

**END SEM / RE-EXAM EXAMINATION MAY / JUN 2026**Program: First Year M. Tech Civil - Structures

Duration: 3 Hrs.

Course Code: PC-MTSE201Sem - II

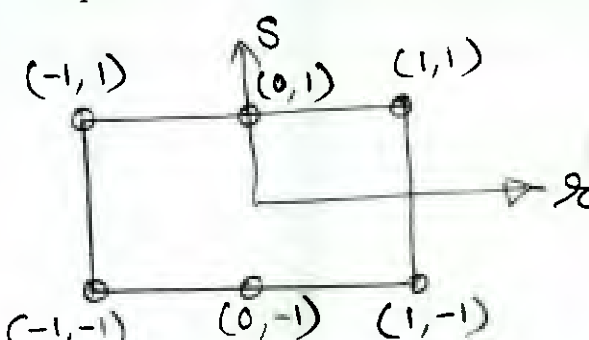
Maximum Points: 100

Course Name: Finite Element AnalysisSemester: II

19/05/26

Instructions for the Students:

1. Attempt any 05 (FIVE) questions
2. Assume suitable data if necessary and state it clearly.
3. Illustrate your answers with neat sketches wherever required.

Q. No.	Questions	Points	CO	BL	Module No.
1 a	Explain the following terms: i. Convergence, ii. Compatibility requirements iii. Geometric invariance	10	1	2	2
1 b	Determine the interpolation functions for the element as shown in the figure below 	10	2	4	3
2 a	Derive a stiffness matrix for a CST element having joint coordinates as follows: Node 1 (0.5m, 0.5m), Node 2 (1m, 0.5m), Node 3 (0.5m, 1m). Assume the element as plane stress element with thickness of 0.012 m, $E = 200 \text{ GPa}$ and $\nu = 0.25$.	10	2	4	3,5
2 b	For the simply supported beam subjected to uniformly distributed load acting over entire span, determine the maximum displacement using variational approach.	10	1,2	4	1

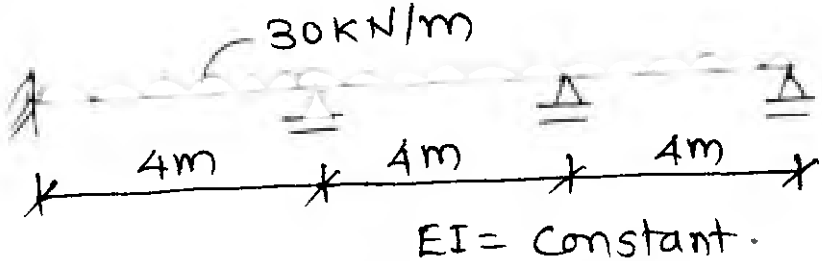
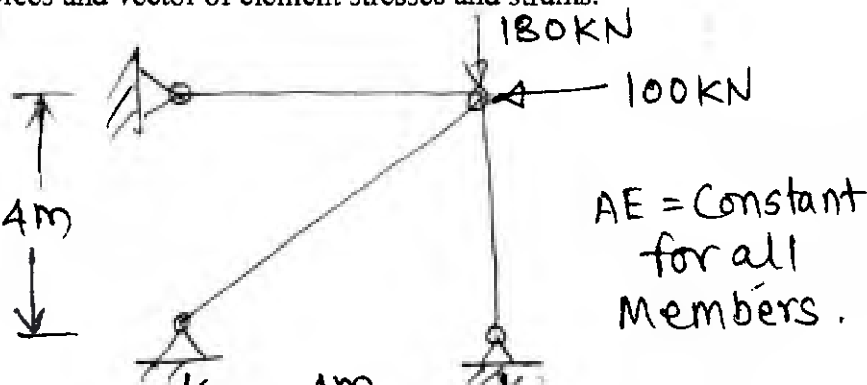


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3 a	Determine the nodal load vector for a four noded rectangular element of size 1 m in X direction and 0.75 m in Y direction. Note that the element is subjected to a concentrated load of 50 kN in X direction and 30 kN in Y direction, both loads acting at point A. Note that distance of point A measured from left bottom corner node is 0.4 m along X direction and 0.3 m along Y direction.	10	2	4	3,5
3 b	For the element shown in Q3a, if the joint displacements for the top left and top right nodes are 0.004m, 0.008m in x direction respectively and 0.003m, 0.006m in y direction respectively, determine element stresses and element strains at a point (0.2m, 0.2m). Take $E = 200 \text{ GPa}$ and $\nu = 0.2$ and assume element in plane strain. Note that displacement at all other joints is zero.	10	2	4	3,6
4	For the continuous beam shown in figure below, using finite element techniques, determine element stiffness matrix, structure stiffness matrix, effective structure stiffness matrix, loading vector, displacement vector and member forces.  $EI = \text{Constant.}$	20	1,2	4	3,4
5	For the truss shown in figure below, using finite element techniques, determine member stiffness matrix, structure stiffness matrix, effective structure stiffness matrix, loading vector, displacement vector, element forces and vector of element stresses and strains.  $AE = \text{Constant for all Members.}$	20	1,2	4	3,4

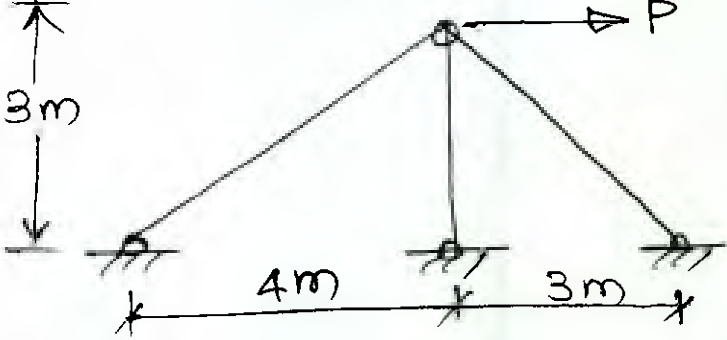


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6	For the truss shown in figure 7, using finite element techniques, determine member stiffness matrix, structure stiffness matrix, geometric stiffness matrix and buckling load for the truss.  AE = Constant for all Members	20	1,2	4	3,6
7	For the Fixed beam of span 6m, using finite element techniques, determine member stiffness matrix, structure stiffness matrix, consistent mass matrix and first two natural frequencies. Take the density of material as 7850 kg/m^3 and EI value as 75000 kN-m^2.	20	1,2	4	3,7



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End Semester Examination

May - 2026



Max. Marks: 100

Class: M.Tech.

Name of the Course: Earthquake Engineering

Semester: II

Duration: 3 Hours

Program: Civil Engineering

Course Code : PC-MSTE 202

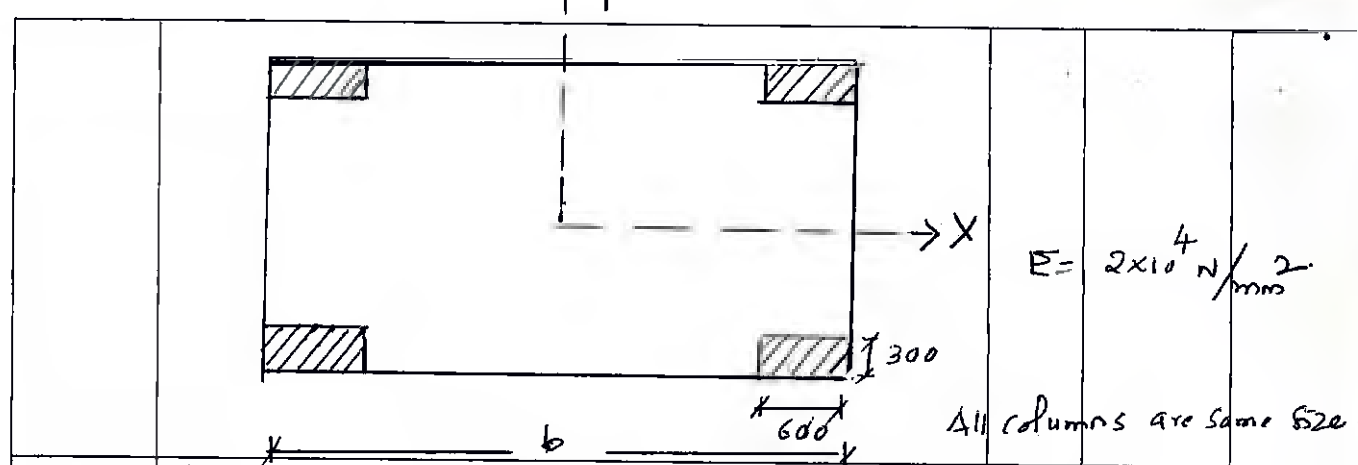
Sem-II

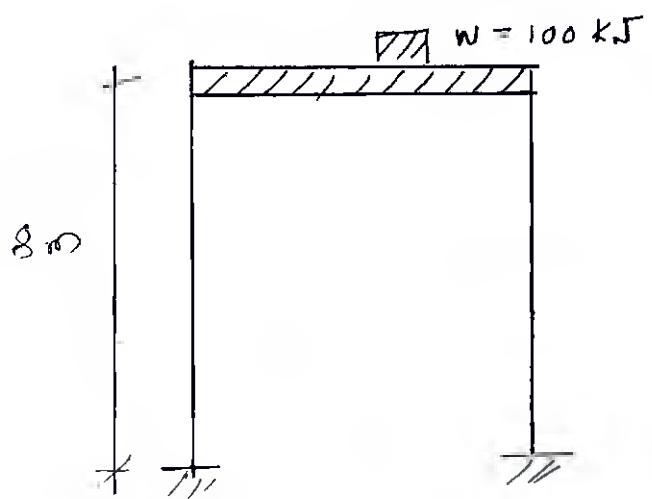
21/5/26

Instructions:

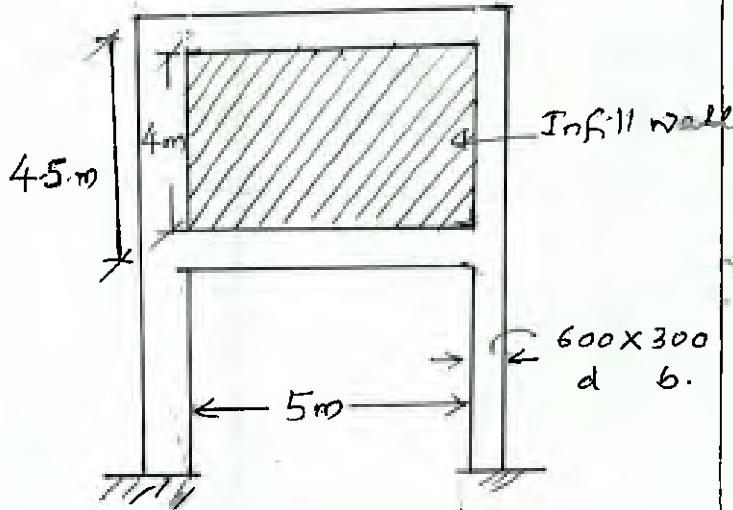
- Attempt any FIVE questions out of SEVEN questions.
- Answers to all sub questions should be grouped together.
- Figures to the right indicate full marks.
- Assume suitable data if necessary and state the same clearly

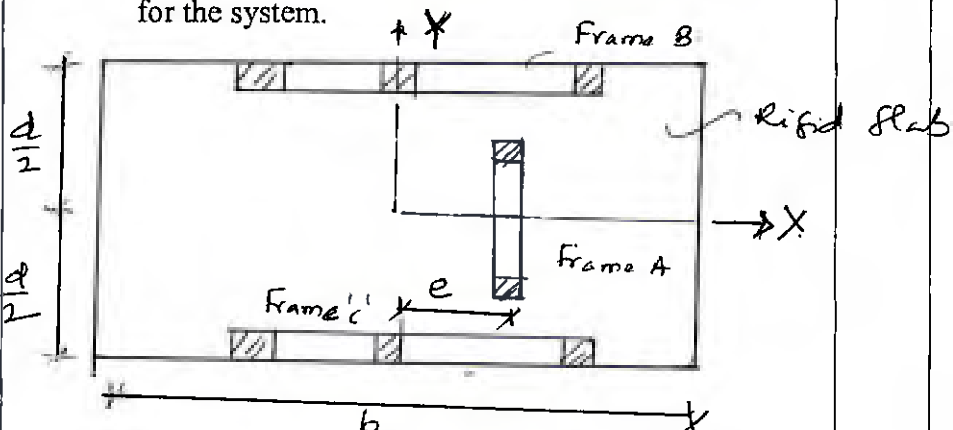
Question No		Max. Marks	Course outcome	Module No.
Q1 (a)	Answer the followings:			
	(i) What is Response Reduction factor? It depends on what? Explain briefly its significance	3	1	2
	(ii) Briefly explain the Plate Tectonic Theory of an earthquake occurrence	4	1	2
Q1 (b)	The plan of one storey building is as shown in figure. The structure consists of a roof idealized as a rigid diaphragm, supported on four corner columns as shown in figure. The roof weight is uniformly distributed and has magnitude 200 kg/m ² . The plan dimensions are b= 30 m d=15m. Height of the building is 5m.			
	(i) Derive the stiffness matrix and determine the natural frequencies and modes shapes of vibrations of the structure	8	2	1
	(ii) If the system is subjected to the ground motion only in X direction, the response spectrum of which is shown in figure1. Determine the design value of lateral deformation, base shear and bending moment for the system.	5	2,3	4



Q2 (a)	(i) A single-storey frame with a rigid girder as shown in the figure below is to be designed for ground motion, the response spectrum of which is shown in Figure 1. Determine the design value of lateral deformation and bending moments in the columns.	3	2,3	1,4
	(ii) If the columns of the frame are hinged at the base, determine the design values of lateral deformation and bending moments in columns. Comment on the influence of base fixity on the design deformation and bending moments.	3	2,3	1,4
	(iii) If the beam cross-section is much smaller than that of columns, so the beam stiffness can be neglected, and columns are fixed at the bottom, determine the design values of lateral deformation and bending moments in columns. Compare the design values with the case i & ii above.	4	2,3	1,4
	 Diagram of a single-storey frame with a rigid girder. The frame consists of two vertical columns and a horizontal beam. The columns are fixed at the base. The beam is rigidly connected to the columns. The dimensions are given: column height is 8m, column width is 300mm, and beam width is 300mm. The material properties are given as $E = 30,000 \text{ N/mm}^2$. The columns are made of the same material as the beam.			

