

Course Name: **INTRODUCTION TO TRANSPORTATION ENGINEERING**

Model Question Paper

Marks:100

Duration: 3 hrs

PART A

(Answer all Questions: Each question carries 3 marks)

- 1 What is the role of roads in Indian economy?
- 2 Explain briefly the classification of highways in India.
- 3 Differentiate flexible and rigid pavement
- 4 Differentiate tack coat and prime coat. What are the objectives of application of each?
- 5 Distinguish between traffic capacity, basic capacity and practical capacity.
- 6 Discuss about the requirements of traffic control devices.
- 7 List and define the component parts of a railway track.
- 8 What are the detrimental forces acting on a break water?
- 9 List the role of transportation planning to society
- 10 What are the advantages of green fuel?

(3 x 10=30 marks)

PART B

(Answer one full question from each module)

- | | | |
|-----------|---|---|
| 11 a. | What are the factors controlling the alignment of highways? Explain the influence each of them in detail? | 7 |
| b. | Discuss about the various cross section elements to be considered in the geometric design of highways? | 7 |
| OR | | |
| 12 a. | Design the rate of super elevation for a horizontal highway curve of radius 500 m and speed 100 kmph | 7 |
| b. | What is overtaking sight distance? Derive the equation for OSD. | 7 |
| OR | | |
| 13 a. | Differentiate flexible and rigid pavements. Sketch a typical section for each. | 7 |
| b. | Discuss the desirable properties of aggregates used for road construction. | 7 |
| OR | | |
| 14 a. | Discuss any three properties of bitumen and their effect on the performance of bituminous mixes in pavements. | 7 |
| b. | What are the factors to be considered in design of flexible pavements and indicate their significance? | 7 |

- 15 a. Explain the effect of various vehicular characteristics on traffic stream behaviour. 7
 b. Draw a typical Speed-flow diagram and indicate the Levels of service as per IRC. 7
- OR**
- 16 a. What are the advantages and disadvantages of traffic signals? 7
 b. Enumerate the basic types of intersections and basic principles involved. 7
- 17 a. Explain with neat sketches the concept of coning of wheels. 7
 b. How are harbours classified? Explain with sketches any two types. 7
- OR**
- 18 a. Distinguish between wet docks and dry docks? What are its functions? 7
 b. Enumerate the factors that are to be considered for site selection of an airport? 7
- 19 a. Enumerate how land use and transportation planning are inter related. 7
 b. Briefly explain the various stages in travel demand estimation 7
- OR**
- 20 a. What are the ways to overcome the issues and challenges in transportation? 7
 b. How can green vehicles and green roads contribute to sustainable transportation? 7

CET 286	Climate Change and Hazard Mitigation	Category	L	T	P	Credit	Year of Introduction
		VAC	4	0	0	4	2019

Preamble: The course is designed to build climate literacy among students, encourages them to adapt to climate change related issues. It helps learners to understand the fundamentals of climate, climate change and climate models, evaluate the impacts of climate change on ecosystems, and empower learners to take appropriate actions to adopt various hazard mitigation measures.

Pre-requisite: Nil

Course outcome

After the course, the student will able to:

CO1	Explain the basic physical principles of the global climate system.
CO2	Describe the large-scale climatic changes which has influenced the ecosystem.
CO3	List actions in key sectors to mitigate hazards due to climate change.
CO4	Identify international initiatives which support countries to address the climate change challenges.
CO5	Analyse the impact of climate change on ecosystem.

CET 256 Climate Change and Hazard Mitigation		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
	CO1	3					2	1							1	
	CO2	3					2	1								
	CO3	3					2	1								
	CO4	3					2									
	CO5	3					2	1								

Assessment pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination (Marks)
	Test 1 (Marks)	Test 2 (Marks)	
Remember	15	15	30
Understand	20	20	40
Apply			
Analyze	15	15	30
Evaluate			
Create			

Continuous Internal Evaluation Pattern:

Attendance	:	10 marks
Continuous Assessment Test(2 numbers)	:	25 marks
Assignment/Quiz/Course project	:	15 marks
Total	:	50 marks

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

Course Level Assessment

Qn No	Question	Marks	Course outcome (CO) Assessed
Part A			
1	Define climate system.	3	CO1
2	How does Albedo affect climate of a place?	3	CO1
3	Briefly explain El Nino and its effects.	3	CO2

4	What is carbon cycling?	3	CO2
5	Describe about General Circulation Models.	3	CO5
6	Comment on Ocean Acidification.	3	CO5
7	Discuss the mission of Intergovernmental Panel on Climate Change.	3	CO4
8	What is Montreal Protocol?	3	CO4
9	Briefly explain Carbon dioxide Capture and Storage.	3	CO3
10	Discuss the importance of bio energy crops.	3	CO3
Part B			
(Answer ANY ONE FULL question from each module)			
Module I			
11(a)	What is the general circulation of the atmosphere?	7	CO1
11(b)	How does the general circulation affect the earth's climate?	7	CO1
12(a)	What is the composition and structure of the atmosphere?	7	CO1
12(b)	Explain the significance of water in the atmosphere on climate of earth.	7	CO1
Module II			
13(a)	State and explain Global Warming Potential.	7	CO2
13(b)	Briefly explain Gandhian ideas on Global warming.	7	CO2
14(a)	Describe the importance of Greenhouse effect on global climate system.	7	CO2

14(b)	Discuss the role of carbon dioxide in Greenhouse effect	7	CO2
Module III			
15	Briefly explain the impact of climate change on surface temperature and precipitation.	14	CO5
16	Describe the different uncertainties inherent in the projection of climate.	14	CO5
Module IV			
17	Enumerate the international initiatives to address climate change challenges and explain any two.	14	CO4
18(a)	Outline the structure of the Intergovernmental Panel on Climate Change.	4	CO4
18(b)	Explain the comprehensive Assessment Reports of IPCC.	10	CO4
Module V			
19 (a)	Explain hazards due to climate change and describe the possible mitigation measures to it.	14	CO3
20 (a)	Discuss the concept of energy efficiency in buildings in response to climate change.	5	CO3
20 (b)	Discuss the impact of climate change on Ecosystem and its adaptation measures.	9	CO3

Model Question Paper

Reg No.:.....

QP CODE:.....

Name:.....

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

Course Code: CET 286

Climate Change and Hazard Mitigation

Max. Marks: 100

Duration: 3 hours

Part A

(Answer all questions; each question carries 3 marks)

1. Define climate system.
2. How does Albedo affect climate?
3. Briefly explain El Nino and its effects.
4. What is carbon cycling?
5. Describe about General Circulation Models.
6. Comment on Ocean Acidification.
7. Discuss the mission of Intergovernmental Panel on Climate Change.
8. What is Montreal Protocol?
9. Briefly explain Carbon dioxide Capture and Storage.
10. Discuss the importance of bio energy crops.

Part B

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

Module I

11. a) What is the general circulation of the atmosphere? (7 Marks)
- b) How does the general circulation affect the earth's climate? (7 Marks)

OR

12. a) What is the composition and structure of the atmosphere? (7 Marks)
b) Explain the significance of water in the atmosphere on climate of earth. (7 Marks)

Module II

13. (a) State and explain Global Warming Potential. (7 Marks)
b) Briefly explain Gandhian ideas on Global warming. (7 Marks)

OR

14. (a) Describe the importance of Greenhouse effect on global climate system. (7 Marks)
b) Discuss the role of carbon dioxide in Greenhouse effect. (7 Marks)

Module III

15. Explain the impact of climate change on surface temperature and precipitation. (14 Marks)

OR

16. Describe the different uncertainties inherent in the projection of climate. (14 Marks)

Module IV

17. Enumerate the international initiatives to address climate change challenges and explain any two. (14 Marks)

OR

18. a) Outline the structure of the Intergovernmental Panel on Climate Change. (4 Marks)
b) Explain the comprehensive Assessment Reports of IPCC. (10 Marks)

Module V

19. Explain hazards due to climate change and describe the possible mitigation measures to it. (14 Marks)

OR

20. (a) Discuss the concept of energy efficiency in buildings in response to climate change. (5 Marks)
b) Discuss the impact of climate change on Ecosystem and its adaptation measures. (9 Marks)

Course Code: CET 286
Climate Change and Hazard Mitigation

Module I

Introduction to Earth's Climate System: Basic concepts- Radiation, Albedo, Emissivity, scales of motion, large-scale motion, general circulation, troposphere-stratosphere transport. Atmospheric structure and thermodynamics: pressure, density, composition, temperature structure, water in the atmosphere. Atmospheric photochemistry and chemical kinetics

Module II

Hurricanes and Global warming: Global Ocean Circulation - El Nino and its effects - Paleo- indicators of climate -The Nature of Storms—cyclones, tornadoes and hurricanes. Greenhouse effect-greenhouse gases-sources of emission - The Role of Carbon Dioxide, The Earth's Carbon Reservoirs, Carbon Cycling-Climate and Weather Global warming potential - Effects of Global warming- Gandhian ideas on global warming.

Module III

Climate data and Models: Equations of atmospheric fluid mechanics, energy equation, turbulence, mixing length models, Atmospheric chemical transport and general circulation models. Analyses of climate data. Climate projections and their uncertainties. Impacts of climate change on Surface temperature, Precipitation, Ocean pH, Sea-level and Arctic sea-ice extent.

Module IV

International initiatives to address the climate change challenges: History of Earth's climate – 1970s (IIASA, DOE), 1980s, Startup of the U.N IPCC, Mission of the IPCC, The Framework Convention on Climate Change, The Kyoto Protocol to the Framework Convention, Earth Summit, Montreal Protocol. Policy Analyses, Internationally Adopted Emissions Restrictions.

Module V

Climate Change Adaptation & Mitigation Measures: Adaptation to climate change in the fields of Ecosystems and biodiversity - Agriculture and food security, land use, forestry, human health, water supply, sanitation and infrastructure. Hazards due to climate change

and Mitigation Measures: Extreme weather events. Mitigation measures in sectors vital to humanity (food, water, health): Brief explanation of - Carbon dioxide capture and storage (CCS), Bio-energy crops, Energy efficiency in buildings.

Text Books

- Mark Masli, Climate Change: A Very Short Introduction, Oxford University Press, 2014.
- Jan C van Dam, Impacts of Climate Change and Climate Variability on Hydrological Regimes, Cambridge University Press, UK, 2003.
- Trenberth, K.E. (Editor), 1992: *Climate System Modeling*, Cambridge University Press, Cambridge, U.K.

References

- IPCC second assessment report - Working Group I Report, The Science of climate change, 1995.
- IPCC fourth assessment report - The AR4 synthesis report, 2007
- IPCC fourth assessment report - Working Group I Report, The physical Science Basis, 2007.
- IPCC fourth assessment report - Working Group II Report, Impacts, Adaptation and Vulnerability, 2007.
- IPCC fourth assessment report - Working Group III Report Mitigation of Climate change, 2007
- IPCC fifth assessment report - The AR5 synthesis report, 2014

Course Code: CET 286
Climate Change and Hazard Mitigation
Course content and Schedule of Lecture (sample)

Module	Topic	Course outcome addressed	No of Hours
Module I (9 Hours)			
1.1	Introduction to Earth's Climate System: Basic concepts	CO1	1
1.2	Radiation, Albedo, Emissivity,	CO1	1
1.3	Scales of motion, large-scale motion	CO1	1
1.4	General circulation, troposphere-stratosphere transport	CO1	1
1.5	Atmospheric structure and thermodynamics	CO1	1
1.6	Pressure, density, composition	CO1	1

1.7	Temperature structure, water in the atmosphere	CO1	1
1.8	Atmospheric photochemistry	CO1	1
1.9	Chemical kinetics	CO1	1
Module II (9 Hours)			
2.1	Hurricanes and Global warming: Global Ocean Circulation	CO2	1
2.2	El Nino and its effects - Paleo- indicators of climate	CO2	1
2.3	The Nature of Storms—cyclones, tornadoes and hurricanes	CO2	1
2.4	Greenhouse effect-greenhouse gases-sources of emission	CO2	1
2.5	The Role of Carbon Dioxide, The Earth's Carbon Reservoirs	CO2	1
2.6	Carbon Cycling-Climate and Weather Global warming potential	CO2	1
2.7	Effects of Global warming	CO2	1
2.8	Effects of Global warming	CO2	1
2.9	Gandhian ideas on global warming.	CO2	1

Module III (9 Hours)			
3.1	Climate data and Models; Equations of atmospheric fluid mechanics, energy equation, turbulence	CO5	1
3.2	Mixing length models	CO5	1
3.3	Atmospheric chemical transport	CO5	1
3.4	General circulation models	CO5	1
3.5	Analyses of climate data	CO5	1
3.6	Climate projections and their uncertainties	CO5	1
3.7	Impacts of climate change on Surface temperature, Precipitation	CO5	1
3.8	Impacts of climate change on Ocean pH, Sea-level and Arctic sea-ice extent	CO5	1

3.9	Impacts of climate change on Ocean pH, Sea-level and Arctic sea-ice extent	CO5	1
Module IV (9 Hours)			
4.1	International initiatives to address the climate change challenges	CO4	1
4.2	History of Earth's climate – 1970s (IIASA, DOE), 1980s	CO4	1
4.3	Startup of the U.N IPCC, Mission of the IPCC	CO4	1
4.4	The Framework Convention on Climate Change	CO4	1
4.5	The Kyoto Protocol to the Framework Convention	CO4	1
4.6	Earth Summit	CO4	1
4.7	Montreal Protocol	CO4	1
4.8	Policy Analyses	CO4	1
4.9	Internationally Adopted Emissions Restrictions	CO4	1

Module V (9 Hours)			
5.1	Climate Change Adaptation & Mitigation Measures	CO3	1
5.2	Adaptation to climate change in the fields of Ecosystems and biodiversity	CO3	1
5.3	Agriculture and food security, land use, forestry, human health	CO3	1
5.4	Water supply, sanitation and infrastructure	CO3	1
5.5	Hazards due to climate change and Mitigation Measures: Extreme weather events	CO3	1
5.6	Mitigation measures in sectors vital to humanity (food, water, health)	CO3	1
5.7	Carbon dioxide capture and storage (CCS)	CO3	1
5.8	Bio-energy crops, Energy efficiency in buildings.	CO3	1
5.9	Energy efficiency in buildings.	CO3	1

AM JABDUL KALAM
TECHNOLOGICAL
UNIVERSITY

SEMESTER -4
HONOURS



CET292	COURSE NAME ADVANCED MECHANICS OF SOLIDS	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: Objective of this course is to expose the students to the advanced concepts of mechanics of materials and enhance their problem-solving skills. The course aims to understand the stresses and strains in 2D and 3D solid bodies. It introduces students to the elements of theories of elasticity, failure and failure criteria. Students will be able to understand concepts, principles and governing equations in dealing with elastic solids. After this course students will be in a position to find mechanical behaviour of elastic materials by determining the stress, strains produced by the application of load.

Prerequisite: Mechanics of Solids

Course Outcomes:

Course Outcome	Description of Course Outcome	Prescribed learning level
CO 1	To explain the material properties of solids and the state of stress and strain developed in solids due to applied loads.	Remembering, Understanding & Applying
CO 2	To illustrate the different failure theories and apply the apt failure criteria to find out the Factor of Safety against structural failure.	Applying & Analysing
CO 3	To predict the structural response of standard cross sections of isotropic materials due to applied torsion.	Applying & Analysing

Mapping of course outcomes with program outcomes (Minimum requirement)

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	15
Understand	10	10	15
Apply	15	15	35
Analyse	15	15	35
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions**Part A**

Course Outcome 1 (CO1): (Two questions each from module 1 to module 3 to meet the course objective 1: To understand the material properties of solids and the state of stress and strain developed in solids due to applied loads.)

1. Explain stress invariants
2. Explain Stress space
3. Explain the transformation of strain
4. Explain transformation of stress
5. List the differential equations of equilibrium for three dimensional stress state.
6. State the assumptions in classical linear elasticity
7. Differentiate between principal stress and principal strain
8. List the six compatibility equations for a three dimensional system.
9. Distinguish between rectangular strain rosette and equiangular strain rosette.
10. Differentiate between stress tensor and strain tensor
12. Explain octahedral stresses & strain

Course Outcome 2 (CO2) (Two questions from module 4 to meet the course objective 2: To understand the different failure theories and apply the apt failure criteria to find the Factor of Safety.)

1. Discuss the failure criteria for ductile materials
2. Discuss the failure criteria for brittle materials
3. Explain Palm miner rule
4. Discuss the failure due to stress reversal
5. Explain SN Curve
6. Explain stress concentration factor

Course Outcome 3 (CO3) (Two questions from module 5 to meet the course objective 3: To predict the structural response of standard cross sections of isotropic materials due to applied torsion.)

1. Discuss the use of St Venants semi inverse method
2. Explain Prandtl’s membrane analogy

Part B

All the questions under this section shall assess the learning levels corresponding to the course outcomes listed below.

CO 1	To understand the material properties of solids and the state of stress and strain developed in solids due to applied loads.
CO 2	To learn the different failure theories and apply the apt failure criteria to find the Factor of Safety against structural failure.
CO 3	To predict the structural response of standard cross sections of isotropic materials due to applied torsion.

1. The state of strain at a point in an isotropic material is given by strain tensor.

$$\begin{bmatrix} 0.002 & 0 & -0.002 \\ 0 & -0.004 & 0.0006 \\ -0.002 & 0.0006 & 0 \end{bmatrix}$$

Determine stress tensor at this point. Take E = 200 GPa. Poisson’s ratio = 0.3.

Course outcome identifier	Description of course outcome	Learning level assessed	Marks allocated
CO 1	To explain the material properties of solids and the state of stress and strain developed in solids due to applied loads.	Remembering – (Relation between Lamé’s Constants and E & Poisson’s ratio) (D matrix for Isotropic Material)	4
		Understanding- (Constitutive Stress – strain Relationship)	2
		Analysing- (Computation of stress from strain with application of Constitutive stress strain relationship)	6
		Applying- (Formation of Stress tensor from stress components)	2
Total			14

2. A low carbon steel shaft is designed to have a diameter of 25 mm. It is to be subjected to an axial load $P = 20 \text{ kN}$, a moment $M = 130 \text{ N m}$, and a torque $T = 220 \text{ Nm}$. If the yield point for the steel is 260 MPa, determine the factor of safety used in the design of the shaft based on the a) Tresca criterion of failure b) Von mises criterion of failure assuming that failure occurs at initiation of yielding.

Course outcome identifier	Description of course outcome	Learning level assessed	Marks allocated
CO 1	To explain the material properties of solids and the state of stress and strain developed in solids due to applied loads.	Analysing – (Computation of state of stress from loading situation)	6
CO 2	To illustrate the different failure theories and apply the apt failure criteria to find the Factor of Safety against structural failure.	Remembering – (Formulae for the Tresca & Von mises Criteria)	4
		Applying – Computation of Factor of Safety	4
Total			14

3. A square shaft has 42.0 mm sides and has the same cross sectional area as shafts having circular and equilateral triangular cross sections. If each shaft is subjected to a torque of 1kNm, Determine the maximum shearing stress for each of the three shafts.

Course outcome identifier	Description of course outcome	Learning level assessed	Marks allocated
CO 3	To predict the structural response of standard cross sections of isotropic materials due to applied torsion.	Understanding – (Knowledge regarding Saint Venant's Semi Inverse Method)	4
		Applying-(Use of Stress Function)	2
		Remembering- (Relation between maximum shear stress with applied Torsion and the geometric parameters	4
		Applying- (Use of appropriate Equation)	4
Total			14

Model Question Paper CET292 - Advanced Mechanics of Solids			
Qn No	Questions	Marks	Course Outcome (CO) Assessed
Part A (Answer all questions; each question carry 3 marks)			
1	Explain transformation of stress	3	1
2	Differentiate between spherical and Deviatorial stress tensor	3	1
3	Explain strain invariants	3	1
4	Distinguish between rectangular strain rosette and equiangular strain rosette	3	1
5	List the six compatibility equations for a three dimensional system	3	1
6	List out the differential equations of equilibrium for three dimensional stress state.	3	1
7	Discuss the failure criteria for ductile materials	3	2
8	Explain stress concentration factor	3	2
9	Discuss the use of St Venants semi inverse method	3	3
10	Explain Prandtl's membrane analogy	3	3
Part B (Answer one full question from each module, each question carry 14 marks)			
Module I			
11(a)	Derive the expression for the stress on arbitrarily plane whose unit normal vector is defined by $li+mj+nk$ for a rectangular coordinate system with x,y and z as reference axes.	6	1
11 (b)	Find the expression for the Normal stress and Shearing stress on a new coordinate system with X,Y and Z as the reference axes.X axis is defined by $l_1i +m_1j+n_1k$, Y axis is defined by $l_2i +m_2j+n_2k$ and Z axis is defined by $l_3i +m_3j+n_3k$	8	1
OR			
12 (a)	A rectangular bar of metal of cross section 20 mm x 35 mm is subjected to an axial tensile force of 180 kN. Calculate the normal, shear and resultant stresses on a plane whose normal has the following direction cosines $l=m=n=1/\sqrt{3}$	7	1
12(b)	The state of stress at a point is given by the following array of terms	7	1

	$\begin{bmatrix} 3 & 6 & 3 \\ 6 & 6 & 2 \\ 3 & 2 & 9 \end{bmatrix}$ MPa Determine the principal stresses and the principal directions. Find out the stress invariants in principal plane and show that it remains unchanged.		
Module II			
13 (a)	By means of strain rosette, the following strains were recorded during the test on a structural member. $\epsilon_0 = 950$ micrometres/m, $\epsilon_{45} = -110$ micrometres/m, $\epsilon_{90} = 110$ micrometres/m. Determine the magnitude and directions of principal strains.	7	1
13(b)	If the displacement field in a body is specified as $u = (x^2+4) 10^{-3}$, $v = 5y^2z * 10^{-3}$ and $w = (x + 2z) 10^{-3}$. Determine the strain tensor at a point whose coordinates are (3,2,3)	7	1
OR			
14	The strain components at a point with respect to xyz co-ordinate system are $\epsilon_x = 0.15$, $\epsilon_y = 0.16$, $\epsilon_z = 0.35$, $\gamma_{xy} = \gamma_{yz} = \gamma_{xz} = 0.170$. If the coordinate axes are rotated about the z-axis through 45° in the anticlockwise direction, determine the new strain components.	14	1
Module III			
15	The state of strain at a point is given by strain tensor. $\begin{bmatrix} 0.002 & 0 & -0.002 \\ 0 & -0.004 & 0.0006 \\ -0.002 & 0.0006 & 0 \end{bmatrix}$ Determine stress tensor at this point. Take $E = 200$ GPa. Poisson's ratio = 0.3.	14	1
OR			
16(a)	Under what conditions are the following expressions for the components of strain at a point compatible? $\epsilon_x = 2axy^2 + by^2 + 2cxy$, $\epsilon_y = ax^2 + bx$, $\gamma_{xy} = \alpha x^2 + \beta xy + ax^2 + \eta y$	7	1
16(b)	The stress components at a point in a body are given by $\sigma_x = 5xy^2z + 2x$, $\sigma_y = 3xyz + 3y$, $\sigma_z = x^2y + y^2z$, $\tau_{xy} = 0$, $\tau_{yz} = \tau_{xz} = 2xy^2z + 2xy$ Determine whether these components of stress satisfy the equilibrium equations or not at the point (1,-1,2). If not then determine the suitable body force required at this point so that these stress components are under equilibrium.	7	1

Module IV			
17	Represent all the yield criteria for failure graphically in the 2D stress space with rectangular axes σ_1 and σ_2 for the material steel. Assume the yield point of steel as 350 MPa and poisson ratio as 0.25. Mention the equation also in the graph.	14	2
OR			
18	A closed end thin-walled cylindrical of a metal with yield point = 700 MPa has an inside diameter of 20mm. The cylinder is subjected to an internal pressure of 22 MPa and an axial load of 50 kN. Determine the torque that can be applied to the cylinder if the factor of safety for design is 1.80. Check whether the material is safe under Von mises criteria.	14	2
Module V			
19	A hollow thin-wall brass tube has an equilateral triangular cross section. The mean length of each side of the triangle is 40.0mm. The wall thickness is 4.00mm. Determine the torque and unit angle of twist for an average shearing stress of 20.0 MPa. ($G = 31.1 \text{ GPa}$)	14	3
OR			
20	A torsion member has an elliptical cross section with major and minor dimensions of 100 mm and 70 mm, respectively. The yield stress of the material is 350 MPa. Determine the maximum torque that can be applied to the torsion member based on a factor of safety 1.8 using maximum shearing stress criterion of failure.	14	3

Syllabus**Module 1 Stress in 3-D**

Definition of stress at a point, Stress Notation, Stress Tensor, Normal stress and Shearing Stress on an oblique plane, Transformation of stress, Principal Stress, Stress Invariants, Octahedral Stress, Mean and Deviator Stress, Plane stress, Mohr's Circle in Two Dimensions, Differential Equations of motion of a deformable body.

