SEMESTER II

Discipline:CIVIL ENGINEERING

Stream : CE4

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222TCE100	ADVANCED NUMERICAL METHODS	DISCIPLINE CORE 2	3	0	0	3

Preamble: For solving complex problems in mechanics and engineering, a post-graduate student must be well versed in numerical methods along with skills to apply them. This course equips the student with various numerical techniques that finds applications in civil engineering, across various streams (specialisations). Special focus is given to finite element method, explaining the relevance, versatility and fundamental concepts of this numerical tool.

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

CO 1	Obtain the solution of simultaneous Linear system of equations
CO 2	Obtain the numerical solutions of ordinary differential equations
CO 3	Obtain the numerical solutions for solving boundary value problems of partial differential equations
CO 4	Describe the terminologies, applications or procedure of finite element method
CO 5	Describe or apply the concept of finite element method

Mapping of course outcomes with program outcomes

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

(1-Weak, 2-Medium, 3- strong)

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	25
Analyse	25
Evaluate	5
Create	5

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern: 40 marks

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

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

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

Note: Enough opportunity to explore the practical examples from specialization should be given to the students. One assignment/course project should be based on the coding or use of packages

End Semester Examination Pattern: 60 marks

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

Model Question Paper

QP CODE:

Reg No.:______________

Name:__________________________ ___

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

Course Code: XXXXXX

ADVANCED NUMERICAL METHODS

Max. Marks: 60 Duration: 2.5 hours

PART A

(Answer ***ALL*** questions; each question carries 5 marks)

1. Explain the procedure of solution of Tridiagonal systems
2. Explain single shooting method for solving Boundary value problems
3. Explain the parabolic and elliptic partial differential equations with examples
4. Explain any five practical applications of Finite element in the con
5. Explain Generalised coordinates and Natural coordinates in Finite Element analysis

PART B

(Answer ***any FIVE*** questions; each question carries 7 marks)

6. Solve the system of equations by Jacobi's iteration considering initial approximation as $[0.5, -0.5, 0.5]^T$

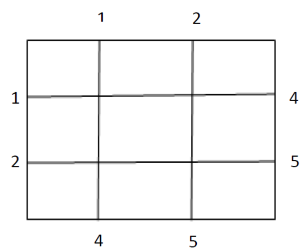
$$4x_1 + x_2 + x_3 = 2$$

$$x_1 + 5x_2 + 2x_3 = -6$$

$$x_1 + 2x_2 + 3x_3 = -4$$

7. Solve $y' = x^2 + y$ for y=0.1, given that $y(0)$=1 considering h=0.05 using (i) Eulers method and (ii) Runge Kutta method

8. Solve the equation $u_{xx} + u_{yy} = 0$ for the square mesh with boundary value as shown in figure



9. Solve $\left(\frac{\partial u}{\partial t}\right)=\left(\frac{\partial^2 u}{\partial x^2}\right)$ subject to the conditions $u(x,0)=\sin(\pi x)$ for $0 \le x \le 1$ $u(0,t)$=u(1, t)=0. Perform the computations of two levels taking h=1/3and t=1/36 using Crank Nicolson implicit scheme

10. Explain in detail the steps of finite element analysis

11. Explain forms of shape functions in finite element analysis

12. Explain the convergence criteria in finite element applications in detail

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Syllabus

Module 1 **(7 hours)**

Solutions of simultaneous Linear Systems of Equations- Solution of linear systems – Direct methods, Gauss-Jordan Method-Method of factorization- Solution of Tridiagonal Systems. Solution by matrix decomposition Iterative methods: Jacobi, Gauss-Siedel iteration for ordinary and sparse systems, Convergence of iterative solution schemes with examples.

Module 2 **(7 hours)**

Solving Ordinary Differential Equations- The Elementary Theory of Initial-Value Problems -Euler's Method- Higher-Order Taylor Methods. Runge-Kutta Method-Introduction to solution methods for differential algebraic equations- Single shooting method for solving ODE-BVPs.

Module 3 **(7 hours)**

Partial differential equations in two dimensions- Parabolic equations- Explicit finite difference method. Crank-Nicholson implicit method - Ellipse equations- Finite difference method-Problems with irregular boundaries.

Module 4 **(7 hours)**

Introduction to Finite Element Method – Historical Background — Mathematical Modeling of field problems in Engineering — Governing Equations — Discrete and continuous models — Boundary, Initial and Eigen Value problems– Basic concepts of the Finite Element Method- Displacement approach-Concept of Stiffness Matrix and Boundary Condition-- General procedure of FEA

Module5 **(7 hours)**

Concept of Finite Element Method- Concept of Nodes, elements, Generalised coordinates and Natural coordinates in FEA. Shape functions – Polynomials - Lagrangian and Hermitian Interpolation –- Compatibility - C0 and C1 elements - Convergence criteria - Conforming & nonconforming elements. Development of element matrices for one dimensional elements.

Text Books

1.Gupta,S.K. Numerical Methods for Engineers. Wiley Eastern, New Delhi, 1995.

2. Cook, RD. Concepts and Applications of Finite Element Analysis , Wiley.

Reference Books

1. Gilbert Strang, Linear Algebra and its Applications (4th Ed.), Wellesley Cambridge Press 2009
2. Gourdin, A. and M Boumhrat. Applied Numerical Methods.Prentice Hall India, New Delhi 2000
3. Chopra S.C. and Canale R.P. Numerical Methods for Engineers,McGraw Hill 2006
4. Krishnamoorthy C S, *Finite Element Analysis- Theory and Programming*, Tata McGraw Hill, New Delhi., 1994
5. Rao, SS. Finite Element Analysis, Elsevier Butterworth-Heinemann
6. Gerald and Wheatly, *Applied Numerical Analysis,* Pearson Education.
7. Rajasekharan S., *Numerical Methods in Science and Engineering,* S Chand & Company, 2003.
8. Bathe K J, *Finite Element Procedures in Engineering Analysis*, Prentice Hall, New Delhi. 1982
9. Chandrupatla T R and Belegundu A D, *Introduction to Finite Elements in Engineering*, Pearson Education, New Delhi 1998
10. Rajasekharan S, *Finite Element Analysis in Engineering Design*, Wheeler, New Delhi
11. Hutton D V, *Fundamentals of Finite Element Analysis*, Tata McGraw Hill Education Private Ltd, New Delhi

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CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221TCE003	FINITE ELEMENT METHOD	PROGRAM CORE 3	3	0	0	3

Preamble: Nil

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

CO 1	Develop approximate solution to boundary value problems in structural mechanics using method of weighted residuals and variational methods.
CO 2	Develop field approximations for various one- and two-dimensional finite elements.
CO 3	Formulate element equilibrium equations for 1D and 2D finite elements for solution of structural mechanics problems using energy principles.
CO 4	Understand the computational techniques for numerical integrations, large system of equation solvers etc. and apply the same for implementation of finite element method.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment test	End Semester Examination
Understand	10	15
Apply	10	15
Analyse	20	30
Evaluate	-	-
Create	-	-

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Continuous Internal Evaluation: 40 marks Micro project/Course based project : 20 marks

Course based task/Seminar/Quiz : 10 marks

Test paper, 1 no. : 10 marks

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

End Semester Examination Pattern:

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

Model Question Paper

Max. Marks: 60
Duration: 2.5 Hours

PART A

Answer all questions; each question carries 5 marks

1. The stress components at a point in a body are given by

   $\sigma_x = 2xy^2z + 2x;\ \sigma_y = 5xyz + 3y;\ \sigma_z = x^2y + y^2z;\ \tau_{xy} = 0;\ \tau_{yz} = \tau_{xz} = 2xy^2z + 2xy$

   Check whether these stress components satisfy the conditions of equilibrium or not at the point (1,-1,2). If not, determine the suitable body force components required at this point so that the stress components satisfy equilibrium.

2. What are conforming and non-conforming elements? Briefly explain the convergence characteristics of both.

3. Starting from the Hermitian shape functions develop the consistent load vector for a two node 1D beam element subjected to a uniformly distributed of intensity w covering full span.

4. Evaluate the following integrals using two point Gauss quadrature.

(i) $\int_{-1}^{1}\int_{-1}^{1} xy\, dx dy$

(ii) $\int_1^3 \frac{dx}{(x^4+1)^{1/2}}$

5. Write short notes on:
   (i) Shear locking (ii) Storage schemes in FEA

PART B

Answer any five questions; each question carries 7 marks

6. Using modified Galerkin method obtain an approximate solution of the following boundary value problem

$$2u''(x) + 3u(x) = 0, \qquad 1 < x < 3$$

$u(1) = 1$ Essential boundary condition

$u'(3) = 1$ Natural boundary condition

Assume a quadratic polynomial satisfying the essential boundary condition as a trial solution.

7. A two-member truss is loaded as shown in Fig.2. The area of cross section of each element is 500 mm^2 and E = 200 GPa. Compute the displacement components at node 3, reactions at supports and member stresses

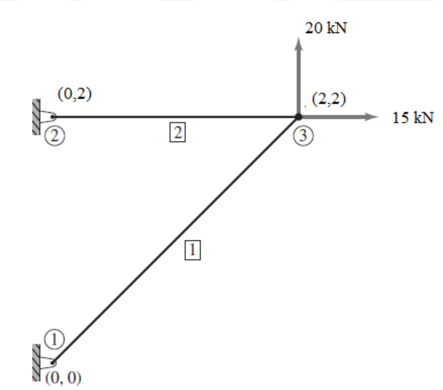


Fig. 2

8. The nodal displacement components (in mm units) of a triangular element from the finite element analysis of a thin plate is shown in Fig.3. Develop appropriate approximations for the u and v fields within the element in terms of area coordinates .

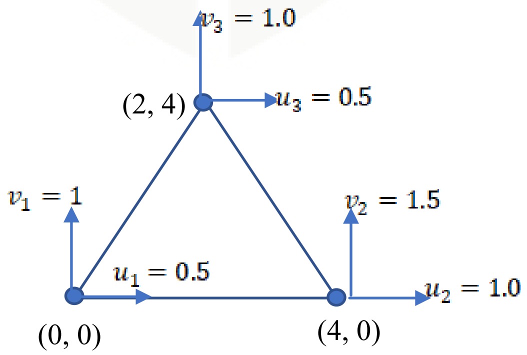


Fig.3.

9. (i) Differentiate between Lagrangian and Hermitian interpolation. (2 marks)

   (ii) Compute the consistent nodal load vector when a surface traction of uniform intensity w N/m length acts normal to the edge containing nodes with coordinates (4,0) and (2,4) of the triangular element shown in Fig.3.