c/s of columns $300 \text{ mm} \times 300 \text{ mm}$
 $E = 30,000 \text{ N/mm}^2$

Q2 (b)	A two storey building frame with brick infill wall is shown in figure. Assuming the beams are rigid, calculate the lateral stiffness of the 2nd storey considering the effect of infill wall considering the infill was stiffness also as per IS 1893-2016. Compare the stiffness of the 2nd storey of frame with and without infill wall.  For URM infill walls without any opening, width w_{ds} of equivalent diagonal strut (see Fig. 7) shall be taken as: $w_{ds} = 0.175 \alpha_h^{-0.4} L_{ds}$ where $\alpha_h = h \left(\sqrt[4]{\frac{E_m t \sin 2\theta}{4 E_f I_c h}} \right)$ Width of beam & col = 300 mm Depth of beam & col = 500 mm $I_c = I_b = 0.002278125 \text{ m}^4$ $E_m = 13800 \text{ MPa}$ $t = 230 \text{ mm}$ $h = 4 \text{ m}$ $L = 5 \text{ m}$ $E_f = 5000 \sqrt{f_{ck}}$ $f_{ck} = 25 \text{ MPa}$	10	2,4	1.6
Q3 (a)	What is response spectrum? Briefly explain the characteristics of response spectrum.	4	3	3
Q3 (b)	The plan of one storey building is as shown in figure. The structure consists of a roof idealized as a rigid diaphragm, supported on three frames A, B, and C as shown. The roof weight is uniformly distributed and has magnitude 200 Kg/m^2. The lateral stiffness are $K_y = 30000 \text{ KN/m}$ for frame A and $K_x = 20000 \text{ KN/m}$ for frames B and $K_x = 30,000$ for frame C The plan dimensions are $b = 30 \text{ m}$ $d = 20 \text{ m}$. The height of building is 6 m. $e = 6 \text{ m}$ (i) In general how many degrees of freedom for this system? Identify those dof. (ii) Calculate the stiffness matrix and write down the	10	1,3	1,4

	equation of motion if the system is subjected to ground motion $u_{gx}(t)$ in X direction only. (iii) If $K_x = 20,000\text{KN/m}$ for both frames B & C, and $e=0$ and the system is subjected to the ground motion only in Y direction, the response spectrum of which is shown in figure1. Determine the design value of lateral deformation, base shear and bending moment for the system. 	5	3	1,4																								
Q4 (a)	For a residential RCC special moment resisting building frame the seismic weights on floors are $W_1 = 400 \text{ KN}$, $W_2 = 400 \text{ KN}$ and $W_3 = 300 \text{ KN}$. The ground story height is 4.0m and first and second story height is 3.0m. The building is founded on hard soil and situated in zone IV. Determine the distribution of lateral forces and story shear by using equivalent static method. Use the response spectra given in figure1	10	4	5																								
Q4(b)	A two storey frame has the following free vibration characteristics. The frame is to be designed for the ground motion $u_g = u_{g0} \sin \omega t$ where $u_{g0} = 0.4g$ and $\omega = 25.0 \text{ rad/sec}$. Calculate maximum displacements of each storey. Assume damping ratio $\xi = 5\%$. Calculate also the storey drifts. <table border="1"> <thead> <tr> <th>Floor No.</th> <th>Mass (t)</th> <th>Mode No.</th> <th>ω, rad/sec</th> <th colspan="2">Mode shapes</th> </tr> <tr> <th></th> <th></th> <th></th> <th></th> <th>Φ_{i1}</th> <th>Φ_{i2}</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>20</td> <td>1</td> <td>14.58</td> <td>1.0</td> <td>1.481</td> </tr> <tr> <td>2</td> <td>25</td> <td>2</td> <td>38.07</td> <td>1.0</td> <td>-0.822</td> </tr> </tbody> </table>	Floor No.	Mass (t)	Mode No.	ω , rad/sec	Mode shapes						Φ_{i1}	Φ_{i2}	1	20	1	14.58	1.0	1.481	2	25	2	38.07	1.0	-0.822	10	4	5
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Q5 (a)	Explain the three requirements of displacement design of structure for earthquake load as per IS 1893-2016.	4	4	5																								
Q5 (b)	As per IS 1893-2016, how many mode need to be considered	2	4	5																								

	in the earthquake force calculation by Response Spectrum Method																																						
Q5 (c)	State the limitations of Equivalent static Method. As per IS 1893-2016, under what conditions the Equivalent static Method is permitted to use to calculate the earthquake forces.	2	4	5																																			
Q5 (d)	Using response spectrum method, calculate the seismic force on each floor of the frame whose pre vibration properties are given below. Use the following additional data: Z=0.36, I=1.2, R=4.0 and ξ = 5%. Assume foundation strata as medium and use response spectrum given in figure 3 Assume the story height as 4m for all story	12	4	5																																			
	<table><tr><td>Storey No.</td><td>Mass No.</td><td>Mass (t)</td><td>ω rad/sec</td><td colspan="3">Mode shapes</td></tr><tr><td></td><td></td><td></td><td></td><td>Φ_{i1}</td><td>Φ_{i2}</td><td>Φ_{i3}</td></tr><tr><td>1</td><td>1</td><td>36</td><td>4.92</td><td>0.336</td><td>0.759</td><td>1.0</td></tr><tr><td>2</td><td>2</td><td>36</td><td>13.45</td><td>-2.46</td><td>-0.804</td><td>1.0</td></tr><tr><td>3</td><td>3</td><td>36</td><td>18.7</td><td>1.58</td><td>-1.157</td><td>2.58</td></tr></table>	Storey No.	Mass No.	Mass (t)	ω rad/sec	Mode shapes							Φ_{i1}	Φ_{i2}	Φ_{i3}	1	1	36	4.92	0.336	0.759	1.0	2	2	36	13.45	-2.46	-0.804	1.0	3	3	36	18.7	1.58	-1.157	2.58			
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Q 6(a)	What is ductility? Explain the importance of ductility in earthquake resistant structures.	3	4	6																																			
Q 6(b)	Briefly explain the following: (i) When the structure is subjected to torsion ? Briefly explain the IS 1893-2016 provisions for design for torsion. (ii) What are boundary elements? Explain briefly the need of boundary elements as per IS 1893-2016	6	4	5																																			
Q 6(c)	(i) A building having a non-uniform distribution of mass is shown in figure 4. Locate its center of mass (ii) The plan of a simple one-storied building shown in figure 5. The stiffness of each column is indicated in figure. Obtain the center of stiffness. (Centre of Rigidity).	4	4	5																																			
Q 6(d)	The first floor plan of a building with shear walls is as shown in figure 6. The plinth level plan is also same. Calculate the fundamental period of the building as per the provision of 7.6.2, of IS 1893-2016 both in X and Y direction. The total height of building is 24 m.	4	4	5																																			

Q 6(e)	For the SMRFs idealized as shear building with rigid girders shown in figure 7, investigate whether the building structure has soft story. The height of first story is 4.0 m and that of remaining is 3.0 m.	2	4	5
Q 7(a)	Explain the provisions of IS 13920-2016, for (i) Shear wall: General provisions (Excluding Minimum reinforcement requirements) and provisions for design for shear	5	4	6
Q 7(b)	A beam of a frame is shown in figure 8 with limiting moment of resistance at both ends and for both sway from left right and right to left. Calculate the design shear force as per IS 13920-2016. The calculated factored shear force is 152 KN DL+LL = 32.6 kN/m 4.6 m For sway from left to right $M_{ulim}^{AS} = 140 \text{ kNm}$ $M_{ulim}^{BS} = 120 \text{ kNm}$ For sway from right to left $M_{ulim}^{AH} = 200 \text{ kNm}$ $M_{ulim}^{BS} = 80 \text{ kNm}$	5	4	6
Q 7(c)	For a column of cross section 530mm x 300mm calculate the special confinement reinforcement (i.e diameter and spacing of ties as a special confinement reinforcement) as per IS 13920-2026. The grade of concrete is M 30 and that of steel is Fe 415, consider clear cover to the ties is 50 mm. Also calculate the length l_0 of special confinement reinforcement. The clear height of column is 4.0 m.	5	4	6
Q 7(d)	With regards to steel structures, explain the terms : Capacity design and capacity protected elements. Explain how capacity based design is ensured in steel structures.	5	4	7