Module 2 Strain in 3-D

Types of Strain, Deformation of a deformable body, Strain Tensor, Strain Transformation, Spherical and Deviatorial Strain Tensor, Principal Strains, Strain Invariants, Octahedral Strains, Mohr Circle for strain, Equations of Compatibility for Strain, Strain Rosettes

Module 3 Elements of Theory of Elasticity

Strain Energy Density, Complementary Internal Energy Density, Elasticity and Strain Energy Density, Elasticity and Complementary Internal Energy Density, Generalized Hooke's Law, Anisotropic Elasticity, Isotropic Elasticity, Displacements-strains and compatibility-equilibrium equations and boundary conditions

Module 4 Failure and Failure criteria

Modes of failure, yield failure criteria, Maximum Principal Stress Criteria, Maximum Shear stress criteria, Maximum Strain Criteria, Maximum Strain Energy Density Criteria, Von Mises Criteria, fatigue, Stress Concentration Factor, Palm Miner Rule, SN Curve

Module 5 Torsion

Torsion of a cylindrical bar of circular cross section- St.Venant's semi inverse method-stress function approach-elliptical, equilateral triangle & narrow rectangular cross sections - Prandtl's membrane analogy-Hollow thin wall torsion members

Text Books

1. A.P. Boresi and O.M. Sidebottom, Advanced Mechanics of Materials, 4th edition, John Wiley & Sons, 1985
2. R.D. Cook and W.C. Young, Advanced Mechanics of Materials, 2nd edition, Prentice Hall Intl, Inc. 1999
3. Srinath L.S., Advanced Mechanics of Solids, Tata McGraw Hill, 3e, 2009

Reference Books

1. S P Timoshenko, Strength of Materials Vol II, CBS Publishers, 2002
2. Shames, E.H., Mechanics of Deformable solids, Prentice Hall Inc., 1964
3. Timoshenko S.P and Goodier J.N, Theory of elasticity, McGraw Hill, 3e, 1970

Lecture Plan – Advanced Mechanics of Solids

<i>Module</i>	<i>Topic</i>	<i>Course outcomes addressed</i>	<i>No. of Lectures</i>
1	Module I : Total lecture hours : 9		
1.1	Definition of stress at a point, Stress Notation, Stress Tensor, Mean and Deviator Stress	CO1	Lecture 1
1.2	Definition of Plane, Normal Stress on an oblique plane	CO1	Lecture 2
1.3	Shearing Stress on an oblique plane	CO1	Lecture 3
1.4	Transformation of stress, Principal Stress,	CO1	Lecture 4
1.5	Stress Invariants & Octahedral Stress.	CO1	Lecture 5
1.6	Plane stress & Mohr's Circle in Two Dimensions	CO1	Lecture 6
1.7	Differential Equations of motion of a deformable body	CO1	Lecture 7
2	Module II : Total lecture hours : 9		
2.1	Types of Strain & Deformation of a deformable body	CO2	Lecture 1
2.2	Strain Tensor & Strain Transformation,	CO2	Lecture 2
2.3	Spherical and Deviatorial Strain Tensor	CO2	Lecture 3
2.4	Principal Strains & Strain Invariants	CO2	Lecture 4
2.5	Octahedral Strains & Mohr Circle for strain	CO2	Lecture 5
2.6	Equations of Compatibility for Strain	CO2	Lecture 6
2.7	Strain Rosettes	CO2	Lecture 7
3	Module III : Total lecture hours : 9		
3.1	Strain Energy Density & Complementary Internal Energy Density	CO3	Lecture 1
3.2	Elasticity and Strain Energy Density	CO3	Lecture 2
3.3	Elasticity and Complementary Internal Energy Density	CO3	Lecture 3
3.4	Generalized Hooke's Law	CO3	Lecture 4
3.5	Anisotropic Elasticity & Isotropic Elasticity	CO3	Lecture 5
3.6	Displacements-strains and compatibility	CO3	Lecture 6
3.7	Equilibrium equations and boundary conditions	CO3	Lecture 7

4	Module IV : Total lecture hours : 9		
4.1	Modes of failure, yield failure criteria,	CO4	Lecture 1
4.2	Maximum Principal Stress Criteria & Maximum Shear stress criteria	CO4	Lecture 2
4.3	Maximum Strain Criteria	CO4	Lecture 3
4.4	Maximum Strain Energy Density Criteria	CO4	Lecture 4
4.5	Von Mises Criteria	CO4	Lecture 5
4.6	fatigue, Stress Concentration Factor	CO4	Lecture 6
4.7	Palm Miner Rule & SN Curve	CO4	Lecture 7
5	Module V : Total lecture hours : 9		
5.1	Torsion of a cylindrical bar of circular cross section	CO3	Lecture 1
5.2	St. Venant's semi inverse method	CO3	Lecture 2
5.3	Stress function approach- elliptical	CO3	Lecture 3
5.4	Torsion- Equilateral triangle cross sections	CO3	Lecture 4
5.5	Torsion- narrow rectangular cross sections	CO3	Lecture 5
5.6	Prandtl's membrane analogy	CO3	Lecture 6
5.7	Hollow thin wall torsion members	CO3	Lecture 7

CET 294	PAVEMENT CONSTRUCTION AND MANAGEMENT	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		VAC	4	0	0	4	2019

Preamble

Objective of the course is to introduce the principles and practice of Highway construction and infrastructure asset management

Prerequisite: NIL

Course Outcomes:

	Description
CO No.	At the end of the course, students will be able to:
CO 1	To understand the characterization of materials used for pavement construction
CO 2	To carry out mix design of various bituminous mixes
CO 3	To study construction practices of flexible pavement and equipment used
CO 4	To understand the construction practices and reinforcement design of rigid pavement
CO 5	To study the fundamentals of pavement evaluation and pavement management system

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO 1	3	3	3	1		1	3	1		2		1	2	3
CO 2	3	1	3	1		1	1	1		1		1	2	2
CO 3	3	2	2	1					1	2		2	2	3
CO 4	2						2	1				2	2	3
CO 5	3	3	3			3		2					2	3

Assessment Pattern

Bloom's Category	Continuous Assessment		End Semester Examination (marks)
	Test 1 Marks	Test 2 Marks	
Remember	10	10	30
Understand	10	10	30
Apply	5	5	20
Analyse	5	5	20
Evaluate			
Create			

Mark Distribution

Total Marks	CIE (Marks)	ESE (Marks)	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

End Semester Examination Pattern:

The question consists of two parts- Part A and Part B. Part A consists of 10 questions with 3 marks for each (two questions from each module). Part B consists of two questions from each module, out of which one has to be answered. Each question carries 14 marks and can have maximum 2 subdivisions.

Sample Course Level Assessment Questions:

Course Outcome 1 (CO1): Explain the desirable properties of aggregates to be used in different types of pavement construction?

Course Outcome 2 (CO2): A bitumen mixture contains 60% coarse aggregate; 35% fine aggregate; 5% asphalt (by weight). Determine unit weight of mixture after compaction with 7% air voids? $G_{CA}=2.72$, $G_{FA}=2.66$, $G_A=1.0$

Course Outcome 3 (CO3): Explain the method of preparation of mix and construction steps for laying bituminous macadam base course?

Course Outcome 4 (CO4): With neat sketch explain the joints in cement concrete pavements?

Course Outcome 5 (CO5): Compare project level and network level pavement management systems.

Syllabus

Module 1

Pavement: functions and characteristics- Types of pavement: flexible pavement, rigid pavement, comparison- Different layers of flexible and rigid pavement

Pavement materials: characterization of sub grade soil, soil classification system, properties of road aggregate, principles and methods of gradation of soil aggregate mixes, characteristics and uses of bitumen, emulsion cutback and modified bitumen.

Module 2

Bituminous pavement types: penetration layer system and premixed aggregate- specification of materials,

Mix design: physical and volumetric properties of bituminous mix, Marshall method of mix design, Super pave mix design

Module 3

Construction of flexible pavement: functions of various layers, preparation and construction of sub grade, granular sub base (GSB), WBM, WMM, Bituminous macadam, Different types of wearing courses. specifications/ guild lines, equipment used for the construction of different layers in flexible pavement, quality control for flexible pavement construction

Module 4

Construction of cement concrete pavement: material characterization, preparation of subgrade and base, Types of joints in Rigid pavements its functions and design, presetting reinforcement in joints and PCC slab construction

Module 5

Introduction to pavement management system(PMS): concept, definition, objectives, components, general structure- data collection pavement evaluation, functional and structural evaluation, pavement deterioration models, pavement management levels: network, programme and project level- types of pavement management system, Types of Maintenance and rehabilitation activities, life cycle cost analysis of strategies, popular software

TEXT BOOKS

1. Khanna, S.K, Justo E.G, .A Veeraragavan, Highway Engineering 10th edition, Khanna Publishers.2018
2. Kadiyali, L. R., Principles of Highway Engineering, Khanna Publishers, 2001
3. Rajib B. Mallick and TaharEl-Korchi, Pavement Engineering CRC press, 2009
4. Rao G. V, Principles of Transportation and Highway Engineering, Tata McGrawHill, 1996
5. Prithvi Singh Khandhal, Bituminous Road Construction in India, PHI Learning, 2019

REFERENCES

1. Manual for construction and supervision of Bituminous works, MoRTH 2001
2. Shahin M.Y, Pavement Management for Airports, Roads and Parking lots, Chapman & Hall, 2005
3. IRC: 37-2018, Guidelines for the Design of Flexible Pavements, IRC 2018, New Delhi
4. MoRTH, IRC code for pavement evaluation, data collection

Course Content and lecture Schedule:

Sl No.	Topic	Course Outcome	No of Hours
1	Module 1		Total:10
1.1	Functions and characteristics of pavements, Types of pavement and comparison (flexible pavement, rigid pavement)	CO1	1
1.2	Different layers and properties of flexible and rigid pavement	CO1	1
1.3	characterization of sub grade soil and soil classification system	CO1	2
1.4	Properties of road aggregate, principles and methods of gradation of soil aggregate mixes	CO1	3
1.5	Characteristics and uses of bitumen, emulsion cutback and modified bitumen	CO1	3
2	Module 2		Total:8
2.1	Penetration layer system and premixed aggregate system	CO2	2
2.2	Physical and volumetric properties of bituminous mix, Marshall method of mix design, Superpave Mix design	CO2	6
3	Module 3		Total:8
3.1	Functions of various layers of flexible pavement, preparation and construction of sub grade, granular sub base (GSB), WBM, WMM, Bituminous macadam, Different types of wearing courses specifications/ guidelines	CO3	4
3.2	Equipment used for the construction of different layers in flexible pavement, quality control for flexible pavement construction	CO3	4
	Module 4		Total:6
4.1	Construction of cement concrete pavement :material characterization, preparation of subgrade and base	CO4	3
4.2	Types of joints in Rigid pavements its functions and design, presetting reinforcement in joints and PCC slab construction	CO4	3
	Module 5		Total:13
5.1	Introduction to pavement management system(PMS): concept, definition, objectives, components, general structure-data collection	CO5	3
5.2	Pavement evaluation, functional and structural evaluation, pavement deterioration models,	CO5	3
5.3	Pavement management levels: network, program and project level	CO5	2
5.4	Types of pavement management system, Types of Maintenance and rehabilitation activities	CO5	2
5.5	life cycle cost analysis of strategies, popular software	CO5	3

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

Course Code: CET 294

Course Name: **PAVEMENT CONSTRUCTION AND MANAGEMENT**
Model Question Paper

Marks: 100

Duration: 3 hrs

PART A

(Answer all Questions: Each question carries 3 marks)

1. What are the functions of pavement?
2. Define emulsified and cutback bitumen
3. What are the types of bitumen mixes for pavement?
4. Define VMA and VFB
5. Draw a typical cross section of a highway in cutting and show the various flexible pavement layers
6. What are the common types of equipment for compaction of soil for embankment and subgrade?
7. Draw a neat diagram showing various component layers of a CC pavement structure.
8. What are objects of providing dowel bars in CC pavement?
9. Differentiate between functional and structural evaluation of pavement.
10. What are the objectives of Pavement Management System?

(3 x 10 = 30)

PART B

(Answer one full question from each module)

11. a) Differentiate between flexible and rigid pavement
(7)
b) Explain CBR and the test procedure in the laboratory. How are the results of the test obtained and interpreted?
(7)

OR

12. a) What are the desirable properties of road aggregates? Explain aggregate impact test and shape test.
(10)

b) Explain grading of bitumen
(4)

13. a) Differentiate between dense graded and gap graded mixtures, giving one example for each
(6)

b) In a Marshall test, bituminous concrete cylinder is made whose weight is 1250 gms with the volume of 820 cc. The weights and specific gravities of various ingredients are given in the table. Determine VMA and VFB.
(8)

Type	A1	A2	A3	Flyash	Bitumen
Wt (g)	868	322	430	350	180
G	2.78	2.63	2.32	2.36	1.05

OR

14. a) Explain the Marshall method of bituminous mix design
(10)

b) In a bituminous concrete mix the theoretical specific gravity is 2.434, bulk specific gravity is 2.323, specific gravity of bitumen used is 1.05 with 4.35% weight of bitumen in the mix. Determine VMA, VFB.
(4)

15. a) Explain the construction procedure for base and sub-base courses in flexible pavement construction
(7)

b) List various excavating machinery used during highway construction. Mention the uses and limitations of each
(7)

OR

16. a) Write notes on the following types of bituminous pavement layers (i) stone matrix asphalt (ii) slurry seal (iii) micro-surfacing
(7)

b) What are the quality control tests during the construction of bituminous concrete layer? Mention the objectives of each
(7)

17. a) Write a note on importance and construction of (i) drainage layer for CC pavement (ii) dry lean concrete sub-base course (iii) separation membrane (10)

b) A rigid pavement is constructed at 28°C, peak summer temperature is 45°C, peak winter temperature is 10°C, the gap at expansion joint is 25mm, $\alpha_c=10 \times 10^{-6} / ^\circ\text{C}$. Calculate the spacing of expansion joint?

(4)

OR

18. a) What are the different materials required for the construction of a CC pavement? Mention how a concrete mix is designed for obtaining PQC.

(7)

b) Classify different types of joints in CC pavements and mention the objects of each.

(7)

19. a) Differentiate between destructive and non-destructive structural evaluation of pavement.

(7)

b) Compare project level and network level pavement management system

(7)

OR

20. a) Discuss the structure (component) of a Pavement Management System

(8)

b) Explain Life Cycle Cost Analysis

(6)

CET 296	GEOGRAPHICAL INFORMATION SYSTEMS	CATEGORY	L	T	P	CREDIT	Year of Introduction
		VAC	4	0	0	4	2019

Preamble: Goal of this course is to expose the students to the fundamental concepts and components of Geographical Information System (GIS). After successful completion this course, students will be able to identify the requirements for the development of GIS module for various applications.

Prerequisite: Nil

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

Course outcome identifier	Description of course outcome	Prescribed learning level
CO 1	To define terms, basic concepts and operations in GIS	Remembering
CO2	To identify various data types and their characteristics.	Understanding
CO 3	To illustrate various approaches of spatial data analysis and their significance in decision making.	Applying
CO 4	To demonstrate the application of GIS and allied technologies across diverse fields.	Applying

Mapping of course outcomes with program outcomes (Minimum requirement)

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination (Marks)
	Test 1 (Marks)	Test 2 (Marks)	
Remember	7.5	7.5	30
Understand	7.5	7.5	30
Apply	10	10	40
Analyse			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE (Marks)	ESE (Marks)	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

End Semester Examination Pattern:

There will be two parts: Part A and Part B.

Part A contains 10 questions with 2 questions from each module and each question shall carry 3 marks. Students should answer all questions.

Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-divisions

Syllabus**Module 1**

Basic concepts of GIS , History of GIS, Components of GIS-Geospatial Data, Attribute data, GIS operations, Application of GIS, Popular GIS Softwares.

Geographic Co-ordinate system, Map Projections, Commonly used Map Projections, Projected co-ordinate system, Georeferencing, Geometric Transformations.

Tutorial- Introducing any GIS software and its tools.

Module 2

Data structure -Vector Data model, Raster Data model, Types of Raster data, Data inputs to GIS platform, Metadata, Vector to Raster conversion, Digitization.

Geodatabase management, Attribute data management. Cartography and map making elements.

Tutorial exercises: Georeferencing, raster to vector conversion, assigning attribute data

Module 3

GIS Data Processing –Vector data Analysis- Buffering, Overlay-Point-in-Polygon, Line-in-polygon, Polygon-in-polygon, Distance measurement, Pattern analysis, Map manipulation, Network Analysis

Raster Data Analysis- Local operations, Neighbourhood operation, Zonal Operation, other Raster data operations.

Tutorial exercises: Digitization using available data source and creating a Map Using different map elements.

Module 4

Advanced Applications: Introduction to terrain mapping, DEM and TIN, terrain mapping techniques, Slope and aspect, WebGIS.

Data quality analysis – Sources of Error – Components of Data Quality

Tutorial exercises: working with a surface / terrain models

Module 5

Remote sensing: Definition, Basic Principles, Application of remote sensing in GIS.

Global Positioning System (GPS) - GPS Basic concepts, GPS segments-satellites & receivers, GPS applications. Application of *GPS data in GIS environment*.

Tutorial exercises: Create a small GIS module using GPS or RS data.

Text Books:

1. Chang,K , “Introduction to Geographic Information Systems”, Tata McGraw-Hill Publishing Co. Ltd, 2008
2. George Joseph, “Fundamentals of Remote Sensing”, University Press, 2003
3. Robert Laurini and Derek Thompson, “Fundamentals of Spatial Information Systems”, Academic Press, 1996.

References:

1. BurroughP, Principles of Geographical Information systems, Oxford University Press, 1998
2. Iliffe, C.J., Datums and Map Projections for Remote Sensing, GIS and Surveying, Whittles Publishing, 2006
3. Kang-tsung Chang, „Introduction to GIS“ , Tata McGraw-Hill Publishing Co. Ltd, 8e, 2016
4. Lillesand M and Kiefer W, “Remote Sensing and Image Interpretation”. John Wiley and Sons,Inc., 2000
5. Iliffe, C.J., Datums and Map Projections for Remote Sensing, GIS and Surveying, Whittles Publishing, 2006

Course Contents and Lecture Schedule:

No.	Topic	Course Outcome	No. of Hrs
1	Module 1		Total: 9
1.1	Basic concepts of GIS , History of GIS, Components of GIS- Geospatial Data, Attribute data, GIS operations, Application of GIS , Popular GIS Softwares.	CO1, CO2	3
1.2	Co-ordinate system: Geographic Co-ordinate system, Map Projections, Commonly used Map Projections, Projected co-ordinate system, Georeferencing, Geometric Transformations.	CO1, CO2	4
1.3	Tutorial- Introducing a GIS software and its tools.	CO1, CO2	2
2	Module 2		Total: 9
2.1	Data structure -Vector Data model, Raster Data model, Types of Raster data, Data inputs to GIS platform, Metadata, Vector to Raster conversion, Digitization.	CO1. CO2 CO3	4
2.2	Database management and map making: Geodatabase management, Attribute data management. Cartography and map making elements.	CO1, CO2 CO3	3
2.3	<i>Tutorial exercises: Digitization using available data source and creating a Map Using different map elements.</i>	CO2, CO3	2
3	Module 3		Total: 9
3.1	GIS Data Processing – Vector data Analysis- Buffering, Overlay- Point-in-Polygon, Line-in-polygon, Polygon-in-polygon, Distance measurement, Pattern analysis, Map manipulation, Network Analysis	CO1, CO2 CO3,CO4	4
3.2	Raster Data Analysis - Local operations, Neighbourhood operation, Zonal Operation, other Raster data operations.	CO1,CO2 CO3,CO4	3
3.3	<i>Tutorial exercises: Digitization using available data source and creating a Map Using different map elements.</i>	CO3,CO4	2
4	Module 4		Total: 9
4.1	Advanced Applications: Introduction to terrain mapping, DEM and TIN, terrain mapping techniques, Slope and aspect, WebGIS.	CO1,CO2 CO3,CO4	4
4.2	Data quality analysis – Sources of Error – Components of Data Quality	CO1,CO2 CO3,CO4	3
4.3	<i>Tutorial exercises: working with a surface / terrain models</i>		2
5	Module 5		Total: 9
5.1	Remote sensing: Definition, Basic Principles, Application of remote sensing in GIS.	CO1,CO2 CO3,CO4	3
5.2	Global Positioning System (GPS) - GPS Basic concepts, GPS segments-satellites & receivers, GPS applications. Application of GPS data in GIS environment.	CO1,CO2 CO3,CO4	4
5.3	<i>Tutorial exercises: Create a small GIS module using GPS or RS data.</i>	CO3, CO4	2

Sample Course Level Assessment Questions

CO 1	To define terms, basic concepts and operations in GIS
CO 2	To identify various data types and their characteristics.
CO 3	To illustrate various approaches of spatial data analysis and their significance in decision making.
CO 4	To demonstrate the application of GIS and allied technologies across diverse fields.

CO1

1. Prepare a short account on Geodetic datum, Ellipsoid earth model and Georeferencing
2. State any two functions of a GIS module
3. Write a short note on Digital Elevation Model.

CO2

1. Compare raster data sets and vector data sets. Highlight their significance in GIS environment
2. Briefly explain raster data form in GIS.
3. Explain any two approaches for spatial data acquisition for infrastructure development process.

CO3

1. Prepare short description on (i) Positional accuracy (ii) Attribute accuracy
2. Explain any two types of errors associated with spatial data analysis.
3. Explain different type of image resolutions and establish their importance in the GIS analysis.

CO4

1. Briefly illustrate the utility of GIS module in tracking and navigation.
2. Explain how GPS is used in the map preparation and locating ground features.
3. Highlight the advantages offered by remote sensing operation in the developmental decision making.