   (5 marks)

10. Develop the FE formulation for an isoparametric 4 node quadratic element for solution of 2D elasticity problems.

11. Develop the Finite element formulation for a Resinner-Mindlin plate element.

12. Write short notes on:

   (i) Spurious energy modes. (4 marks)

   (ii) Frontal solver in FEA. (3 marks)

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**Module I: Classical approximate solution of boundary value problems & Introduction to FEA**	
1.1	Idealization of physical problems & mathematical modelling;	1
1.2	Basic equations of elasticity: Equilibrium, traction boundary conditions, Strain – Displacement relations — Constitutive relations; 2D idealization – Plane stress & Plane strain conditions	1
1.3	Approximate solution of boundary value problems – method of least squares,	1
1.4	Approximate solution of BVP-Weighted residual methods-structural mechanics applications.	2
1.5	Approximate solution of BVP -Variational approach (Rayleigh-Ritz method)- structural mechanics applications.	2
1.6	Introduction to Finite Element Method – History of development – Advantages – Disadvantages - General description of the method.	1
2	**Module II: Review of direct stiffness method & field approximations in FEA**	
2.1	Direct stiffness method – Review of basic concepts of matrix displacement analysis – formulation element stiffness matrices and load vectors for truss & beam	2

	elements	
2.2	Coordinate transformations, global assembly, global equilibrium solution, estimation of element forces.	2
2.3	Field approximation in FEA: Polynomial approximations - Convergence & Compatibility requirements	1
2.4	Polynomial approximation for 1D & 2D fields in global coordinates; continuity requirements.	1
2.5	1D & 2D Field approximation using Lagrange polynomials	1
2.6	Area coordinates and field approximation for CST & LST elements	1
2.7	Shape functions for serendipity elements	1
3	**Module III: Formulation of element equations**	
3.1	Development of equilibrium equations for finite elements– using principle of virtual work	1
3.2	Formulation of element equations (including consistent load vector) for 1D bar element for modelling axial behaviour.	1
3.3	Formulation of element equations (including consistent load vector) for 1D beam (Euler-Bernoulli) element for modelling flexural behaviour	2
3.4	Formulation of element equations (including consistent load vector) for CST element for modelling plane stress/strain problems	2
3.5	Formulation of LST & 4 node quadrilateral elements for modelling plane stress/strain problems	1
4	**Module IV: Isoparametric formulations & Numerical Integrations**	
4.1	Geometric approximation – concept of mapping – Isoparametric, sub-parametric and super-parametric mapping. Isoparametric Mapping/formulations for 1D line elements	2
4.2	Isoparametric mapping for planar bilinear elements; formulation of element equations for four node isoparametric quadrilateral element	2
4.3	Restrictions in mapping	1
4.4	Numerical integrations – introduction to Newton-Cotes and Gauss quadrature - Gauss quadrature formulae for 1D integration	2
4.5	Gauss quadrature formulae for 2D	1
5	**Module V: Plate elements, Storage & solution schemes for large system of equations**	
5.1	Introduction to plate bending – Kirchoff and Mindlin plate theories	2
5.2	FE formulations for Kirchoff and Mindlin Plate elements;	2
5.3	Shear locking, reduced and selective reduced integrations; Spurious energy modes;	1
5.4	Global assembly of element equations; Storage schemes in FEA – Banded and Skyline storage; Calculation of semi-band width – node numbering for optimal bandwidth	2
5.5	Solution schemes in FEA – Frontal solver; Discussion of modelling and analysis using recent commercial finite	1

	element software packages	

Reference Books

1. *Cook R D et al., Concepts and Applications of Finite Element Analysis, John Wiley & Sons, Singapore.*
2. *Logan D L, A First Course in Element Method,* Thomson, 2007.
3. *M. Asghar Bhatti, Fundamentals of Finite Element Analysis and Applications, John Wiley &Sons NewJersy, U.S.*
4. *J.N. Reddy, An Introduction to Finite Element Method, Tata McGraw Hill Publishing Company Ltd., New Delhi.*
5. *Hutton D V, Fundamentals of Finite Element Analysis, Tata McGraw Hill Education Private Ltd. New Delhi.*
6. *Krishnamoorthy C S, Finite Element Analysis- Theory and Programming, Tata McGraw Hill, New Delhi*
7. *Rajasekharan S, Finite Element Analysis in Engineering Design, Wheeler, New Delhi*
8. *Chandrupatla T R and Belegundu A D, Introduction to Finite Elements in Engineering, Pearson Education, New Delhi*
9. *Bathe K J, Finite Element Procedures in Engineering Analysis, Prentice Hall, New Delhi*
10. *Zienkiewicz O C and Taylor R W., Finite Element Method, Elsevier Butterworth-Heinemann, UK*

COURSE CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222PCE100	MINI PROJECT	PROJECT	0	0	4	2

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

The introduction of mini projects ensures preparedness of students to undertake dissertation. Students should identify a topic of interest in consultation with PG Programme Coordinator that should lead to their dissertation/research project. Demonstrate the novelty of the project through the results and outputs.The progress of the mini project is evaluated based on three reviews, two interim reviews and a final review. A report is required at the end of the semester.

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

Sl. No	Type of evaluations	Mark	Evaluation criteria
1	Interim evaluation 1	20	
2	Interim evaluation 2	20	
3	Final evaluation by a Committee	35	Will be evaluating the level of completion and demonstration of functionality/ specifications, clarity of presentation, oral examination, work knowledge and involvement
4	Report	15	the committee will be evaluating for the technical content, adequacy of references, templates followed and permitted plagiarism level(not more than 25%)
5	Supervisor/Guide	10	
	Total Marks	100	

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222LCE003	COMPUTATIONAL LAB	LABORATORY	0	0	2	1

Preamble: The course is intended to provide the students with an ability to model, analyse and interpret results by analysing and design various structural elements/whole structure using software packages such as SAP2000, ETABS, STAAD, ANSYS,ABAQUS, MATLAB, MATHCAD, MATHEMATICA, MS-EXCEL, MIDAS CIVIL, CSI BRIDGE, TEKLA, AUTOCAD, REVIT and. It also encompasses to develop a firm foundation for research and practice in StructuralEngineering. It also enables students to familiarize with industry standards projects with the help of cutting-edge technology and software available in the field at presentto have no gap between academia and industry. All design and detailing shall be done as per the latest BIS, IRC and other relevant Codes of Practice.

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

CO 1	Model structural elements/ whole structures using finite element packages.
CO 2	Analyse and design structural elements/ whole structures using finite element packages.
CO 3	Interpret results from finite element analysis packages.
CO 4	Draw structural details using AutoCAD.
CO 5	Write design reports.
CO 6	Develop bar bending schedule and bill of quantities from the structural drawings.

Mapping of course outcomes with program outcomes

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	100	–	–

Continuous Internal Evaluation Pattern:

The laboratory courses will be having only Continuous Internal Evaluation and carries 100 marks. Final assessment shall be done by two examiners; one examiner will be a senior faculty from the same department.

Syllabus and Course Plan

Concrete Structures

Analysis, design and detailing of a G + 10 residential building – Analysis, design and detailing of an overhead circular and rectangular water tanks with staging – Analysis, design and detailing of a ribbed slab floor system–Analysis, design and detailing of shear walls –Application of strut-and-tie method to design and detail various RC elements and junctions – Develop a spreadsheet for generation of interaction curves for RC rectangular columns– Design of slab bridge.

Steel Structures

Design of Steel Industrial Building –Design of Steel Multi-storey Building.

List of Experiments

Expt. No.	**Title**	**Hours Allotted**
1	Analysis, design and detailing of a G + 10 residential building without shear wall.	2
2	Analysis, design and detailing of an overhead circular water tank with staging.	2
3	Analysis, design and detailing of an overhead rectangular water tank with staging using LSM and IS 1893(Part 2)	2
4	Analysis, design and detailing of a ribbed slab floor system.	2
5	Analysis, design and detailing of a G + 10 residential building with shear wall.	2
6	Using strut-and-tie method, design and detail various RC elements and beam-column joints.	2
7	Develop a spreadsheet for generation of interaction curves for RC rectangular columns.	2
8	Design and detail a simply supported slab bridge of spans less than or equal to 6 m.	2
9	Design and detail a Multi-storey Steel Building.	2
10	Design and detail a Steel industrial building.	2
11	Design and detail a single span, straight RC Slab bridge.	2

Reference Books/Resources:

1. Manuals of SAP2000, ETABS, STAAD, ANYSYS, MATLAB, MATHCAD, MATHEMATICA, MS-EXCEL, MIDAS CIVIL, CSI BRIDGE, TEKLA, AUTOCAD, REVIT and ABAQUS.

2. IS 456:2000, "PLAIN AND REINFORCED CONCRETE - CODE OF PRACTICE", Bureau of Indian Standards New Delhi.

3. IS800:2007, "GENERAL CONSTRUCTION IN STEEL - CODE OF PRACTICE", Bureau of Indian Standards New Delhi.

4. IS 3370 (Part 1 to 4), "Concrete Structures for Retaining Aqueous Liquids - Code of Practice", Bureau of Indian Standards New Delhi.

5. IS 1893 (Part 1 to 6), "Criteria for Earthquake Resistant Design of Structures", Bureau of Indian Standards New Delhi.

6. IRC:112-2020,"Code of Practice for Concrete Road Bridges", Indian Roads CongressNew Delhi.

7. V. L. Shah and S. R. Karve,"Illustrated Design of Reinforced Concrete Buildings", Assorted Editorial.

SEMESTER II

PROGRAM ELECTIVE III

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222ECE036	STRUCTURAL HEALTH MONITORING	PROGRAMME ELECTIVE 3	3	0	0	3

Preamble: This subject is taught to impart knowledge about the Structural Health Monitoring Concepts.Diagnosis the distress in the structure by understanding the causes and factors.Assess the health of structure using static field methods and dynamic field tests.Suggest repairs and rehabilitation measures of the structure

Course Outcomes: The COs shown are only indicative. For each course, there can be 4 to 6 COs.

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

CO 1	Know the causes of Distress in structures, factors effecting structural health, need of regular maintenance of structures
CO 2	Understand the concept of structural health monitoring and various methods applied for monitoring of structures and structural safety
CO 3	Understand the importance of structural audit and Assessment of Health Structure, Collapse and Investigation, Investigation Management, SHM Procedures
CO 4	Know The Importance of Static field testing, Types of Static Tests, Simulation and Loading Methods, sensor systems and hardware requirements, Static Response Measurement
CO 5	Understand the Dynamic Field testing, stress History Data, Dynamic Response Methods, Hardware for Remote Data Acquisition systems, Remote Structural Health Monitoring.
CO 6	Introduction to Repairs and Rehabilitations of Structures impedance (EMI) technique, Adaptations of EMI technique

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment test	End Semester Examination
Remember	10	15
Understand	20	30
Apply	10	15
Create		

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Continuous Internal Evaluation: 40 marks Micro project/Course based project : 20 marks

Course based task/Seminar/Quiz : 10 marks

Test paper, 1 no. : 10 marks

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

End Semester Examination Pattern:

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. State the factors affecting Health of Structures

2.Write short notes on division of maintenance.

3.Define distress

4.Name different types of distress

5. What do you mean by deterioration? Explain themechanism of deterioration in concrete structures?

6. Discuss in detail various construction stage defects & their preventive measures?

7. Explain preventive maintenance of structures? Explainthem in detail

8. Write the different reasons for development of cracksdue to errors in design and detailing. Give preventivemeasures.

Course Outcome 2 (CO2)

1. Define the concept of health monitoring of structures

2. Explain the working system of components of structural health monitoring in detail.

3. Explain Active and Passive Smart Materials

4. What are SHM Technologies? Explain briefly.

5. Enumerate the dynamic response analysis using Laser Doppler Vibrometer

6. What are the challenges in Implementation of SHM

Course Outcome 3(CO3):

1. What are the importance and need of Non-Destructive Testing
2. Basic Methods for NDT of Concrete Structures. Explain
3. What are quality control tests
4. Explain fundamental principle of partial destructive tests
5. Visual Inspection Test
6. Schmidt Rebound Hammer Test

Course Outcome 4 (CO4):

1. Explain the different Types of Static Tests in detail.
2. Discuss Simulation and Loading Methods in staticstructural health monitoring.
3. Explain the role of sensor systems in static structuralhealth monitoring.
4. What are the functions of hardware tools in staticstructural health monitoring?
5. Explain about Static Response Measurement Remember
6. Explain long-Term static structural health monitoring?
7. What is seismic structural health monitoring?
8. Write short notes on intelligent structural healthmonitoring?
9. List out the applications of structural health monitoring in post-earth quake controls.
10. What are smart material and explain their applications in structural health monitoring

Course Outcome 5 (CO5):

1. Explain the application and Adaptations of EMItechnique in structural health monitoring.

2.Write a short notes on data based techniques invibration based structural health monitoring.