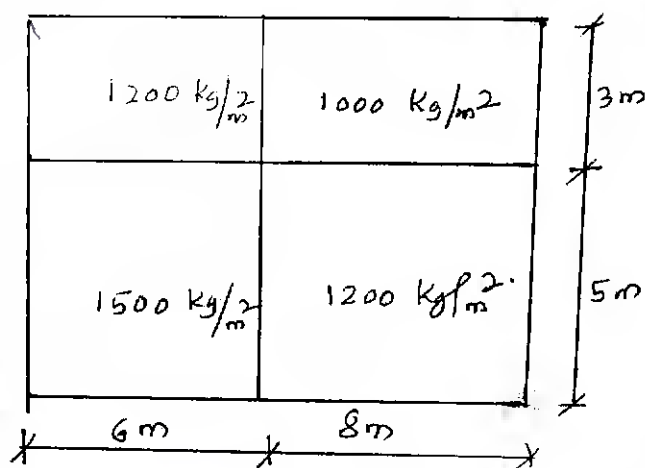


Fig 4

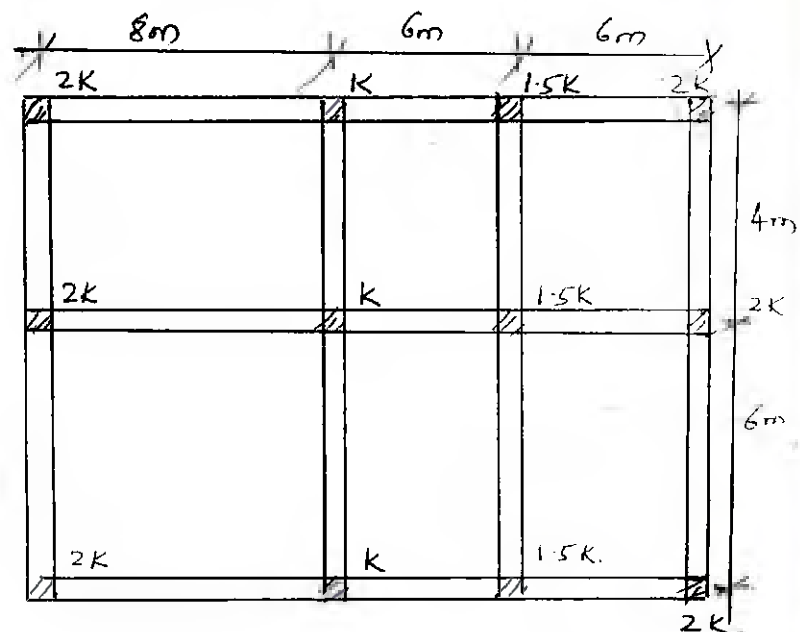


Fig 5

DISPLACEMENT RESPONSE SPECTRA
FOR EL-CENTRO EARTHQUAKE FOR 5% DAMPING $PGA = 0.32g$

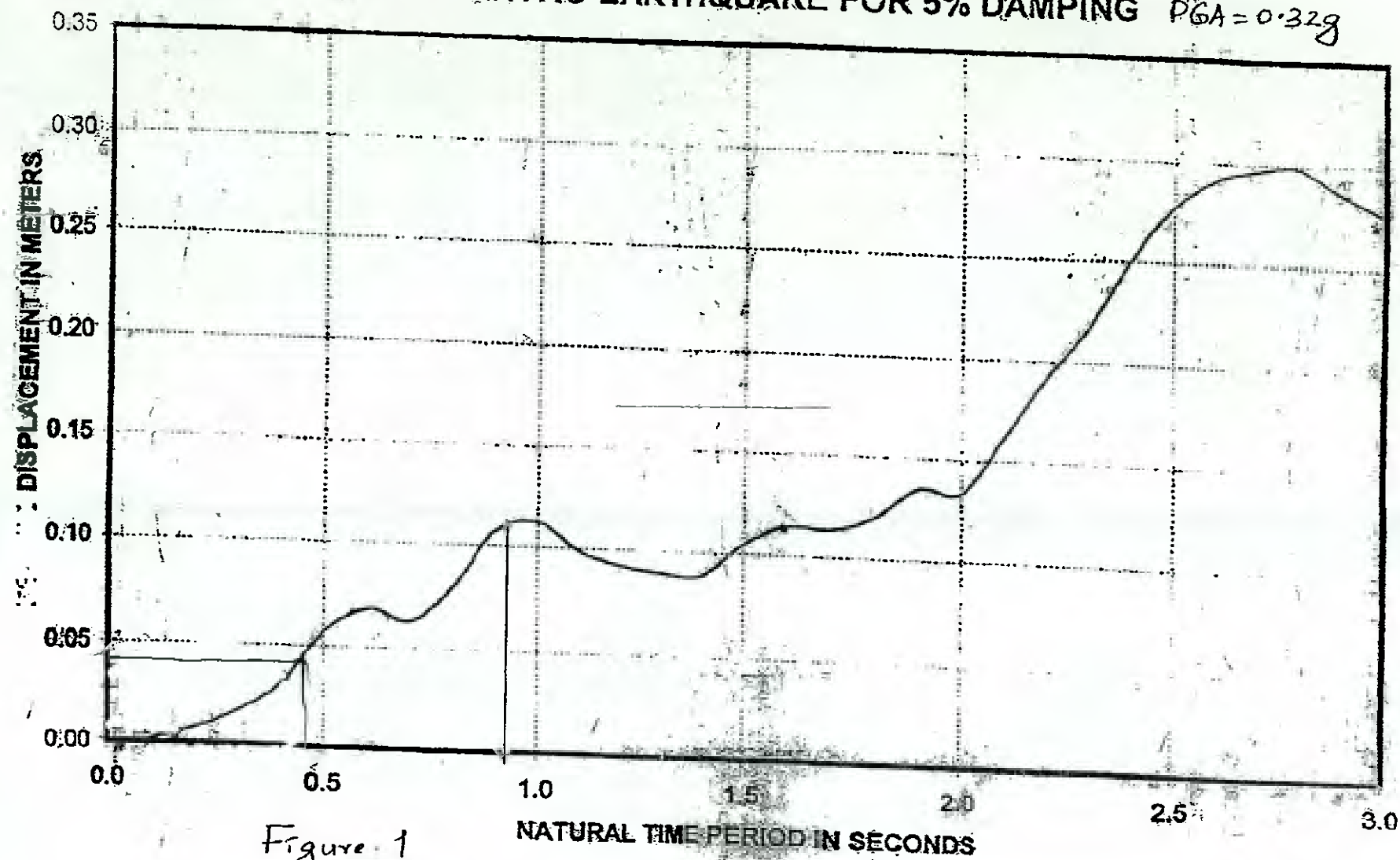


Figure 1

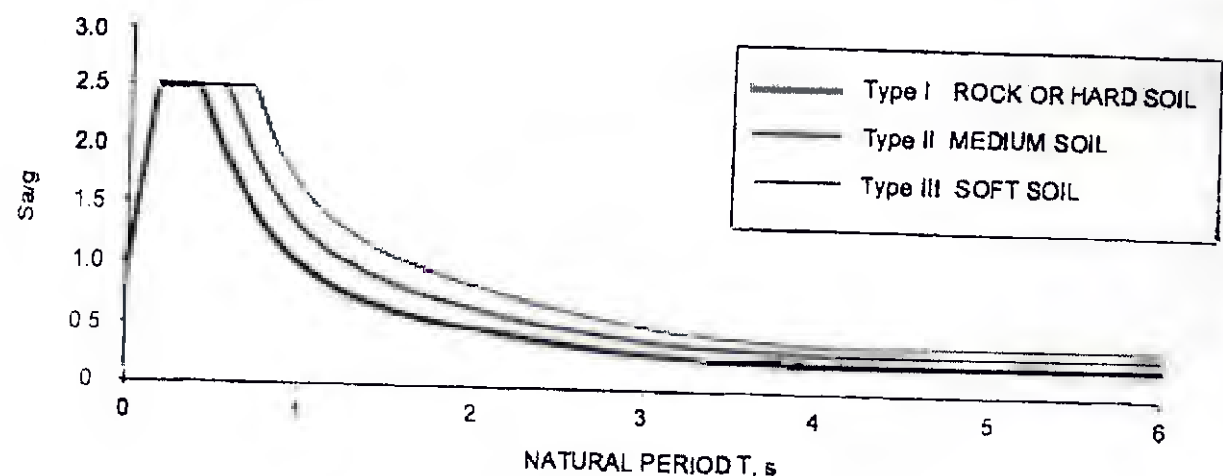
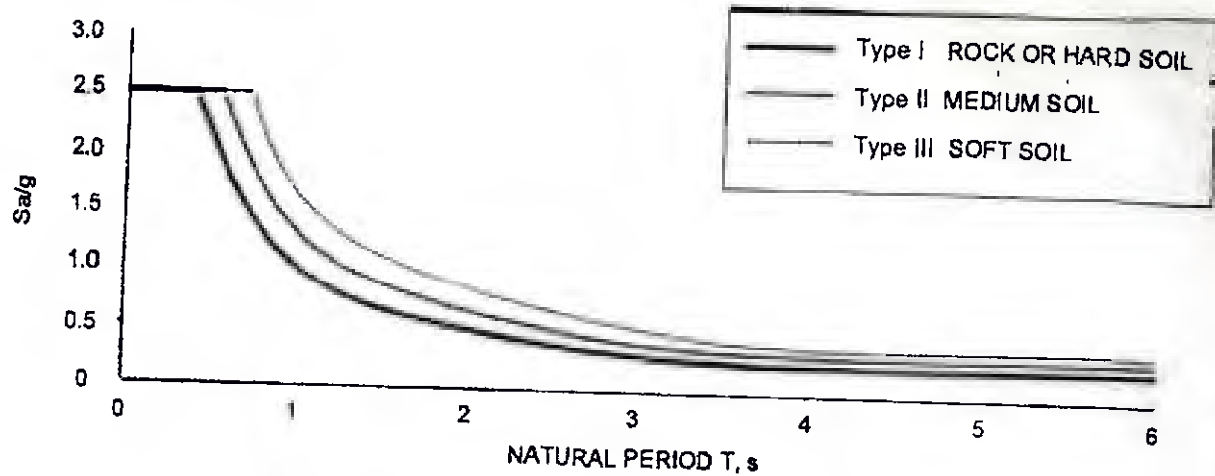


FIG. 2 DESIGN ACCELERATION COEFFICIENT (S_a/g) (CORRESPONDING TO 5 PERCENT DAMPING)

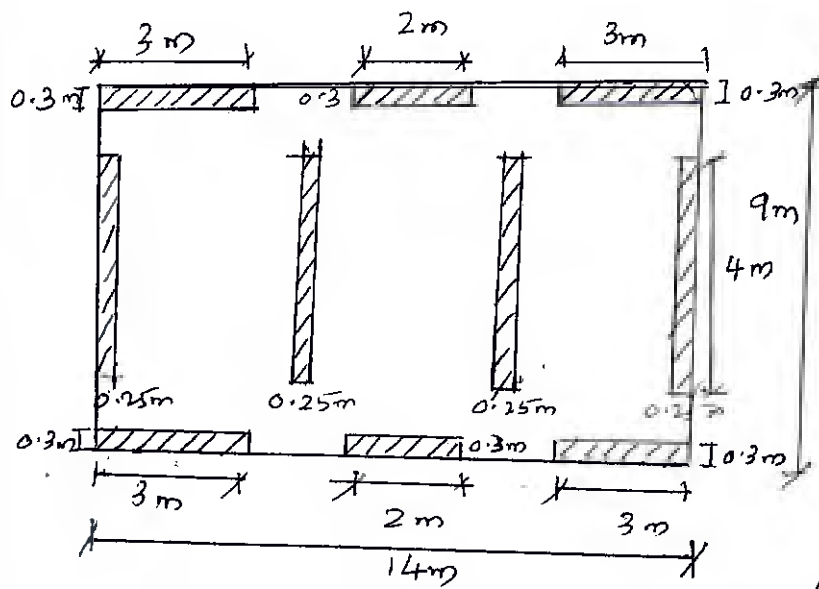


Fig. 6

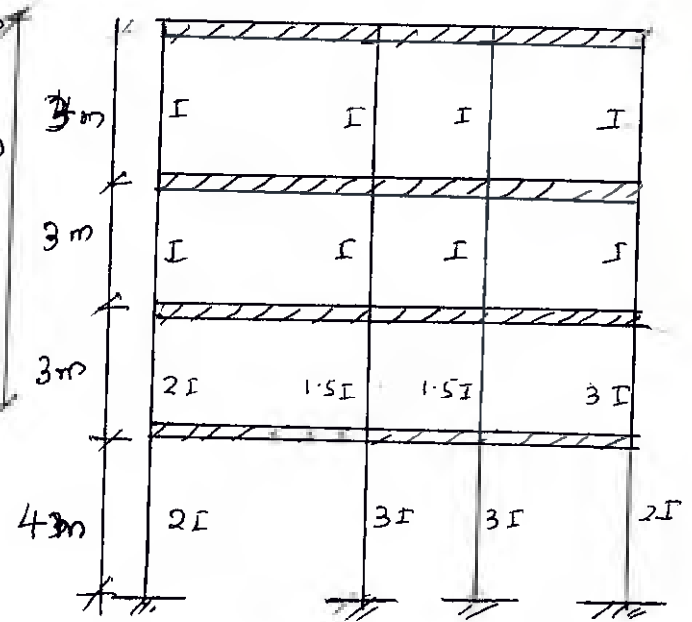


Fig. 7

End Semester/Re-examination - May /July 2026 ExaminationsProgram: M.Tech Civil Engg (Structure) first Year Duration: 3HoursCourse Code: PE-MTSE211

Maximum Points: 100

Course Name: Bridge EngineeringSem - IISemester: II

26/05/26

- Notes: 1) Attempt any 5 main questions
 2) Assume suitable data if missing and mention the same clearly
 3) Draw neat sketches wherever possible
 4) Use of IRC 6, IRC 112 and IS 800 is permissible

Q.No.	Questions	Points	CO	BL	Module
1.a)	Enlist the various methods of bridge construction. Explain balanced cantilever method of construction highlighting the special provisions to be made for cast in situ as well as precast elements. Explain the impact of construction stages in the design of such bridges.	10	2,4	3	6
1.b)	Explain the points to be considered during planning and conceptual design of bridges	10	1	2	1
2.a)	Design an RC slab culvert for a clear span of 5.85m and a carriageway of 9m. Wearing coat is of 60mm thickness. Consider single train of IRC Class 70R wheeled vehicle loading. $SIDL = 8kN/m^2$. Use M30 and Fe500. Provide checks for limit state of strength and limit state of serviceability.	20	1,3,5	4	2,3
3	A deck type trussed steel bridge to be used as foot-over bridge, has the following details : The total dead load per nodal point = 220kN Span of bridge = 35m; Deck width = 7.5m; Slab thickness 200mm Select a suitable arrangement of truss members such that the maximum depth of truss does not exceed 4.5m. Evaluate the design forces in members for appropriate load combinations and Design the bottom chord member.	20	1,3,5	4	2,4
4.a)	Explain with neat sketch - POT PTFE bearings	10	1	2	5
4.b)	Evaluate the axial load and moment carrying capacity for a pier having following data : Size : 1250mm x 1250mm Reinforcement on each face = 6nos-25mm dia(each face) Effective cover = 60mm Assume N.A = 500mm from extreme compression fibre Concrete grade is M45 and steel grade is Fe500.	10	3	4	5
5.a)	Obtain the maximum bending moment and maximum shear force for a girder of span 20m subjected to a single class 70R wheeled vehicle and having a courbon factor of 0.48	7	1,5	4	2,3
5.b)	Design an RCC girder of span 20m as per IRC 112 with following specifications: UDL on girder due to footpath and crash barrier = 20kN/m UDL on girder due to wearing course = 4.5kN/m Live load as per Q.5(a) Effective slab width as beam flange = 1.8m Depth of slab = 0.2m	13	3	4	3

	Use M35 and Fe500				
6.a)	Calculate the forces in each pile using rivet theory if the axial compression load is 3200kN and Moment about transverse axis is 2600kNm. There are 9 piles arranged in 3*3 manner and c/c distance between all piles is 2.5m in both directions.	06	4	4	5
6.b)	For bridge pier having seismic mass as 5000kN, the height of pier is 10m and the cross section is 1.5m diameter made of M45 concrete. Assume the base to be fixed and obtain : i) Time period as per IRC ii) Base shear acting on the pier	10	1,5	2	2,7
6.c)	Explain the need to consider the impact factor in live load analysis.	04	3	2	1
7	Design a shallow foundation as per IRC 112 for a pier of size 1.25m x 1.25m. The design axial load = 5000kN and design moment along transverse axis = 1100kNm. SBC of soil = 180kN/m ² . Use M35 and Fe500. Provide checks for : a) Flexure b) One way shear c) Punching shear at distance = depth of footing from face of pier and at face of pier	20	3,5	4	5



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2026 Examinations – END - SEM

SET B

Semester: II

M.Tech

Program: M Tech

Course Code: AE MTSE 201

Course Name: **English For Technical Paper Writing**

English for Research Paper Writing

Duration: 03 hours

Maximum Points: 100

29/05/26

Note:

- Question 01 is Compulsory
- Total Seven Questions
- Out of remaining 06 questions attempt any four
- Attempt main questions and sub questions together.