Model Question Paper

QP CODE:

Reg No.: _____

Name: _____

ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FOURTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CET 296

Course Name : GEOGRAPHICAL INFORMATION SYSTEMS

Max. Marks: 100

Duration: 3 hours

PART A

(Answer all questions)

(10 × 3 = 30)

1. Illustrate any two spatial data collection methods adopted for preparation of GIS.
2. What are the different components in GIS?
3. Define (i) Vector data (ii) Raster data
4. Establish the role of shapefiles in GIS.
5. Distinguish between pattern analysis and network analysis.
6. Demonstrate the significance of buffering in GIS
7. State any two sources of data error.
8. Define the terms : Slope and Aspect
9. List any two applications of GIS in combination with GPS.
10. Illustrate the role of atomic clock in GPS.

PART B

- 11 (i) Explain different techniques of remote sensing used for data collection
(ii) What is the role of georeferencing in GIS operation

(7 + 7)

or

- 12 (i) illustrate any three applications of GIS
(ii) Compare cylindrical projections and conical projections

(6+ 8)

- 13 (i) What are the different models adopted to represent vector data?
(iii) Highlight the role of digitisation in map preparation

(7 + 7)

or

14 (i) List the steps involved in the preparation of a digital map.

(ii) Compare continuous raster and discrete raster

(6+ 8)

15. (i) Prepare a short account on (a) Pattern analysis (b) Network analysis.

(ii) Illustrate any two raster data operations

(7 + 7)

or

16. (i) Explain any three factors that influences the choice of weights in the analysis of networks.

(ii) What are the different zonal operations suggested in the neighborhood analysis of raster data ?

(6 + 8)

17. (i) Explain the importance of using DEM for various engineering analysis.

(ii) Prepare different sources of error in a GIS operation.

(7 + 7)

or

18 (i) State any two approaches to reduce the error in GPS data transfer

(ii)Prepare a brief description of GIS data standard.

(7+7)

19. (i) Differentiate between ground based remote sensing and satellite based remote sensing ?

(ii) Justify - integration of GIS and GPS technologies could solve different problems faced in logistic operations.

(6 + 8)

or

20. (i) Explain different components of a GPS segment.

(ii) Illustrate the utility of remote sensing data in GIS module using any two cases.

(7+ 7)



SEMESTER -4

MATHEMATICS – 4 th semester

(All branches except Electrical, Electronics, Computer science, Information Technology and Applied Electronics)

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MAT 202	PROBABILITY, STATISTICS AND NUMERICAL METHODS	BASIC SCIENCE COURSE	3	1	0	4

Preamble: This course introduces students to the modern theory of probability and statistics, covering important models of random variables and techniques of parameter estimation and hypothesis testing. A brief course in numerical methods familiarises students with some basic numerical techniques for finding roots of equations, evaluating definite integrals solving systems of linear equations, and solving ordinary differential equations which are especially useful when analytical solutions are hard to find.

Prerequisite: A basic course in one-variable and multi-variable calculus.

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

CO 1	Understand the concept, properties and important models of discrete random variables and, using them, analyse suitable random phenomena.
CO 2	Understand the concept, properties and important models of continuous random variables and, using them, analyse suitable random phenomena.
CO 3	Perform statistical inferences concerning characteristics of a population based on attributes of samples drawn from the population
CO 4	Compute roots of equations, evaluate definite integrals and perform interpolation on given numerical data using standard numerical techniques
CO 5	Apply standard numerical techniques for solving systems of equations, fitting curves on given numerical data and solving ordinary differential equations.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests(%)		End Semester Examination(%)
	1	2	
Remember	10	10	10
Understand	30	30	30
Apply	30	30	30
Analyse	20	20	20
Evaluate	10	10	10
Create			

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Let X denote the number that shows up when an unfair die is tossed. Faces 1 to 5 of the die are equally likely, while face 6 is twice as likely as any other. Find the probability distribution, mean and variance of X .
2. An equipment consists of 5 componets each of which may fail independently with probability 0.15. If the equipment is able to function properly when at least 3 of the componets are operational, what is the probability that it functions properly?
3. X is a binomial random variable $B(n,p)$ with $n = 100$ and $p = 0.1$. How would you approximate it by a Poisson random variable?
4. Three balls are drawn at random without replacement from a box containing 2 white, 3 red and 4 black balls. If X denotes the number of white balls drawn and Y denotes the number of red balls drawn, find the joint probability distribution of (X,Y)

Course Outcome 2 (CO2)

1. What can you say about $P(X = a)$ for any real number a when X is a (i) discrete random variable? (ii) continuous random variable?

2. A string, 1 meter long, is cut into two pieces at a random point between its ends. What is the probability that the length of one piece is at least twice the length of the other?
3. A random variable has a normal distribution with standard deviation 10. If the probability that it will take on a value less than 82.5 is 0.82, what is the probability that it will take on a value more than 58.3?
4. X and Y are independent random variables with X following an exponential distribution with parameter μ and Y following an exponential distribution with parameter λ . Find $P(X + Y \leq 1)$

Course Outcome 3(CO3):

1. In a random sample of 500 people selected from the population of a city 60 were found to be left-handed. Find a 95% confidence interval for the proportion of left-handed people in the city population.
2. What are the types of errors involved in statistical hypothesis testing. Explain the level of risks associated with each type of error.
3. A soft drink maker claims that a majority of adults prefer its leading beverage over that of its main competitor's. To test this claim 500 randomly selected people were given the two beverages in random order to taste. Among them, 270 preferred the soft drink maker's brand, 211 preferred the competitor's brand, and 19 could not make up their minds. Determine whether there is sufficient evidence, at the 5% level of significance, to support the soft drink maker's claim against the default that the population is evenly split in its preference.
4. A nutritionist is interested in whether two proposed diets, *diet A* and *diet B* work equally well in providing weight-loss for customers. In order to assess a difference between the two diets, she puts 50 customers on diet A and 60 other customers on diet B for two weeks. Those on the former had weight losses with an average of 11 pounds and a standard deviation of 3 pounds, while those on the latter lost an average of 8 pounds with a standard deviation of 2 pounds. Do the diets differ in terms of their weight loss?

Course Outcome 4(CO4):

1. Use Newton-Raphson method to find a real root of the equation $f(x) = e^{2x} - x - 6$ correct to 4 decimal places.
2. Compare Newton's divided difference method and Lagrange's method of interpolation.

3. Use Newton's forward interpolation formula to compute the approximate values of the function f at $x = 0.25$ from the following table of values of x and $f(x)$

x	0	0.5	1	1.5	2
$f(x)$	1.0000	1.0513	1.1052	1.1618	1.2214

4. Find a polynomial of degree 3 or less the graph of which passes through the points $(-1,3)$, $(0,-4)$, $(1,5)$ and $(2,-6)$

Course Outcome 5 (CO5):

- Apply Gauss-Seidel method to solve the following system of equations

$$\begin{aligned} 4x_1 - x_2 - x_3 &= 3 \\ -2x_1 + 6x_2 + x_3 &= 9 \\ -x_1 + x_2 + 7x_3 &= -6 \end{aligned}$$
- Using the method of least squares fit a straight line of the form $y = ax + b$ to the following set of ordered pairs (x, y) : $(2,4)$, $(3,5)$, $(5,7)$, $(7,10)$, $(9,15)$
- Write the normal equations for fitting a curve of the form $y = a_0 + a_1x^2$ to a given set of pairs of data points.
- Use Runge-Kutta method of fourth order to compute $y(0.25)$ and $y(0.5)$, given the initial value problem

$$y' = x + xy + y, y(0) = 1$$

Syllabus

Module 1 (Discrete probability distributions) 9 hours

(Text-1: Relevant topics from sections-3.1-3.4, 3.6, 5.1)

Discrete random variables and their probability distributions, Expectation, mean and variance, Binomial distribution, Poisson distribution, Poisson approximation to the binomial distribution, Discrete bivariate distributions, marginal distributions, Independent random variables, Expectation -multiple random variables.

Module 2 (Continuous probability distributions) 9 hours

(Text-1: Relevant topics from sections-4.1-4.4, 3.6, 5.1)

Continuous random variables and their probability distributions, Expectation, mean and variance, Uniform, exponential and normal distributions, Continuous bivariate distributions, marginal distributions, Independent random variables, Expectation-multiple random variables, i.i.d random variables and Central limit theorem (**without proof**).

Module 3 (Statistical inference)

9 hours

(Text-1: Relevant topics from sections-5.4., 3.6, 5.1,7.2, 8.1, 8.3, 9.1-9.2,9.4)

Population and samples, Sampling distribution of the mean and proportion (for large samples only), Confidence interval for single mean and single proportions(for large samples only). Test of hypotheses: Large sample test for single mean and single proportion, equality of means and equality of proportions of two populations, small sample t-tests for single mean of normal population, equality of means (**only pooled t-test, for independent samples from two normal populations with equal variance**)

Module 4 (Numerical methods -I)

9 hours

(Text 2- Relevant topics from sections 19.1, 19.2, 19.3, 19.5)

Errors in numerical computation-round-off, truncation and relative error, Solution of equations – Newton-Raphson method and Regula-Falsi method. Interpolation-finite differences, Newton's forward and backward difference method, Newton's divided difference method and Lagrange's method. Numerical integration-Trapezoidal rule and Simpson's 1/3rd rule (**Proof or derivation of the formulae not required for any of the methods in this module**)

Module 5 (Numerical methods -II)

9 hours

(Text 2- Relevant topics from sections 20.3, 20.5, 21.1)

Solution of linear systems-Gauss-Siedal and Jacobi iteration methods. Curve fitting-method of least squares, fitting straight lines and parabolas. Solution of ordinary differential equations-Euler and Classical Runge-Kutta method of second and fourth order, Adams-Moulton predictor-correction method (**Proof or derivation of the formulae not required for any of the methods in this module**)

Text Books

1. (Text-1) Jay L. Devore, *Probability and Statistics for Engineering and the Sciences*, 8th edition, Cengage, 2012
2. (Text-2) Erwin Kreyszig, *Advanced Engineering Mathematics*, 10 th Edition, John Wiley & Sons, 2016.

Reference Books

1. Hossein Pishro-Nik, *Introduction to Probability, Statistics and Random Processes*, Kappa Research, 2014 (Also available online at www.probabilitycourse.com)
2. Sheldon M. Ross, *Introduction to probability and statistics for engineers and*

- scientists*, 4th edition, Elsevier, 2009.
3. T. Veera Rajan, *Probability, Statistics and Random processes*, Tata McGraw-Hill, 2008
 4. B.S. Grewal, *Higher Engineering Mathematics*, Khanna Publishers, 36 Edition, 2010.

Assignments

Assignments should include specific problems highlighting the applications of the methods introduced in this course in physical sciences and engineering.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	Discrete Probability distributions	9 hours
1.1	Discrete random variables and probability distributions, expected value, mean and variance (discrete)	3
1.2	Binomial distribution-mean, variance, Poisson distribution-mean, variance, Poisson approximation to binomial	3
1.3	Discrete bivariate distributions, marginal distributions, Independence of random variables (discrete), Expected values	3
2	Continuous Probability distributions	9 hours
2.1	Continuous random variables and probability distributions, expected value, mean and variance (continuous)	2
2.2	Uniform, exponential and normal distributions, mean and variance of these distributions	4
2.3	Continuous bivariate distributions, marginal distributions, Independent random variables, Expected values, Central limit theorem.	3
3	Statistical inference	9 hours
3.1	Population and samples, Sampling distribution of single mean and single proportion(large samples)	1
3.2	Confidence interval for single mean and single proportions (large samples)	2
3.3	Hypothesis testing basics, large sample test for single proportion, single proportion	2
3.4	Large sample test for equality of means and equality of proportions of two populations	2

3.5	t-distribution and small sample t-test for single mean and pooled t-test for equality of means	2
4	Numerical methods-I	9 hours
4.1	Roots of equations- Newton-Raphson, regulafalsi methods	2
4.2	Interpolation-finite differences, Newton's forward and backward formula,	3
4.3	Newton's divided difference method, Lagrange's method	2
4.3	Numerical integration-trapezoidal rule and Simpson's 1/3-rd rule	2
5	Numerical methods-II	9 hours
5.1	Solution of linear systems-Gauss-Siedal method, Jacobi iteration method	2
5.2	Curve-fitting-fitting straight lines and parabolas to pairs of data points using method of least squares	2
5.3	Solution of ODE-Euler and Classical Runge-Kutta methods of second and fourth order	4
5.4	Adams-Moulton predictor-corrector methods	1



Model Question Paper
(2019 Scheme)

Reg No:
Name:

Total Pages: 4

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FOURTH SEMESTER B.TECH DEGREE EXAMINATION

(Month & year)

Course Code: MAT

Course Name: PROBABILITY, STATISTICS AND NUMERICAL METHODS

(Common to all branches except (i) Electrical and Electronics, (ii) Electronics and Communication, (iii) Applied Electronics and Instrumentation (iv) Computer Science and Engineering (v) Information Technology)

Max Marks :100

Duration : 3 Hours

PART A

(Answer all questions. Each question carries 3 marks)

1. Suppose X is binomial random variable with parameters $n = 100$ and $p = 0.02$. Find $P(X < 3)$ using Poisson approximation to X . (3)
2. The diameter of circular metallic discs produced by a machine is a random variable with mean 6cm and variance 2cm. Find the mean area of the discs. (3)
3. Find the mean and variance of the continuous random variable X with probability density function (3)

$$f(x) = \begin{cases} 2x - 4, & 2 \leq x \leq 3 \\ 0 & \text{otherwise} \end{cases}$$
4. The random variable X is exponentially distributed with mean 3. Find $P(X > t + 3 | X > t)$ where t is any positive real number. (3)
5. The 95% confidence interval for the mean mass (in grams) of tablets produced by a machine is [0.56 0.57], as calculated from a random sample of 50 tablets. What do you understand from this statement? (3)
6. The mean volume of liquid in bottles of lemonade should be at least 2 litres. A sample of bottles is taken in order to test whether the mean volume has fallen below 2 litres. Give a null and alternate hypothesis for this test and specify whether the test would be one-tailed or two-tailed. (3)
7. Find all the first and second order forward and backward differences of y for the following set of (x, y) values: (0.5, 1.13), (0.6, 1.19), (0.7, 1.26), (0.8, 1.34) (3)
8. The following table gives the values of a function $f(x)$ for certain values of x . (3)

x	0	0.25	0.50	0.75	1
$f(x)$	1	0.9412	0.8	0.64	0.5

Evaluate $\int_0^1 f(x)dx$ using trapezoidal rule.

9. Explain the principle of least squares for determining a line of best fit to a given data (3)
10. Given the initial value problem $y' = y + x$, $y(0) = 0$, find $y(0.1)$ and $y(0.2)$ using Euler method. (3)

PART B
(Answer one question from each module)

MODULE 1

11. (a) The probability mass function of a discrete random variable is $p(x) = kx, x = 1, 2, 3$ where k is a positive constant. Find (i) the value of k (ii) $P(X \leq 2)$ (iii) $E[X]$ and (iv) $\text{var}(1 - X)$. (7)
- (b) Find the mean and variance of a binomial random variable (7)

OR

12. (a) Accidents occur at an intersection at a Poisson rate of 2 per day. What is the probability that there would be no accidents on a given day? What is the probability that in January there are at least 3 days (not necessarily consecutive) without any accidents? (7)
- (b) Two fair dice are rolled. Let X denote the number on the first die and $Y = 0$ or 1 , according as the first die shows an even number or odd number. Find (i) the joint probability distribution of X and Y , (ii) the marginal distributions. (iii) Are X and Y independent? (7)

MODULE 2

13. (a) The IQ of an individual randomly selected from a population is a normal distribution with mean 100 and standard deviation 15. Find the probability that an individual has IQ (i) above 140 (ii) between 120 and 130. (7)
- (b) A continuous random variable X is uniformly distributed with mean 1 and variance $4/3$. Find $P(X < 0)$ (7)

OR

14. (a) The joint density function of random variables X and Y is given by (7)

$$f(x, y) = \begin{cases} e^{-(x+y)}, & x > 0, \quad y > 0 \\ 0 & \text{otherwise.} \end{cases}$$

Find $P(X + Y \leq 1)$. Are X and Y independent? Justify.

- (b) The lifetime of a certain type of electric bulb may be considered as an exponential random variable with mean 50 hours. Using central limit theorem, find the approximate probability that 100 of these electric bulbs will provide a total of more than 6000 hours of burning time. (7)

MODULE 3

15. (a) The mean blood pressure of 100 randomly selected persons from a target population is 127.3 units. Find a 95% confidence interval for the mean blood pressure of the population. (7)
- (b) The CEO of a large electric utility claims that 80 percent of his 1,000,000 customers are very satisfied with the service they receive. To test this claim, the local newspaper surveyed 100 customers, using simple random sampling. Among the sampled customers, 73 percent say they are very satisfied. Based on these findings, do you think that the CEO is making a false claim of high satisfaction levels among his customers? Use a 0.05 level of significance. (7)

OR

16. (a) A magazine reported the results of a telephone poll of 800 adult citizens of a country. The question posed was: "Should the tax on cigarettes be raised to pay for health care reform?" The results of the survey were: Out of the 800 persons surveyed, 605 were non-smokers out of which 351 answered "yes" and the rest "no". Out of the remaining 195, who were smokers, 41 answered "yes" and the remaining "no". Is there sufficient evidence, at the 0.05 significance level, to conclude that the two populations smokers and non-smokers differ significantly with respect to their opinions? (7)
- (b) Two types of cars are compared for acceleration rate. 40 test runs are recorded for each car and the results for the mean elapsed time recorded below: (7)

	Sample mean	Sample standard deviation
Car A	7.4	1.5
Car B	7.1	1.8

determine if there is a difference in the mean elapsed times of the two car models at 95% confidence level.

MODULE 4

17. (a) Use Newton-Raphson method to find a non-zero solution of $x = 2 \sin x$. Start with $x_0 = 1$ (7)
- (b) Using Lagrange's interpolating polynomial estimate $f(1.5)$ for the following data (7)

x	0	1	2	3
$y = f(x)$	0	0.9826	0.6299	0.5532

OR

18. (a) Consider the data given in the following table (7)

x	0	0.5	1	1.5	2
$f(x)$	1.0000	1.0513	1.1052	1.1618	1.2214

Estimate the value of $f(1.80)$ using Newton's backward interpolation formula.

- (b) Evaluate $\int_0^1 e^{-x^2/2} dx$ using Simpson's one-third rule, dividing the interval $[0, 1]$ into 8 subintervals (7)

MODULE 5

19. (a) Using Gauss-Seidel method, solve the following system of equations (7)

$$\begin{aligned} 20x + y - 2z &= 17 \\ 3x + 20y - z &= -18 \\ 2x - 3y + 20z &= 25 \end{aligned}$$

- (b) The table below gives the estimated population of a country (in millions) for during 1980-1995 (7)

year	1980	1985	1990	1995
population	227	237	249	262

Plot a graph of this data and fit an appropriate curve to the data using the method of least squares. Hence predict the population for the year 2010.

OR

20. (a) Use Runge-Kutta method of fourth order to find $y(0.2)$ given the initial value problem (7)

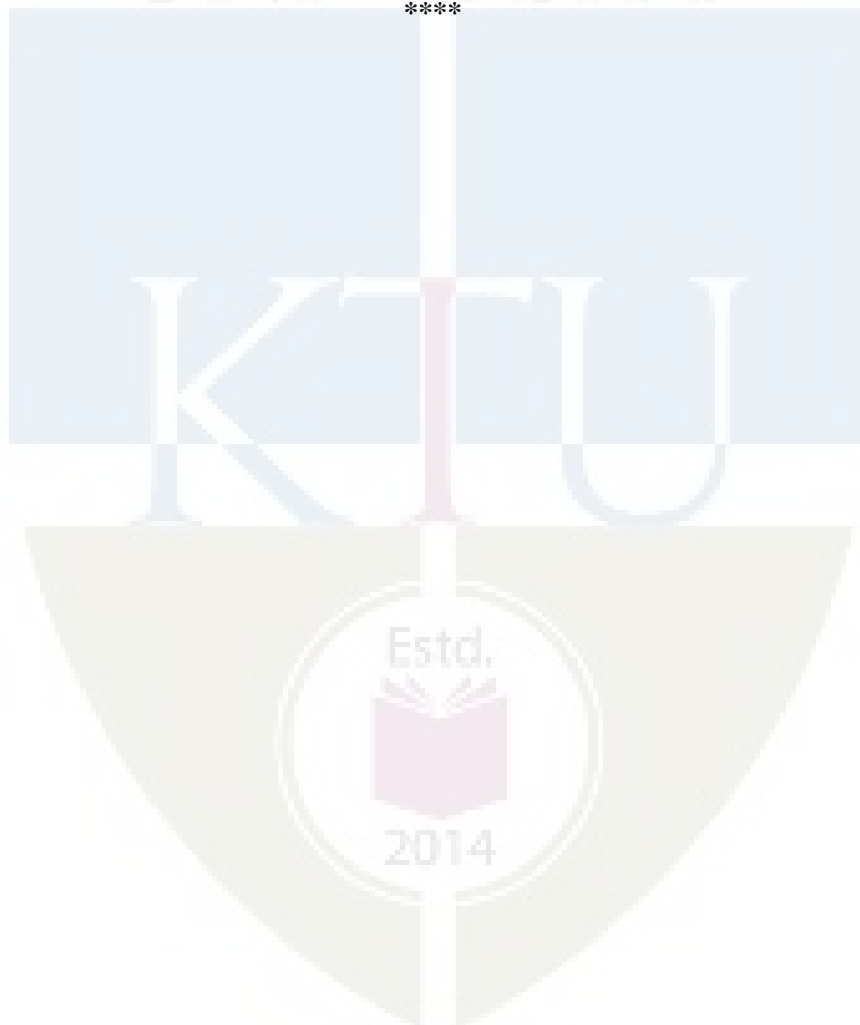
$$\frac{dy}{dx} = \frac{xy}{1+x^2}, \quad y(0) = 1$$

Take step-size, $h = 0.1$.

- (b) Solve the initial value problem (7)

$$\frac{dy}{dx} = x + y, \quad y(0) = 0,$$

in the interval $0 \leq x \leq 1$, taking step-size $h = 0.2$. Calculate $y(0.2)$, $y(0.4)$ and $y(0.6)$ using Runge-Kutta second order method, and $y(0.8)$ and $y(1.0)$ using Adam-Moulton predictor-corrector method.



MATHEMATICS – 4

(For Electrical, Electronics and Applied Electronics)

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MAT 204	PROBABILITY, RANDOM PROCESSES AND NUMERICAL METHODS	BASIC SCIENCE COURSE	3	1	0	4

Preamble: This course introduces students to the modern theory of probability and statistics, covering important models of random variables and analysis of random processes using appropriate time and frequency domain tools. A brief course in numerical methods familiarises students with some basic numerical techniques for finding roots of equations, evaluating definite integrals solving systems of linear equations and solving ordinary differential equations which are especially useful when analytical solutions are hard to find.

Prerequisite: A basic course in one-variable and multi-variable calculus.