3. Define and explain in detail about electro–mechanicalimpedance (EMI) technique

4. Explain the procedure for Adaptations of EMItechnique.

5. Name the types of Dynamic Field Test

6. What is vibration based structural health monitoring.

7. State the different forms of Dynamic ResponseMethods

8. What is Dynamic Response Method remember

9. Name different types of sensors used in structuralhealth monitoring

10. Define epoxy resins.

Course Outcome 6 (CO6):

1. Define repair in a structure

2.Discuss the method of underpinning in detail.

3. Discuss the various types of blanket repair techniques.

4. Enumerate the different methods available for repairsof concrete works. Discuss the any one in detail.

Model Question Paper

Time 2.5 hrs Maximum: 60marks

PART A

Answer all questions; each question carries 5 marks

1. What is the structural health monitoring? Explain scope of structural health monitoring?

2. Explain the role of piezoelectric sensors in structural health monitoring

3. Fundamental Principle of Partial Destructive Tests

4. What are the pros and cons of static structural healthmonitoring system

5.Explain about Electrical-Mechanical Impedance (EMI) Method?

PART B

Answer any five questions; each question carries 7 marks

6. What is distress? Give its classification.

7. Explain the Role of Smart Materials in Structural Health Monitoring System and Discuss aboutActive and Passive Smart Materials?

8. Explain in detail assessment of a health of a structure by NDT's equipment.

9.Describe the procedure of behavioral test and its importance.

10.Explain stress history data of dynamic field testing

11.Enumerate the different methods available for repairsof concrete works. Discuss the any one in detail.

12.Explain the Process of Guniting in Detail With Figure.

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**Introduction to Structural Health Monitoring**:	
1.1	Definition of Structural Health Monitoring SHM – Principle and Organization of a SHM System – SHM versus NDE – Advantages of SHM - Factors affecting Health of Structures	2hr
1.2	Repair and Rehabilitation - Facets of Maintenance – importance of Maintenance	1hr
1.3	Various aspects of Inspection - Assessment procedure for evaluating a damaged structure – causes of deterioration	1.5hr
2	**Structural Health Monitoring :**	
2.1	Concepts, Various Measures, Structural Safety in Alteration	1hr
2.2	Active and Passive Smart Materials – SHM Technologies – Piezoelectric Sensors – Magneto strictive Sensors – Optical Fibre Sensors	2hr
2.3	Dynamic Response Analysis using Laser Doppler Vibrometer – Challenges in Implementation of SHM	1hr
3	**Structural Audit :**	
3.1	Assessment of Health of Structure- Assessment by NDT equipment‘s	1hr
3.2	Introduction to NDT – Importance and Need of Non-Destructive Testing – Basic Methods for NDT of Concrete Structures – Testing of Concrete – Quality Control Tests	2hr
3.3	Partial Destructive Tests – Fundamental Principle – Equipment –General Procedure - Visual Inspection Test-Schmidt Rebound Hammer Test	2hr
3.4	Collapse and Investigation Management, SHM Procedures	1hr
4	**Static Field Testing :**	
4.1	Types of Static Tests, Static Testing- Static field testing-types of static tests loading methods	2hr
4.2	Behavioral/ Diagnostic tests - Proof tests -Static response measurement – strain gauges, LVDTs, dial gauges	2hr
4.3	Case study	2hr
5	**Dynamic Field Testing and rehabilitation:**	
5.1	Types of dynamic tests - Stress history data -Dynamic load allowance tests Ambient vibration tests – Forced Vibration Method - Dynamic response methods - Impact hammer testing- Shaker testing - Periodic and continuous monitoring	3hr
5.2	Introduction to Repairs and Rehabilitations of Structures:	3hr

	Repair of Structure – Common types of Repairs – Repair in Concrete Structures – Repairs in Under Water Structures – Guniting– Shot Create – Underpinning. Strengthening of Structures – Strengthening Methods – Retrofitting– Jacketing.	
5.3	Case Studies(Site Visits) electro mechanical impedance (EMI) technique, adaptations of EMI technique	1hr

Reference Books

1. Hua-Peng Chen, Structural Health Monitoring of Large Civil Engineering Structures ,John Wiley & Sons Ltd, Year: 2018

2. Douglas E Adams, Health Monitoring of Structural Materials and Component - Methods with Applications, John Wiley and Sons, 2007.

3. Bhattacharjee, Concrete Structures Repair Rehabilitation and Retrofitting, CBS; first edition (2019).

4. J. P. Ou, H. Li and Z. D. Duan, Taylor, Structural Health Monitoring and Intelligent Infrastructure, Vol1, and Francis Group, London, UK, 2006

5. Victor Giurglutiu, Structural Health Monitoring with Wafer Active Sensors, Academic Press Inc, 2007

6. Daniel Balageas, Claus Peter Fritzen, Alfredo Güemes, Structural Health Monitoring,John Wiley and Sons, 2006

7. Fu-Kuo, Chang Structural Health Monitoring: Current Status and Perspectives CRC Press; 1 edition (24 April 1998)

8. Structural Health Monitoring of Civil Infrastructure System, Vistasp M. Karbhari and Farhad Ansari, Wood Head Publishing Limited, Cambridge, 2009.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222ECE037	DESIGN OF BRIDGES	PROGRAMME ELECTIVE 3	3	0	0	3

Preamble: The course aims to provide a basic understanding of the concepts and design of both concrete and steel bridges as per the latest Indian Road Congress (IRC) and Indian Railway Standard (IRS) specifications. The student is expected to independently plan, analyse, design, and detail various types and components of bridges after completion of this course. The students will be exposed through field visits (whenever feasible) to real-life bridge design and construction practices.

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

CO 1	Review bridge specifications as per current IRC and IRS standards for bridges.
CO 2	Design and detail slab and T beam bridges.
CO 3	Design and detail box culvert and Prestressed Concrete bridges.
CO 4	Design and detail plate girder and composite bridges
CO 5	Design elastomeric bearings in bridges.
CO 6	Analyse substructures and foundations in bridges.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	Continuous Evaluation (Marks)	End Semester Examination(Marks)
Remember	10	15
Understand	10	15
Apply	15	25
Analyse	5	5
Evaluate	–	–
Create	–	–

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

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

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

Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

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

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

Model Question Paper

C

PART A

(Answer *ALL* questions)

1. What are impact factors? How these factors vary with respect to the type of loading, span, and type of bridge?
2. List the live loads to be considered in the design of road bridges?
3. Explain the effective width procedure for finding moments due to concentrated loads acting on one-way slabs.
4. Explain Courbon's method of finding reaction factors in a T beam girder bridge using an example.
5. Sketch a single cell box culvert and mark the components.

PART B

(Answer Any *FIVE* questions only)

6. (a) Explain the classification of bridges with sketches.
   (b) Explain the importance of site investigation in bridge engineering.

12. Design an interior cross girder for a T beam bridge for the following data: Effective span = 16 m, Live load – IRC Class 70R tracked; Materials – M25 concrete and Fe 415 steel; spacing of cross girders 5 m c/c; width of carriage way 7.5m; thickness of wearing coat = 80 mm; kerbs on either side = 600 mm wide × 300 mm deep; width of main girder = 300 mm; width of cross girder = 300 mm; spacing of main girders = 2.5 m c/c. Sketch reinforcement details.

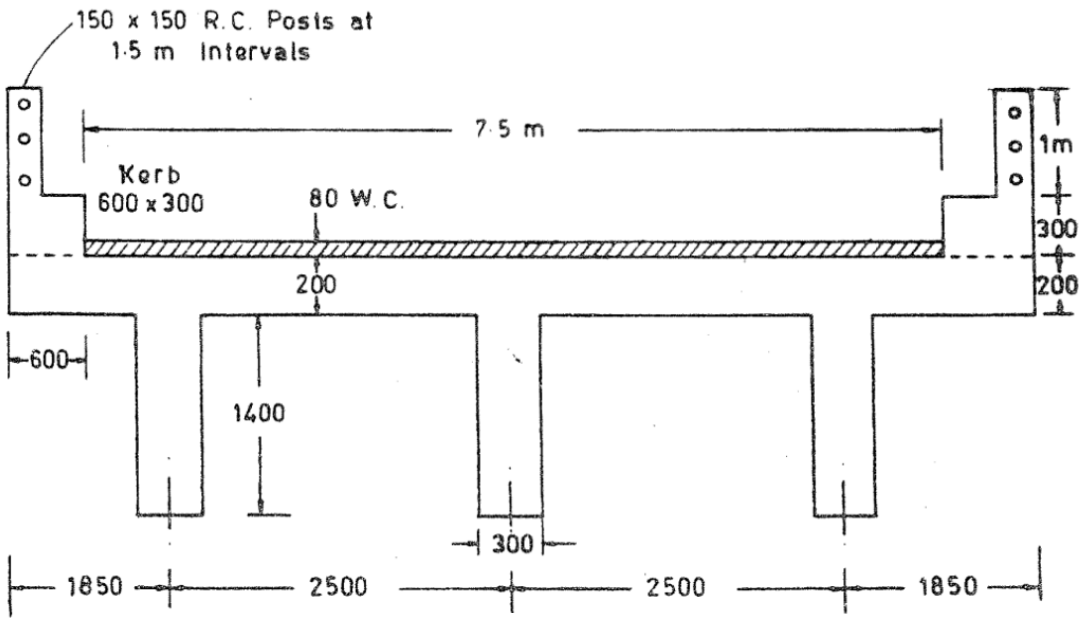
13. Design an interior longitudinal girder of a post tensioned prestressed concrete T beam bridge with the following data: Effective span = 24 m; Width of carriageway = 7.5 m; Kerbs 600 mm wide on either side; Spacing of main girders = 2 m; Spacing of cross girders = 4 m; Loading is IRC Class 70R tracked vehicle; Adopt M50 concrete and high tensile steel strands of 7 ply – 15.2 mm diameter with ultimate strength of 1800 MPa. Use Fe 415 grade steel for supplementary reinforcements. Assume loss ratio = 0.85.

14. Design a welded deck type plate girder bridge for a BG track to suit the following data: Effective span = 40 m; Dead load of track = 10 kN/m; Equivalent uniformly distributed load for bending moment calculations/track = 3498 kN; Equivalent uniformly distributed load for shear force calculations/track = 3815 kN. Take CDA = 0.324. Use plates of Fe410 grade.
15. Design an elastomeric bearing as per IRC 83 Part 2:2018 with the following data.