Sr.No	Questions	Poi nts	CO	BL
Q.1.	Attempt ANY TWO Questions 1. Explain the major characteristics of academic and technical writing. How do they differ from general writing? 2. What is a research abstract? Discuss its purpose and major components. 3. Explain the significance of audience awareness in technical communication with suitable examples. 4. Conduct a SWOT analysis of an engineering sector related to your specialization.	20	01, 2,3 ,4, 5,6 ,7	02
Q.2.	The paragraph below lacks structure and clarity. Rewrite it using the MAP method. Paragraph A. During the fourth phase of metro tunnel excavation, the geotechnical monitoring team recorded differential ground settlement beyond the permissible threshold near the retaining wall. Field measurements indicated that excessive groundwater ingress and delayed grouting operations had contributed to the instability. Subsequent analysis showed that unless corrective measures are implemented immediately, adjacent utility lines may be affected. The site engineering committee therefore recommended continuous settlement monitoring, pressure grouting, and	20	02	L3

	revision of excavation sequencing to control further displacement. Paragraph B Testing of a three-phase power distribution panel in the laboratory revealed abnormal harmonic distortion under fluctuating load conditions. Measurements obtained through the power quality analyzer showed total harmonic distortion values exceeding the recommended standards. Technical examination indicated that nonlinear loads connected to the system were the principal source of distortion. If left unresolved, the condition may reduce equipment efficiency and shorten component life. The electrical maintenance team has proposed harmonic filters, periodic load balancing, and continuous monitoring of system performance.			
Q.3.	Identify and Explain the PEEL structure (Point, Evidence, Explanation, Link) in the following paragraphs. Paragraph A Sustainable transportation systems have become essential for urban development. A recent report published by the International Energy Agency indicates that electric public transit networks can significantly reduce carbon emissions in metropolitan regions. However, the report also notes that long-term sustainability depends upon reliable energy infrastructure and lifecycle battery management. This evidence suggests that transportation planning must combine technological innovation with environmental accountability. Therefore, engineers must adopt integrated strategies that address both operational efficiency and ecological responsibility. Paragraph B Automation is rapidly transforming industrial manufacturing processes. According to recent studies in the <i>Journal of Manufacturing Systems</i>, automated inspection systems improve production accuracy and reduce operational downtime. Nevertheless, researchers have also observed that excessive dependence on automation may reduce human intervention during critical failures. This demonstrates that productivity gains should be balanced with human oversight and adaptive decision-making. Hence, effective industrial automation requires both technical advancement and responsible management practices.	20	3	L1
Q.4.A	Discuss the importance of coherence, precision, and objectivity in technical report writing. Why are these qualities especially important in engineering communication? Differentiate between the following with suitable engineering examples: • Progress report and feasibility report • Periodic report and Inventory report	10	3	L2
Q.4.B	Your classmate was absent for the lecture on "Planning and Delivering Technical Presentations." He has to deliver a seminar presentation next week. Explain in detail:	10	4	L3

	• How to define the objective of the presentation • How to structure the content logically • How to use the Pyramid Principle for organizing arguments • Techniques of effective delivery (voice, body language, eye contact, time management) Talk Power Program • Guidelines for designing effective PowerPoint slides			
Q.5.A	Rewrite the following passive voice sentences into active voice. Explain when passive voice might be preferred in academic writing. Sentences: a) The experiment was conducted by the research team. b) The proposal was approved by the committee. c) The data was analyzed using SPSS. d) The paper was written by a group of scholars. e) The solution was heated until it boiled.	10	1	L6
Q.5.B	Your classmate was absent for the lecture on “Planning and Delivering Technical Presentations.” He has to deliver a seminar presentation next week. Explain in detail: • how to define the objective of the presentation • how to structure the content logically • how to use the Pyramid Principle for organizing arguments • techniques of effective delivery (voice, body language, eye contact, time management) • guidelines for designing effective PowerPoint slides	10	2	L4
Q.6.A	Describe the selection interview process in detail. Explain the following types of interviews with suitable examples: • Technical interview • HR interview • Panel interview • Stress interview • Behavioural interview	10	4	L2
Q.6.B	Explain how research grant proposals differ from industrial/technical project proposals in terms of objectives, audience, tone, and evaluation criteria. Prepare a brief research grant proposal outline (main headings with 1–2 bullet points each) on the topic: <i>“Integrating Renewable Energy Solutions in Urban Public Transport Systems.”</i>	10		
Q.6.B	Write a detailed Feasibility report for the following situation. Include all standard report components (Title, to/from, date, subject, introduction, body with headings/subheadings, findings, conclusions, recommendations, etc.) and indicate the format (Memo or Letter) clearly. You are appointed the coordinator of the Research and Development Cell at Sardar Patel College of Engineering. The principal has instructed you to prepare a feasibility report on establishing a <i>Central Research Innovation Hub</i> with shared laboratories, writing support cell, and industry-	20	5	L3

	collaboration desk for PG and PhD students.				
Q.7.A	In response to the advertisement below, prepare: A. Cover Letter B. Detailed Resume Exciting Research Career Opportunity for Engineers Organization: Indian Institute of Advanced Technology (IIAT) – Centre for Emerging Materials & Smart Systems Position: Junior Research Fellow (JRF) – Smart Infrastructure Monitoring Eligible Branches: Civil, Mechanical, Electrical, Electronics Eligible Students: M.Tech (Batch of 2026) – Final Year Location: Bengaluru (with project-related field visits across India) What We Offer: • Opportunity to work on a government-funded multi-institutional research project • Hands-on experience with sensors, data acquisition, and structural health monitoring • Possibility of PhD conversion based on performance • Stipend as per funding agency norms Eligibility Criteria: • Currently pursuing M.Tech in Civil / Mechanical / Electrical / Electronics Engineering • Minimum 60% aggregate or equivalent CGPA in all previous semesters • Strong fundamentals in core engineering and basic programming • Demonstrated interest in research (projects, seminars, publications, or internships) • Good written and oral communication skills and ability to work in a team Prepare a formal cover letter applying for this position and attach a well-structured CV suited to a research role.	20	4	L6	03



Bharatiya Vidya Bhavan's

Sardar Patel College of Engineering

(A Government Aided Autonomous Institute)

Munshi Nagar, Andheri (West), Mumbai - 400058.

End Semester Examination/ Re-Examination, May /June 2026

First Year M.Tech Civil

Max. Marks: 100

Class: M.Tech (SE) SE

Semester: II

Name of the Course: Theory of Plates

Duration: 3 hours

Program: Civil Engineering

Course Code: PE-MTSE222

Sem - II

04/06/26

Instructions:

1. All the questions refer to a thin plate with small deflection
2. Draw neat diagram to elaborate the derivations and the numerical
3. Assume suitable data, if necessary, and state the same clearly
4. Attempt any 5 out of 7 questions

Question No		Maximum Marks	Course Outcome Number	Module No.
Q.1	a) Draw a neat sketch of a plate element acted upon by internal forces and moments i. In pure bending ii. With external load b) Derive expression for slope in any direction 'n' c) Show that direction of zero slope and direction of maximum slope are at right angles to each other d) Derive expression for curvature along any two perpendicular directions 'n' and 't' and show that sum of curvatures along any two mutually perpendicular directions is constant. e) Explain assumptions of classical plate theory and discuss limitations	20	2	2,3
Q.2	a) Explain Kirchhoff's assumptions b) Write the mathematical expressions for the following boundary conditions. Explain with an appropriate diagram i. Simply supported edge ii. Free edge iii. Clamped edge iv. Elastic support c) Explain difference between Levy's Method and Navier's Method of analysis of plate. d) Explain the importance of influence surface and write the steps to plot it with appropriate diagram	20	1,2	1,3,5,6

Q.3	Derive plate biharmonic equation where w is the deflection, q is the loading and D is the flexural rigidity $\nabla^4 w = \frac{q}{D}$	20	2	3
Q.4	Using Levy's method, show that the expression for the deflection w of a uniformly loaded rectangular plate of dimensions $a \times b$, simply supported along all four edges and having flexural rigidity D, is $w = \sum_{m=1,3,\dots}^{\infty} \frac{4q_0 a^4}{m^5 \pi^5 D} \left[1 - \frac{2 + \alpha_m \tanh \alpha_m}{2 \cosh \alpha_m} \cosh \frac{m\pi y}{a} + \frac{1}{2 \cosh \alpha_m} \frac{m\pi y}{a} \sinh \frac{m\pi y}{a} \right] \sin \frac{m\pi x}{a}$ Where $\alpha_m = \frac{m\pi b}{2a}$ Using Levy's formula, calculate the maximum deflection for a rectangular plate of size 2m x 2m x 0.1m simply supported along all edges subjected to uniformly distributed load of 8 kN/m².	20	2	5,6
Q.5	Derive the expression for deflection 'w' of a uniformly loaded rectangular plate simply supported at all four edges using Navier's Method A rectangular plate of size 3.5m x 2.2m x 0.12m simply supported along all edges is subjected to uniformly distributed load of 10 kN/m². Using Navier's method, calculate - maximum deflection - maximum bending moment Take Young's modulus of elasticity $E = 22$ GPa and poisson's ratio $\nu = 0.2$	20	2	5,6
Q.6	A rectangular plate of size 4m x 4m x 0.15m simply supported along all edges is subjected to uniformly distributed load of 6.5 kN/m². Using finite difference method, with grid size $h = 1$ m calculate - maximum deflection - maximum bending moment - reactive corner force 'R' Take Young's modulus of elasticity $E = 20$ GPa and poisson's ratio $\nu = 0.15$	20	4	7

Q.7	Derive the expression for deflection 'w' and maximum moment 'Mr' for a simply supported circular plate of radius 'a' with uniformly distributed load of intensity 'q' over entire area. Note: Start the derivation using the axi-symmetric circular plate equation for radius r where Q_r = radial shear per unit length as follows: $\frac{\partial}{\partial r} \left[\frac{1}{r} \frac{\partial}{\partial r} \left(r \frac{\partial w}{\partial r} \right) \right] = -\frac{Q_r}{D}$ A circular plate of radius 0.8 m simply supported at outer edge is subjected to uniformly distributed load of 5 MPa. If allowable stress in the plate is 50 MPa, calculate - required thickness of plate - maximum deflection Take Young's modulus of elasticity $E = 22 \text{ GPa}$ and poisson's ratio $\nu = 0.25$	20	3	4
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Bharatiya Vidya Bhavan's

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Munshi Nagar, Andheri (West), Mumbai – 400058.

End Semester Examination/ ~~Re-Examination~~, May /June 2026



First Year M. Tech Civil

Max. Marks: 100

Class: M. Tech (Struct)

Program: M. Tech (Civil)

Name of the Course: Advanced design of concrete structures

Course Code : PE-MTSE221

Sem - II

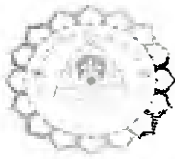
Duration: 03 Hrs

Semester: II

Instructions:

- 1) Use of IS code allowed
- 2) Assume data if required and state it clearly.
- 3) Question no. 1 is compulsory, Solve any 4 questions out of 6 remaining questions

Question No		Maximum Marks	Course Outcome Number	Module No.
Q1(a)	For a doubly reinforced beam of size 25 cm x 40 cm (overall depth) is provided with 3-20 mm dia steel as compression and tension reinforcement at an effective cover of 5 cm each, calculate ultimate moment carrying capacity of beam. The concrete has a 28-day cube strength of 250 kg/cm ² and steel has compressive and tensile yield stress of 2500 kg/cm ² and 2800 kg/cm ² respectively. Use ultimate load method	12	CO1	1
Q1(b)	Explain concept of tension hinge and compression hinge with proper diagrams and equations used in Baker's method of analysis.	08	CO2	2
Q2(a)	What are different limit states used for design ? Explain characteristic strength and characteristic load for limit state design.	06	CO2	4
Q.2 (b)	For pile of 400 mm dia , safe load on pile is 400 kn. Design pile cap for column 300 mm x 300 mm subjected to service load of 750 Kn Use M 25 concrete and Fe 415 steel. Draw reinforcement placement in pile cap with proper section.	14	CO4	7



Bharatiya Vidya Bhavan's

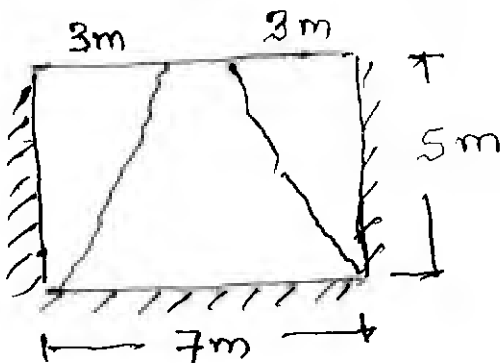
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End Semester Examination/ Re-Examination, May /June 2026



	Use M 25 grade of concrete and Fe 415 steel			
Q3	For the 3 equal span continuous beam of each span 5.0 m is subjected to service UDL of 2.50 T/m including self weight. Use load factor 2.0. Size of beam : 23 cm x 50 cm effective depth $\sigma_{cu} = 200 \text{ kg/cm}^2$ $\sigma_{sy} = 2400 \text{ kg/cm}^2$ $\epsilon_{sy} = 0.0012$ Tensile steel 4- 20 dia bars Use Baker's method of design - Calculate EI - Calculate plastic moment - Calculate influence coefficients - Calculate relative rotation and permissible rotation - Check for increase in capacity of section	20	CO2	2
Q4(a)	Using the yield line theory and virtual work method, determine the ultimate resisting moment per linear meter (m) for the isotropic reinforced two-way slab sustaining a uniformly distributed load of 9 kN/m^2 and a line load of 5 kN/m as shown in the figure below. 	08	CO3	3
Q. 4(b)	Analyze intermediate panel of flat slab and Calculate design bending moments for slab of size 5.0 m x 7.0 m. The slab is subjected to live load of 4.0 kN/m^2 in addition to floor load 1 kN/m^2 and self-weight The slab is supported by columns of size 500 mm x 500 mm. Provide drop panel. Use M 40 grade of concrete and Fe 415 steel	12	CO4	5



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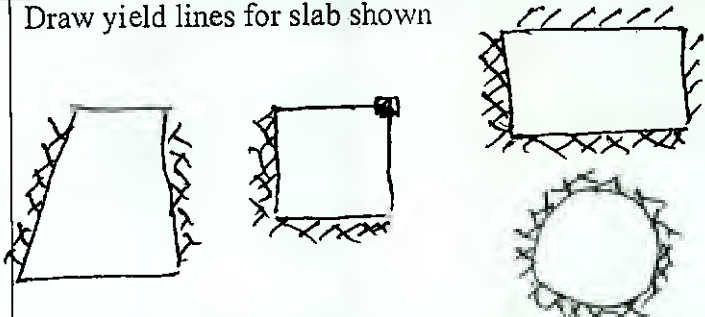
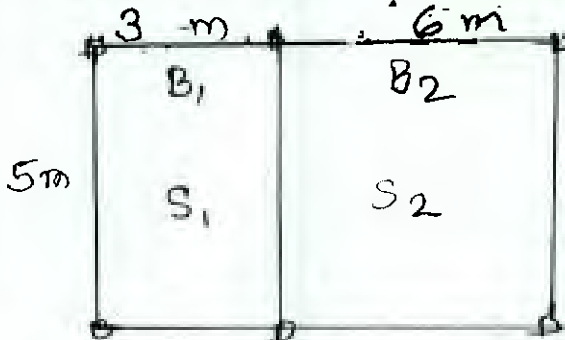
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End Semester Examination/ Re-Examination, May /June 2026