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

CO 1	Understand the concept, properties and important models of discrete random variables and, using them, analyse suitable random phenomena.
CO 2	Understand the concept, properties and important models of continuous random variables and, using them, analyse suitable random phenomena.
CO 3	Analyse random processes using autocorrelation, power spectrum and Poisson process model as appropriate.
CO 4	Compute roots of equations, evaluate definite integrals and perform interpolation on given numerical data using standard numerical techniques
CO 5	Apply standard numerical techniques for solving systems of equations, fitting curves on given numerical data and solving ordinary differential equations.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests(%)		End Semester Examination(%)
	1	2	
Remember	10	10	10
Understand	30	30	30
Apply	30	30	30
Analyse	20	20	20
Evaluate	10	10	10
Create			

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Let X denote the number that shows up when an unfair die is tossed. Faces 1 to 5 of the die are equally likely, while face 6 is twice as likely as any other. Find the probability distribution, mean and variance of X .
2. An equipment consists of 5 components each of which may fail independently with probability 0.15. If the equipment is able to function properly when at least 3 of the components are operational, what is the probability that it functions properly?
3. X is a binomial random variable $B(n, p)$ with $n = 100$ and $p = 0.1$. How would you approximate it by a Poisson random variable?
4. Three balls are drawn at random without replacement from a box containing 2 white, 3 red and 4 black balls. If X denotes the number of white balls drawn and Y denotes the number of red balls drawn, find the joint probability distribution of (X, Y)

Course Outcome 2 (CO2)

1. What can you say about $P(X = a)$ for any real number a when X is (i) a discrete random variable? (ii) a continuous random variable?
2. A string, 1 meter long, is cut into two pieces at a random point between its ends. What is the probability that the length of one piece is at least twice the length of the other?

3. A random variable has a normal distribution with standard deviation 10. If the probability that it will take on a value less than 82.5 is 0.82, what is the probability that it will take on a value more than 58.3?
4. X and Y are independent random variables with X following an exponential distribution with parameter μ and Y following an exponential distribution with parameter λ . Find $P(X + Y \leq 1)$

Course Outcome 3(CO3):

1. A random process $X(t)$ is defined by $a \cos(\omega t + \theta)$ where a and ω are constants and θ is uniformly distributed in $[0, 2\pi]$. Show that $X(t)$ is WSS
2. How are the autocorrelation function and power spectral density of a WSS process related to each other?
3. Find the power spectral density of the WSS random process $X(t)$, given the autocorrelation function $R_X(\tau) = 9e^{-|\tau|}$
4. A conversation in a wireless ad-hoc network is severely disturbed by interference signals according to a Poisson process of rate $\lambda = 0.01$ per minute. (a) What is the probability that no interference signals occur within the first two minutes of the conversation? (b) Given that the first two minutes are free of disturbing effects, what is the probability that in the next minute precisely 1 interfering signal disturbs the conversation? (c) Given that there was only 1 interfering signal in the first 3 minutes, what is the probability that there would be at most 2 disturbances in the first 4 minutes?

Course Outcome 4(CO4):

1. Use Newton-Raphson method to find a real root of the equation $f(x) = e^{2x} - x - 6$ correct to 4 decimal places.
2. Compare Newton's divided difference method and Lagrange's method of interpolation.
3. Use Newton's forward interpolation formula to compute the approximate values of the function f at $x = 0.25$ from the following table of values of x and $f(x)$

x	0	0.5	1	1.5	2
f(x)	1.0000	1.0513	1.1052	1.1618	1.2214

4. Find a polynomial of degree 3 or less the graph of which passes through the points $(-1, 3)$, $(0, -4)$, $(1, 5)$ and $(2, -6)$

Course Outcome 5 (CO5):

1. Apply Gauss-Seidel method to solve the following system of equations

$$\begin{aligned} 4x_1 - x_2 - x_3 &= 3 \\ -2x_1 + 6x_2 + x_3 &= 9 \\ -x_1 + x_2 + 7x_3 &= -6 \end{aligned}$$

2. Using the method of least squares fit a straight line of the form $y = ax + b$ to the following set of ordered pairs (x, y) :
(2,4), (3,5), (5,7), (7,10), (9,15)
3. Write the normal equations for fitting a curve of the form $y = a_0 + a_1x^2$ to a given set of pairs of data points.
4. Use Runge-Kutta method of fourth order to compute $y(0.25)$ and $y(0.5)$, given the initial value problem

$$y' = x + xy + y, y(0) = 1$$

Syllabus

Module 1 (Discrete probability distributions) 9 hours

(Text-1: Relevant topics from sections-3.1-3.4, 3.6, 5.1)

Discrete random variables and their probability distributions, Expectation, mean and variance, Binomial distribution, Poisson distribution, Poisson approximation to the binomial distribution, Discrete bivariate distributions, marginal distributions, Independent random variables, Expectation (multiple random variables)

Module 2 (Continuous probability distributions) 9 hours

(Text-1: Relevant topics from sections-4.1-4.4, 3.6, 5.1)

Continuous random variables and their probability distributions, Expectation, mean and variance, Uniform, exponential and normal distributions, Continuous bivariate distributions, marginal distributions, Independent random variables, Expectation (multiple random variables), i. i. d random variables and Central limit theorem (without proof).

Module 3 (Random Processes) 9 hours

(Text-2: Relevant topics from sections-8.1-8.5, 8.7, 10.5)

Random processes and classification, mean and autocorrelation, wide sense stationary (WSS) processes, autocorrelation and power spectral density of WSS processes and their properties, Poisson process-distribution of inter-arrival times, combination of independent Poisson processes (merging) and subdivision (splitting) of Poisson processes (**results without proof**).

Module 4 (Numerical methods -I) 9 hours**(Text 3- Relevant topics from sections 19.1, 19.2, 19.3, 19.5)**

Errors in numerical computation-round-off, truncation and relative error, Solution of equations – Newton-Raphson method and Regula-Falsi method. Interpolation-finite differences, Newton's forward and backward difference method, Newton's divided difference method and Lagrange's method. Numerical integration-Trapezoidal rule and Simpson's 1/3rd rule (**Proof or derivation of the formulae not required for any of the methods in this module**)

Module 5 (Numerical methods -II)**9 hours****(Text 3- Relevant topics from sections 20.3, 20.5, 21.1)**

Solution of linear systems-Gauss-Seidel and Jacobi iteration methods. Curve fitting-method of least squares, fitting straight lines and parabolas. Solution of ordinary differential equations-Euler and Classical Runge-Kutta method of second and fourth order, Adams-Moulton predictor-correction method (**Proof or derivation of the formulae not required for any of the methods in this module**)

Text Books

1. (Text-1) Jay L. Devore, *Probability and Statistics for Engineering and the Sciences*, 8th edition, Cengage, 2012
2. (Text-2) Oliver C. Ibe, *Fundamentals of Applied Probability and Random Processes*, Elsevier, 2005.
3. (Text-3) Erwin Kreyszig, *Advanced Engineering Mathematics*, 10 th Edition, John Wiley & Sons, 2016.

Reference Books

1. Hossein Pishro-Nik, *Introduction to Probability, Statistics and Random Processes*, Kappa Research, 2014 (Also available online at www.probabilitycourse.com)
2. V.Sundarapandian, *Probability, Statistics and Queueing theory*, PHI Learning, 2009
3. Gubner, *Probability and Random Processes for Electrical and Computer Engineers*, Cambridge University Press,2006.
4. B.S. Grewal, *Higher Engineering Mathematics*, Khanna Publishers, 36 Edition, 2010.

Assignments

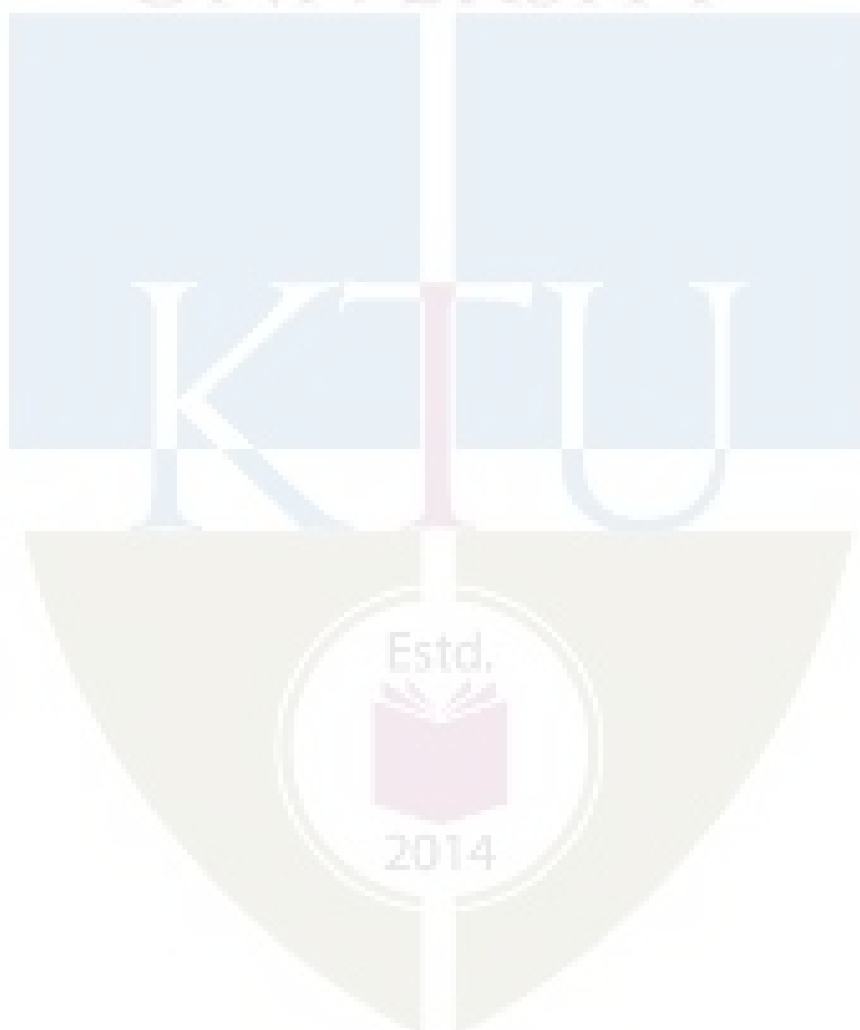
Assignments should include specific problems highlighting the applications of the methods introduced in this course in physical sciences and engineering.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	Discrete Probability distributions	9 hours
1.1	Discrete random variables and probability distributions, expected value, mean and variance (discrete)	3
1.2	Binomial distribution-mean, variance, Poisson distribution-mean, variance, Poisson approximation to binomial	3
1.3	Discrete bivariate distributions, marginal distributions, Independence of random variables (discrete), Expected values	3
2	Continuous Probability distributions	9 hours
2.1	Continuous random variables and probability distributions, expected value, mean and variance (continuous)	2
2.2	Uniform, exponential and normal distributions, mean and variance of these distributions	4
2.3	Continuous bivariate distributions, marginal distributions, Independent random variables, Expected values, Central limit theorem.	3
3	Random processes	9 hours
3.1	Random process -definition and classification, mean , autocorrelation	2
3.2	WSS processes its autocorrelation function and properties	2
3.3	Power spectral density	2
3.4	Poisson process, inter-distribution of arrival time, merging and splitting	3
4	Numerical methods-I	9 hours
4.1	Roots of equations- Newton-Raphson, regulafalsi methods	2
4.2	Interpolation-finite differences, Newton's forward and backward formula,	3
4.3	Newton's divided difference method, Lagrange's method	2
4.3	Numerical integration-trapezoidal rule and Simpson's 1/3-rd rule	2
5	Numerical methods-II	9 hours
5.1	Solution of linear systems-Gauss-Siedal method, Jacobi iteration	2

	method	
5.2	Curve-fitting-fitting straight lines and parabolas to pairs of data points using method of least squares	2
5.3	Solution of ODE-Euler and Classical Runge-Kutta methods of second and fourth order	4
5.4	Adams-Moulton predictor-corrector method	1

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Model Question Paper
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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FOURTH SEMESTER B.TECH DEGREE EXAMINATION
(Month & year)

Course Code: MAT 204

Course Name: PROBABILITY, RANDOM PROCESSES AND NUMERICAL METHODS

(For (i) Electrical and Electronics, (ii) Electronics and Communication, (iii) Applied Electronics and Instrumentation Engineering branches)

Max Marks :100

Duration : 3 Hours

PART A

(Answer all questions. Each question carries 3 marks)

1. Suppose X is binomial random variable with parameters $n = 100$ and $p = 0.02$. Find $P(X < 3)$ using Poisson approximation to X . (3)
2. The diameter of circular metallic discs produced by a machine is a random variable with mean 6cm and variance 2cm. Find the mean area of the discs. (3)
3. Find the mean and variance of the continuous random variable X with probability density function (3)

$$f(x) = \begin{cases} 2x - 4, & 2 \leq x \leq 3 \\ 0 & \text{otherwise} \end{cases}$$
4. The random variable X is exponentially distributed with mean 3. Find $P(X > t + 3 | X > t)$ where t is any positive real number. (3)
5. Give any two examples of a continuous time discrete state random processes. (3)
6. How will you calculate the mean, variance and total power of a WSS process from its autocorrelation function? (3)
7. Find all the first and second order forward and backward differences of y for the following set of (x, y) values: (0.5, 1.13), (0.6, 1.19), (0.7, 1.26), (0.8, 1.34) (3)
8. The following table gives the values of a function $f(x)$ for certain values of x . (3)

x	0	0.25	0.50	0.75	1
$f(x)$	1	0.9412	0.8	0.64	0.5

Evaluate $\int_0^1 f(x)dx$ using trapezoidal rule.

9. Explain the principle of least squares for determining a line of best fit to a given data (3)
10. Given the initial value problem $y' = y + x$, $y(0) = 0$, find $y(0.1)$ and $y(0.2)$ using Euler method. (3)

PART B

(Answer one question from each module)

MODULE 1

11. (a) The probability mass function of a discrete random variable is $p(x) = kx, x = 1, 2, 3$ where k is a positive constant. Find (i) the value of k (ii) $P(X \leq 2)$ (iii) $E[X]$ and (iv) $\text{var}(1 - X)$. (7)
- (b) Find the mean and variance of a binomial random variable (7)

OR

12. (a) Accidents occur at an intersection at a Poisson rate of 2 per day. What is the probability that there would be no accidents on a given day? What is the probability that in January there are at least 3 days (not necessarily consecutive) without any accidents? (7)
- (b) Two fair dice are rolled. Let X denote the number on the first die and $Y = 0$ or 1 , according as the first die shows an even number or odd number. Find (i) the joint probability distribution of X and Y , (ii) the marginal distributions. (iii) Are X and Y independent? (7)

MODULE 2

13. (a) The IQ of an individual randomly selected from a population is a normal distribution with mean 100 and standard deviation 15. Find the probability that an individual has IQ (i) above 140 (ii) between 120 and 130. (7)
- (b) A continuous random variable X is uniformly distributed with mean 1 and variance $4/3$. Find $P(X < 0)$ (7)

OR

14. (a) The joint density function of random variables X and Y is given by (7)

$$f(x, y) = \begin{cases} e^{-(x+y)}, & x > 0, \quad y > 0 \\ 0 & \text{otherwise.} \end{cases}$$

Find $P(X + Y \leq 1)$. Are X and Y independent? Justify.

- (b) The lifetime of a certain type of electric bulb may be considered as an exponential random variable with mean 50 hours. Using central limit theorem, find the approximate probability that 100 of these electric bulbs will provide a total of more than 6000 hours of burning time. (7)

MODULE 3

15. (a) A random process $X(t)$ is defined by $X(t) = Y(t) \cos(\omega t + \Theta)$ where $Y(t)$ is a WSS process, ω is a constant and Θ is uniformly distributed in $[0, 2\pi]$ and is independent of $Y(t)$. Show that $X(t)$ is WSS (7)
- (b) Find the power spectral density of the random process $X(t) = a \sin(\omega_0 t + \Theta)$, ω_0 constant and Θ is uniformly distributed in $(0, 2\pi)$ (7)

OR

16. Cell-phone calls processed by a certain wireless base station arrive according to a Poisson process with an average of 12 per minute.
- (a) What is the probability that more than three calls arrive in an interval of length 20 seconds? (7)
- (b) What is the probability that more than 3 calls arrive in each of two consecutive intervals of length 20 seconds? (7)

MODULE 4

17. (a) Use Newton-Raphson method to find a non-zero solution of $x = 2 \sin x$. Start with $x_0 = 1$ (7)
 (b) Using Lagrange's interpolating polynomial estimate $f(1.5)$ for the following data (7)

x	0	1	2	3
$y = f(x)$	0	0.9826	0.6299	0.5532

OR

18. (a) Consider the data given in the following table (7)

x	0	0.5	1	1.5	2
$f(x)$	1.0000	1.0513	1.1052	1.1618	1.2214

Estimate the value of $f(1.80)$ using newton's backward interpolation formula.

- (b) Evaluate $\int_0^1 e^{-x^2/2} dx$ using Simpson's one-third rule, dividing the interval $[0, 1]$ into 8 subintervals (7)

MODULE 5

19. (a) Using Gauss-Seidel method, solve the following system of equations (7)

$$\begin{aligned} 20x + y - 2z &= 17 \\ 3x + 20y - z &= -18 \\ 2x - 3y + 20z &= 25 \end{aligned}$$

- (b) The table below gives the estimated population of a country (in millions) for during 1980-1995 (7)

year	1980	1985	1990	1995
population	227	237	249	262

Plot a graph of this data and fit an appropriate curve to the data using the method of least squares. Hence predict the population for the year 2010.

OR

20. (a) Use Runge-Kutta method of fourth order to find $y(0.2)$ given the initial value problem (7)

$$\frac{dy}{dx} = \frac{xy}{1+x^2}, \quad y(0) = 1$$

Take step-size, $h = 0.1$.

- (b) Solve the initial value problem (7)

$$\frac{dy}{dx} = x + y, \quad y(0) = 0,$$

in the interval $0 \leq x \leq 1$, taking step-size $h = 0.2$. Calculate $y(0.2), y(0.4)$ and $y(0.6)$ using Runge-Kutta second order method, and $y(0.8)$ and $y(1.0)$ using Adam-Moulton predictor-corrector method.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MAT 206	GRAPH THEORY	BSC	3	1	0	4

Preamble: This course introduces fundamental concepts in Graph Theory, including properties and characterisation of graph/trees and graph theoretic algorithms, which are widely used in Mathematical modelling and has got applications across Computer Science and other branches in Engineering.

Prerequisite: The topics covered under the course Discrete Mathematical Structures (MAT 203)

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

CO 1	Explain vertices and their properties, types of paths, classification of graphs and trees & their properties. (Cognitive Knowledge Level: Understand)
CO 2	Demonstrate the fundamental theorems on Eulerian and Hamiltonian graphs. (Cognitive Knowledge Level: Understand)
CO 3	Illustrate the working of Prim's and Kruskal's algorithms for finding minimum cost spanning tree and Dijkstra's and Floyd-Warshall algorithms for finding shortest paths. (Cognitive Knowledge Level: Apply)
CO 4	Explain planar graphs, their properties and an application for planar graphs. (Cognitive Knowledge Level: Apply)
CO 5	Illustrate how one can represent a graph in a computer. (Cognitive Knowledge Level: Apply)
CO 6	Explain the Vertex Color problem in graphs and illustrate an example application for vertex coloring. (Cognitive Knowledge Level: Apply)

Mapping of course outcomes with program outcomes

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

Abstract POs defined by National Board of Accreditation			
PO#	Broad PO	PO#	Broad PO
PO1	Engineering Knowledge	PO7	Environment and Sustainability
PO2	Problem Analysis	PO8	Ethics
PO3	Design/Development of solutions	PO9	Individual and team work
PO4	Conduct investigations of complex problems	PO10	Communication
PO5	Modern tool usage	PO11	Project Management and Finance
PO6	The Engineer and Society	PO12	Life long learning

Assessment Pattern

Bloom's Category	Continuous Assessment Tests (%)		End Semester Examination (%)
	1	2	
Remember	30	30	30
Understand	30	30	30
Apply	40	40	40
Analyse			
Evaluate			
Create			

Mark Distribution

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

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Tests : 25 marks

Continuous Assessment Assignment : 15 marks

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks

First Internal Examination shall be preferably conducted after completing the first half of the syllabus and the Second Internal Examination shall be preferably conducted after completing remaining part of the syllabus.

There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly covered module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly covered module), each with 7 marks. Out of the 7 questions in Part B, a student should answer any 5.

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

Syllabus

Module 1

Introduction to Graphs : Introduction- Basic definition – Application of graphs – finite, infinite and bipartite graphs – Incidence and Degree – Isolated vertex, pendant vertex and Null graph. Paths and circuits – Isomorphism, sub graphs, walks, paths and circuits, connected graphs, disconnected graphs and components.

Module 2

Eulerian and Hamiltonian graphs : Euler graphs, Operations on graphs, Hamiltonian paths and circuits, Travelling salesman problem. Directed graphs – types of digraphs, Digraphs and binary relation, Directed paths, Fleury's algorithm.

Module 3

Trees and Graph Algorithms : Trees – properties, pendant vertex, Distance and centres in a tree - Rooted and binary trees, counting trees, spanning trees, Prim's algorithm and Kruskal's algorithm, Dijkstra's shortest path algorithm, Floyd-Warshall shortest path algorithm.

Module 4

Connectivity and Planar Graphs : Vertex Connectivity, Edge Connectivity, Cut set and Cut Vertices, Fundamental circuits, Planar graphs, Kuratowski's theorem (proof not required), Different representations of planar graphs, Euler's theorem, Geometric dual.

Module 5

Graph Representations and Vertex Colouring : Matrix representation of graphs- Adjacency matrix, Incidence Matrix, Circuit Matrix, Path Matrix. Coloring- Chromatic number, Chromatic polynomial, Matchings, Coverings, Four color problem and Five color problem. Greedy colouring algorithm.

Text book:

1. Narsingh Deo, Graph theory, PHI, 1979

Reference Books:

1. R. Diestel, *Graph Theory*, free online edition, 2016: diestel-graph-theory.com/basic.html.
2. Douglas B. West, *Introduction to Graph Theory*, Prentice Hall India Ltd., 2001
3. Robin J. Wilson, *Introduction to Graph Theory*, Longman Group Ltd., 2010
4. J.A. Bondy and U.S.R. Murty. *Graph theory with Applications*

Sample Course Level Assessment Questions.

Course Outcome 1 (CO1):

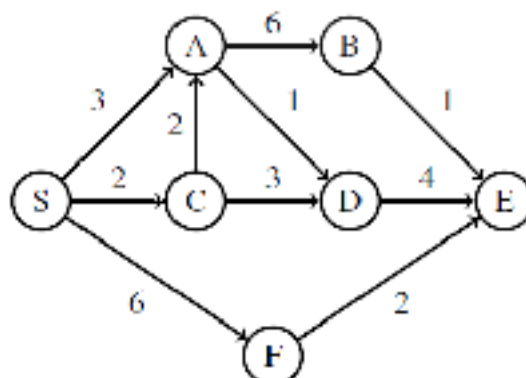
1. Differentiate a walk, path and circuit in a graph.
2. Is it possible to construct a graph with 12 vertices such that two of the vertices have degree 3 and the remaining vertices have degree 4? Justify
3. Prove that a simple graph with n vertices must be connected, if it has more than $\frac{(n-1)(n-2)}{2}$ edges.
4. Prove the statement: If a graph (connected or disconnected) has exactly two odd degree, then there must be a path joining these two vertices.