    Maximum vertical design force = 1009 kN

Minimum vertical design force = 666 kN
Horizontal force along span direction = 10.39 kN
Horizontal force along width direction = 41.56 kN
Resultant of all horizontal forces = 42.84 kN
Relative displacement in the direction of dimension '*a*' = 3.77 mm
Relative displacement in the direction of dimension '*b*' = 1.88 mm
Angle of rotation across the width 'a' of bearing = 0.00381
Angle of rotation across the length 'b' of bearing = 0.001
Adopt an elastomeric bearing (based on International Standards) of dimension 250 mm(*a*) × 400 mm(*b*)
Yield strength of steel laminate = 500 MPa

16. Design the main girder of a steel-concrete composite bridge as per relevant IRC standards to cover a span of 36m and for a three-lane carriage way. Use IRC- Class A loading.
17. Find out the distribution coefficient for the outer and central girder having the same moment of inertia as shown in the figure below, when single lane of class AA tracked loading is placed on the deck with maximum eccentricity. The distance between centre lines of bearing of the deck is 16 meters.



All dimensions are in mm.

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Syllabus

Module 1

Introduction to bridges: Importance of site investigation–Classification and components of bridges–Review of road (IRC) and railway (IRS) bridge specifications.

Module 2

Slab and T Beam Bridges: Loads on slabs, Effective width method–Design of straight and skew slab bridges as per relevant IRC loads–Design of interior panel of deck slab, Pigeauds curves–Distribution of loads on Girders – Courbon's method–Design of T beam bridges (up to three girders only) as per relevant IRC loads.

Module 3

Box culvert and Prestressed Concrete Bridges: Box culvert bridges–General aspects–Design of box culvert bridges (single cell) as per relevant IRC loads–Pre-stressed Concrete Bridges: Design of single span bridges–Introduction to various forms-Slab bridges-girder bridges-box girder bridges.

Module 4

Steel and Composite bridges: Design of plate girder (bolted and welded connection)–Design of Composite bridge (RCC slab over steel girder)–Theory-Load carrying action of folded plates.

Module 5

Bearings, substructures, and foundations in bridges: Design of elastomeric bearings–Abutments – General features, Loads on abutments, Stability analysis of abutments–Piers – Types, Loads on Piers, Stability analysis of Piers–Bridge Foundations – Types, selection criteria and suitability.

Course Plan

No	Topic	No. of Lectures
1	**Introduction to bridges (6)**	
1.1	Importance of site investigation	1
1.2	Classification and components of bridges	2
1.3	Review of road (IRC) and railway (IRS) bridge specifications	3
2	**Slab and T Beam Bridges (10)**	
2.1	Loads on slabs, Effective width method	1
2.2	Design of straight and skew slab bridges as per relevant IRC loads	3
2.3	Design of interior panel of deck slab, Pigeauds curves	1
2.4	Distribution of loads on Girders – Courbon's method	1

2.5	Design of T beam bridges (up to three girders only)as per relevant IRC loads	4
3	**Box culvert and Prestressed Concrete Bridges (9)**	
3.1	Box culvert bridges **-** General aspects	1
3.2	Design of box culvert bridges (single cell) as per relevant IRC loads	3
3.3	Pre- stressed Concrete Bridges: Design of single span bridges-	3
3.4	Introduction to various forms-Slab bridges-girder bridges-box girder bridges	2
4	**Steel and Composite bridges (6)**	
4.1	Design of plate girder [bolted and welded connection]	3
4.2	Design of Composite bridge (RCC slab over steel girder)	3
5	**Bearings, substructures, and foundations in bridges (9)**	
5.1	Design of elastomeric bearings	3
5.2	Abutments – General features, Loads on abutments, Stability analysis of abutments	3
5.3	Piers – Types, Loads on Piers, Stability analysis of Piers	2
5.4	Bridge Foundations – Types, selection criteria and suitability	1

Reference Books

1.Johnson Victor. D, “Essentials of Bridge Engineering”, Oxford.
2.N Krishna Raju, “Design of Bridges, Oxford and IBH publishing.
3.Jagadeesh T. R. and Jayaram M. A., “Design of bridge structures”, Prentice Hall of India.
4.Praveen Nagarajan, “Design of Concrete Bridges”, Wiley India Pvt. Ltd.
5. S. Ponnuswamy, “Bridge Engineering”, McGraw Hill Education.
6. Wai-Fah Chen, “Bridge Engineering Handbook: Substructure Design”, CRC Press.
7. V. K. Raina, Raina's Guiding Principles for Design, Construction, Load Capacity Evaluation, Load Testing, & Approximate Costing of 99% of All Bridges, Shroff Publisher.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222ECE038	STABILITY OF STRUCTURES	PROGRAMME ELECTIVE 3	3	0	0	3

Preamble: The course aims to provide anin-depth understanding on how and under what loading condition, a structure becomes unstable. The student is expected to learn stabilty analysis of various structures and how this theoretical knowledge can be transferred to design methods and guidelines. The students will be able to appreciate all structural design standards and confidentally design various structures.

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

CO 1	To Identify the relevance of Stability analysis in structures
CO 2	Perform Stabilty Analysis of Columns
CO 3	Perform Stabilty Analysis of Beam - Columns
CO 4	Carryout Stability analysis of Frames with various Boundary and loading conditions
CO 5	To analyse the lateral stability of beams & Buckling of Thin-Walled Open Sections
CO 6	Perform Stability analysis of Plated and shell structures

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	End Semester Examination
Remember	10
Understand	15
Apply	25
Analyse	10
Evaluate	–
Create	–

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewedoriginal publications (minimum 10 publications shall be referred): 15 marks

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

Test paper 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

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

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

Model Question Paper

Max Marks 60 **Duration 2.5 Hours**

PART A

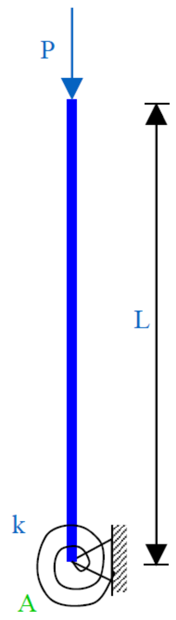
(Answer *ALL* questions , each question carries 5 marks)

1. Explain bifurcation buckling and limit load buckling.
2. Explain Rayleigh-Ritz method for estimation of buckling load of columns.
3. Derive the differential equation for a beam-column.
4. Describe in detail torsional and torsional-flexural buckling.
5. Differentiate between thin and thick plates.

PART B

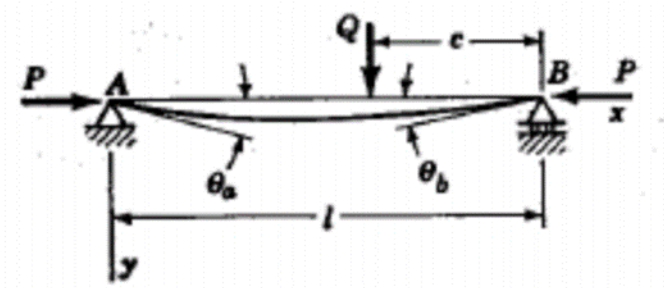
(Answer Any *FIVE* questions only, each question carries 7 marks)

6. Obtain the elastic buckling load of the system composed of a rigid bar partially fixed at the base by a rotational spring as shown in the figure. Use energy approach.



7. Using higher order differential equation representing the buckling behaviour of columns , estimate the buckling load for a column with fixed-fixed conditions

8. Find the buckling load of given beam- column



9. Explain post buckling strength.
10. Describe various buckling modes of Thin-walled open sections
11. Find the buckling load of cylindrical shell subjected to uniform external pressure.
12. Find the critical load for a simply supported plate uniformly compressed in one direction.

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**Concepts of Stability (6)**	
1.1	Introduction - Stability Criteria – Stable, unstable and neutral Equilibrium	2
1.2	Fourth order Elastic- largedeflection of bars - differential equation for generalizedbending problems	2
1.3	Elastic instability of columns-Euler's theory-assumptions and limitations-Energy principles	2
2	**Compression Members (9)**	
2.1	Higher order Differential equations - analysis for various boundary conditions	2
2.2	Behaviour of imperfect column -initially bent column - eccentrically loaded column	2
2.3	Energy method- Rayleigh Ritz, Galerkin methods	1
2.4	Effect of shear on buckling – Large deflection ofcolumns.	2
2.5	Matrix Stiffness Method – Flexural members and compression members	2
3	**Beam Columns & Buckling of Frames (7)**	
3.1	Beam Columns:Introduction – Differential Equation forBeam-columns	1
3.2	Solution of differential equation forconcentrated lateral loads - distributed loads – differentend conditions - bottom fixed-bottom hinged	3
3.3	Buckling of frames: Solutions for various end conditions	2
3.4	Horizontal compressionmembers	1
4	**Lateral Stability of Beams & Buckling of Thin-Walled Open Sections (7)**	
4.1	Lateral Stability of Beams: Differential equations forlateral buckling	2
4.2	Lateral buckling of beams in purebending	1
4.3	Lateral buckling of cantilever and simplysupported I beams	1
4.4	Buckling of Thin-Walled Open Sections: Introduction	1
4.5	Torsional buckling - Torsional flexural buckling	1
4.6	Equilibrium and energy approaches	1
5	**Stability of Plates and Shells(11)**	
5.1	Stability of Plates -Governing Differential equation - Equilibrium, energy concepts	2
5.2	Buckling of rectangularplates of various end conditions	3
5.3	Finite differencemethod - post-buckling strength	2
6.1	Donnel's Equation – SymmetricalBuckling of Cylinder under uniform axial Compression	2
6.2	Cylinder under uniform external lateral pressure	1
6.3	Cylinder subjected to torsion.	1

Reference Books

1. Chajes, A., " Principles of Structural Stability Theory", Prentice Hall, 1974.
2. Iyengar, N.G.R., "Elastic Stability of Structural Elements", Macmillan India Ltd.,Newdelhi,2007.
3. Ziegler H, “Principles of structural stability”, Blarsdell, Wallham, Mass, 1963.
4. Thompson J M, G W Hunt, “General stability of elastic stability”, Wiley,New York.
5. Timoshenko, Gere, “Theory of elastic stability”, Mc Graw Hill, New York.
6. Don O Brush, B O Almorth, “Buckling of Bars, plates and shells”, Mc Graw Hill,1975
7. Cox H L, “The buckling of plates and shells”, Macmillam, New York, 1963.
8. AshwiniKukar, "Stability of Structures ", Allied Publishers LTD, New Delhi, 1998.
9. Murali L. Gambir,” Stability Analysis and Design of Strucures”, Springer-Verlog, Berlin, 2004

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222ECE039	THEORY OF PLATES AND SHELLS	PROGRAMME ELECTIVE 3	3	0	0	3

Preamble: The course aims to provide a basic understating of the behaviour of the plates and shells with different geometry under various types of loads. The student is expected to identify the various thin-walled structures in the form of plates and shellssuitable foruse in different structural systems.