	Use direct design method Draw reinforcement in plan			
Q.5(a).	Draw yield lines for slab shown 	08	CO3	3
Q.5(b).	For the slab beam arrangement shown calculate design bending moments for Beam 1 and 2 and design beam 1 for flexure and shear. The thickness of slabs is 125 mm and are subjected to live load of 4.0 Kn/m ² in addition to floor load 1 Kn/m ² Design of slab is not required. Use M 20 grade of concrete and Fe 415 steel 	12	CO2	4
Q.6.	For 15 m x 15 m raft with 1.0 m Over hang on all four sides is having slab beam arrangement as shown. The extra load of parking from plinth is 10 kn/m ² The service load on columns is C1= 900 Kn , C2= 1500 Kn, C3= 3000Kn SBC of soil at a depth of 4.00 m is 150kn/m ² a) Perform calculations for load equilibrium b) Design typical slab. c) Draw Bending moment and shear force diagram for Beam B1-B2- B3 Beam B7, B8, B9	20	CO4	7



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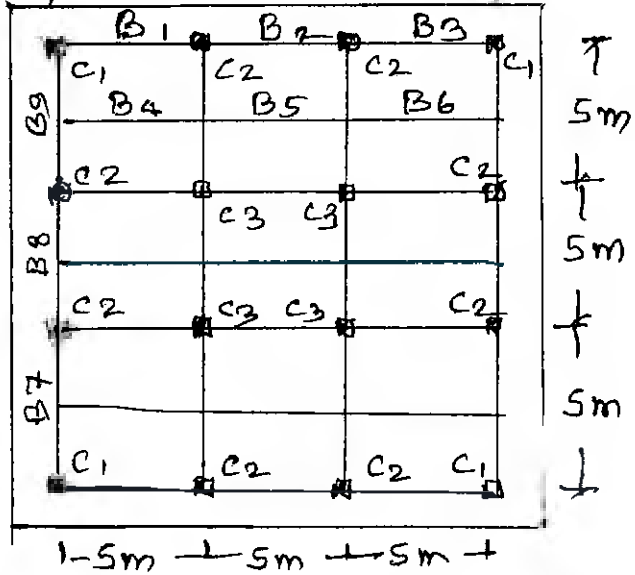
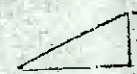
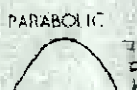
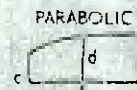
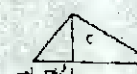
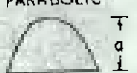
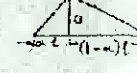
	d) Design Beam B1-B2- B3 e) Draw Reinforcement detail for beam in elevation Use M 25 grade of concrete and Fe 415 steel 			
Q.7	Design Silo with conical hopper bottom to store wheat. The dimensions of silo are as shown in the figure. Design ring beam also. Use Airy's theory Assume unit weight of wheat as 8340 N/m³. Use M20 grade of concrete and mild steel reinforcement Fe 250. Height of silo cylinder 20 m , Internal diameter of silo 5.0 m, conical bottom height = 2.25m. , opening at bottom of silo 0.5 m Perform calculations at h = 5 m, 10 m, 15m, and 20m Use $\mu = 0.46$, $\mu' = 0.43$ Draw reinforcement in section (A) $P_h = \gamma h \left[\frac{1}{\sqrt{1+\mu^2} + \sqrt{\mu(\mu+\mu')}} \right]^2$ $P_w = P_h \times \frac{h}{2}$ (B) $P_h = \frac{\gamma b}{(\mu+\mu')} \left[1 - \frac{\sqrt{1+\mu^2}}{\sqrt{\frac{2b}{b}(\mu+\mu')} + \sqrt{1-\mu\mu'}} \right]$ $P_h = \frac{\gamma b^2}{2(\mu+\mu')^2} \left[\sqrt{\frac{2b}{b}(\mu+\mu')} + (1-\mu\mu') - \sqrt{1+\mu^2} \right]$	20	CO4	6

TABLE 8.1 PRODUCT

$M_1 \backslash M_2$			
	lac	$\frac{1}{2} lac$	$\frac{1}{2} lac$
	$\frac{1}{2} lac$	$\frac{1}{2} lac$	$\frac{1}{2} lac$
	$\frac{1}{2} lac$	$\frac{1}{2} lac$	$\frac{1}{2} lac$
	$\frac{2}{3} lac$	$\frac{1}{2} lac$	$\frac{1}{2} lac$
	$\frac{1}{2} lac$	$\frac{1}{2} lac$	$\frac{1}{2} lac$
	$\frac{1}{2} la(c+d)$	$\frac{1}{6} la(2c+d)$	$\frac{1}{6} la(c+2d)$
	$\frac{1}{6} la(c+4d+e)$ $d = \text{central ordinate}$	$\frac{1}{6} la(c+2d)$	$\frac{1}{6} la(2d+e)$
	$\frac{1}{2} lac$	$\frac{1}{2} lac(2-\alpha)$	$\frac{1}{6} lac(1+\alpha)$

INTEGRALS— $\int M_1 M_2 ds$ Values

PARABOLIC 			
$\frac{2}{3} lac$	$\frac{1}{2} lac$	$\frac{1}{2} l(a+b)c$	$\frac{1}{2} lac$
$\frac{1}{2} lac$	$\frac{1}{2} lac$	$\frac{1}{6} l(2a+b)c$	$\frac{1}{6} lac(2-\alpha)$
$\frac{1}{2} lac$	$\frac{1}{2} lac$	$\frac{1}{6} l(a+2b)c$	$\frac{1}{6} lac(1+\alpha)$
$\frac{1}{5} lac$	$\frac{1}{2} lac$	$\frac{1}{6} l(a+b)c$	$\frac{1}{6} lac(\alpha+1-\alpha^2)$
$\frac{1}{5} lac$	$\frac{1}{2} lac$	$\frac{1}{6} l(a+b)c$	$\frac{1}{12} lac \frac{(3-4\alpha^2)}{(1-\alpha)}$ If $\alpha > 0.5$ $\frac{lac}{12\alpha} (8\alpha - 4\alpha^2 - 1)$
$\frac{1}{3} la(c+d)$	$\frac{1}{2} la(c+d)$	$\frac{1}{6} l[a(2c+d) + b(2d+c)]$	$\frac{1}{6} al[d(1+\alpha) + c(2-\alpha)]$
$\frac{1}{15} la(c+8d)$	$\frac{1}{24} la(c+10d+e)$	$\frac{1}{6} la(2d+c) + \frac{1}{6} lb(2d+e)$	$\frac{1}{12} al \times [2\alpha^2(c-2d+e) + 4\alpha(d-c) + 2c+4d]$
$\frac{1}{6} lac(1+\alpha-\alpha^2)$	$\frac{1}{12} lac \frac{(3-4\alpha^2)}{1-\alpha}$ $\alpha > 0.5$ $\frac{lac}{12\alpha} (8\alpha - 4\alpha^2 - 1)$	$\frac{1}{6} l[c(b(1+\alpha) + a(2-\alpha))]$	$\frac{1}{6} lac$



Bharatiya Vidya Bhavan's

Sardar Patel College of Engineering

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End Semester Examination/ Re-Examination, May /June 2026



Max. Marks: 100

Duration: 3 hours

Class: MTech CM/SE SE

Semester: II

Program: M Tech

Name of the Course: Legal Aspects In Construction Course Code : OEMTCM202

Instructions:

Questions to be attempted in the series

Question No. 1 is compulsory

Sem-II

02/06/26

Question No		Maximum Marks	Course Outcome Number	Module No.
Q1 A	MCQ's	15	1, 2, 3, 4	1, 2, 3, 4, 5, 6
	1. An agreement which is enforceable by law at the option of one or more of the parties thereto, but not at the option of the other, is a.....: (a) Valid contract (b) Unenforceable contract (c) Voidable contract (d) Void agreement 2. In case of illegal agreements, the collateral agreements are: (a) Valid (b) Voidable (c) Void (d) None 3. If the contract is illegally terminated, the contractor can demand claims on a percentage basis. (a) % of overhead on remaining work (b) % of loss of profit on remaining work 4. As per Section 62 of the Indian Contract Act, additions, alterations in the contract can be made: (a) Unilaterally by any party (b) The contract cannot be changed			

	(c) Only by consent of both parties to the contract. 5. If a party does not co-operate in constituting an Arbitral Tribunal, the Court can appoint an arbitrator under Section _____ of the Arbitration and Conciliation Act, 1996 (a) Section 34 (b) Section 11 (c) Section 16 6. In absence of any provision in the contract in respect of variation in quantity, the Supreme Court of India laid down the law for considering the variations as: (a) +/- 10% (b) +/- 20% (c) +/- 30% (d) +/- 40% 7. If an offer is required to be kept valid for certain days from the date of submission of an offer, it is called: (a) Contingent contract (b) Option contract (c) Void contract 8. Acceptance of an offer with additional terms in the work order is said to be: (a) Counter offer (b) Absolute Acceptance (c) Rejection of an offer. 9. Before any change is made in a Contract, Notice is mandatory a) True b) False 10. A entered a Contract with B with an understanding that the contract would come into existence after A would get acceptance from the Competent Authority. The validity of the bid was 6 months. Can B withdraw the offer before 6 months? a) Yes b) No 11. In absence of an arbitration clause in the contract, one party can still insist on arbitration.			
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	i) True ii) False 12. There is no special act in India for engineering contracts. i) True ii) False 13. If the Employer insists on signing the Bills, No Claims Certificate etc. for which the Contractor is not willing but has no choice but to sign it, in that event, the remedy available for the Contractor is; a) Not to sign it b) Has to sign it (can it be Must sign it) c) Can sign under protest 14. If the Employer does not allow the Contractor to sign a certain document under protest, what is the legal remedy available with contractor which can create his rights by using the doctrine of a) Res judicata b) Estoppel c) Coercion 15. When both the parties simultaneously delay their part of an obligation then such an act is said to be a a) Breach by both parties b) Breach of promise c) Concurrent delay d) Critical delay			
Q1 B	Write a note on the Workmen's Compensation Act, 1923	05	4	6
Q2 A	Discuss the Legal, contractor and practical remedies A construction project is awarded to M/S XYZ to be completed in 24 months. For the first 10 months, the project is delayed due to the lack of environmental permission. The owner promised to give an extension of time to complete the work at the appropriate time. At the time of extension, the Owner levied LD. What is the remedy with the Contractor?	15	2	2, 4
Q2B	Enlist various types of Construction Contracts and explain the BOT contract.	05	3	3
Q3 A	What is FIDIC? Advantages, Disadvantages and colour Coding	15	3	7
Q3 B	Enlist in sequence the Stages and Parts in the Tendering process	05	3	3

Q4 A	Write a short note on the following Acts Contract Labours Act Professional Liability	10	4	6
Q4 B	Enlist the various ADR and explain Mini Jury Trial	10	4	5
Q5 A	Explain the doctrine of 1. Good Faith 2. Privity of contract 3. Waiver 4. Constructive Notice 5. Notice	10	2	2
Q5 B	Enlist the different types of claims in a construction contract and discuss the claim for loss of profit.	10	2	4
Q6 A	A contractor was engaged in the construction of a hospital project. Due to delays attributable to the employer, the contractor seeks compensation for head office overheads and loss of profit. The following data is available: • Contract Value: ₹ 200 crore • Contract Duration: 36months • Actual Duration (including delay): 50 months • Delay attributable to employer: 10 months • Contractor's audited annual head office overheads: ₹ 20 crore • Annual turnover of contractor: ₹ 250 crore • Overhead (expected): 8% of contract value Calculate damages based on Hudson, Emden and Eichleay Formulas.	15	2, 3	4
Q6 B	Enlist the essential conditions of the construction contract	05	3	3
Q7 A	A contractor was awarded a contract for the construction of a municipal office building. • Original Contract Value: ₹ 100 crore • Work Completed: ₹ 20 crore • The Employer terminated the contract. The contractor seeks compensation for loss of profit on the unexecuted portion of the contract. Calculate the loss of profit with detailed calculations, assuming a loss of profit @12%	10	2, 3	4
Q7 B	Enlist the Rules of interpretation of a Contract and explain any one rule in detail.	10	2	2



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End Semester Examination/ ~~Re-Examination~~, May /June 2026



*First year M. Tech Civil
Sem - II*

Max. Marks: 100

Duration: 03 Hours

Class: FY M. Tech, Civil/Electrical Engineering, Semester: II

Program: PG

Name of the Course: Artificial Intelligence in Engineering

Course Code: OE-MTCE205/OE-MTSE205

02/06/26

Instructions:

- Attempt any five questions.
- Answer to all sub questions should be grouped together.
- Figure to right indicates full marks.
- Assume suitable data wherever necessary and state it clearly.