Course Outcome 2 (CO2):

1. Define Hamiltonian circuit and Euler graph. Give one example for each.
2. Define directed graphs. Differentiate between symmetric digraphs and asymmetric digraphs.
3. Prove that a connected graph G is an Euler graph if all vertices of G are of even degree.
4. Prove that a graph G of n vertices always has a Hamiltonian path if the sum of the degrees of every pair of vertices V_i, V_j in G satisfies the condition $d(V_i) + d(V_j) = n - 1$

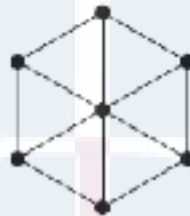
Course Outcome 3 (CO3):

1. Discuss the centre of a tree with suitable example.
2. Define binary tree. Then prove that number of pendant vertices in a binary tree is $\frac{(n+1)}{2}$
3. Prove that a tree with n vertices has $n - 1$ edges.
4. Explain Floyd Warshall algorithm.
5. Run Dijkstra's algorithm on the following directed graph, starting at vertex S .



Course Outcome 4 (CO4):

1. Define edge connectivity, vertex connectivity and separable graphs. Give an example for each.
2. Prove that a connected graph with n vertices and e edges has $e - n + 2$ faces.
3. Prove the statement: Every cut set in a connected graph G must also contain at least one branch of every spanning tree of G .
4. Draw the geometrical dual (G^*) of the graph given below, also check whether G and G^* are self-duals or not, substantiate your answer clearly.



Course Outcome 5 (CO5):

1. Show that if $A(G)$ is an incidence matrix of a connected graph G with n vertices, then rank of $A(G)$ is $n-1$.
2. Show that if B is a cycle matrix of a connected graph G with n vertices and m edges, then rank $B = m-n+1$.
3. Derive the relations between the reduced incidence matrix, the fundamental cycle matrix, and the fundamental cut-set matrix of a graph G .
4. Characterize simple, self-dual graphs in terms of their cycle and cut-set matrices.

Course Outcome 6 (CO6):

1. Show that an n vertex graph is a tree iff its chromatic polynomial is $P_n(\lambda) = \lambda(\lambda - 1)^{n-1}$
2. Prove the statement: "A covering g of a graph is minimal if g contains no path of length three or more."
3. Find the chromatic polynomial of the graph



Model Question paper

QP
Code :

Total Pages: 4

Reg No.: _____

Name: _____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
IV SEMESTER B.TECH DEGREE EXAMINATION, MONTH and YEAR

Course Code: MAT 206

Course Name: GRAPH THEORY

Max. Marks: 100

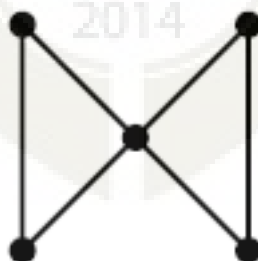
Duration: 3 Hours

PART A

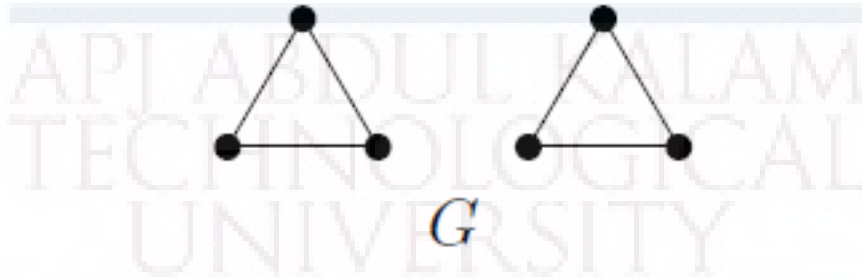
Answer all questions, each carries 3 marks.

Marks

- 1 Construct a simple graph of 12 vertices with two of them having degree 1, three having degree 3 and the remaining seven having degree 10. (3)
- 2 What is the largest number of vertices in a graph with 35 edges, if all vertices are of degree at least 3 ? (3)
- 3 Define a Euler graph. Give an example of Eulerian graph which is not Hamiltonian (3)
- 4 Give an example of a strongly connected simple digraph without a directed Hamiltonian path. (3)
- 5 What is the sum of the degrees of any tree of n vertices? (3)
- 6 How many spanning trees are there for the following graph (3)



- 7 Show that in a simple connected planar graph G having V -vertices, E -edges, (3)
and no triangles $E \leq 3V - 6$.
- 8 Let G be the following disconnected planar graph. Draw its dual G^* , and the (3)
dual of the dual $(G^*)^*$.



- 9 Consider the circuit matrix B and incidence matrix A of a simple connected (3)
graph whose columns are arranged using the same order of edges. Prove that
every row of B is orthogonal to every row of A ?
- 10 A graph is *critical* if the removal of any one of its vertices (and the edges (3)
adjacent to that vertex) results in a graph with a lower chromatic number.
Show that K_n is critical for all $n > 1$.

PART B

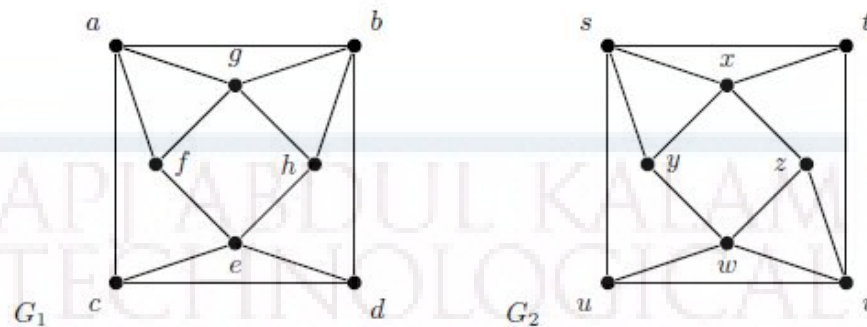
Answer any one Question from each module. Each question carries 14 Marks

- 11 a) Prove that for any simple graph with at least two vertices has two vertices of (6)
the same degree.
- b) Prove that in a complete graph with n vertices there are $(n-1)/2$ edge disjoint (8)
Hamiltonian circuits and $n \geq 3$

OR

2014

- 12 a) Determine whether the following graphs $G_1 = (V_1, E_1)$ and $G_2 = (V_2, E_2)$ are isomorphic or not. Give justification. (6)

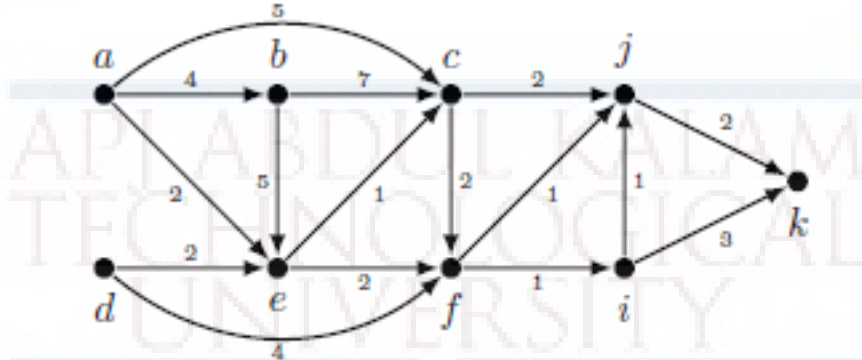


- b) Prove that a simple graph with n vertices and k components can have at most $(n-k)(n-k+1)/2$ edges (8)
- 13 a) Let S be a set of 5 elements. Construct a graph G whose vertices are subsets of S of size 2 and two such subsets are adjacent in G if they are disjoint. (8)
- Draw the graph G .
 - How many edges must be added to G in order for G to have a Hamiltonian cycle?
- b) Let G be a graph with exactly two connected components, both being Eulerian. What is the minimum number of edges that need to be added to G to obtain an Eulerian graph? (6)

OR

- 14 a) Show that a k -connected graph with no hamiltonian cycle has an independent set of size $k + 1$. (8)
- b) i. Let G be a graph that has exactly two connected components, both being Hamiltonian graphs. Find the minimum number of edges that one needs to add to G to obtain a Hamiltonian graph. (6)
- ii. For which values of n the graph Q_n (hyper-cube on n vertices) is Eulerian.
- 15 a) A tree T has at least one vertex v of degree 4, and at least one vertex w of degree 3. Prove that T has at least 5 leaves. (5)

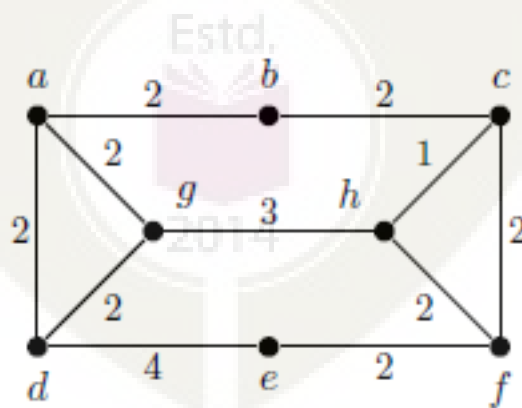
- b) Write Dijkstra's shortest path algorithm. (9)
 Consider the following weighted directed graph G .



Find the shortest path between a and every other vertices in G using Dijkstra's shortest path algorithm.

OR

- 16 a) Define pendent vertices in a binary tree? Prove that the number of pendent vertices in a binary tree with n vertices is $(n+1)/2$. (5)
- b) Write Prim's algorithm for finding minimum spanning tree. (9)
 Find a minimum spanning tree in the following weighted graph, using Prim's algorithm.

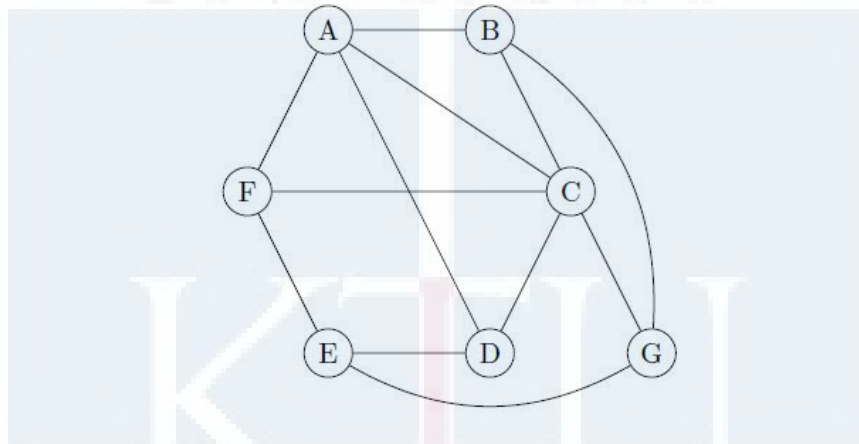


Determine the number of minimum spanning trees for the given graph.

- 17 a) i. State and prove Euler's Theorem relating the number of faces, edges and vertices for a planar graph. (9)
- ii. If G is a 5-regular simple graph and $|V| = 10$, prove that G is non-planar.
- b) Let G be a connected graph and e an edge of G . Show that e is a cut-edge if and only if e belongs to every spanning tree. (5)

OR

- 18 a) State Kuratowski's theorem, and use it to show that the graph G below is not planar. Draw G on the plane without edges crossing. Your drawing should use the labelling of the vertices given. (9)



- b) Let G be a connected graph and e an edge of G . Show that e belongs to a loop if and only if e belongs to no spanning tree. (5)
- 19 a) Define the circuit matrix $B(G)$ of a connected graph G with n vertices and e edges with an example. Prove that the rank of $B(G)$ is $e-n+1$ (7)
- b) Give the definition of the chromatic polynomial $P_G(k)$. Directly from the definition, prove that the chromatic polynomials of W_n and C_n satisfy the identity $P_{W_n}(k) = k P_{C_{n-1}}(k-1)$. (7)

OR

- 20 a) Define the incidence matrix of a graph G with an example. Prove that the rank of an incidence matrix of a connected graph with n vertices is $n-1$. (4)

- b) i. A graph G has chromatic polynomial $P_G(k) = k^4 - 4k^3 + 5k^2 - 2k$. How many vertices and edges does G have? Is G bipartite? Justify your answers.
- ii. Find a maximum matching in the graph below and use Hall's theorem to show that it is indeed maximum.



(10)

Assignments

Assignment must include applications of the above theory in Computer Science.

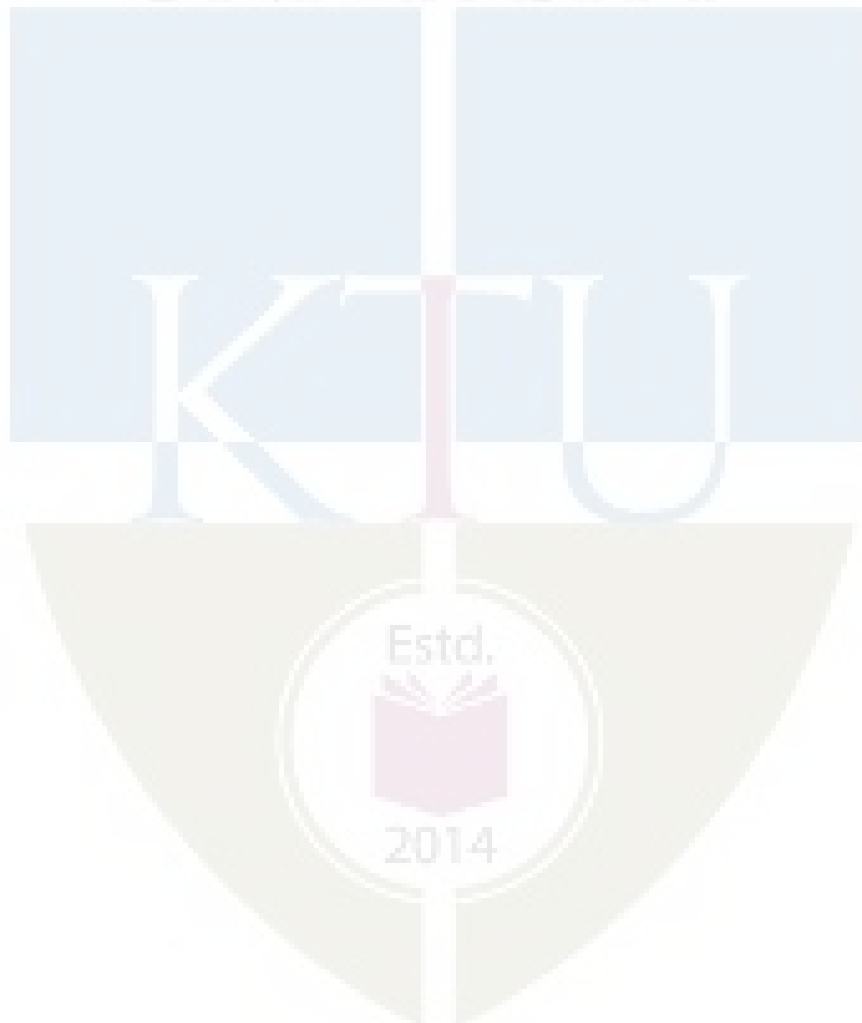


Teaching Plan		
No	Topic	No. of Lectures
1	Module-I (Introduction to Graphs)	(8)
1.	Introduction- Basic definition – Application of graphs – finite and infinite graphs, bipartite graphs,	1
2.	Incidence and Degree – Isolated vertex, pendent vertex and Null graph	1
3.	Paths and circuits	1
4.	Isomorphism	1
5.	Sub graphs, walks	1
6.	Paths and circuits	1
7.	Connected graphs.	1
8.	Disconnected graphs and components	1
2	Module-II (Eulerian and Hamiltonian graphs)	(8)
1.	Euler graphs	1
2.	Operations on graphs	1
3.	Hamiltonian paths and circuits	1
4.	Hamiltonian paths circuits	1
5.	Travelling salesman problem	1
6.	Directed graphs – types of digraphs,	1
7.	Digraphs and binary relation, Directed paths	1
8.	Fleury's algorithm	1
3	Module-III (Trees and Graph Algorithms)	(11)
1.	Trees – properties	1
2.	Trees – properties	1
3.	Trees – properties, pendent vertex	1
4.	Distance and centres in a tree	1

5.	Rooted and binary tree	1
6.	Counting trees	1
7.	Spanning trees, Fundamental circuits	1
8.	Prim's algorithm	1
9.	Kruskal's algorithm	1
10.	Dijkstra's shortest path algorithm	1
11.	Floyd-Warshall shortest path algorithm	1
4	Module-IV (Connectivity and Planar Graphs)	(9)
1.	Vertex Connectivity, Edge Connectivity	1
2.	Cut set and Cut Vertices	1
3.	Fundamental circuits	1
4.	Fundamental circuits	1
5.	Planar graphs	1
6.	Kuratowski's theorem	1
7.	Different representations of planar graphs	1
8.	Euler's theorem	1
9.	Geometric dual	1
5	Module-V (Graph Representations and Vertex Colouring)	(9)
1.	Matrix representation of graphs- Adjacency matrix, Incidence Matrix	1
2.	Circuit Matrix, Path Matrix	1
3.	Colouring- chromatic number,	1
4.	Chromatic polynomial	1
5.	Matching	1
6.	Covering	1
7.	Four colour problem and five colour problem	1

8.	Four colour problem and five colour problem	1
9.	Greedy colouring algorithm.	1

APJ ABDUL KALAM
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MATHEMATICS – (4th semester)

(For Information Technology)

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MAT 208	PROBABILITY,STATISTICS AND ADVANCED GRAPH THEORY	BASIC SCIENCE COURSE	3	1	0	4

Preamble: This course introduces students to the modern theory of probability and statistics, covering important models of random variables and techniques of parameter estimation and hypothesis testing. This course introduce fundamental concepts in Graph Theory, including properties and characterisation of Graph/Trees and Graph theoretic algorithms, which are widely used in Mathematical modelling and has got applications across **Information Technology**

Prerequisite: A basic course in one-variable and multi-variable calculus, knowledge of elementary set theory, matrices

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

CO 1	Understand the concept, properties and important models of discrete random variables and, using them, analyse suitable random phenomena.
CO 2	Understand the concept, properties and important models of continuous random variables and, using them, analyse suitable random phenomena.
CO 3	Perform statistical inferences concerning characteristics of a population based on attributes of samples drawn from the population
CO 4	Understand the basic concept in Graph theory, Understand planar graphs and it's properties. Demonstrate the knowledge of fundamental concepts of matrix representation of graphs, Apply fundamental theorems on Eulerian graphs and Hamiltonian graphs.
CO 5	Understand the basic concept in Trees,coloring of graphs. Apply coloring of graphs, Apply algorithm to find the minimum spanning tree

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests(%)		End Semester Examination(%)
	1	2	
Remember	10	10	10
Understand	30	30	30
Apply	30	30	30
Analyse	20	20	20
Evaluate	10	10	10
Create			

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

Course Level Assessment Questions**Course Outcome 1 (CO1):**

1. Let X denote the number that shows up when an unfair die is tossed. Faces 1 to 5 of the die are equally likely, while face 6 is twice as likely as any other. Find the probability distribution, mean and variance of X .
2. An equipment consists of 5 components each of which may fail independently with probability 0.15. If the equipment is able to function properly when at least 3 of the components are operational, what is the probability that it functions properly?
3. X is a binomial random variable $B(n, p)$ with $n = 100$ and $p = 0.1$. How would you approximate it by a Poisson random variable?
4. Three balls are drawn at random without replacement from a box containing 2 white, 3 red and 4 black balls. If X denotes the number of white balls drawn and Y denotes the number of red balls drawn, find the joint probability distribution of (X, Y)

Course Outcome 2 (CO2)

1. What can you say about $P(X = a)$ for any real number a when X is a (i) discrete random variable? (ii) continuous random variable?
2. A string, 1 meter long, is cut into two pieces at a random point between its ends. What is the probability that the length of one piece is at least twice the length of the other?

3. A random variable has a normal distribution with standard deviation 10. If the probability that it will take on a value less than 82.5 is 0.82, what is the probability that it will take on a value more than 58.3?
4. X and Y are independent random variables with X following an exponential distribution with parameter μ and Y following an exponential distribution with parameter λ . Find $P(X + Y \leq 1)$

Course Outcome 3(CO3):

1. In a random sample of 500 people selected from the population of a city 60 were found to be left-handed. Find a 95% confidence interval for the proportion of left-handed people in the city population.
2. What are the types of errors involved in statistical hypothesis testing? Explain the level of risks associated with each type of error.
3. A soft drink maker claims that a majority of adults prefer its leading beverage over that of its main competitor's. To test this claim 500 randomly selected people were given the two beverages in random order to taste. Among them, 270 preferred the soft drink maker's brand, 211 preferred the competitor's brand, and 19 could not make up their minds. Determine whether there is sufficient evidence, at the 5% level of significance, to support the soft drink maker's claim against the default that the population is evenly split in its preference.
4. A nutritionist is interested in whether two proposed diets, *diet A* and *diet B* work equally well in providing weight-loss for customers. In order to assess a difference between the two diets, she puts 50 customers on diet A and 60 other customers on diet B for two weeks. Those on the former had weight losses with an average of 11 pounds and a standard deviation of 3 pounds, while those on the latter lost an average of 8 pounds with a standard deviation of 2 pounds. Do the diets differ in terms of their weight loss?

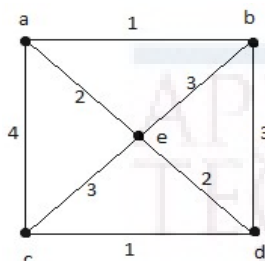
Course Outcome 4(CO4):

1. How many edges are there in a graph with ten vertices each of degree six?
2. Prove that a simple graph with n vertices must be connected, if it has more than $\frac{(n-1)(n-2)}{2}$ edges
3. Prove that a connected graph G is an Euler graph if all vertices of G are of even degree.
4. Use Kuratowski's theorem to determine whether $K_{4,4}$ is planar.

Course Outcome 5 (CO5):

1. Prove that a tree with n vertices has $n - 1$ edges.
2. Find the chromatic number of $K_{m,n}$

3. Using graph model, how can the final exam at a university be scheduled so that no student has two exams at the same time?
4. Explain Prim's algorithm and use it to find the minimum spanning tree for the graph given below



Syllabus

Module 1 (Discrete probability distributions)

9 hours

(Text-1: *Relevant topics* from sections-3.1-3.4, 3.6, 5.1)

Discrete random variables and their probability distributions, Expectation, mean and variance, Binomial distribution, Poisson distribution, Poisson approximation to the binomial distribution, Discrete bivariate distributions, marginal distributions, Independent random variables, Expectation -multiple random variables.

Module 2 (Continuous probability distributions)

9 hours

(Text-1: *Relevant topics* from sections-4.1-4.4, 3.6, 5.1)

Continuous random variables and their probability distributions, Expectation, mean and variance, Uniform, exponential and normal distributions, Continuous bivariate distributions, marginal distributions, Independent random variables, Expectation-multiple random variables, i.i.d random variables and Central limit theorem (**without proof**).