Course Outcomes: After the completion of the course on Theory of Plates and Shellsthe student will be able to

CO 1	Explain the classification of plates, assumptions in the theory of thin plates and bending of long rectangular plates to a cylindrical surface
CO 2	Describe symmetrical bending of circular plates and use the concept to analyse annular plates
CO 3	Derive the differential equations for small deflections of laterally loaded plates for different boundary conditions and solve using Navier and Levy's method
CO 4	Understand the theory of folded plates
CO 5	Explain the theory, load carrying mechanism, state of stress and classification of shells
CO 6	Compute the stresses in cylindrical shell under dead and snow loads

Mapping of course outcomes with program outcomes

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

(1-Weak, 2-Medium, 3- strong)

Assessment Pattern

Bloom's Category	End Semester Examination
Remember	10
Understand	38
Apply	12
Analyse	
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed

original publications (minimum 10 publications shall be referred): 15 marks

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

Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

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

Students should answer all questions. Part B will contain 7 questions (suchquestions shall be useful in the testing of overall achievement and maturity of thestudents in a course, through long answer questions relating totheoretical/practical knowledge, derivations, problem solving and quantitativeevaluation), with minimum one question from each module of which studentshould answer any five. Each question can carry 7 marks.

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

Model Question Paper

QP CODE:

Reg No.:______________

Name:_________________________ ___

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

MONTH & YEAR

Course Code: XXXX

THEORY OF PLATES AND SHELLS

Max. Marks: 60 Duration: 2.5 hours

PART A

(Answer ALL questions; each question carries 5 marks)

1. Show that for the small deflection of a plate subjected to pure bending, the directions of zero slope and max slope are perpendicular to each other.
2. A solid circular plate of radius 0.3 m with its outer edge completely restrained is subjected to a pressure load of 10 MPa. If the allowable stress in the plate is limited to 100 MPa, determine (i) The thickness of the plate, (ii) The maximum deflection, (iii) The stress at the centre of the plate. Take E = 200 GPa, ν = 0.3.
3. How would you compare Navier solution and Levy's solution as used for simply supported rectangular plates?
4. How shells are classified based on Gaussian curvature?
5. Show that there is a compression along the meridians of a spherical shell of radius a subjected to the action of its own weight of magnitude q per unit area.

PART B

(Answer any FIVE questions; each question carries 7 marks)

6. Derive the differential equation for the cylindrical bending of long rectangular plates.
7. Derive the differential equation for symmetrical bending of laterally loaded circular plates and obtain the expression for maximum deflection for circular plate with clamped edges.
8. Find the deflection of a circular plate (radius a) with a hole (radius b) at the centre and subjected to moments M1 and M2 at the inner and outer edges respectively.

9. Obtain the differential equation for the small deflections of a laterally loaded plate.
10. A rectangular plate ($\boldsymbol{a} \times \boldsymbol{b} \times \boldsymbol{h}$), simply supported on all four edges is subjected to sinusoidal load ($\boldsymbol{q_0 \sin\frac{\pi x}{a} \sin\frac{\pi y}{b}}$) distributed over the surface of the plate. Find expressions for deflection ($\boldsymbol{w}$), bending moments ($\boldsymbol{M_x}$, $\boldsymbol{M_y}$)
11. Explain the load carrying mechanism of shells.
12. Develop the expressions for the displacements in symmetrically loaded shells having the form of a surface of revolution.

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Syllabus

Module 1

Introduction- Classification of plates -Assumptions in the theory of thin plates-Bending of long rectangular plates to a cylindrical surface. Pure bending of plates-Slope and curvature - Relations between bending moments and curvature-Particular cases of pure bending.

Module 2

Symmetrical bending of circular plates-Differentialequation. Uniformly loaded circular plates with simplysupported and fixed boundary conditions-Annular plate withuniform moments and shear forces along the boundaries.

Module 3

Small deflections of laterally loaded plates-Differentialequation-Boundary conditions-Navier solution and Levy'ssolution for simply supported rectangular plates.

Module 4

Theory-Load carrying action of folded plates.

Classical shell theory- Load carrying mechanism of shells - Types of state of stress for thin shells-Classification of Shells.

Module 5

Shells in the form of a surface of revolution, displacements. Membrane theory of cylindrical shells. General theory of cylindrical shells-A circular cylindrical shell loaded symmetrically with respect to its axis- stresses in cylindrical shell under dead and snow loads.

Course Plan

No	Topic	No. of Lectures
1	**Pure Bending of Plates (10)**	
1.1	Introduction- Classification of plates -Assumptions in the theory of thin plates. Bending of long rectangular plates to a cylindrical surface – Differential equation.	2
1.2	Pure bending of plates-Slope and curvature.	2
1.3	Relations between bending moments and curvature-Particular cases of pure bending.	6
2	**Circular Plates (6)**	
2.1	Symmetrical bending of circular plates-Differentialequation.	1
2.2	Uniformly loaded circular plates with simplysupported and fixed boundary conditions	2
2.3	Annular plate withuniform moments and shear forces along the boundaries.	3
3	**Laterally loaded Plates (10)**	
3.1	Small deflections of laterally loaded plates-Differential equation - Boundary conditions.	4
3.2	Simply supported rectangular plates under sinusoidal load.	2
3.3	Navier solution and Levy's solution for simply supported rectangular plates.	4
4	**Folded Plates and shells (6)**	
4.1	Theory-Load carrying action of folded plates.	2
4.2	Classical shell theory- Load carrying mechanism of shells.	2
4.3	Types of state of stress for thin shells-Classification of shells.	2
5	**Theory of Shells (8)**	
5.1	Displacements in symmetrically loaded shells having the form of a surface of revolution.	2
5.2	Membrane theory of cylindrical shells.	2
5.3	General theory of cylindrical shells-A circular cylindrical shell loaded symmetrically with respect to its axis- stresses in cylindrical shell under dead and snow loads.	4

Reference Books

1. Timoshenko S.P. and Krieger S. W., Theory of Plates and Shells, Tata McGraw Hill, 1959
2. Chandrashekhara K., Theory of Shells, Universities(India)Press Ltd., 2001
3. Ramaswamy G. S., Design and Construction of Concrete Shell Roofs, CBS Publishers, 2005
4. Bairagi N. K., Plate Analysis, Khanna Publishers, 1986

5. Kelkar V. S. and Sewell R.T., Fundamentals of the Analysis and Design of Shell Structures, Prentice Hall Inc., 1987
6. T.K.Varadan& K. Bhaskar, Análysis of plates – Theory and problems, Narosha Publishing Co., 1999.
7. Reddy J N., Theory and Analysis of Plates and Shells, Taylor and Francis, 2006

SEMESTER II

PROGRAM ELECTIVE IV

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222TCE042	ADVANCED COMPOSITE STRUCTURES	PROGRAMME ELECTIVE 4	3	0	0	3

Preamble: The course aims to provide a basic understating of the concepts and design of both concrete and steel composite structures. The student is expected to analyse and design various types composite structures, after the completion of this course The students are also able to apply the knowledge in real civil engineering problems and to design new and advanced composite structures.

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

CO 1	Understand the behaviour of composite structures and its components.
CO 2	Familiarise the various types of composite structural elements.
CO 3	Describe shear connectors and profile sheeting
CO 4	Analyse the various composite structural elements.
CO 5	Design the various composite structural elements.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	End Semester Examination
Remember	10
Understand	10
Apply	25
Analyse	15
Evaluate	..
Create	..

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

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

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

Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

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

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

Model Question Paper

PART A

(Answer ALL questions; each question carries 5 marks)

1. What is the difference between RCC and steel-concrete composite construction?
2. What are the characteristics of shear connectors?
3. Write short note on selection of effective breadth of composite beam?
4. What are the structural benefits of using composite floors with profiled steel decking?
5. Comment on the mechanism of load resistance in composite columns

PART B

(Answer any FIVE questions; each question carries 7 marks)

6. Explain with sketches no interaction and full interaction cases in a composite beam.
7. What are shear connectors? Explain different types of shear connectors.
8. Design a simple supported composite beam with 10 m span spaced at 3.2 m c/c. Thickness of the slab is 150 mm. The floor has to carry an imposed load of 3.5kN/m2, a construction load of 1 kN/m2 and floor finish load of 1kN/m2. Assume that the floor is not propped during construction. Use M30 grade concrete.
9. Describe the structural elements of a composite floor system.
10. Obtain the plastic resistance of a steel section made of ISHB350 encased in M30 concrete. The height of the column is 3.4 m and is pinned at both the supports. The dimension of the column is 450 mm × 450 mm. The cover to the flanges is 50 mm. Reinforcement steel is provided as 0.4 % of gross concrete
11. Check the adequacy of the composite beam at composite stage having a span 12 m, spacing of the beams= 3 m, thickness of slab = 120 mm. Floor is carrying an imposed load of 3.0 kN/m^2, partition load of 1.5 kN/m^2 and floor finish of 0.5 kN/m^2.
12. What are the Analysis for internal forces and moments of composite slabs? Describe the effective width of composite slab for concentrated point and line loads.

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**Composite structures (8)**	
1.1	Introduction to Composite construction	2
1.2	General behaviour of composite beams and columns	3
1.3	Elastic behaviour of composite beams No interaction case, Full interaction case	3
2	**Shear connectors (7)**	
2.1	Types of shear connectors	1
2.2	Mechanism of dowel action	1
2.3	Characteristics of shear connectors	3
2.4	Load bearing mechanism of shear connectors	1
2.5	Strength of connectors	1
3	**Composite beam (8)**	
3.1	Ultimate load behaviour of composite beam	2
3.2	Provision for service opening in composite beams	1
3.3	Serviceability limit states, Basic design considerations	2
3.4	Design of composite beams	3
4	**Composite floors (8)**	
4.1	Composite profiled slabs and profiled decking	2
4.2	Bending resistance of composite slab	2
4.3	Shear resistance of composite slab	2
4.4	Analysis for internal forces and moments	1
4.5	Serviceability criteria, Design steps of profiled decking	1
5	**Composite columns (9)**	
5.1	Material properties and partial safety factors of composite construction	1
5.2	Combined compression and uni-axial bending	2
5.3	Combined compression and bi-axial bending	2
5.4	Composite column design	4

Reference Books

1. Johnson R.P, Composite Structures of Steel and Concrete, Vol.1Beams, Slabs, Columns and Frames in Buildings, Oxford Blackwell Scientific Publications, London.
2. INSDAG teaching resource for structural steel design, Vol 2, INSDAG, IspatNiketan, Calcutta.
3. Deric J. Oehlers, and Mark A. Bradford, Composite Steel and Concrete Structural Members Fundamental Behaviour, The University of Adelaide, Australia and University of New South Wales, Australia, Pergamon

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222ECE043	DESIGN OF EARTHQUAKE RESISTANT STRUCTURES	PROGRAMME ELECTIVE 4	3	0	0	3

Preamble: The course provides the basic principles of earthquake resistant design of structures. Students are introduced to the engineering aspects of earthquakes, their characterisation and effects. The course covers seismic design force computation, design and detailing as per Indian Standards. An introduction to seismic evaluation and retrofitting is also included.

Course Outcomes: After the completion of the course on Design of Earthquake Resistant Structures the student will be able to

CO 1	Describe various engineering aspects of earthquakes, earthquake effects and earthquake resistant design.
CO 2	Apply IS code provisions for the analysis, design and detailing of earthquake resistant structures.
CO 3	Develop earthquake response spectrum.
CO 4	Perform response spectrum analysis of multi-storied frames.
CO 5	Analyse and design shear walls.
CO 6	Describe different strategies for seismic evaluation and seismic retrofitting.