Question No.		Maximum Marks	Course Outcome Number	Module No.
Q1.	(a) What are data driven methods? What are the advantages of data driven methods over the traditional methods? State its engineering applications with an example.	10	1	1
	(b) How are digital computers comparable to human brain? Explain the concept of computing and state the characteristics of soft computing.	10	1	1
Q2.	(a) What is fuzzy logic? Explain in brief fuzzy set, crisp set, fuzzy logic and probability.	10	1	2
	(b) Discuss the role of membership function in Fuzzy logic. Explain its various types.	10	2	2
Q3.	(a) Explain the working of Artificial Neural Networks (ANN) with neat sketch. State the importance of every terminology used in ANN.	10	2	3
	(b) Explain Machine learning with supervised learning, unsupervised learning and reinforcement learning with an example.	10	2	3
Q4.	(a) What are the limitations of traditional optimization approaches? Discuss Genetic Algorithm (GA) as a	10	1	4

	probabilistic search method and the principle on which it works.			
	(b)Deliberate applications of Genetic Algorithm (GA) in engineering.	10	2	4
Q5.	(a)What is Genetic Programming (GP)? Discuss role of terminal set, function set, fitness measure, parameters and termination criteria with result designation in GP.	10	2	4
	(b) Explain the important requirement of closure property and sufficiency property in the Genetic Programming (GP). Also explain control parameters used in GP.	10	2	4
Q6.	(a) Explain the importance of Model tree (MT) technique in data mining. State and explain the principle on which Model tree works.	10	2	4
	(b) Differentiate Classification vs. association rules used in data mining and decision making. Give an example	10	2	5
Q7.	Write short notes on:			
	(a) Fuzzy logic controlled genetic algorithms	05	1	5
	(b) Genetic algorithm based back propagation network	05	1	5
	(c) Neuro genetic hybrids	05	1	5
	(d) Fuzzy back propagation networks	05	1	5



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End Semester Examination/ Re-Examination, May /June 2026



First Year M. Tech Civil

Max. Marks: 100

Class: F.Y.M.Tech

Semester: II

Duration: 3 HRS
Program: MTech(CM)

Name of the Course: Operations Research

Code : OE-MTCM201

SE

Sem - II

SE

02/06/26

Instructions:

1. Draw neat diagrams
2. Assume suitable data if necessary and state the clearly.

Question No		Maximum Marks	Course Outcome Number	Modu No.																		
Q1-A	Solve following LPP using Revised simplex method (Standard form-I) method- Max $Z = X_1 + 2X_2$ Subject to, $X_1 + X_2 \leq 3$ $X_1 + X_2 \leq 5$ $3X_1 + X_2 \leq 6$ $X_1, X_2, X_3 \geq 0$	10	1	2																		
Q1-B	There are 5 jobs, each of which has to go through the machines A and B in the order AB. The processing times (in hours) are given as <table><tr><th>Job</th><th>J1</th><th>J2</th><th>J3</th><th>J4</th><th>J5</th></tr><tr><td>Machine A</td><td>2</td><td>4</td><td>5</td><td>7</td><td>1</td></tr><tr><td>Machine B</td><td>3</td><td>6</td><td>1</td><td>4</td><td>8</td></tr></table> Determine a sequence of these jobs that will minimize the total elapsed time T. Also obtain: i) the minimum elapsed time; and ii) the idle time for each of the machines.	Job	J1	J2	J3	J4	J5	Machine A	2	4	5	7	1	Machine B	3	6	1	4	8	10	3,2	4
Job	J1	J2	J3	J4	J5																	
Machine A	2	4	5	7	1																	
Machine B	3	6	1	4	8																	
Q2 A	1.Explain all types of cost involved in Deterministic inventory model.	10	3	7																		

	2. If for a project, annual demand is 10000/year, order cost=300/order, carrying cost = Rs 4/unit/year then- a) Estimate Economic order quantity and Total cost of project according to continuous demand instantaneous replenishment model. b) Draw graphs for all types of costs in EOQ concept.			
Q2 B	Derive formulae for total cost and EOQ for continuous demand instantaneous replenishment model with backordering.	10	3	7
Q3- A	Solve by Kunh-tucker Conditions- Minimize $F(X) = X_1^2 + X_2^2 + 60 X_1$ Subject to, $g1 = X_1 - 80 \geq 0$ $g2 = X_1 + X_2 - 120 \geq 0$ $X_1, X_2 \geq 0$	10	2	3
Q3 -B	A retail store stocks two types of shirts A and B. These are packed in attractive cardboard boxes. During a week the store can sell a maximum of 400 shirts of type A and a maximum of 300 shirts of type B. The storage capacity, however, is limited to a maximum of 600, of both types combined. Type A shirt fetches a profit of Rs. 2/- per unit and type B a profit of Rs. 5/- per unit. How many of each type the store should stock per week to maximize the total profit? Formulate a LPP model of the problem.	10	2	1
Q4	Minimise $f(x) = 7 * X_1 * X_2^{-1} + 3 * X_2 * X_3^{-2} + 5 * X_1^{-3} * X_2 * X_3 + X_1 * X_2 * X_3$ Where, $X_1, X_2, X_3 \geq 0$ Solve above model using geometric programming	20	4	5
Q5	Consider following parametric linear programming problem- Max $Z = (10 - 2t)X_1 + (5 - 3t)X_2$ S.T. $8X_1 + 2X_2 \leq 48$ $2X_1 + 4X_2 \leq 24$ $X_1, X_2, t \geq 0$	20	4	6

Perform parametric analysis with respect to objective function coefficient and find the range of t over which optimal solution will not change.
Use following linear programming The optimum table –

C_B	C_j	10	5	0	0	Solution
	Basic variable	x_1	x_2	s_1	s_2	
10	x_1	1	0	1/7	-1/14	36/7
5	x_2	0	1	-1/14	2/7	24/7
	Z_j	10	5	15/14	5/7	480/7
	$C_j - Z_j$	0	0	-15/14	-5/7	

Q 6 A

Write Dual form of following LPP-

$$\text{Max } Z = X_1 + 3X_2$$

$$\text{Subject to, } 3X_1 + 2X_2 \leq 6$$

$$3X_1 + X_2 = 4$$

$$X_1, X_2 \geq 0$$

Q6 -B

A small project is composed of 7 activities whose time estimates are listed below. Activities are being identified by their beginning (i) and ending (j) node numbers.

Activities		Time in weeks		
i	j	t_o	t_f	t_p
1	2	1	1	7
1	3	1	4	7
1	4	2	2	8
2	5	1	1	1
3	5	2	5	14
4	6	2	5	6
5	6	3	6	15

1. Draw the network
2. Calculate the expected variances for each
3. Find the expected project completed time
4. Calculate the probability that the project will be completed at least 3 weeks than expected
5. If the project due date is 18 weeks, what is the probability of not meeting the due date?

Q7	Solve Following LPP by Simplex method- Max $Z = 23X_1 + 32X_2$ Subject to, $10X_1 + 6X_2 \leq 2500$ $5X_1 + 10X_2 \leq 2000$ $X_1 + 2X_2 \leq 500$ $X_1, X_2 \geq 0$	20	1	3
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Bharatiya Vidya Bhavan's

Sardar Patel College of Engineering

(A Government Aided Autonomous Institute)

Munshi Nagar, Andheri (West), Mumbai - 400058.

~~End Semester Examination/ Re-Examination~~

May - 2026



Max. Marks: 100

Class: M.Tech *first year* Semester: II

Name of the Course: Earthquake Engineering

Duration: 3 Hours

Program: Civil Engineering

Course Code : PC-MST 202

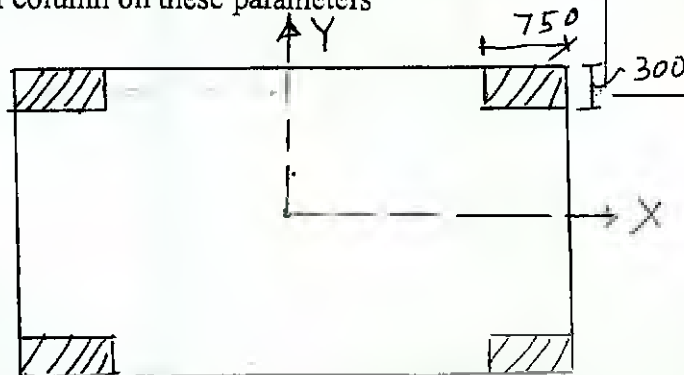
Sem-II

14/11/26

Instructions:

- Attempt any FIVE questions out of SEVEN questions.
- Answers to all sub questions should be grouped together.
- Figures to the right indicate full marks.
- Assume suitable data if necessary and state the same clearly

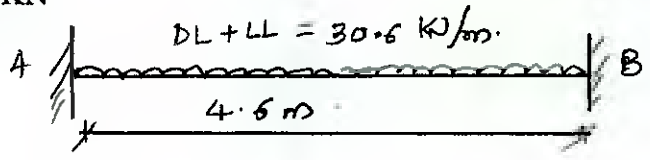
Question No		Max. Marks	Course outcome	Module No.
Q1 (a)	Answer the followings:			
	(ii) What is Seismic Zone Factor? Explain briefly its significance	2	4	6
	(iii) Briefly explain the Plate Tectonic Theory of an earthquake	4	1	2
	(iii) Explain briefly the structure of earth.	3	1	2
Q1 (b)	(i) A uniform rigid slab of total mass 30 t is supported by four columns of height 6.0 m. rigidly connected to the top of slab and fixed at bottom. Each column is rectangular section of 750 mm x 300 mm as shown in figure. Calculate the natural frequencies in X and Y directions. If the system is subjected to harmonic ground motion of amplitude 0.3g at frequency of 10 rad/sec in X direction only, calculate the maximum lateral displacement of slab in X direction and maximum stress in each column $\zeta = 5\%$ and $E = 20,000$ MPa.	6	2	1
	(ii) In the above problem, If the columns are hinged at bottom, then calculate the maximum lateral displacement of slab in X direction and maximum stress in each column. Comment on the effect of fixity of column on these parameters	5	2	1,4



Q2 (a)	A rigid slab is supported on the four corner columns as shown in figure. Calculate the natural frequency and mode shapes for the structure. $E = 20,000 \text{ Mpa}$ Mass on slab 200 kg/m^2. Height of col = 6m Col. fixed at bottom.	10	2	1
Q2(b)	If all the column sizes are same, calculate all the three natural frequencies	4	2	1
Q2(c)	If the above structure (With all columns sizes same) is subjected to an El Centro earthquake ground motion whose response spectra is shown in Figure 1 (i) only in X direction and (ii) Only in Y direction separately. Calculate the maximum displacements of slab for both cases. Assume damping ratio $\xi = 5\%$.	6	3	4
Q3 (a)	A two storey building frame with brick infill wall is shown in figure. Assuming the beams are rigid, calculate the lateral stiffness of the 2nd storey considering the effect of infill wall considering the infill was stiffness also as per IS 1893-2016. Compare the stiffness of the 2nd storey of frame with and without infill wall. $E_m = 13800 \text{ Mpa}$ $E_f = 5000 \sqrt{f_{ck}}$ $f_{ck} = 30 \text{ Mpa}$ $I_c = I_b = 0.002278125 \text{ m}^4$	10	2,4	1.6

	For URM infill walls without any opening, width w_{ds} of equivalent diagonal strut (see Fig. 7) shall be taken as: $w_{ds} = 0.175\alpha_h^{-0.4} L_{ds}$ where $\alpha_h = h \left(\sqrt[4]{\frac{E_m t \sin 2\theta}{4E_f I_c h}} \right)$			
Q3 (b)	The plan of one story building is as shown in figure. The structure consists of a roof idealized as a rigid diaphragm, supported on four frames A, B, C and D as shown. The roof weight is uniformly distributed and has magnitude 200 Kg/m². The lateral stiffness are $K_y = 20000$ KN/m for frame A and B and $K_x = 25000$ KN/m for frame C and D. The plan dimensions are $b = 30$ m $d = 15$ m. The height of building is 6m. (i) Derive the stiffness matrix (ii) If the structure is subjected to ground motion only in Y direction, write down the equations of motion for the system	6	2	1
		2	1	1
Q3(c)	If the above system is subjected to the ground motion only in X direction, the response spectrum of which is shown in figure 1. Determine the design value of lateral deformation, base shear and bending moment for the system	4	3	4

Q4(a)	What is the response spectrum? Explain the procedure to construct an elastic response spectrum for a given peak ground motion parameters including amplification factors	5	3	3																																			
Q4(b)	Briefly explain the earthquake design principle as per IS 1893-2016 (i.e. fail safe criteria)	3	3	3																																			
Q4 (c)	A four-story school building special moment resisting frame has a story height of 4 m for the ground story and 3 m for the 2 nd to 4 th story. The building is located in Mumbai. The weight on the 1 st to 3 rd floor is 400 KN and on the 4 th floor, it is 300KN. Using the equivalent static method, calculate the distribution of lateral loads and story shear. Assume soil strata as a medium. Use the response spectra given in Figure 2	12	4	5																																			
Q5 (a)	Explain the three requirements of displacement design of structure for earthquake load as per IS 1893-2016.	3	4	5																																			
Q5 (b)	Explain the different methods of seismic analysis as per IS 1893-2016	2	4	5																																			
Q5 (c)	Briefly explain the different types of structural systems used in a building structure to resist lateral loads due to earthquake.	3	4	5																																			
Q5 (d)	Using response spectrum method, calculate the seismic force on each floor of the frame whose pre vibration properties are given below. Use the following additional data: $Z=0.24$, $I=1.5$, $R=5.0$ and $\xi = 5\%$. Assume foundation strata as soft soil and use response spectrum given in figure 3. Assume the story height as 4m for all storey. <table><tr><th>Story No.</th><th>Mass No.</th><th>Mass (t)</th><th>ω rad/sec</th><th colspan="3">Mode shapes</th></tr><tr><td></td><td></td><td></td><td></td><th>Φ_{i1}</th><th>Φ_{i2}</th><th>Φ_{i3}</th></tr><tr><td>1</td><td>1</td><td>50</td><td>14.52</td><td>1.00</td><td>2.160</td><td>3.313</td></tr><tr><td>2</td><td>2</td><td>50</td><td>31.05</td><td>1.00</td><td>0.893</td><td>-1.473</td></tr><tr><td>3</td><td>3</td><td>40</td><td>46.10</td><td>1.00</td><td>-1.042</td><td>0.410</td></tr></table>	Story No.	Mass No.	Mass (t)	ω rad/sec	Mode shapes							Φ_{i1}	Φ_{i2}	Φ_{i3}	1	1	50	14.52	1.00	2.160	3.313	2	2	50	31.05	1.00	0.893	-1.473	3	3	40	46.10	1.00	-1.042	0.410	12	4	5
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3	3	40	46.10	1.00	-1.042	0.410																																	
Q 6(a)	Briefly explain the Response Spectrum characteristics	4	3	3																																			

Q 6(b)	Briefly explain the following: (i) Explain briefly that as per IS 1893-2016 provisions, under what condition and which structures the vertical ground motion to be considered? (ii) What is Response Reduction factor? It depends on what? Briefly explain its significance in earthquake resistant design of structure per IS 1893-2016.	6	4	5
Q 6(c)	(i) A building having a non-uniform distribution of mass is shown in figure 4. Locate its center of mass (ii) The plan of a simple one-storied building shown in figure. The stiffness of each column is shown in figure 5. Obtain the center of stiffness. (Centre of Rigidity).	4	4	5
Q 6(d)	The first floor plan of a building with shear walls is as shown in figure 6. The plinth level plan is also same. Calculate the fundamental period of the building as per the provision of 7.6.2, of IS 1893-2016 both in X and Y direction. The total height of building is 24 m.	4	4	5
Q 6(e)	For the SMRFs idealized as shear building with rigid girders shown in figure 7, investigate whether the building structure has soft story. The height of first story is 4.5 m and that of remaining is 3.0 m.	2	4	5
Q 7(a)	A beam of a frame is shown in figure 8 with limiting moment of resistance at both ends and for both sway from left right and right to left. Calculate the design shear force as per IS 13920 -2016. The calculated factored shear force is 142 KN  For sway from left to right At A $M_{u\lim} = 140 \text{ kNm}$ At B $M_{u\lim} = 120 \text{ kNm}$ For sway from right to left At A $M_{u\lim} = 200 \text{ kNm}$ At B $M_{u\lim} = 90 \text{ kNm}$	5	4	6