Module 3 (Statistical inference)

9 hours

(Text-1: *Relevant topics* from sections-5.4, 3.6, 5.1, 7.2, 8.1, 8.3, 9.1-9.2, 9.4)

Population and samples, Sampling distribution of the mean and proportion (for large samples only), Confidence interval for single mean and single proportions (for large samples only). Test of hypotheses: Large sample test for single mean and single proportion, equality of means and equality of proportions of two populations, small sample t-tests for single mean of normal population, equality of means (**only pooled t-test, for independent samples from two normal populations with equal variance**)

Module 4 (Advanced Graph theory -I)

9 hours

(Text-2: *Relevant topics* of sections -10.1, 10.2, 10.3, 10.4, 10.5, 10.7)

Introduction- Basic definitions, Directed graphs, pseudo graph, multigraph, Graph models, Graph terminology-vertex degree, simple graph, Complete graphs, cycles, bipartite graph,

new graphs from old-union, complement, Representing graph-Adjacency matrix, Incidence Matrix , Isomorphism, Connectivity, path , cut vertices , cut edges ,connectedness in directed and undirected graphs, Counting paths between vertices-Euler paths and circuits , Fleury's algorithm(**proof of algorithm omitted**) , Hamiltonian paths and circuits. Ore's theorem, Planar graph, -Euler's formula on planar graphs, Kuratowski's theorem (**Proof of theorem omitted**)

Module 5 (Advanced Graph theory -II) (9 hours)

(Text-2: Relevant topics of sections –(10.8,11.1, 11.4, 11.5)

Graph colouring, dual graph, chromatic number, chromatic number of complete graph K_n , chromatic number of complete bipartite graph $K_{m,n}$, chromatic number of cycle C_n , Four color theorem, applications of graph colouring-scheduling and assignments

Trees-rooted trees, Properties of trees-level, height, balanced rooted tree, Spanning tree- basic theorems on spanning tree (**DFS, BFS algorithms and it's applications omitted**), Minimum spanning tree, Prim's algorithm and Kruskal's algorithm(**proofs of algorithms omitted**)

(9 hours)

Text Books

1. (Text-1) Jay L. Devore, *Probability and Statistics for Engineering and the Sciences*, 8th edition, Cengage, 2012
2. (Text-2) Kenneth H Rosen, *Discrete Mathematics and it's applications*, Tata Mc Graw Hill, 8th Edition,

Reference Books

1. Hossein Pishro-Nik, *Introduction to Probability, Statistics and Random Processes*, Kappa Research, 2014 (Also available online at www.probabilitycourse.com)
2. Sheldon M. Ross, *Introduction to probability and statistics for engineers and scientists*, 4th edition, Elsevier, 2009.
3. T.Veera Rajan, *Probability, Statistics and Random processes*, Tata McGraw-Hill, 2008
4. Ralph P Grimaldi, *Discrete and Combinatorial Mathematics, An applied Introduction*, 4th edition, Pearson
5. C L Liu, *Elements of Discrete Mathematics*, Tata McGraw Hill, 4th edition,2017
6. NarasinghDeo, *Graph theory*, PHI, 1979
7. John Clark , Derek Allan Holton, *A first look at Graph Theory*.

Assignments

Assignments should include specific problems highlighting the applications of the methods introduced in this course in physical sciences and engineering.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	Discrete Probability distributions	9 hours
1.1	Discrete random variables and probability distributions, expected value, mean and variance (discrete)	3
1.2	Binomial distribution-mean, variance, Poisson distribution-mean, variance, Poisson approximation to binomial	3
1.3	Discrete bivariate distributions, marginal distributions, Independence of random variables (discrete), Expected values	3
2	Continuous Probability distributions	9 hours
2.1	Continuous random variables and probability distributions, expected value, mean and variance (continuous)	2
2.2	Uniform, exponential and normal distributions, mean and variance of these distributions	4
2.3	Continuous bivariate distributions, marginal distributions, Independent random variables, Expected values, Central limit theorem.	3
3	Statistical inference	9 hours
3.1	Population and samples, Sampling distribution of single mean and single proportion(large samples)	1
3.2	Confidence interval for single mean and single proportions (large samples)	2
3.3	Hypothesis testing basics, large sample test for single mean, single proportion	2
3.4	Large sample test for equality of means and equality of proportions of two populations	2
3.5	t-distribution and small sample t-test for single mean and pooled t-test for equality of means	2
4	Advanced Graph Theory -I	9 hours
4.1	Introduction- Basic definition – Application of graphs Incidence	1

	and Degree – Isolated vertex, pendent vertex and Null graph	
4.2	Theorems connecting vertex degree and edges, bipartite graphs.	1
4.3	Adjacency matrix, incidence matrix, Isomorphism	1
4.4	Path, cut set, cut edges, Connectedness of directed and undirected graphs ,path isomorphism	2
4.5	Euler paths and circuits , Fleury’s algorithm(proof of algorithm omitted) , Hamiltonian paths and circuits. Ore’s theorem(proof omitted)	3
4.6	Planar graph, - Euler’s theorem on planar graph , applications of Kuratowski’s theorem	1
5	Advanced Graph Theory -II	9 hours
5.1	Graph colouring, dual graph	1
5.2	Chromatic number, chromatic number of $K_n, K_{m,n}, C_n$,	2
5.3	Four colour theorem, applications of graph colouring-scheduling and assignments,	2
5.4	Trees-spanning trees-definition and example, minimum spanning tree,	2
5.5	Prim’s algorithm and Kruskal’s algorithm(proofs of algorithms omitted)	2



MODEL QUESTION PAPER (2019 Scheme)

Reg. No: Total Pages: 4

Name :

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FOURTH SEMESTER B.TECH DEGREE EXAMINATION (Month & year)

Course Code: MAT208

Course Name: PROBABILITY, STATISTICS AND ADVANCED GRAPH THEORY

(For Information Technology)

Max Marks:100Duration : 3 Hours

PART A (Answer all questions. Each question carries 3 marks)

1. Suppose X is a Poisson random variable find $P(X = 1) = P(X = 2)$. Find the mean and variance. (3)
2. The diameter of a circular metallic discs produced by a machine is a random variable with mean 6cm and variance 2cm. Find the mean area of the discs. (3)
3. If the cumulative distribution of a continuous random variable is given by

$$F(x) = \begin{cases} 0 & x \leq 1 \\ 0.5 & 1 < x < 3, \\ 1 & x \geq 3 \end{cases}$$

find $P(X \leq 2)$ (3)

4. The random variable X is exponentially distributed with mean 3. Find $P(X > t + 3 | X > t)$ where t is any positive real number. (3)
5. The 95% confidence interval for the mean mass (in grams) of tablets produced by a machine is $[0.56, 0.57]$, as calculated from a random sample of 50 tablets. What do you understand from this statement? (3)
6. The mean volume of liquid in bottles of lemonade should be at least 2 litres. A sample of bottles is taken in order to test whether the mean volume has fallen below 2 litres. Give a null and alternate hypothesis for this test and specify whether the test would be one-tailed or two-tailed. (3)
7. Draw the graph represented by the following adjacency matrix

$$\begin{bmatrix} 1 & 2 & 1 \\ 2 & 0 & 0 \\ 0 & 2 & 2 \end{bmatrix} \quad (3)$$

8. Give an example of a graph which has a circuit that is (i) Eulerian but not Hamiltonian (ii) Hamiltonian but not Eulerian (iii) neither Eulerian nor Hamiltonian (3)
9. Find the value of $\chi^2(K_3)$ (3)

10. How many non isomorphic spanning tree does K_3 have ?. Justify your answer
(3)

PART B (Answer one question from each module)

MODULE 1

11. (a) Verify that $p(x) = \left(\frac{8}{7}\right)\left(\frac{1}{2}\right)^x$, $x = 1, 2, 3$ is a probability distribution. Find (i) $P(X \leq 2)$ (ii) $E[X]$ and (iii) $var(X)$. (7)
- (b) Find the mean and variance of a binomial random variable (7)

OR

12. (a) Accidents occur at an intersection at a Poisson rate of 2 per day. What is the probability that there would be no accidents on a given day? What is the probability that in January there are at least 3 days (not necessarily consecutive) without any accidents?
(7)
- (b) Two fair dice are rolled. Let X denote the number on the first die and $Y = 0$ or 1 , according as the first die shows an even number or odd number. Find (i) the joint probability distribution of X and Y , (ii) the marginal distributions. (iii) Are X and Y independent?
(7)

MODULE 2

13. (a) The IQ of an individual randomly selected from a population is a normal distribution with mean 100 and standard deviation 15. Find the probability that an individual has IQ (i) above 140 (ii) between 120 and 130. (7)
- (b) A continuous random variable X is uniformly distributed with mean 1 and variance $4/3$. Find $P(X < 0)$ (7)

OR

14. (a) Determine the value of c so that $f(x, y) = cxy$ for $0 < x < 3$, $0 < y < 3$ and $f(x, y) = 0$ otherwise satisfies the properties of a joint density function of random variables X and Y . Also find $P(X + Y \leq 1)$. Are X and Y independent? Justify your answer
(7)
- (b) The lifetime of a certain type of electric bulb may be considered as an exponential random variable with mean 50 hours. Using central limit theorem, find the approximate probability that 100 of these electric bulbs will provide a total of more than 6000 hours of burning time. (7)

MODULE 3

15. (a) The mean blood pressure of 100 randomly selected persons from a target population is 127.3 units. Find a 95% confidence interval for the mean blood pressure of the population.
(7)

(b) The CEO of a large electric utility claims that 80 percent of his 1,000,000 customers are very satisfied with the service they receive. To test this claim, the local newspaper surveyed 100 customers, using simple random sampling. Among the sampled customers, 73 percent say they are very satisfied. Based on these findings, do you think that the CEO is making a false claim of high satisfaction levels among his customers? Use a 0.05 level of significance. (7)

OR

16. (a) A magazine reported the results of a telephone poll of 800 adult citizens of a country. The question posed was: "Should the tax on cigarettes be raised to pay for health care reform?" The results of the survey were: Out of the 800 persons surveyed, 605 were non-smokers out of which 351 answered "yes" and the rest "no". Out of the remaining 195, who were smokers, 41 answered "yes" and the remaining "no". Is there sufficient evidence, at the 0.05 significance level, to conclude that the two populations smokers and non-smokers differ significantly with respect to their opinions? (7)

(b) Two types of cars are compared for acceleration rate. 40 test runs are recorded for each car and the results for the mean elapsed time recorded below:

	Sample mean	Sample Standard Deviation
Car A	7.4	1.5
Car B	7.1	1.8

Determine if there is a difference in the mean elapsed times of the two car models at 95% confidence level. (7)

MODULE 4

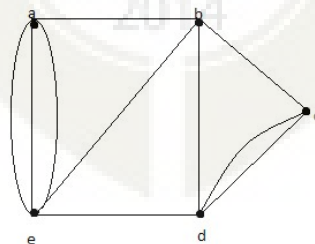
17. (a) Prove that an undirected graph has an even number of odd degree vertices (7)

(b) Show that a bipartite graph with an odd number of vertices does not have a Hamilton circuit (7)

OR

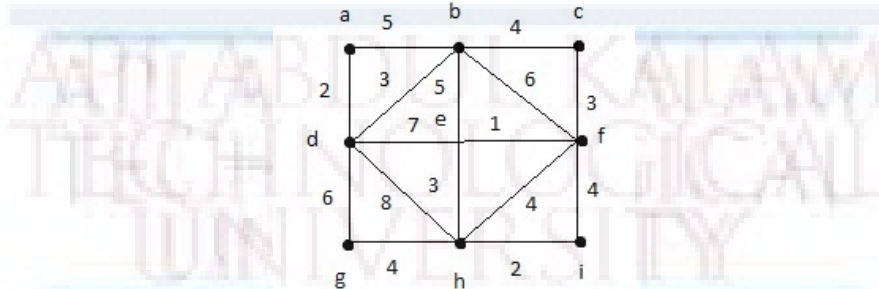
18. (a) Show that an edge in a simple graph is a cut edge if and only if this edge is not part of any simple circuit in the graph. (7)

(b) Use Fleury's algorithm to find an Euler circuit in the following graph (7)



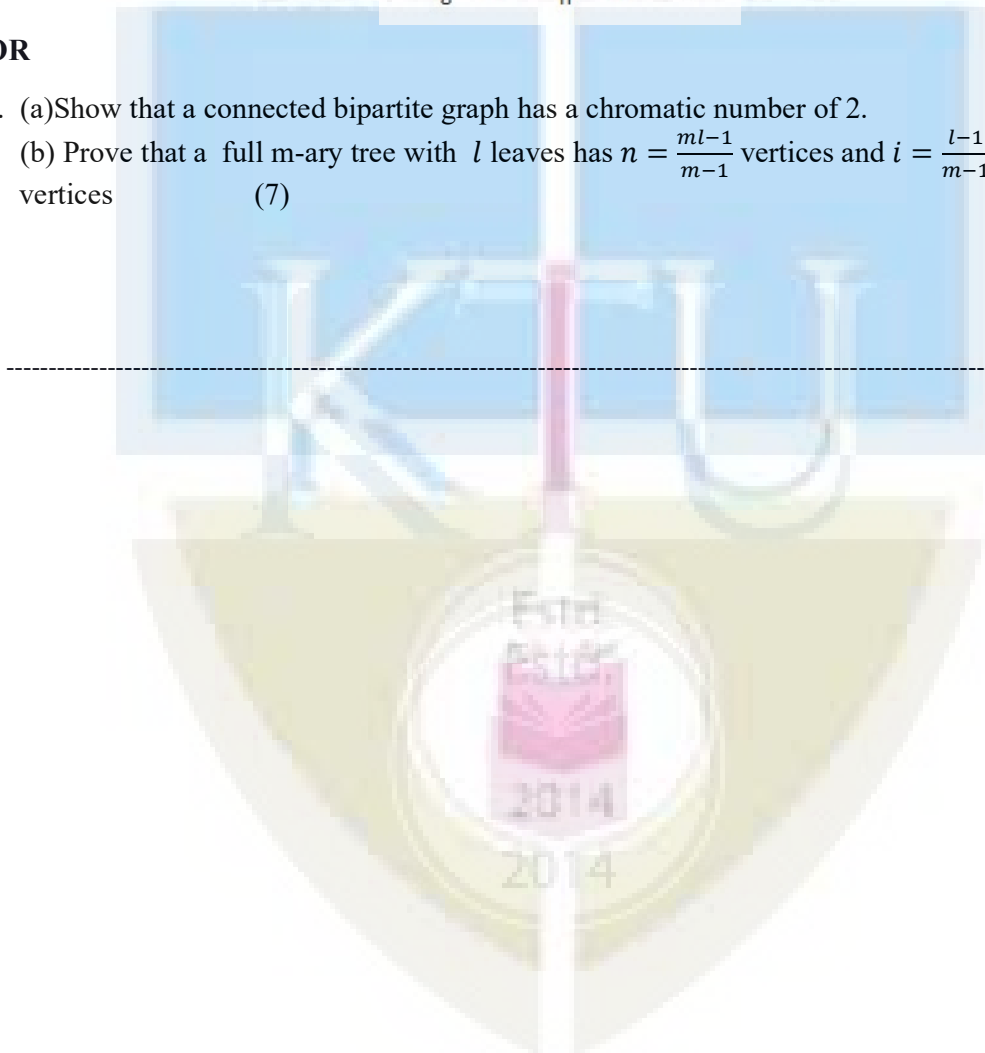
MODULE 5

19. (a) Prove that a simple graph is a tree if and only if it is connected, but the deletion of any of its edges produces a graph that is not connected (7)
 (b) Find the minimal spanning tree for the following graph by Prim's algorithm (7)



OR

20. (a) Show that a connected bipartite graph has a chromatic number of 2. (7)
 (b) Prove that a full m -ary tree with l leaves has $n = \frac{ml-1}{m-1}$ vertices and $i = \frac{l-1}{m-1}$ internal vertices (7)



MAT 212	INTRODUCTION TO STOCHASTIC MODELS	CATEGORY	L	T	P	CREDIT
		BASIC SCIENCE COURSE	3	1	0	4

Preamble: This course introduces students to the modern theory of probability and its applications to modelling and analysis of stochastic systems, covering important models of random variables stochastic processes. These stochastic models have important applications in engineering and are indispensable tools in reliability theory, queueing theory and decision analysis.

Prerequisite: A basic course in one-variable and multi-variable calculus.

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

CO 1	Develop techniques to compute probabilities of discrete distributions and selectively apply them to solve real world problems
CO 2	Develop techniques to compute probabilities of continuous distributions and selectively apply them to solve real world problems
CO 3	Analyse joint distributions, correlations and collective behaviour of multiple random variables.
CO 4	Explore stochastic phenomena using appropriate tools and models like Poisson processes
CO 5	Develop Markov chain models of selected real world phenomena and analyse them using appropriate tools

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests (%)		End Semester Examination (%)
	1	2	
Remember	10	10	10
Understand	35	35	35
Apply	35	35	35
Analyse	10	10	10
Evaluate	10	10	10
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Let X denote the number that shows up when an unfair die is tossed. Faces 1 to 5 of the die are equally likely, while face 6 is twice as likely as any other. Find the probability distribution, mean and variance of X .
2. An equipment consists of 5 componets each of which may fail independently with probability 0.15. If the equipment is able to function properly when at least 3 of the componets are operational, what is the probability that it functions properly~?
3. X is a binomial random variable $B(n, p)$ with $n = 100$ and $p = 0.1$. How would you approximate it by a Poisson random variable?
4. Fit a Poisson distribution to the following data which gives the number of days (f) on which x number of accidents have occured in an accident-prone highway for a stretch of 500 days. Fit a Poisson distribution to the data and calculate the theoretical frequencies.

x	0	1	2	3	4	5	6	7	8
f	56	156	132	92	37	22	4	0	1

Course Outcome 2 (CO2)

1. What can you say about $P(X=a)P(X = a)$ for any real number a when X is a (i) discrete random variable? (ii) continuous random variable?
2. A string, 1 meter long, is cut into two pieces at a random point between its ends. What is the probability that the length of one piece is at least twice the length of the other?
3. A random variable has a normal distribution with standard deviation 10. If the probability that it will take on a value less than 82.5 is 0.82, what is the probability that it will take on a value more than 58.3?
4. State and prove the memoryless property of exponential random variable.

Course Outcome 3(CO3):

1. Three balls are drawn at random without replacement from a box containing 2 white, 3 red and 4 black balls. If X denotes the number of white balls drawn and Y denotes the number of red balls drawn, find the joint probability distribution of (X,Y)
2. X and Y are independent random variables with X following an exponential distribution with parameter μ and Y following an exponential distribution with parameter λ . Find $P(X + Y \leq 1)$
3. Random variables X and Y are independent with X uniformly distributed in $(-2,2)$ and Y uniformly distributed in $(-1,1)$. If $U = X + Y$ and $V = X - Y$ find $\text{cov}(X,Y)$.
4. A communication channel is designed to transmit a sequence of signals. But due to noise in the transmission system each signal has a probability 0.02 of being received in error. If 1000 signals are transmitted, find using Central Limit Theorem the probability that at least 800 of them are received without error.

Course Outcome 4(CO4):

1. A random experiment consists of observing a busy traffic intersection continuously for one hour and counting the number of cars crossing the intersection from the start of the hour upto the current time. Classify this process and plot a possible sample function (realisation) of this process.
2. A random process $X(t)$ is defined by $a \cos(\omega t + \theta)$ where a and ω are constants and θ is uniformly distributed in $[0,2\pi]$. Show that $X(t)$ is WSS
3. Find the mean, variance and total power of the WSS random process $X(t)$, given the autocorrelation function $R_X(\tau) = 9e^{-|\tau|}$
4. A conversation in a wireless ad-hoc network is severely disturbed by interference signals according to a Poisson process of rate $\lambda = 0.01$ per minute. (a) What is the

probability that no interference signals occur within the first two minutes of the conversation? (b) Given that the first two minutes are free of disturbing effects, what is the probability that in the next minute precisely 1 interfering signal disturbs the conversation? (c) Given that there was only 1 interfering signal in the first 3 minutes, what is the probability that there would be at most 2 disturbances in the first 4 minutes?

Course Outcome 5 (CO5):

1. Consider the experiment of sending a sequence of messages across a communication channel. Due to noise, there is a small probability p that the message may be received in error. Let X_n denote the number of messages received correctly up to and including the n -th transmission. Show that X_n is a homogeneous Markov chain. What are the transition probabilities?
2. A survey conducted among consumers of two brands (A and B) of toothpastes revealed the following data; given that a person last purchased brand A, there is a 90% chance that her next purchase will be again brand A and given that a person last purchased brand B, there is an 80% chance that her next purchase will be again brand B. (i) If a person is currently a brand B purchaser, what is the probability that she will purchase brand A two purchases from now? (ii) What fraction of the consumers surveyed purchase brand A? Brand B? (iii) It is estimated that a total of 1.2 crores of tooth paste units (of brand A and B combined) are purchased every year. On selling one unit of brand A tooth paste, the company earns a profit of Rs.2. For Rs.10 lakhs, an advertising firm guarantees to decrease from 10% to 5% the fraction of brand A customers who switch to brand B after a purchase. Should the company that makes brand A hire the advertising firm?
3. If P is the transition probability matrix of an ergodic chain, what happens to P^n as $n \rightarrow \infty$?
4. Give an example of transition probability matrix of a Markov chain in which all states are periodic of period 3.

Syllabus

Module 1 (Discrete probability distributions)

Discrete random variables and their probability distributions, Expectation, mean and variance, Binomial distribution, Poisson distribution, Poisson approximation to the binomial distribution, Geometric distribution, Fitting binomial and Poisson distributions.

Module 2 (Continuous probability distributions)

Continuous random variables and their probability distributions, Expectation, mean and variance, Uniform distribution-mean variance, exponential distribution-mean, variance, memory less property, Normal distribution-mean, variance, use of normal tables.

Module 3 (Joint distributions)

Joint distributions- discrete and continuous, marginal distributions, expectations involving multiple random variables, independence, correlations and covariance involving pairs of random variables, central limit theorem.

Module 4 (Stochastic processes)

Stochastic processes-definition and classification, mean, autocorrelation, cross correlations, wide sense stationary processes, Poisson process-distribution of inter-arrival times, splitting and merging properties.

Module 5 (Markov chains)

Discrete time Markov chain, transition probability matrix, Chapman-Kolmogorov theorem (without proof), Computation of transient probabilities, classification of states of finite-state chains,-irreducible and ergodic chains, steady-state probability distribution,

Text Books

1. SaeedGhahramani, Fundamentals of probability with stochastic processes, Pearson Education, Third edition, 2012
2. HosseinPishro-Nik, "Introduction to Probability, Statistics and Random Processes", Kappa Research, 2014 (Also available online at www.probabilitycourse.com)

Reference Books

1. Sheldon M Ross, "Introduction to probability models", Elsevier.
2. Geoffrey R. Grimmett and David R. Stirzaker, "Probability and random processes", Oxford University Press
3. Oliver C. Ibe, "Fundamentals of Applied Probability and Random Processes", Elsevier, 2005.
4. Sundarapandian, "Probability, Statistics and Queuing Theory", Prentice-Hall Of India.