Mapping of course outcomes with program outcomes

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

(1- Weak, 2-Medium, 3- strong)

Assessment Pattern

Bloom's Category	End Semester Examination
Remember	
Understand	25
Apply	14
Analyse	21
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed

original publications (minimum 10 publications shall be referred): 15 marks

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

Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

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

Students should answer all questions. Part B will contain 7 questions (suchquestions shall be useful in the testing of overall achievement and maturity of thestudents in a course, through long answer questions relating totheoretical/practical knowledge, derivations, problem solving and quantitativeevaluation), with minimum one question from each module of which studentshould answer any five. Each question can carry 7 marks.

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

Model Question Paper

QP CODE:

Reg No.:______________

Name:__________________________ ___

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

MONTH & YEAR

Course Code: XXXX

DESIGN OF EARTHQUAKE RESISTANT STRUCTURES

Max. Marks: 60 Duration: 2.5 hours

PART A

(Answer ***ALL*** questions; each question carries 5 marks)

1. Distinguish between *magnitude* and *intensity* of earthquake.
2. Explain the philosophy of earthquake resistant design.
3. Can the exact value of maximum seismic response of a multi-degree of freedom be determined using response spectrum analysis? Explain.
4. Explain the significance of ductility in earthquake resistant design.
5. What do you mean by retrofitting of structures? Explain the retrofitting methods used for RC columns.

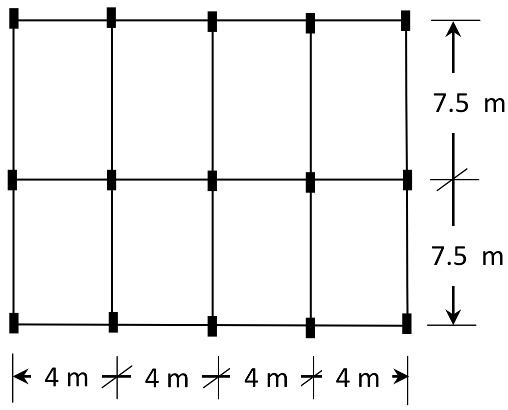
PART B

(Answer ***any FIVE*** questions; each question carries 7 marks)

6. Figure shows the plan of a four storied RC framed structure to be constructed in Bangalore. Height of each story is 3.0 m. Calculate the seismic forces at various floor levels.

   Data given:

   Column section : 23×60 cm.
   Beam section : 23×55 cm.
   Slab Thickness : 13 cm.
   Thickness of brick wall around: 23 cm.
   Live load on floors : 4 kN/m^2
   Live load on roof : 1.5 kN/m^2
   Unit weight of concrete : 25 kN/m^3
   Unit weight of brick wall : 20 kN/m^3



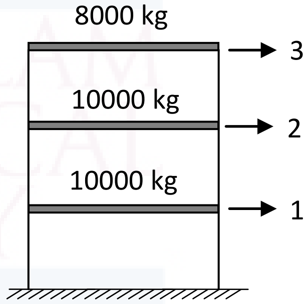
Frame type : SMRF
Type of soil : Soft soil

Missing data may be suitably assumed.

7. Explain the factors which ensure proper seismic behaviour of a building.

8. The natural frequencies (in rad/s) of the three storied shear building shown below are 6.57, 16.91 and 24.67. The mass normalized modal matrix is

$$\begin{bmatrix} 0.0034 & 0.0066 & 0.0067 \\ 0.0061 & 0.0038 & -0.0069 \\ 0.0080 & -0.0072 & 0.0031 \end{bmatrix}.$$

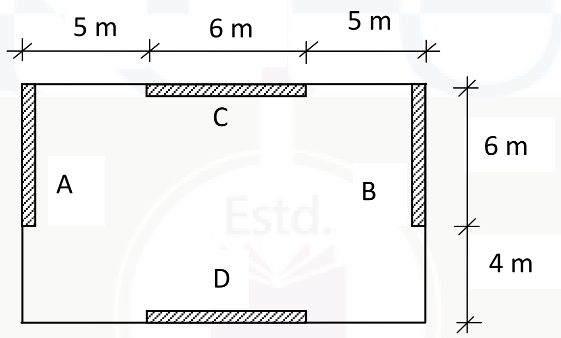


The damping may be assumed as 5% for all modes. Using response spectrum method calculate the base shear.

Assume that the building is to be constructed in Zone V and the foundation soil is Type I (hard soil). The frame may be assumed as SMRF. Take importance factor as 1.5. Use SRSS rule to combine the modal responses.

9. Explain how the ductility of RC members can be increased.

10. Plan of a single storey building having two shear walls in each direction is shown. The shear walls are 6 m long and 200 mm thick. Design shear force on the building is 120 kN in either direction. Determine the design lateral force in shear wall A using the torsion provisions of the IS code.



11. A slender shear wall of length 6 m and thickness 200 mm carries an axial load of 2700 kN. The wall is reinforced with 10# bars at 250 mm c/c in two layers. If M25 concrete and Fe415 steel are used, estimate the moment of resistance of the wall.

12. What is seismic evaluation? When is it required? Explain the different steps in seismic evaluation.

****

Syllabus

Module 1

Introduction to earthquakes and earthquake engineering, Mechanism of earthquake, seismic waves, effects of earthquakes. Measurement of earthquakes, magnitude and intensity, seismographs. Strong motion characteristics, response spectrum, Fourier spectrum. Characteristics of response spectrum, Design spectrum, construction of tripartite response spectrum.

Module 2

Effect of architectural features and structural irregularities. Damages of structures during past earthquakes, principles of earthquake resistant construction.

Philosophy of earthquake resistant design. Code provisions as per IS:1893 and IS:4326.

Module 3

Design seismic force calculation in multi storied frames. Dynamic analysis, Introduction to response spectrum analysis – theoretical aspects, Modal combination rules.

Design seismic force calculation in multi storied frames using response spectrum method.

Module 4

Ductility – Significance, Ductility factors. Ductile detailing considerations as per IS:13920. Design and detailing of structural members. Reinforcement detailing in joints.

Module 5

Torsion – code provisions, Shear walls – design force calculation, Design of shear wall, Design and detailing for earthquake resistance – Discussion of code provisions in IS 13920.

Repair and rehabilitation. Seismic evaluation and vulnerability assessment – Methods, Disaster mitigation, Response reduction techniques, Base isolation.

Course Plan

No	Topic	No. of Lectures
1	**Earthquakes and Response Spectrum (9)**	
1.1	Earthquakes, Mechanism, Elastic rebound theory. Seismic waves, Effects of earthquakes	3
1.2	Size of earthquake – magnitude & intensity, moment magnitude Measurement of earthquakes – seismographs	2
1.3	Strong motion characteristics, response spectrum, Fourier spectrum	2

1.4	Characteristics of response spectrum, design spectrum, construction of tripartite response spectrum	2
2	**Earthquake Effects and Philosophy of Earthquake Resistant Construction (7)**	
2.1	Structural irregularities, Effect of architectural features, Damages during past earthquakes.	2
2.2	Seismo-resistant building architecture	1
2.3	Philosophy of earthquake resistant construction. Principle of earthquake resistant construction	2
2.4	Introduction of IS codes (1893 & 4326), Code provision	2
3	**Design Seismic Force Computation (8)**	
3.1	Seismic force computation using IS code provisions	2
3.2	Response spectrum analysis – theoretical aspects, Modal combination rules	2
3.3	Seismic force computation using Response spectrum method	2
3.4	Modal combination using ABS, SRSS & CQC rules	2
4	**Ductility Aspects and Ductile Detailing (7)**	
4.1	Ductility – significance in earthquake resistant design, Ductility factors.	2
4.2	Ductile detailing considerations as per IS:13920	2
4.3	Design & detailing of structural members & joints	3
5	**Torsion and Shear Walls (9)**	
5.1	Torsion – code provisions Design eccentricity computation	1
5.2	Shear walls – design force calculation. Design of shear wall.	3
5.3	Seismic evaluation – methods	2
5.4	Repair and rehabilitation – methods	2
5.5	Response reduction techniques, Base isolation	1

Reference Books

1. PankajAgarwal and Manish Shrikhande, Earthquake Resistant Design of Structures, Prentice- Hall of India, New Delhi.
2. Anil K Chopra, Dynamics of Structures, Prentice- Hall of India, New Delhi.
3. S. K. Duggal-Earthquake Resistant Design of Structures-Oxford University Press-2007
4. T.K. Datta, Seismic Analysis of Structures, John Wiley & Sons (Asia) Pte Ltd.
5. IS: 1893-2016, Indian Standard criteria for Earthquake Resistant Design of Structures, Bureau of Indian Standards, New Delhi
6. IS: 4326-2013, Indian Standard code for practice for Earthquake Resistant Design and Construction of Buildings, Bureau of Indian Standards, New Delhi.
7. IS: 13920-2006, Indian Standard Ductile Detailing of RCC Structures subjected to seismic forces Code of practice, Bureau of Indian Standards, New Delhi

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222ECE044	THEORY OF PLASTICITY	PROGRAMME ELECTIVE 4	3	0	0	3

Preamble: Nil

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

CO 1	Understand stress, strain, deformations, the relation between stress and strain, and plastic deformation in solids.
CO 2	Understand plastic stress-strain relations and associated flow rules.
CO 3	Perform stress analysis in beams and bars including Material nonlinearity.
CO 4	Analyze the yielding of a material according to different yield theories for a given state of stress.
CO 5	Interpret the importance of the plastic deformation of metals in engineering problems.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	10
Analyse	20
Evaluate	10
Create	-

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Continuous Internal Evaluation: 40 marks Micro project/Course based project : 20 marks

Course based task/Seminar/Quiz : 10 marks

Test paper, 1 no. : 10 marks

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1): Understand stress, strain, deformations, the relation between stress and strain, and plastic deformation in solids.

1. Explain spherical and deviatoric stress tensors.

2. Explain various factors affecting plastic deformation.

3. Derive the equilibrium equation in two dimensions considering the body forces.

4. Write a note on octahedral stresses.

5. Explain effective and representative strain.

6. Derive an expression for cubical dilatation stress.

7. Explain true stress and true strain.

Course Outcome 2 (CO2):Understand plastic stress-strain relations and associated flow rules.

1. Explain various theories of plastic flow

2. Explain the different stress strain diagram employed to describe elasto-plastic behaviour of materials.

3. Derive an expression for cubical dilation strain.

4. Enumerate different types of materials encountered in practice from plastic flow point of view. Also sketch the corresponding mechanical models.

5. Explain St. Venants theory of plastic flow in detail. What are the limitations of this theory?

6. Write a short note on Luder's line.

Course Outcome 3(CO3): Perform stress analysis in beams and bars including Material nonlinearity.

1. A rectangular beam having linear stress strain behaviour is 80 mm wide and 120 mm deep. it is 3 m long simply supported at the ends and carries a uniformly distributed load over the entire span. The load is increased so that the outer 30 mm depth of the beam yields plastically. If the yield stress for the beam is 240MPa, plot the residual stress distribution in the beam

2. A hollow circular shaft of inner radius 30 mm and outer radius 60 mm is subjected to a twisting moment so that the outer 10 mm deep shell yields plastically. the yield stress in shear for the shaft material is 160 mega pascal and it is made of a non-linear material whose shear stress strain curve given by j = $300g^{0}$. If the twisting moment is now released determine the residual stress distribution in the shaft. Assume G =80 GPa for the shaft material

3.A circular shaft of inner radius 40 mm and outer radius 100 mm is subjected to a twisting couple so that the outer 20 mm deep shell yields plastically. Determine the twisting couple applied to the shaft. Yield stress in shear for the shaft material is 145 N/mm^2. also determine the couple for full yielding

Course Outcome 4 (CO4): Analyze the yielding of a material according to different yield theories for a given state of stress.