Q 7(b)	For a column of cross section 530mm x 300mm calculate the special confinement reinforcement (i.e diameter and spacing of ties as a special confinement reinforcement) as per IS 13920-2026. The grade of concrete is M 30 and that of steel is Fe 415, consider clear cover to the ties is 60 mm. Also calculate the length l_0 of special confinement reinforcement. The clear height of column is 4.0 m.	5	4	6
Q 7(c)	Explain the provisions of IS 13920 for (i) Beams: General provisions, longitudinal reinforcement and web reinforcement.	5	4	5,6
Q 7(d)	Explain in brief the different types of bracings with neat sketches that can be used as lateral load resisting systems in steel structures	5	4	7

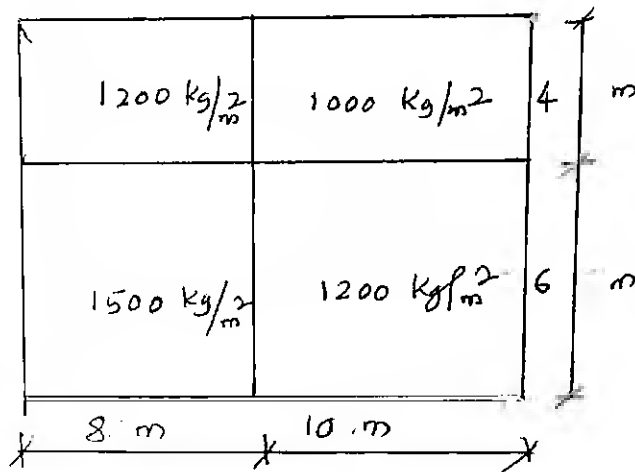


Fig. 4

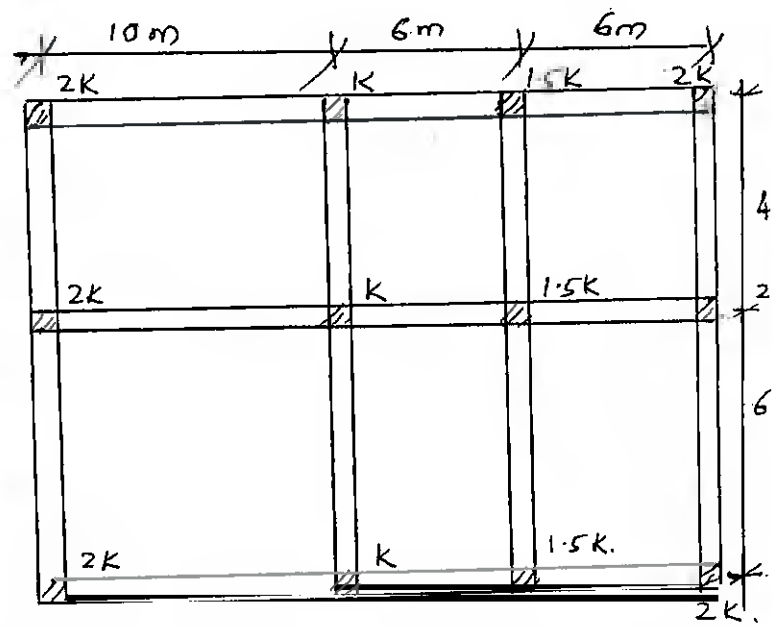


Fig 5

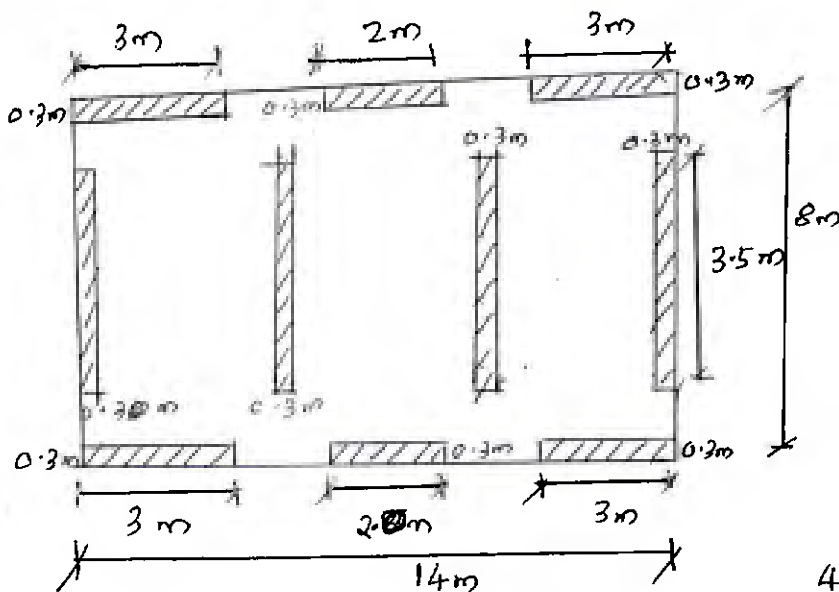


Fig. 6

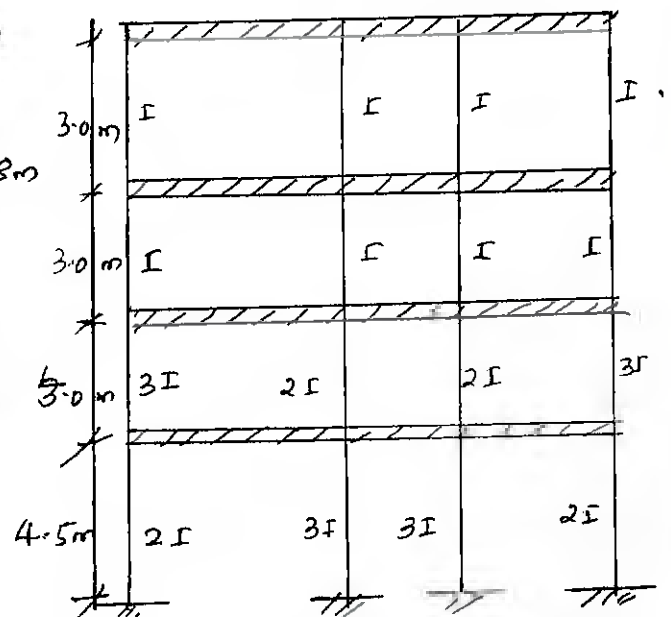


Fig. 7

7

DISPLACEMENT RESPONSE SPECTRA
FOR EL-CENTRO EARTHQUAKE FOR 5% DAMPING $PGA = 0.32g$

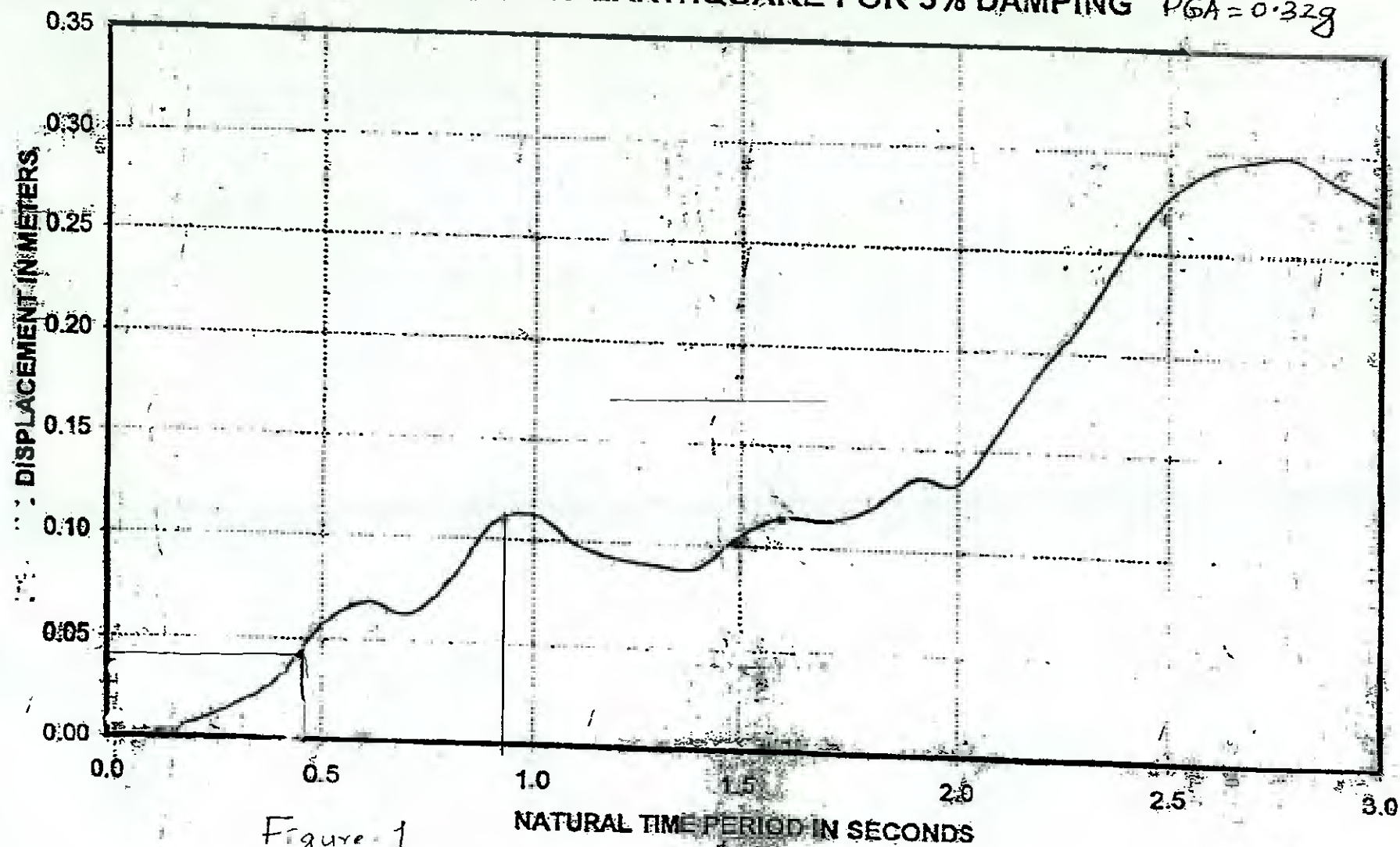


Figure 1

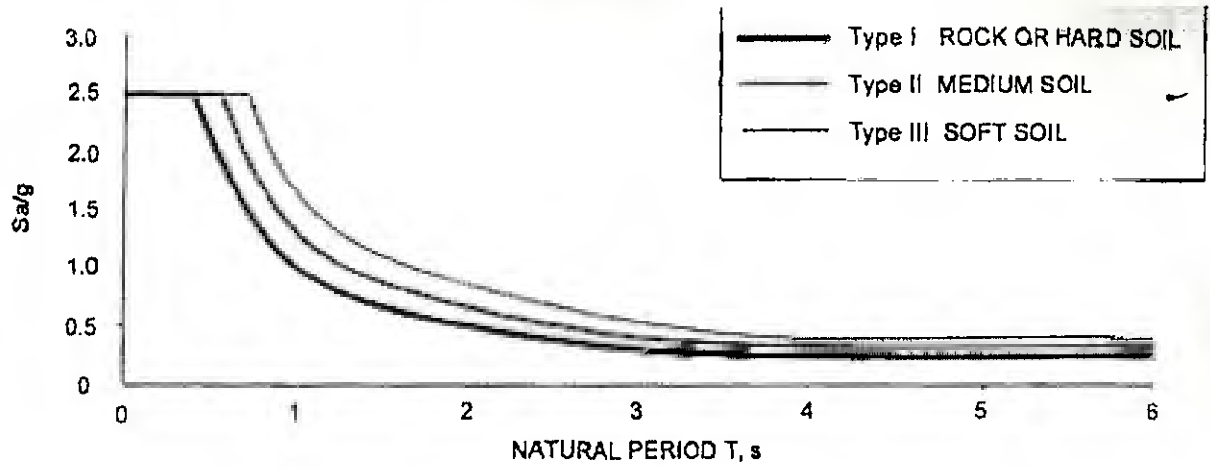


Fig. 2A SPECTRA FOR EQUIVALENT STATIC METHOD

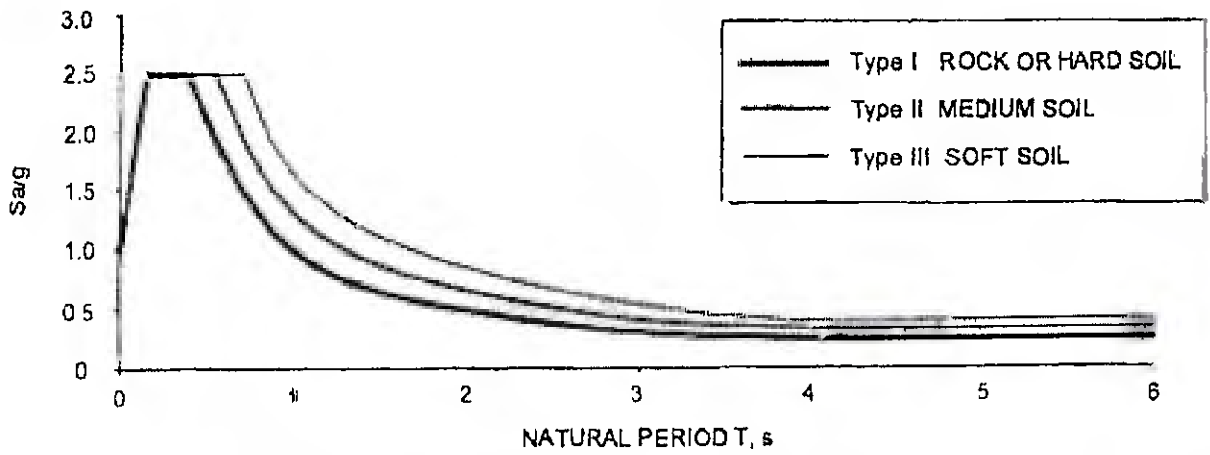


Fig. 2B SPECTRA FOR RESPONSE SPECTRUM METHOD

FIG. 2 DESIGN ACCELERATION COEFFICIENT (S_a/g) (CORRESPONDING TO 5 PERCENT DAMPING)