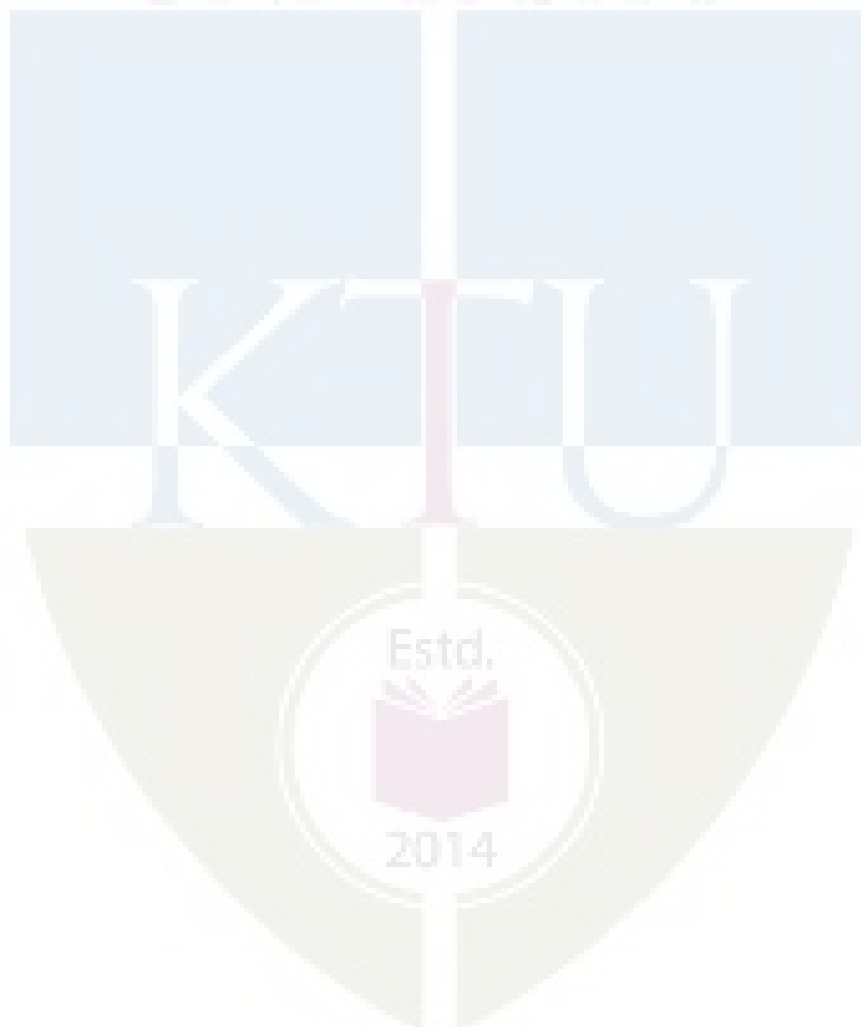
Assignments

Assignments should include specific problems highlighting the applications of the methods introduced in this course in physical sciences and engineering.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	Discrete Probability distributions	
1.1	Discrete random variables and probability distributions, expected value, mean and variance (discrete)	3
1.2	Binomial distribution-mean, variance, Poisson distribution-mean, variance, Poisson approximation to binomial	3
1.3	Geometric distribution, distribution fitting	3
2	Continuous Probability distributions	
2.1	Continuous random variables and probability distributions, expected value, mean and variance (continuous)	3
2.2	Uniform distribution, exponential distribution, and normal distributions, mean and variance of these distributions, other properties	4
2.3	Normal distribution-mean, variance, use of normal tables	2
3	Joint distributions	
3.1	Discrete joint distributions, computation of probability, marginal distributions	2
3.2	Continuous joint distributions, computation of probability, marginal distributions	2
3.3	Independence of random variables, expectation involving more than one random variable	2
3.4	correlations and covariance involving pairs of random variables, central limit theorem	3
4	Stochastic processes	
4.1	Stochastic processes-definition and classification, mean, autocorrelation, cross correlations	3
4.2	wide sense stationary processes, properties	2
4.3	Poisson process, distribution of inter-arrival times	2

4.3	Splitting and merging of Poisson processes	2
5	Discrete time Markov chains	
5.1	Discrete time Markov chain, transition probability matrix, Chapman-Kolmogorov theorem	3
5.2	Computation of transient probabilities	2
5.3	classification of states of finite-state chains,-irreducible and ergodic chains	2
5.4	Steady state probability distribution of ergodic chains	2



APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
MODEL QUESTION PAPER

FOURTH SEMESTER B.TECH DEGREE EXAMINATION
(Industrial Engineering)

INTRODUCTION TO STOCHASTIC MODELS

Max Marks :100

Duration : 3 Hours

PART A

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

1. Suppose X is binomial random variable with parameters $n = 100$ and $p = 0.02$. Find $P(X < 3)$ using Poisson approximation to X . (3)
2. The diameter of circular metallic discs produced by a machine is a random variable with mean 6cm and variance 2cm. Find the mean area of the discs. (3)
3. Find the mean and variance of the continuous random variable X with probability density function (3)

$$f(x) = \begin{cases} 2x - 4, & 2 \leq x \leq 3 \\ 0 & \text{otherwise} \end{cases}$$
4. The random variable X is exponentially distributed with mean 3. Find $P(X > t + 3 | X > t)$ where t is any positive real number. (3)
5. Let X denote the height (in inches) and Y denote the weight (in pounds) of a randomly chosen individual. If the units of X and Y are changed to centimeters and kilograms respectively, how would it affect $\text{cov}(X, Y)$ and the correlation coefficient $\rho(X, Y)$? (3)
6. State giving reasons whether the relation $\text{var}(X + Y) = \text{var}(X) + \text{var}(Y)$ is true for random variables X and Y . (3)
7. Give an example of a continuous time discrete state random process, with non-constant mean function. (3)
8. $N(t)$ is a Poisson process with $P[N(2) = 0] = 0.1353$. Find $P[N(4) = 0]$ (3)
9. Consider the experiment of sending a sequence of messages across a communication channel. Due to noise, there is a small probability p that the message may be received in error. Let X_n denote the number of messages received correctly upto and including the n -th transmission. Is X_n a Markov chain? Justify. (3)
10. The transition probability matrix of a Markov chain is $P = \begin{pmatrix} 0.3 & 0.7 \\ 0.4 & 0.6 \end{pmatrix}$. Find $P(X_3 = 2 | X_1 = 1)$. (3)

PART B

(Answer one question from each module)

MODULE 1

11. (a) The probability mass function of a discrete random variable is $p(x) = kx$, $x = 1, 2, 3$ where k is a positive constant. Find (i) the value of k (ii) $P(X \leq 2)$ (iii) $E[X]$ and (iv) $\text{var}(1 - X)$. (7)
- (b) Find the mean and variance of a binomial random variable (7)

OR

12. (a) Accidents occur at an intersection at a Poisson rate of 2 per day. what is the probability that there would be no accidents on a given day? What is the probability that in January there are at least 3 days (not necessarily consecutive) without any accidents? (7)
- (b) A safety engineer feels that 35% of all industrial accidents in her plant are caused by failure of employees to follow instructions. She decides to look at the accident reports (selected randomly and replaced in the pile after reading) until she finds one that shows an accident caused by failure of employees to follow instructions. On average, how many reports would the safety engineer expect to look at until she finds a report showing an accident caused by employee failure to follow instructions? What is the probability that the safety engineer will have to examine at least three reports until she finds a report showing an accident caused by employee failure to follow instructions? (7)

MODULE 2

13. (a) Let X be a continuous random variable with density (7)

$$f(x) = \begin{cases} 0 & x < -1 \\ x & -1 \leq x < 0 \\ ae^{-bx} & x \geq 0 \end{cases}$$

and expected value 1. Find the values of a and b . Also find $\text{var}(X)$.

- (b) The IQ of an individual randomly selected from a population is a normal distribution with mean 100 and standard deviation 15. Find the probability that an individual has IQ (i) above 140 (ii) between 120 and 130. (7)

OR

14. (a) A continuous random variable X is uniformly distributed with mean 1 and variance $4/3$. Find $P(X < 0)$ (7)
- (b) Suppose that the time between customer arrivals in a store is given by an exponential random variable X , such that the average time between arrivals is 2 minutes. Suppose you walk past the store and notice its empty. What is the probability from the time you walk past the store, the store remains empty for more than 5 minutes? (7)

MODULE 3

15. (a) Two fair dice are rolled. Let X denote the number on the first die and $Y = 0$ or 1 , according as the first die shows an even number or odd number. Find (i) the joint probability distribution of X and Y , (ii) the marginal distributions. (iii) Are X and Y independent? (7)
- (b) The joint density function of random variables X and Y is given by (7)

$$f(x, y) = \begin{cases} e^{-(x+y)}, & x > 0, \quad y > 0 \\ 0 & \text{otherwise.} \end{cases}$$

Find $P(X + Y \leq 1)$. Are X and Y independent? Justify.

OR

16. (a) Let X and Y be discrete random variables with joint probability mass function defined by (7)

$$f(x, y) = \begin{cases} \frac{1}{4}, & (x, y) \in \{(0, 0), (1, 1), (1, -1), (2, 0)\} \\ 0 & \text{otherwise} \end{cases}$$

Find $\text{cov}(X, Y)$ and interpret the result. Are X and Y independent?

- (b) The lifetime of a certain type of electric bulb may be considered as an exponential random variable with mean 50 hours. Using central limit theorem, find the approximate probability that 100 of these electric bulbs will provide a total of more than 6000 hours of burning time. (7)

MODULE 4

17. (a) A stochastic process is defined by $S_n = S_{n-1} + X_n$ ($n = 1, 2, \dots$) where $S_0 = 0$ and X_i are independent random variables each taking values ± 1 with equal probability. Write any two possible realisations of this process. Also find the ensemble mean of the process. (7)
- (b) A stochastic process $X(t)$ is defined by $X(t) = A \cos(\omega t) + B \sin(\omega t)$ where A and B are independent random variables with zero mean and equal variance. Show that $X(t)$ is stationary in the wide sense. (7)

OR

18. An insurance company models the arrival of insurance claims as a Poisson process with rate 60 per year.
- (a) What is the probability that there are more than 3 claims in a one-month period? What is the expected number and variance of the number of claims in a one-month period? (7)
- (b) The company estimates that the probability that an insurance claim is of more than Rs. 10 lakh is 0.2. What is the probability that there are more than 3 claims with claim amount more than Rs. 10 lakh during a 4-year period? (Assume that the claim amounts are independent). (7)

MODULE 5

19. A survey conducted among consumers of two brands (A and B) of toothpastes reveal the following data; given that a person last purchased brand A, there is a 90% chance that her next purchase will be again brand A and given that a person last purchased brand B, there is an 80% chance that her next purchase will be again brand B,
- (a) What percent of the consumers surveyed purchase brand A? brand B? (7)
- (b) It is estimated that a total of 1.2 crores of tooth paste units (of brand A and B combined) are purchased every year. On selling one unit of brand A tooth paste, the company earns a profit of Rs. 2. For Rs. 10 lakhs, an advertising firm guarantees to decrease from 10% to 5% the fraction of brand A customers who switch to brand B after a purchase. Should the company that makes brand A hire the advertising firm? (7)

OR

20. (a) State the memoryless property of a Markov chain. Give one example each of a random process which is (i) a Markov chain (ii) not a Markov chain. In each case justify your claim mathematically. (7)
- (b) The transition probability matrix of a discrete time Markov chain is (7)

$$P = \begin{bmatrix} 0 & 1 & 0 \\ 0.2 & 0 & 0.8 \\ 0 & 1 & 0 \end{bmatrix}$$

Classify the states as (i) periodic or aperiodic (ii) transient or recurrent. Also check whether the Markov chain is ergodic.



SEMESTER -4
MINOR

CODE MAT 282	Mathematical optimization	CATEGORY	L	T	P	CREDIT
		B. Tech Minor (S4)	3	1	0	4

Preamble: This course introduces basic theory and methods of optimization which have applications in all branches of engineering. Linear programming problems and various methods and algorithms for solving them are covered. Also introduced in this course are transportation and assignment problems and methods of solving them using the theory of linear optimization. Network analysis is applied for planning, scheduling, controlling, monitoring and coordinating large or complex projects involving many activities. The course also includes a selection of techniques for non-linear optimization

Prerequisite: A basic course in the solution of system of equations, basic knowledge on calculus.

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

CO 1	Formulate practical optimization problems as linear programming problems and solve them using graphical or simplex method.
CO 2	Understand the concept of duality in linear programming and use it to solve suitable problems more efficiently .
CO 3	Identify transportation and assignment problems and solve them by applying the theory of linear optimization
CO 4	Solve sequencing and scheduling problems and gain proficiency in the management of complex projects involving numerous activities using appropriate techniques.
CO 5	Develop skills in identifying and classifying non-linear optimization problems and solving them using appropriate methods.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	5	5	10
Understand	10	10	20
Apply	10	10	20
Analyse	10	10	20
Evaluate	15	15	30
Create			

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question.

Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Without sketching find the vertices of the possible solutions of $-x + y \leq 1, 2x + y \leq 2, x, y \geq 0$
2. Solve the LPP $Max 8x_1 + 9x_2$ subject to $2x_1 + 3x_2 \leq 50, 3x_1 + x_2 \leq 3, x_1 + 3x_2 \leq 70, x_1, x_2 \geq 0$ by simplex method
3. Solve the LPP $Max -x_1 + 3x_2$ subject to $x_1 + 2x_2 \geq 2, 2x_1 + 6x_2 \leq 80, x_1 \leq 4, x_1, x_2 \geq 0$ by Big M method.

Course Outcome 2 (CO2)

1. Formulate the dual of the following problem and show that dual of the dual is the primal $Max 5x_1 + 6x_2$ subject to $x_1 + 9x_2 \geq 60, 2x_1 + 3x_2 \leq 45, x_1, x_2 \geq 0$
2. Using duality principle solve $Min 2x_1 + 9x_2 + x_3$ subject to $x_1 + 4x_2 + 2x_3 \geq 5, 3x_1 + x_2 + 2x_3 \geq 4, x_1, x_2 \geq 0$
3. Use dual simplex method to solve $Min z = x_1 + 2x_2 + 4x_3$ subject to $2x_1 + 3x_2 - 5x_3 \leq 2, 3x_1 - x_2 + 6x_3 \geq 1, x_1 + x_2 + x_3 \leq 3, x_1 \geq 0, x_2 \leq 0, x_3$ unrestricted

Course Outcome 3(CO3):

1. Explain the steps involved in finding the initial basic solution feasible solution of a transportation problem by North West Corner rule..
2. A company has factories A, B and C which supply warehouses at W_1, W_2 and W_3 . Weekly factory capacities are 200, 160 and 90 units respectively. Weekly warehouse requirement are 180,120 and 150 respectively. Unit shipping cost in rupees is as follows

16	20	12
14	8	16
26	24	16

Determine the optimal distribution of this company to minimise the shipping cost

3. In a textile sales emporium, sales man A, B and C are available to handle W, X Y and Z. Each sales man can handle any counter . The service time in hours of each counter when manned by each sales man is as follows

	A	B	C	D
W	41	72	39	52
X	22	29	49	65
Y	27	39	60	51
Z	45	50	48	52

Course Outcome 4 (CO4):

1. Draw the network diagram to the following activities.

Activity	1-2	1-3	1-4	2-5	3-5	4-6	5-6
Time duration	2	4	3	1	6	5	7

2. The following table gives the activities in a construction project and other relevant information

Activity	1-2	1-3	1-4	2-5	3-5	4-6	5-6
Time duration	2	4	3	1	6	5	7

Find the free , total and independent float for each activity and determine the critical activities.

3. For a project given below find (i) the expected time for each activity (ii) T_E , T_L values of all events (iii) the critical path.

Task	A	B	C	D	E	F	G	H	I	J	K
Least time	4	5	8	2	4	7	8	4	3	5	6
Greatest time	6	9	12	6	10	15	16	8	7	11	12
Most likely time	5	7	10	4	7	8	12	6	5	8	9

Course Outcome 5 (CO5):

1. Consider the unconstrained optimization problem $\max f(x) = 2x_1x_2 + x_2 - x_1^2 - 2x_2^2$. Starting from the initial solution $(x_1, x_2) = (1, 1)$ interactively apply gradient search procedure with $\epsilon = 0.25$ to get an approximate solution.
2. Consider the following nonlinear programming problem.

$$\text{Max } f(x) = \frac{1}{1+x_2} \text{ subject to } x_1 - x_2 \leq 2, x_1 \geq 0, x_2 \geq 0$$

Use KKT condition to show that $(x_1, x_2) = (4, 2)$ is not an optimal solution

3. Minimize $f = -4x_1 + x_1^2 - 2x_1x_2 + 2x_2^2$ subject to $2x_1 + x_2 \leq 6, x_1 - 4x_2 \leq 0, x_1 \geq 0, x_2 \geq 0$ using Quadratic programming method.

Syllabus**MODULE I**

Linear Programming – 1 : Convex set and Linear Programming Problem – Mathematical Formulation of LPP, Basic feasible solutions, Graphical solution of LPP, Canonical form of LPP, Standard form of LPP, slack variables and Surplus variables, Simplex Method, Artificial variables in LPP, Big-M method.

MODULE II

Linear Programming – 2 : Two-phase method, Degeneracy and unbounded solutions of LPP, Duality of LPP, Solution of LPP using principle of duality, Dual Simplex Method.

MODULE III

Transportation and assignment problems: Transportation Problem, Balanced Transportation Problem, unbalanced Transportation problem. Finding basic feasible solutions – Northwest corner rule, least cost method, Vogel's approximation method. MODI method. Assignment problem, Formulation of assignment problem, Hungarian method for optimal solution, Solution of unbalanced problem. Travelling salesman problem

MODULE IV

Sequencing and Scheduling : Introduction, Problem of Sequencing, the problem of n jobs and two machines, problem of m jobs and m machines, Scheduling Project management-Critical path method (CPM), Project evaluation and review technique (PERT), Optimum scheduling by CPM, Linear programming model for CPM and PERT.

MODULE V

Non Linear Programming: Examples nonlinear programming problems- graphical illustration. One variable unconstrained optimization, multiple variable unconstrained optimization- gradient search. The Karush –Kuhn Tucker condition for constraint

optimization-convex function and concave function. Quadratic programming-modified simplex method-restricted entry rule, Separable programming.

Text Book

1. Frederick S Hillier, Gerald J. Lieberman, Introduction to Operations Research, Seventh Edition, McGraw-Hill Higher Education, 1967.
2. Kanti Swarup, P. K. Gupta, Man Mohan, Operations Research, Sultan Chand & Sons, New Delhi, 2008.

Reference

1. Singiresu S Rao, Engineering Optimization: Theory and Practice ,New Age International Publishers, 1996
2. H A Taha, Operations research : An introduction , Macmillon Publishing company,1976
3. B. S. Goel, S. K. Mittal, Operations research, Pragati Prakashan, 1980
4. S.D Sharma, “Operation Research”, Kedar Nath and RamNath - Meerut , 2008.
5. Phillips, Solberg Ravindran ,Operations Research: Principles and Practice, Wiley,2007

Assignments:

Assignment should include specific problems highlighting the applications of the methods introduced in this course in science and engineering.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	Linear programming – I (9 hours)	
1.1	Convex set and Linear Programming Problem – Mathematical Formulation of LPP	2
1.2	Basic feasible solutions, Graphical solution of LPP	2
1.3	Canonical form of LPP, Standard form of LPP, slack variables and Surplus variables, Artificial variables in LPP	1
1.4	Simplex Method	2
1.5	Big-M method.	2
2	Linear programming – II (9 hours)	
2.1	Two-phase method	2
2.2	Degeneracy and unbounded solutions of LPP	2
2.4	Duality of LPP	1
2.5	Solution of LPP using principle of duality	2

2.3	Dual Simplex Method.	2
3	Transportation and assignment problems - (9 hours)	
3.1	Balanced transportation problem	2
3.2	unbalanced Transportation problem	1
3.3	Finding basic feasible solutions – Northwest corner rule, least cost method	1
3.4	Vogel’s approximation method. MODI method	2
3.5	Assignment problem, Formulation of assignment problem	1
3.6	Hungarian method for optimal solution, Solution of unbalanced problem. Travelling salesman problem	2
4	Sequencing and Scheduling - (9 hours)	
4.1	Introduction, Problem of Sequencing, the problem of n jobs and two machines	2
4.2	problem of m jobs and m machines	1
4.3	Scheduling Project management-Critical path method (CPM)	2
4.4	Project evaluation and review technique (PERT),	2
4.5	Optimum scheduling by CPM, Linear programming model for CPM and PERT.	2
5	Non Linear Programming - (9 hours)	
5.1	Examples , Graphical illustration, One variable unconstrained optimization	2
5.2	Multiple variable unconstrained optimization-- gradient search	2
	The Karush –Kuhn Tucker condition for constraint optimization	1
5.3	Quadratic programming-modified simplex method-	2
5.5	Separable programming	2



SEMESTER -4

CODE MCN202	COURSE NAME CONSTITUTION OF INDIA	CATEGORY	L	T	P	CREDIT
			2	0	0	NIL

Preamble:

The study of their own country constitution and studying the importance environment as well as understanding their own human rights help the students to concentrate on their day to day discipline. It also gives the knowledge and strength to face the society and people.

Prerequisite: Nil

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

CO 1	Explain the background of the present constitution of India and features.
CO 2	Utilize the fundamental rights and duties.
CO 3	Understand the working of the union executive, parliament and judiciary.
CO 4	Understand the working of the state executive, legislature and judiciary.
CO 5	Utilize the special provisions and statutory institutions.
CO 6	Show national and patriotic spirit as responsible citizens of the country

Mapping of course outcomes with program outcomes

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

Assessment Pattern

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

Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions**Course Outcome 1 (CO1):**

- 1 Discuss the historical background of the Indian constitution.
- 2 Explain the salient features of the Indian constitution.
- 3 Discuss the importance of preamble in the implementation of constitution.

Course Outcome 2 (CO2)

- 1 What are fundamental rights ? Examine each of them.
- 2 Examine the scope of freedom of speech and expression underlying the constitution.
- 3 The thumb impression of an accused is taken by the police against his will. He contends that this is a violation of his rights under Art 20(3) of the constitution. Decide.

Course Outcome 3(CO3):

- 1 Explain the powers of the President to suspend the fundamental rights during emergency.

- 2 Explain the salient features of appeal by special leave.
3. List the constitutional powers of President.

Course Outcome 4 (CO4):

- 1 Discuss the constitutional powers of Governor.
- 2 Examine the writ jurisdiction of High court.
- 3 Discuss the qualification and disqualification of membership of state legislature.

Course Outcome 5 (CO5):

- 1 Discuss the duties and powers of comptroller of auditor general.
- 2 Discuss the proclamation of emergency.
- 3 A state levies tax on motor vehicles used in the state, for the purpose of maintaining roads in the state. X challenges the levy of the tax on the ground that it violates the freedom of interstate commerce guaranteed under Art 301. Decide.

Course Outcome 6 (CO6):

- 1 Explain the advantages of citizenship.
- 2 List the important principles contained in the directive principles of state policy.
- 3 Discuss the various aspects contained in the preamble of the constitution

Model Question paper**PART A**

(Answer all questions. Each question carries 3 marks)

- 1 Define and explain the term constitution.
- 2 Explain the need and importance of Preamble.
- 3 What is directive principle of state policy?
- 4 Define the State.
- 5 List the functions of Attorney general of India.

- 6 Explain the review power of Supreme court.
- 7 List the qualifications of Governor.
- 8 Explain the term and removal of Judges in High court.
- 9 Explain the powers of public service commission.
- 10 List three types of emergency under Indian constitution.

(10X3=30marks)

PART B

(Answer on question from each module. Each question carries 14 marks)

Module 1

- 11 Discuss the various methods of acquiring Indian citizenship.
- 12 Examine the salient features of the Indian constitution.