1. What do you mean by yield criteria? Explain any two yield criteria are commonly used.

2. Derive the equation for theory of plastic torsion of circular bar subjected to torsion for following cases.

i) Incipient yielding

ii) Elasto plastic yielding

iii) Fully yielding.

3. Explain experimental verification of yield criteria using Quinny and Taylor's experiments.

Course Outcome 5 (CO5): Interpret the importance of the plastic deformation of metals in engineering problems.

1. Explain various factors affecting plastic deformation.

2. Write short notes on the following

i) Recovery, recrystallization and grain growth.

ii) Flow figures of luder's line.

Model Question Paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

M.TECH DEGREE EXAMINATION

THEORY OF PLASTICITY

Time 2.5 hrs Maximum: 60marks

PART A (***Answer all questions; each question carries 5 marks)***

1. The state of stress at a point in a stressed body is given below:

$$\sigma_{ij} = \begin{bmatrix} 50 & 50 & -40 \\ 50 & -30 & 30 \\ -40 & 30 & -100 \end{bmatrix} \text{MPa}$$

   Calculate stress invariants, principal stresses, spherical and deviatoric stress tensor

2. A material is to be loaded to a stress state

$$[\sigma_{ij}] = \begin{bmatrix} 50 & -30 & 0 \\ -30 & 90 & 0 \\ 0 & 0 & 0 \end{bmatrix} \text{MPa}$$

   What should be the minimum uniaxial yield stress of the material so that it does not fail, according to the Trescacriterian?

3. Explain st.venants theory of plastic flow?

4. A hollow circular shaft of inner radius 30 mm and outer radius 60 mm is subjected to a twisting moment so that the outer 10 mm deep shell yields plastically. the yield stress in shear for the shaft material is 160 mega pascal and it is made of a non-linear material whose shear stress strain curve given by j = 300g^0. If the twisting moment is now released determine the residual stress distribution in the shaft. Assume G =80 GPa for the shaft material.

5. What are assumptions of slip line theory?

PART B (***Answer any five questions; each question carries 7 marks)***

6. Derive the equation of generalized Hook's Law

7. Derive the equilibrium equation in two dimensions considering the body forces.

8. What do you mean by yield criteria? Explain any two yield criteria are commonly used?

9. A rectangular beam having linear stress strain behaviour is 80 mm wide and 120 mm deep. it is 3 m long simply supported at the ends and carries a uniformly distributed load over the entire span. The load is increased so that the outer 30 mm depth of the beam yields plastically. If the yield stress for the beam is 240MPa, plot the residual stress distribution in the beam

10. Explain experimental verification of yield criteria using Quinny and Taylor's experiments.

11. Derive the equation for theory of plastic torsion of circular bar subjected to torsion for following cases.

i) Incipient yielding

ii) Elasto plastic yielding

13. A circular shaft of inner radius 40 mm and outer radius 100 mm is subjected to a twisting couple so that the outer 20 mm deep shell yields plastically. Determine the twisting couple applied to the shaft. Yield stress in shear for the shaft material is 145 N/mm^2. also determine the couple for full yielding

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**Brief review of fundamentals of elasticity**: Concept of stress, stress invariants.	2hr
1.1	Principal Stresses, octahedral normal and shear stresses, spherical and deviatoric stress,	2hr
1.2	Stress transformation; concept of strain, engineering and natural strains, octahedral strain, deviator and spherical strain tensors,	1hr
1.3	strain rate and strain rate tensor, cubical dilation, generalized Hooke's law, numerical problems	1hr
2	**Plastic Deformation of Metals**: Crystalline structure in metals, mechanism of plastic deformation, factors affecting plastic deformation	1hr
2.1	Strain hardening, recovery, re crystallization and grain growth, flow figures or Luder's cubes	1hr
2.2	Yield Criteria: Introduction, yield or plasticity conditions, Von Mises and Tresca criterion,	1hr
2.3	Geometrical representation, yield surface, yield locus (two-dimensional stress space), experimental evidence for yield	1hr
3	**Stress-Strain Relations:** Idealised stress-strain diagrams for different material models	1hr
3.1	Empirical equations, Levy-Von Mises equation, Prandtl - Reuss and Saint Venant theory	2hr
3.2	Experimental verification of Saint Venant's theory of plastic	1hr

	flow.	
3.3	Concept of plastic potential, maximum work hypothesis, mechanical work for deforming a plastic substance.	2hr
4	**Bending of Beams**: Stages of plastic yielding, analysis of stresses,	3hr
4.1	Linear and nonlinear stress strain curve, problems. Torsion of Bars: Introduction, plastic torsion of a circular bar,	3hr
4.2	Elastic perfectly plastic material, elastic work hardening of the material.	1hr
4.3	Numerical problems.	2hr
5	**Slip Line Field Theory**: Introduction, basic equations for incompressible two-dimensional flows,	2hr
5.1	Continuity equations, stresses in conditions of plain strain,	2hr
5.2	convention for slip lines, the geometry of slip line field,	1hr
5.3	Properties of the slip lines, construction of slip line nets.	2hr

Reference Books

1. Theory of Plasticity and Metal forming Process Sadhu Singh Khanna Publishers, Delhi.
2. Chakrabarty, J, Theory of Plasticity, McGraw Hill, New York.
3. Advanced Mechanics of solids L. S. Srinath Tata Mc. Graw Hill 2009
4. Johnson and Mellor, "Plasticity for Mechanical Engineers", Ban Nostrand.
5. R.Hill , "The Mathematic theory of Plasticity", Oxford Publication.
6. Basic Engineering Plasticity DWA Rees Elsevier 1st Edition
7. Engineering Plasticity W. Johnson and P. B. Mellor Van NoStrand Co. Ltd 2000
8. Chen, W.F., and Han, D.J., Plasticity for Structural Engineers, Springer Verlag.
9. Kachanov, L.M., Fundamentals of the Theory of Plasticity, Mir Publishers, Moscow.
10. Martin, J.B., Plasticity: Fundamentals and General Results, MIT Press, London.
11. Plasticity: Fundamentals and applications, P. M. Dixit and U. S. Dixit

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222ECE045	ENGINEERING FRACTURE MECHANICS	PROGRAMME ELECTIVE 4	3	0	0	3

Preamble: This course provides the fundamental aspects of Fracture Mechanics. The students will be exposed to the analysis of fracture of linear and non-linear materials and apply these concepts to structural components. The pre-requisite of this course is Continuum Mechanics, Mechanics of Solids(Desirable)

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

CO 1	Fundamental understanding of fracture mechanics.
CO 2	Ability to analyze and diagnose fractures of linear elastic materials
CO 3	Analyze and diagnose fractures of non-linear materials
CO 4	Assessment of Critical crack growth
CO 5	Apply fracture and fatigue concepts for design of structural components.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	25
Analyse	25
Evaluate	10
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

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

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

Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

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

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

Model Question Paper

QP CODE: **RegNo:....................**

Name:....................

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

Course Code: 222ECE045

ENGINEERING FRACTURE MECHANICS

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

PART A

(Answer *ALL* questions)

1. Discuss the historic overview of fracture mechanics.
2. Define Griffith's theory.
3. Derive the stress intensity of through crack under internal pressure using principle of superposition.
4. Explain plastic zone and plot the plastic zone for plane stress condition
5. State Paris law and its limitations.

PART B

(Answer Any *FIVE* questions only)

6. Explain Airy's stress function and complex stress function.
7. Derive an equation for elliptical flaw in plate and its importance to fracture.
8. Write short note on (a) Leak before break and (b) Damage tolerance analysis.
9. Path independence of J-integral is not valid for elastic-plastic materials, why?
10. Explain any two Direct & indirect method to measure the fracture parameters.
11. Derive an expression for Irwin's plastic zone correction.
12. Describe the importance of R-curve in fracture analysis.

Syllabus

Module 1

Fundamentals of Fracture Mechanics– Introduction - Modes of failure, examples of structural failures due to fracture, fracture mechanics versus strength of materials

Mechanism of crack growth and fracture, fracture control, Review of elasticity, complex variables, complex Airy stress function

Module 2

Linear Elastic Fracture Mechanics -Elasticity based solutions for an infinite plate with circular hole and with elliptical hole

Stress in infinite plate with crack- Westergaard approach and Mushkelishvile approach, stress intensity factor(SIF), Griffith's theory, strain energy release rate, R-curve

Module 3

Design based on LEFM -Design philosophy, SIF due to complex loading, Application of principle of superposition, critical SIF, Leak before break, damage tolerance analysis

Module 4

Elasto-plastic fracture mechanics -J-integral, Crack tip opening displacement (CTOD), relation between CTOD, K_I and G_I for small scale yielding, Equivalence between CTOD and J,

Module 5

Finite element analysis of cracks in solids –Fracture parameters & determination, Mixed mode crack propagation criteria, Analytical models, Fatigue crack growth models to predict life,

Finite elements in fracture mechanics-isotropic singular elements, extraction of SIF using displacement correlation, Displacement extrapolation, Strain energy release rate

Course Plan

No	Topic	No. of Lectures 38
1	Introduction to fracture mechanics	**7**
1.1	Modes of failure, examples of structural failures due to fracture, fracture mechanics versus strength of materials,	2
1.2	Column stability versus fracture instability, mechanism of crack growth and fracture, fracture control	2
1.3	Review of elasticity, complex variables, complex Airy stress function	3
2	Linear Elastic Fracture Mechanics	**8**
2.1	Elasticity based solutions for an infinite plate with circular hole, Elasticity based solutions for an infinite plate with an elliptical hole,	3
2.2	Elasticity based solutions for an infinite plate with crack-Westergaard approach and Mushkelishvile approach, stress intensity factor(SIF),	3
2.3	Griffith's theory, strain energy release rate, R-curve	2
3	Design based on LEFM	**6**
3.1	Design philosophy, SIF due to complex loading	2
3.2	Application of principle of superposition, critical SIF	3
3.3	Leak before break, damage tolerance analysis	1
4	Elasto-plastic fracture mechanics	**8**
4.1	Plastic zone size and shape, effective crack length	2
4.2	J-integral – definition, experimental evaluation, numerical evaluation	3
4.3	Cracktip opening displacement (CTOD), relation between CTOD, K_I and G_I for small scale yielding, Equivalence between CTOD and J	3
5	Finite element analysis of cracks in solids	**9**
5.1	Direct & indirect methods to measure fracture parameters,	2
5.2	Mixed mode crack propagation criteria, Analytical models, empirical models, Fatigue crack growth models, life prediction	3
5.3	Finite elements in fracture mechanics-isotropic singular elements, extraction of SIF using displacement correlation, Displacement extrapolation, Strain energy release rate	4

Reference Books

1.T.L.Anderson, Fracture Mechanics, : Fundamentals and Applications, CRC Press, 3rd Edition

2.D.Broek, Elementary Engineering Fracture Mechanics, MartinusNijhoff publishers.