Module 2

- 13 A high court passes a judgement against X. X desires to file a writ petition in the supreme court under Art32, on the ground that the judgement violates his fundamental rights. Advise him whether he can do so.
- 14 What is meant by directive principles of State policy? List the directives.

Module3

- 15 Describe the procedure of election and removal of the President of India.
- 16 Supreme court may in its discretion grant special leave to appeal. Examine the situation.

Module 4

- 17 Discuss the powers of Governor.
- 18 X filed a writ petition under Art 226 which was dismissed. Subsequently, he filed a writ petition under Art 32 of the constitution, seeking the same remedy. The Government argued that the writ petition should be dismissed, on the ground of res judicata. Decide.

Module 5

19 Examine the scope of the financial relations between the union and the states.

20 Discuss the effects of proclamation of emergency.

(14X5=70marks)

Syllabus

Module 1 Definition, historical back ground, features, preamble, territory, citizenship.

Module 2 State, fundamental rights, directive principles, duties.

Module 3 The machinery of the union government.

Module 4 Government machinery in the states

Module 5 The federal system, Statutory Institutions, miscellaneous provisions.

Text Books

1 D D Basu, Introduction to the constitution of India, Lexis Nexis, New Delhi, 24e, 2019

2 PM Bhakshi, The constitution of India, Universal Law, 14e, 2017

Reference Books

1 Ministry of law and justice, The constitution of India, Govt of India, New Delhi, 2019.

2 JN Pandey, The constitutional law of India, Central Law agency, Allahabad, 51e, 2019

3 MV Pylee, India's Constitution, S Chand and company, New Delhi, 16e, 2016

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	Module 1	
1.1	Definition of constitution, historical back ground, salient features of the constitution.	1
1.2	Preamble of the constitution, union and its territory.	1
1.3	Meaning of citizenship, types, termination of citizenship.	2
2	Module 2	
2.1	Definition of state, fundamental rights, general nature, classification, right to equality ,right to freedom , right against exploitation	2

2.2	Right to freedom of religion, cultural and educational rights, right to constitutional remedies. Protection in respect of conviction for offences.	2
2.3	Directive principles of state policy, classification of directives, fundamental duties.	2
3	Module 3	
3.1	The Union executive, the President, the vice President, the council of ministers, the Prime minister, Attorney-General, functions.	2
3.2	The parliament, composition, Rajya sabha, Lok sabha, qualification and disqualification of membership, functions of parliament.	2
3.3	Union judiciary, the supreme court, jurisdiction, appeal by special leave.	1
4	Module 4	
4.1	The State executive, the Governor, the council of ministers, the Chief minister, advocate general, union Territories.	2
4.2	The State Legislature, composition, qualification and disqualification of membership, functions.	2
4.3	The state judiciary, the high court, jurisdiction, writs jurisdiction.	1
5	Module 5	
5.1	Relations between the Union and the States, legislative relation, administrative relation, financial Relations, Inter State council, finance commission.	1
5.2	Emergency provision, freedom of trade commerce and inter course, comptroller and auditor general of India, public Services, public service commission, administrative Tribunals.	2
5.3	Official language, elections, special provisions relating to certain classes, amendment of the Constitution.	2

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
				2	0	0
EST 200	DESIGN AND ENGINEERING					

Preamble:

The purpose of this course is to

- i) introduce the undergraduate engineering students the fundamental principles of design engineering,
- ii) make them understand the steps involved in the design process and
- iii) familiarize them with the basic tools used and approaches in design.

Students are expected to apply design thinking in learning as well as while practicing engineering, which is very important and relevant for today. Case studies from various practical situations will help the students realize that design is not only concerned about the function but also many other factors like customer requirements, economics, reliability, etc. along with a variety of life cycle issues.

The course will help students to consider aesthetics, ergonomics and sustainability factors in designs and also to practice professional ethics while designing.

Prerequisite:

Nil. The course will be generic to all engineering disciplines and will not require specialized preparation or prerequisites in any of the individual engineering disciplines.

Course Outcomes:

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

CO 1	Explain the different concepts and principles involved in design engineering.
CO 2	Apply design thinking while learning and practicing engineering.
CO 3	Develop innovative, reliable, sustainable and economically viable designs incorporating knowledge in engineering.

Mapping of course outcomes with program outcomes

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

Assessment Pattern**Continuous Internal Evaluation (CIE) Pattern:**

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

End Semester Examination (ESE) Pattern: There will be two parts; Part A and Part B.

Part A : 30 marks

part B : 70 marks

Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions.

Part B contains 2 case study questions from each module of which student should answer any one. Each question carry 14 marks and can have maximum 2 sub questions.

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

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

Course Level Assessment Questions

Course Outcome 1 (CO1): Appreciate the different concepts and principles involved in design engineering.

1. State how engineering design is different from other kinds of design
2. List the different stages in a design process.
3. Describe design thinking.
4. State the function of prototyping and proofing in engineering design.
5. Write notes on the following concepts in connection with design engineering 1) Modular Design, 2) Life Cycle Design, 3) Value Engineering, 4) Concurrent Engineering, and 5) Reverse Engineering
6. State design rights.

Course Outcome 2 (CO2) Apply design thinking while learning and practicing engineering.

1. Construct the iterative process for design thinking in developing simple products like a pen, umbrella, bag, etc.
2. Show with an example how divergent-convergent thinking helps in generating alternative designs and then how to narrow down to the best design.
3. Describe how a problem-based learning helps in creating better design engineering solutions.
4. Discuss as an engineer, how ethics play a decisive role in your designs

Course Outcome 3 (CO3): Develop innovative, reliable, sustainable and economically viable designs incorporating different segments of knowledge in engineering.

1. Illustrate the development of any simple product by passing through the different stages of design process
2. Show the graphical design communication with the help of detailed 2D or 3D drawings for any simple product.
3. Describe how to develop new designs for simple products through bio-mimicry.

Model Question paper

Page 1 of 2

Reg No.: _____ Name: _____

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
THIRD/FOURTH SEMESTER B.TECH DEGREE EXAMINATION**

Course Code: EST 200

Course Name: DESIGN AND ENGINEERING

Max. Marks: 100 Duration: 3 Hours

PART A**Answer all questions, each question carries 3 marks****Use only hand sketches**

- (1) Write about the basic design process.
- (2) Describe how to finalize the design objectives.
- (3) State the role of divergent-convergent questioning in design thinking.
- (4) Discuss how to perform design thinking in a team managing the conflicts.
- (5) Show how engineering sketches and drawings convey designs.
- (6) Explain the role of mathematics and physics in design engineering process.
- (7) Distinguish between project-based learning and problem-based learning in design engineering.
- (8) Describe how concepts like value engineering, concurrent engineering and reverse engineering influence engineering designs?
- (9) Show how designs are varied based on the aspects of production methods, life span, reliability and environment?
- (10) Explain how economics influence the engineering designs?

(10x3 marks =30 marks)**Part B****Answer any ONE question from each module. Each question carry 14 marks****Module 1**

- (11) Show the designing of a wrist watch going through the various stages of the design process. Use hand sketches to illustrate the processes.
- or**
- (12) Find the customer requirements for designing a new car showroom. Show how the design objectives were finalized considering the design constraints?

Module 2

(13) Illustrate the design thinking approach for designing a bag for college students within a limited budget. Describe each stage of the process and the iterative procedure involved. Use hand sketches to support your arguments.

or

(14) Construct a number of possible designs and then refine them to narrow down to the best design for a drug trolley used in hospitals. Show how the divergent-convergent thinking helps in the process. Provide your rationale for each step by using hand sketches only.

Module 3

(15) Graphically communicate the design of a thermo flask used to keep hot coffee. Draw the detailed 2D drawings of the same with design detailing, material selection, scale drawings, dimensions, tolerances, etc. Use only hand sketches.

or

(16) Describe the role of mathematical modelling in design engineering. Show how mathematics and physics play a role in designing a lifting mechanism to raise 100 kg of weight to a floor at a height of 10 meters in a construction site.

Module 4

(17) Show the development of a nature inspired design for a solar powered bus waiting shed beside a highway. Relate between natural and man-made designs. Use hand sketches to support your arguments.

or

(18) Show the design of a simple sofa and then depict how the design changes when considering 1) aesthetics and 2) ergonomics into consideration. Give hand sketches and explanations to justify the changes in designs.

Module 5

(19) Examine the changes in the design of a foot wear with constraints of 1) production methods, 2) life span requirement, 3) reliability issues and 4) environmental factors. Use hand sketches and give proper rationalization for the changes in design.

or

(20) Describe how to estimate the cost of a particular design using ANY of the following: i) a website, ii) the layout of a plant, iii) the elevation of a building, iv) an electrical or electronic system or device and v) a car.

Show how economics will influence the engineering designs. Use hand sketches to support your arguments.

(5x14 marks =70 marks)

Syllabus

Module 1

Design Process:- Introduction to Design and Engineering Design, Defining a Design Process:-Detailing Customer Requirements, Setting Design Objectives, Identifying Constraints, Establishing Functions, Generating Design Alternatives and Choosing a Design.

Module 2

Design Thinking Approach:-Introduction to Design Thinking, Iterative Design Thinking Process Stages: Empathize, Define, Ideate, Prototype and Test. Design Thinking as Divergent-Convergent Questioning. Design Thinking in a Team Environment.

Module 3

Design Communication (Languages of Engineering Design):-Communicating Designs Graphically, Communicating Designs Orally and in Writing. Mathematical Modeling In Design, Prototyping and Proofing the Design.

Module 4

Design Engineering Concepts:-Project-based Learning and Problem-based Learning in Design.Modular Design and Life Cycle Design Approaches. Application of Biomimicry,Aesthetics and Ergonomics in Design. Value Engineering, Concurrent Engineering, and Reverse Engineering in Design.

Module 5

Expediency, Economics and Environment in Design Engineering:-Design for Production, Use, and Sustainability. Engineering Economics in Design. Design Rights. Ethics in Design

Text Books

- 1) YousefHaik, SangarappillaiSivaloganathan, Tamer M. Shahin, Engineering Design Process, Cengage Learning 2003, Third Edition, ISBN-10: 9781305253285,
- 2) Voland, G., Engineering by Design, Pearson India 2014, Second Edition, ISBN 9332535051

Reference Books

- 1.Philip Kosky, Robert Balmer, William Keat, George Wise, Exploring Engineering, Fourth Edition: An Introduction to Engineering and Design, Academic Press 2015, 4th Edition, ISBN: 9780128012420.
2. Clive L. Dym, Engineering Design: A Project-Based Introduction, John Wiley & Sons, New York 2009, Fourth Edition, ISBN: 978-1-118-32458-5
3. Nigel Cross, Design Thinking: Understanding How Designers Think and Work, Berg Publishers 2011, First Edition, ISBN: 978-1847886361
4. Pahl, G., Beitz, W., Feldhusen, J., Grote, K.-H., Engineering Design: A Systematic Approach, Springer 2007, Third Edition, ISBN 978-1-84628-319-2

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	<u>Module 1: Design Process</u>	
1.1	Introduction to Design and Engineering Design. <i>What does it mean to design something? How Is engineering design different from other kinds of design? Where and when do engineers design? What are the basic vocabulary in engineering design? How to learn and do engineering design.</i>	1
1.2	<i>Defining a Design Process-: Detailing Customer Requirements.</i> <i>How to do engineering design? Illustrate the process with an example. How to identify the customer requirements of design?</i>	1
1.3	<i>Defining a Design Process-: Setting Design Objectives, Identifying Constraints, Establishing Functions.</i> <i>How to finalize the design objectives? How to identify the design constraints? How to express the functions a design in engineering terms?</i>	1
1.4	<i>Defining a Design Process-: Generating Design Alternatives and Choosing a Design.</i> <i>How to generate or create feasible design alternatives? How to identify the "best possible design"?</i>	1
1.5	Case Studies:- Stages of Design Process. <i>Conduct exercises for designing simple products going through the different stages of design process.</i>	1
2	<u>Module 2: Design Thinking Approach</u>	
2.1	Introduction to Design Thinking <i>How does the design thinking approach help engineers in creating innovative and efficient designs?</i>	1
2.2	Iterative Design Thinking Process Stages: Empathize, Define, Ideate, Prototype and Test. <i>How can the engineers arrive at better designs utilizing the iterative design thinking process (in which knowledge acquired in the later stages can be applied back to the earlier stages)?</i>	1
2.3	Design Thinking as Divergent-Convergent Questioning. <i>Describe how to create a number of possible designs and then how to refine and narrow down to the 'best design'.</i>	1
2.4	Design Thinking in a Team Environment. <i>How to perform design thinking as a team managing the conflicts ?</i>	1
2.5	Case Studies: Design Thinking Approach. <i>Conduct exercises using the design thinking approach for</i>	1

	<i>designing any simple products within a limited time and budget</i>	
3	<u>Module 3: Design Communication (Languages of Engineering Design)</u>	
3.1	Communicating Designs Graphically. <i>How do engineering sketches and drawings convey designs?</i>	1
3.2	Communicating Designs Orally and in Writing. <i>How can a design be communicated through oral presentation or technical reports efficiently?</i>	1
First Series Examination		
3.3	Mathematical Modelling in Design. <i>How do mathematics and physics become a part of the design process?</i>	1
3.4	Prototyping and Proofing the Design. <i>How to predict whether the design will function well or not?</i>	1
3.5	Case Studies: Communicating Designs Graphically. <i>Conduct exercises for design communication through detailed 2D or 3D drawings of simple products with design detailing, material selection, scale drawings, dimensions, tolerances, etc.</i>	1
4	<u>Module 4: Design Engineering Concepts</u>	
4.1	Project-based Learning and Problem-based Learning in Design. <i>How engineering students can learn design engineering through projects?</i> <i>How students can take up problems to learn design engineering?</i>	1
4.2	Modular Design and Life Cycle Design Approaches. <i>What is modular approach in design engineering? How it helps?</i> <i>How the life cycle design approach influences design decisions?</i>	1
4.3	Application of Bio-mimicry, Aesthetics and Ergonomics in Design. <i>How do aesthetics and ergonomics change engineering designs?</i> <i>How do the intelligence in nature inspire engineering designs? What are the common examples of bio-mimicry in engineering?</i>	1
4.4	Value Engineering, Concurrent Engineering, and Reverse Engineering in Design. <i>How do concepts like value engineering , concurrent engineering and reverse engineering influence engineering designs?</i>	1
4.5	Case Studies: Bio-mimicry based Designs. <i>Conduct exercises to develop new designs for simple</i>	1

	<i>products using bio-mimicry and train students to bring out new nature inspired designs.</i>	
5	<u>Module 5: Expediency, Economics and Environment in Design Engineering</u>	
5.1	Design for Production, Use, and Sustainability. <i>How designs are finalized based on the aspects of production methods, life span, reliability and environment?</i>	1
5.2	Engineering Economics in Design. <i>How to estimate the cost of a particular design and how will economics influence the engineering designs?</i>	1
5.3	Design Rights. <i>What are design rights and how can an engineer put it into practice?</i>	1
5.4	Ethics in Design. <i>How do ethics play a decisive role in engineering design?</i>	1
5.5	Case Studies: Design for Production, Use, and Sustainability. <i>Conduct exercises using simple products to show how designs change with constraints of production methods, life span requirement, reliability issues and environmental factors.</i>	1
Second Series Examination		



Code.	Course Name	L	T	P	Hrs	Credit
HUT 200	Professional Ethics	2	0	0	2	2

Preamble: To enable students to create awareness on ethics and human values.

Prerequisite: Nil

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

CO 1	Understand the core values that shape the ethical behaviour of a professional.
CO 2	Adopt a good character and follow an ethical life.
CO 3	Explain the role and responsibility in technological development by keeping personal ethics and legal ethics.
CO 4	Solve moral and ethical problems through exploration and assessment by established experiments.
CO 5	Apply the knowledge of human values and social values to contemporary ethical values and global issues.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2
CO 1								2			2	
CO 2								2			2	
CO 3								3			2	
CO 4								3			2	
CO 5								3			2	

Assessment Pattern

Bloom's category	Continuous Assessment Tests		End Semester Exam
	1	2	
Remember	15	15	30
Understood	20	20	40
Apply	15	15	30

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance	: 10 marks
Continuous Assessment Tests (2 Nos)	: 25 marks
Assignments/Quiz	: 15 marks

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

Course Level Assessment Questions**Course Outcome 1 (CO1):**

1. Define integrity and point out ethical values.
2. Describe the qualities required to live a peaceful life.
3. Explain the role of engineers in modern society.

Course Outcome 2 (CO2)

1. Derive the codes of ethics.
2. Differentiate consensus and controversy.
3. Discuss in detail about character and confidence.

Course Outcome 3(CO3):

1. Explain the role of professional's ethics in technological development.
2. Distinguish between self interest and conflicts of interest.
3. Review on industrial standards and legal ethics.

Course Outcome 4 (CO4):

1. Illustrate the role of engineers as experimenters.
2. Interpret the terms safety and risk.
3. Show how the occupational crimes are resolved by keeping the rights of employees.

Course Outcome 5 (CO5):

1. Exemplify the engineers as managers.
2. Investigate the causes and effects of acid rain with a case study.
3. Explore the need of environmental ethics in technological development.

Model Question paper

QP CODE:

Reg No: _____

PAGES:3

Name : _____

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY THIRD/FOURTH SEMESTER
B.TECH DEGREE EXAMINATION, MONTH & YEAR**

Course Code: HUT 200

Course Name: PROFESSIONAL ETHICS

Max. Marks: 100

Duration: 3 Hours

(2019-Scheme)

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

1. Define empathy and honesty.
2. Briefly explain about morals, values and ethics.
3. Interpret the two forms of self-respect.
4. List out the models of professional roles.
5. Indicate the advantages of using standards.
6. Point out the conditions required to define a valid consent?
7. Identify the conflicts of interests with an example?
8. Recall confidentiality.
9. Conclude the features of biometric ethics.
10. Name any three professional societies and their role relevant to engineers.

(10x3 = 30 marks)

PART B**(Answer one full question from each module, each question carries 14 marks)****MODULE I****11. a)** Classify the relationship between ethical values and law?**b)** Compare between caring and sharing.

(10+4 = 14 marks)

Or**12. a)** Exemplify a comprehensive review about integrity and respect for others.

b) Discuss about co-operation and commitment.

(8+6 = 14 marks)

MODULE II

13.a) Explain the three main levels of moral developments, devised by Kohlberg.

b) Differentiate moral codes and optimal codes.

(10+4 = 14 marks)

Or

14. a) Extrapolate the duty ethics and right ethics.

b) Discuss in detail the three types of inquiries in engineering ethics

(8+6 = 14 marks)

MODULE III

15.a) Summarize the following features of morally responsible engineers.

(i) Moral autonomy

(ii) Accountability

b) Explain the rights of employees

(8+6 = 14 marks)

Or

16. a) Explain the reasons for Chernobyl mishap ?

b) Describe the methods to improve collegiality and loyalty.

(8+6 = 14 marks)

MODULE IV

17.a) Execute collegiality with respect to commitment, respect and connectedness.

b) Identify conflicts of interests with an example.

(8+6 = 14 marks)

Or

18. a) Explain in detail about professional rights and employee rights.

b) Exemplify engineers as managers.

MODULE V

19.a) Evaluate the technology transfer and appropriate technology.

b) Explain about computer and internet ethics.

(8+6 = 14 marks)

Or

20. a) Investigate the causes and effects of acid rain with a case study.

b) Conclude the features of ecocentric and biocentric ethics.

(8+6 = 14 marks)

Syllabus

Module 1 – Human Values.

Morals, values and Ethics – Integrity- Academic integrity-Work Ethics- Service Learning- Civic Virtue- Respect for others- Living peacefully- Caring and Sharing- Honestly- courage-Cooperation commitment- Empathy-Self Confidence -Social Expectations.

Module 2 - Engineering Ethics & Professionalism.

Senses of Engineering Ethics - Variety of moral issues- Types of inquiry- Moral dilemmas –Moral Autonomy – Kohlberg’s theory- Gilligan’s theory- Consensus and Controversy-Profession and Professionalism- Models of professional roles-Theories about right action –Self interest-Customs and Religion- Uses of Ethical Theories.

Module 3- Engineering as social Experimentation.

Engineering as Experimentation – Engineers as responsible Experimenters- Codes of Ethics- Plagiarism- A balanced outlook on law - Challenges case study- Bhopal gas tragedy.

Module 4- Responsibilities and Rights.

Collegiality and loyalty – Managing conflict- Respect for authority- Collective bargaining- Confidentiality- Role of confidentiality in moral integrity-Conflicts of interest- Occupational crime- Professional rights- Employee right- IPR Discrimination.

Module 5- Global Ethical Issues.

Multinational Corporations- Environmental Ethics- Business Ethics- Computer Ethics -Role in Technological Development-Engineers as Managers- Consulting Engineers- Engineers as Expert witnesses and advisors-Moral leadership.

Text Book

1. M Govindarajan, S Natarajan and V S Senthil Kumar, Engineering Ethics, PHI Learning Private Ltd, New Delhi,2012.
2. R S Naagarazan, A text book on professional ethics and human values, New age international (P) limited ,New Delhi,2006.

Reference Books

1. Mike W Martin and Roland Schinzinger, Ethics in Engineering,4th edition, Tata McGraw Hill Publishing Company Pvt Ltd, New Delhi,2014.
2. Charles D Fleddermann, Engineering Ethics, Pearson Education/ Prentice Hall of India, New Jersey,2004.
3. Charles E Harris, Michael S Protchard and Michael J Rabins, Engineering Ethics- Concepts and cases, Wadsworth Thompson Learning, United states,2005.
4. <http://www.slideword.org/slidestag.aspx/human-values-and-Professional-ethics>.

Course Contents and Lecture Schedule

SL.No	Topic	No. of Lectures 25
1	Module 1 – Human Values.	
1.1	Morals, values and Ethics, Integrity, Academic Integrity, Work Ethics	1
1.2	Service Learning, Civic Virtue, Respect for others, Living peacefully	1
1.3	Caring and Sharing, Honesty, Courage, Co-operation commitment	2
1.4	Empathy, Self Confidence, Social Expectations	1
2	Module 2- Engineering Ethics & Professionalism.	
2.1	Senses of Engineering Ethics, Variety of moral issues, Types of inquiry	1
2.2	Moral dilemmas, Moral Autonomy, Kohlberg's theory	1
2.3	Gilligan's theory, Consensus and Controversy, Profession & Professionalism, Models of professional roles, Theories about right action	2
2.4	Self interest-Customs and Religion, Uses of Ethical Theories	1
3	Module 3- Engineering as social Experimentation.	
3.1	Engineering as Experimentation, Engineers as responsible Experimenters	1
3.2	Codes of Ethics, Plagiarism, A balanced outlook on law	2
3.3	Challenger case study, Bhopal gas tragedy	2
4	Module 4- Responsibilities and Rights.	
4.1	Collegiality and loyalty, Managing conflict, Respect for authority	1
4.2	Collective bargaining, Confidentiality, Role of confidentiality in moral integrity, Conflicts of interest	2
4.3	Occupational crime, Professional rights, Employee right, IPR Discrimination	2
5	Module 5- Global Ethical Issues.	
5.1	Multinational Corporations, Environmental Ethics, Business Ethics, Computer Ethics	2
5.2	Role in Technological Development, Moral leadership	1
5.3	Engineers as Managers, Consulting Engineers, Engineers as Expert witnesses and advisors	2