3.Prashant Kumar, Elements of Fracture Mechanics, Tata McGraw Hill, New Delhi, India

4.Meinhardkuna, Finite Elements in Fracture Mechanics: Theory - Numerics - Applications

SEMESTER II

INTERDISCIPLINARY ELECTIVE

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222ECE097	MECHANICS OF COMPOSITE MATERIALS	INTERDISCIPLINARY ELECTIVE	3	0	0	3

Preamble: Fibre reinforced plastic composite materials are finding wide range of applications in the field of aerospace structures, automobile engineering, offshore structures, maritime structures, ships and civil engineering structures presently due to its outstanding material capabilities such as High strength, low weight, high corrosion resistance, high fatigue strength and faster assembly. The everyday applications of composites in the commercial markets and hence the job opportunities in this field are drastically increasing nowadays. This course will equip the students with the specialist knowledge and skills required by the leading employers in aerospace, marine, automobile, construction and renewable energy industries to design and develop next generation environmental-friendly and structural-efficient advanced lightweight composite materials and components.

Course Outcomes: The COs shown are only indicative. For each course, there can be 4 to 6 COs.

After the completion of the Advanced Composite Structures course the student will be able to

CO 1	Identify the properties of fibre and matrix materials used in commercial composites, as well as some common manufacturing techniques.
CO 2	Explain linear elasticity with emphasis on the difference between layered composite materials and isotropic materials.
CO 3	Apply constitutive equations of composite materials and understand the mechanical behaviour at micro and macro levels.
CO 4	Predict the failure mode and strength of laminated composite structures.
CO 5	Apply the ideas developed in the analysis of composites towards using composites in various fields of engineering.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	End Semester Examination
Remember	15
Understand	15
Apply	25
Analyse	5
Evaluate	-
Create	-

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks
Course based task/Seminar/Data collection and interpretation: 15 marks
Test paper, 1 no.: 10 marks
Test paper shall include minimum 70% of the syllabus.

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

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

Model Question paper

PART A

Answer **all** questions.

All Questions carry **equal** marks

1. How is the mechanical advantage of a composite measured?
2. Write the number of independent elastic constants for three dimensional anisotropic, orthotropic, transversely isotropic and isotropic materials.
3. What is Classical Lamination Theory? Explain its significance in composite analysis.
4. The weight fraction of glass in a glass epoxy composite is 0.8. If the specific gravity of glass and epoxy are 2.5 and 1.2 respectively, find (i) fibre and matrix volume fractions (ii) density of composite?
5. Explain briefly the progressive failure analysis in a composite laminate.

PART B

Answer any **FIVE** questions only

6. Briefly explain the Hooke's law for Anisotropic materials. Derive the stress-strain relation for a material with three planes of reflection and one 90◦ rotation symmetry
7. (a) Explain any two methods of manufacturing of composite in detail.
   (b) Derive the relations connecting the engineering constants and the elements of stiffness and compliance matrices for a specially orthotropic lamina.
8. (a) Calculate the longitudinal modulus and tensile strength of a unidirectional composite containing 60% by volume of carbon fibres (E_{1f} = 294 GPa and σ_{1fu} = 5.6 Gpa) in a toughened epoxy matrix (E_m = 3.6 GPa and σ_{mu} = 105 Gpa). Compare these values with the experimentally determined values of E_1 = 162 GPa and σ_{1u} = 2.94 GPa. What fraction of load is carried by fibres in the composite?
   (b) Explain how to calculate the effective modului of a composite lamina in terms of its constituent properties.
9. (a) Explain the free edge effects and interlaminar stresses in composite laminates
   (b) Explain how to determine the laminae stresses and strains from the analysis of a laminate?
10. Calculate the A, B , D matrices for a [0/90°] laminate each layer of which is of 0.125 mm thickness. The lamina properties are given by E_1 = 140 GPa, E_2 = 10 GPa, G_{12} = 5 GPa, υ_{12} = 0.3
11. (a) Explain the effect of interlaminar stresses in composite laminate in detail
    (b) Explain the importance of the sign of shear stress on strength of composites.

12. Find the maximum value of S>0 if a stress of σ_x = 2S, σ_y = -3S, and τ_{xy} = 4S is applied to a 60° Graphite/epoxy Lamina. Use Tsai-Hill Failure theory.
Given $(\sigma_1^t)_{ult} = 1500MPa$, $(\sigma_1^C)_{ult} = 1500MPa$, $(\sigma_2^t)_{ult} = 40MPa$, $(\sigma_2^C)_{ult} = 246MPa$, $(\tau_{21})_{ult} = 68MPa$

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**Introduction to Composite Materials (6)**	
1.1	Definition of composites, Objectives, constituents and Classification of composites.	2
1.2	Basic terminology used in fibre reinforced composite materials-Lamina, Laminates ,General Characteristics of reinforcement and classifications, Characteristics of matrix- Polymer matrix, Thermoplastics and thermosetting resins, Glass transition temperature , Prepregs	2
1.3	Structural applications of Composite Materials	1
1.4	Processing of Composites	1
2	**Macro mechanical behaviour of a composite lamina (9)**	
2.1	Review of Basic Equations of Mechanics and Materials, Hooke's law for different types of materials- Anisotropic, orthotropic, isotropic, monoclinic and Transversely isotropic materials.	2
2.2	Stress-Strain relations for a Two dimensional unidirectional and orthotropic lamina, lamina of arbitrary orientation, Transformations of stress and strain	3
2.3	Relationship of Compliance and stiffness matrix to elastic constants of a lamina	1
2.4	Strength and Failure theories of Continuous Fibre-reinforced orthotropic Lamina- Failure envelopes, Maximum stress/strain criteria, Tsai-Hill and Tsai-Wu criterion.	2
2.5	Hygrothermal stresses and strains in a lamina –unidirectional and angle lamina	1
3	**Micromechanical Behaviour of a Lamina (6)**	
3.1	Volume and Mass fractions, density and void content	1
3.2	Effective Moduli of a continuous fibre-reinforced lamina – Models based on mechanics of materials, theory of elasticity and experimental methods, Mechanics of materials approach to strength, Numerical Examples	2
3.3	Ultimate Strengths of unidirectional Lamina- longitudinal and transverse tensile and compressive strengths	2
3.4	Coefficients of moisture and thermal expansion	1
4	**Macro mechanical behaviour of Laminates (10)**	

4.1	Classical Lamination Theory-Laminae Stress-strain behaviour, In-plane forces, stress-strain variation in a laminate, resultant laminate stresses and strains,	3
4.2	Special cases of laminate stiffnesses-symmetric and antisymmetric laminates, cross ply and angle ply laminates, quasi-isotropic laminates	3
4.3	Inplane and flexural modulus of a laminate	1
4.4	Effects of stacking sequence-Laminate code	1
4.5	Free-Edge Interlaminar Effects, Hygro-thermal effects and warpage in a laminate	2
5	**Strength and Design of Laminates (9)**	
5.1	Determination of laminae stresses and strains, numerical examples	2
5.2	Laminate strength analysis procedure, Failure envelopes	3
5.3	Analysis of laminates after initial failures, Progressive failure Analysis. Numerical Examples	2
5.4	Composite mechanical design issues-Long-term environmental effects, impact resistance, fracture resistance, fatigue resistance	2

Text Books

1. Jones M. Roberts, Mechanics of Composite Materials, Taylor and Francis,1998
2. Reddy, J.N , Mechanics of Laminated Composite Plates: Theory and Analysis, CRC Press, 2003

Reference Books

1. Calcote, L. R., Analysis of Laminated Composite structures, Van Nostrand, 1969
2. Vinson, J. R. and Chou P, C., Composite materials and their use in Structures, Applied Science Publishers, Ltd. London, 1975
3. Agarwal, B.D. and Broutman, L. J., Analysis and performance of Fibre composites. 3rd Edn.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222ECE098	PROJECT EVALUATION AND MANAGEMENT	INTERDISCIPLINARY ELECTIVE	3	0	0	3

Preamble: Objective of the course is to enable the students to understand the management aspects of project idea formulations, feasibility studies and report preparation, costing of project, project appraisal and project funding.

Course Outcomes: The COs shown are only indicative. For each course, there can be 4 to 6 COs.

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

CO 1	To develop project ideas
CO 2	To do the feasibility analysis of projects
CO 3	To plan and arrive at Project Costs
CO 4	To carry out project appraisals
CO 5	To identify the various funding sources and select the apt source

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	End Semester Examination
Understand	20
Apply	10
Analyse	10
Evaluate	20
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed

Original publications (minimum 10 publications shall be referred) : 15 marks

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

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks. Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %.

Model Question Paper

Model Question paper

Course Code & Name:

Project Evaluation and Management

Max. Marks: 60
Duration: 2.5 hours

PART A

(Answer all Questions: Each question carries 5 marks)

1. Discuss the need for project idea generation ?
2. Why feasibility studies are essential?
3. What do you understand by Present value of a single amount?
4. Explain the international practice of Project Appraisal.
5. Discuss the means of Project Financing.

PART B
(Answer any *five* questions: Each carries 7 marks)

6. Describe the various steps involved in Project Identification.
7. How will you assess the technical feasibility of a project?
8. Explain cash flow and what are the benefits of cash flow statement..
9. Discuss the various methods of Risk Analysis
10. Bluebell Enterprises had invested Rs.2,00,00,000 for the purpose of replacing some of its machinery components. This renovation is expected to result in incremental benefits of Rs.5000000 in 1st year, Rs.3000000 in 2nd year and Rs. 4000000 in 3rd year. Calculate the benefit-cost ratio of the replacement project if the applicable discounting rate is 5%..
11. Discuss the role of various institutions for project financing
12. Discuss the Private Sector Participation on Infrastructure Projects in India

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

No	Topic	No. of Lectures
1	Project formulation	
1.1	Concepts of Project, Capital Investments	2
1.2	Purpose and need for Project Identification	2
1.3	Methodology for Project Identification	2
1.4	Steps in Project Identification	2
2	Project Feasibility	
2.1	Introduction to feasibility Studies, need for feasibility studies	2
2.2	Components of Feasibility Analysis - Market, Technical, Financial, Economic	4
2.3	Feasibility Reports and approvals	2
3	Project Costing	
3.1	Time Value of Money - Future value of single amount, Present value of single amount, Future value of an annuity, Present value of an annuity, Simple interest-Compound interest	3
3.2	Project Cash Flows	3
3.3	Cost of capital	2
4	Project Appraisal	
4.1	Investment Criteria- Discounting criteria-Net present value (NPV), Benefit cost ratio(BCR), internal rate of return(IRR)- Non-Discounting criteria - Pay Back Period, Accounting rate of return(ARR	4
4.2	Indian and International Practice of Appraisal	2
4.3	Methods of Analysis of Risk	2
5	Project Financing	
5.1	Project Financing – Means of Finance	2
5.2	Financial Institutions, schemes	3
5.3	Private sector participation in Infrastructure Development Projects - BOT, BOLT, BOOT	2
5.4	Technology Transfer and Foreign Collaboration	1

Reference Books

1 Project Planning Analysis selection financing Implementation and Review- Tata Mc Graw Hill Publication, 7th edition 2010, Prasana Chandra

2 United Nations Industrial Development Organization (UNIDO) Manual for the preparation of Industrial Feasibility Studies, (IDSI Reproduction), Bombay, 2007.

3 A Systems Approach to Planning, Scheduling, and Controlling Project Management Harold Kerzner (2013), Wiley India, New Delhi

4 Project planning scheduling & control, James P.Lawis, Meo Publishing Company 2001

5 Project planning analysis selection implementation & review Prasanna Chandra, ISBNO-07-462049-5 2002.