**End Semester/Re-examination - ~~May~~ / July 2026 Examinations****Program: M.Tech Civil Engg. (Structure)** *First Year***Duration: 3Hours****Course Code: PE-MTSE211****Maximum Points: 100****Course Name: Bridge Engineering****Semester: II**

Notes: 1) Attempt any 5 main questions

2) Assume suitable data if missing and mention the same clearly

3) Draw neat sketches wherever possible

4) Use of IRC 6, IRC 112 and IS 800 is permissible

Sem-II 15/7/26

Q.No.	Questions	Points	CO	BL	Module
1.a)	Evaluate the maximum bending moment and maximum shear force for a girder of span 18.5m subjected to a single class 70R wheeled vehicle and having a courbon factor of 0.5	7	1,5	4	2,3
1.b)	Design an RCC girder of span 18.5m as per IRC 112 with following specifications: UDL on girder due to footpath and crash barrier = 15kN/m UDL on girder due to wearing course = 4.5kN/m Live load as per Q.1(a) Effective slab width as beam flange = 2.2m Depth of slab = 0.3m Use M35 and Fe500	13	3	4	3
2.	Design an RC slab culvert for an effective span of 5.5m and a carriageway of 9m. Wearing coat is of 80mm thickness. Consider single train of IRC Class 70R tracked vehicle loading. SIDL = 10kN/m ² . Use M30 and Fe500 Provide checks for limit state of strength and limit state of serviceability.	20	1,3,5	4	2,3
3	A through type steel struss bridge is to be designed for the following details : The total dead load of truss per each nodal point = 150kN Deck width = 8.5m; Span of bridge = 40m; Maximum rise = 5m; Slab thickness = 250mm The bridge is to be used as foot over bridge. Select an appropriate member arrangement and Design the top chord member considering appropriate live loads and load combinations. Use $f_y=250\text{N/mm}^2$	20	3	4	2,4
4.a)	Explain the various load cases and conditions to be considered for design of bridge substructure with neat sketches.	10	4	4	5
4b)	For bridge pier having seismic mass as 4800kN, the height of pier is 15m and the cross section is 2.8m diameter made of M45 concrete. Assume the base to be fixed and obtain : i) Time period as per IRC ii) Base shear and overturning moment acting on the pier	10	1,5	3	2,7
5.a)	Explain in detail - Functions of bearings and its types. Also explain articulation of bearings.	10	1	2	5
5.b)	Explain the points the be considered for ensuring good bridge aesthetics.	10	1	2	1
6	Design a shallow foundation as per IRC 112 for a pier of size 1.25m x 1.25m. The design axial load = 3100kN and design moment along transverse axis = 1900kNm. SBC of soil =	20	3,5	4	5

	160kN/m ² . Use M30 and Fe500. Provide checks for : a) Flexure b) One way shear c) Punching shear at distance 2 x depth of footing from face of pier and at face of pier				
7.a)	Enlist the different methods for bridge construction. Explain the incremental launching method for construction of bridges with neat sketches. Explain the suitability of this method, stages of construction and impact of construction stages on design.	10	2,4	3	6
7.b)	Explain the data that needs to be collected for planning and design of a bridge.	10	1	2	1



Bharatiya Vidya Bhavan's

SARDAR PATEL COLLEGE OF ENGINEERING

(Government Aided Autonomous Institute)

Munshi Nagar, Andheri (W) Mumbai - 400058

End Semester 2026 Examinations

RE-Exam July 2026 SET A

M.Tech Semester II

Program: M Tech

Course Code: AE MTSE 201-002

Course Name: English For Technical Writing
English for research paper writing

Duration: **03 hours**

Maximum Points: **100**

Jan-D

16/7/26

Note:

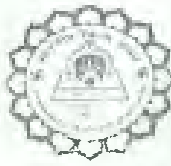
- Total Seven Questions
- Question 01 is Compulsory
- Out of remaining 06 questions attempt any four
- Main questions and sub-questions to be attempted together.
- Start every question from new page.

Sr.No	Questions	Poi nts	C O	BL
Q.1,	Briefly Explain ANY TWO from the following: 1. Define the term <i>report writing</i> and explain how it differs from essay writing in academic and technical contexts. 2. Explain the MAP (Message-Audience-Purpose) framework in academic writing. 3. Role and components of a literature review in a research article. 4. SWOT analysis of the respective branch you are studying	20	1. 2, 3, 4, 5	02
Q.2. A	The paragraph below lacks structure and clarity. Rewrite it using the MAP method. Paragraph A During the third month of the academic block construction project, the project monitoring team observed a schedule variance of 11 percent against the baseline programme. Site records indicate that delayed delivery of reinforcement steel, unplanned equipment downtime, and revision of formwork drawings contributed significantly to the slippage. A structural review further noted that column concreting activities in Zone B cannot proceed until the revised load-transfer calculations are approved by the design consultant. If the present trend continues, the project completion date will be affected by approximately three weeks. To recover the schedule, the project manager has recommended resequencing of activities, deployment of an additional batching unit, and weekly coordination meetings between the contractor, consultant,	20	01	L4

	and procurement team. Paragraph B Performance testing of the 15 kW induction motor used in the conveyor drive system showed a gradual rise in operating temperature beyond the permissible limit during continuous loading. Vibration measurements taken at the drive-end bearing indicated amplitudes higher than the specified design tolerance. Detailed inspection revealed minor shaft misalignment and insufficient lubrication in the bearing housing. Prolonged operation under these conditions may reduce bearing life, increase energy consumption, and cause unplanned shutdown of the production line. The maintenance engineering team has therefore recommended immediate alignment correction, replacement of the lubricant, and periodic condition monitoring using thermal imaging and vibration analysis.			
Q.3.A	Identify and Explain the PEEL structure (Point, Evidence, Explanation, Link) in the following paragraphs. A. Engineering solutions to climate change demand not only technical ingenuity but also accountability. For instance, large-scale geoengineering proposals such as stratospheric aerosol injection have been criticized in <i>Nature Climate Change</i> for their unpredictable ecological consequences, despite promising models that suggest temporary cooling effects. This tension demonstrates that evidence of short-term success cannot be divorced from long-term risks, requiring engineers to balance innovation with precaution. Therefore, the responsibility of engineers extends beyond designing solutions—it links directly to safeguarding future generations, making ethical foresight a central pillar of academic and professional practice. B. Artificial intelligence is transforming healthcare, but its adoption raises complex challenges. Recent reports from <i>The Lancet Digital Health</i> highlight that while AI diagnostic tools can outperform radiologists in detecting early-stage cancers, they often fail when applied to diverse patient populations due to biased training datasets. This paradox illustrates that technological accuracy alone cannot guarantee equitable outcomes; the evidence shows that social and ethical dimensions are inseparable from technical performance. Consequently, the integration of AI into healthcare systems must be accompanied by rigorous data governance and ethical oversight, linking innovation with responsibility to ensure patient trust and safety.	10	03	03
Q.3. B	Rewrite the following sentences to reflect academic tone with clarity, objectivity, and precision. Explain your changes. Given Sentences a) I think the results are quite good. b) We did this study to check what happens.	10	02	L3

	c) A lot of scientists believe this is important. d) This paper talks about solar panels. e) Our results were very surprising!			
Q. 4 A	Explain the importance of objectivity and clarity in report writing. Why are these qualities critical in engineering reports? Differentiate between informational reports and analytical reports. Provide one example of each relevant to engineering practice.	10		L1, L2
Q.4. B.	You Friend missed the lecture on "How to make Effective Presentation" delivered by your faculty advisor. He has a presentation next week. Explain in detail the content, structure of presentation, how to write the presentation using the pyramid method, how to deliver the presentation, and the tips to prepare PowerPoint slides for the presentation	10	04	L2
Q.5. A.	Describe the process of reading and analyzing a primary research article. What barriers an academic reader face while reading the journal papers for literature review. Describe the strategies to effective reading.	10	04	L3
Q.5. B.	Explain the Interview process in detail. Describe the different types of interviews a candidate has to face.	10	05	L2
Q.6 A.	Create a detailed report for the following situations: The Principal of Sardar Patel College of Engineering has to submit a report to the Directorate of Technical Education Maharashtra about the placement's statistics in the institute for last five years. You are the newly appointed Training and placement officer for SPCE. You are assigned the task through an email to prepare the report and submit it by June 2, 2026. The report includes the data of UG and the PG section placements. You are permitted to seek information from heads of departments, collect feedback from placed students, speak to faculty coordinators for Training and Placement, and refer the data from TPO office and also the Disha Magazine. Invent other necessary sources to collect your data. Write the report in Memo format Note: Mention all the contents in sequence and an outline of points and sub-points of your report as taught in class.	20	02	L6
Q.7.A	In response to the advertisement below prepare a Cover Letter (10 Marks) Resume (10 Marks) Exciting Career Opportunity for Core Branch Engineers Company: Larsen & Toubro (L&T) Position: Senior Engineer Core Engineering Roles Eligible Branches: Civil Mechanical Electrical	20	03	L6

	Eligible Students: M tech (Batch of 2026) Location: Pan-India Project Sites & Offices What We Offer: Hands-on training on real-world mega projects Opportunity to work with industry experts Career growth in core engineering fields Competitive compensation and benefits Eligibility Criteria: • Currently pursuing MTech in Civil, Mechanical, or Electrical Engineering • Minimum 60% aggregate across academics (B.Tech semesters till date) • Strong technical fundamentals and aptitude for fieldwork Excellent communication and teamwork skills			
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Bharatiya Vidya Bhavan's

Sardar Patel College of Engineering

(A Government Aided Autonomous Institute)

Munshi Nagar, Andheri (West), Mumbai – 400058.

End Semester Examination/ Re-Examination, May /June 2026



Max. Marks: 100

Class: M. Tech (Struct)

Program: M. Tech (Civil)

Name of the Course: Advanced design of concrete structures

Course Code : PE-MTSE221

Duration: 03 Hrs

Semester: II

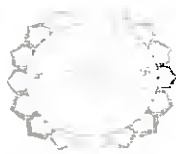
Sem - II

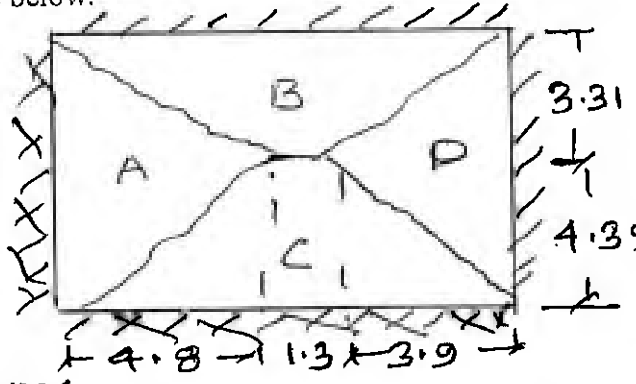
16/7/26

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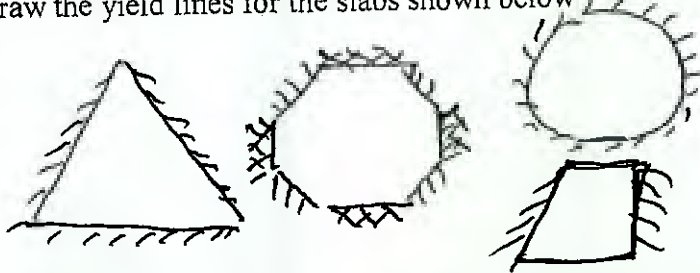
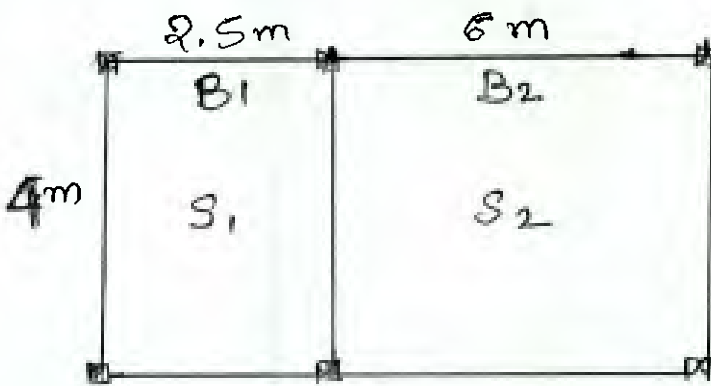
- 1) Use of IS code allowed
- 2) Assume data if required and state it clearly.
- 3) Solve any 5 questions

Question No		Maximum Marks	Course Outcome Number	Module No.
Q1(a)	For a doubly reinforced beam of size 25 cm x 45 cm (overall depth) is provided with 4-20 mm dia steel as compression and tension reinforcement at an effective cover of 5 cm each, calculate ultimate moment carrying capacity of beam. The concrete has a 28-day cube strength of 250 kg/cm ² and steel has compressive and tensile yield stress of 2500 kg/cm ² and 2800 kg/cm ² respectively. Use ultimate load method	12	CO1	1
Q1(b)	Explain concept of tension hinge and compression hinge with proper diagrams and equations used in Baker's method of analysis.	08	CO2	2
Q2(a)	Explain design steps for pile as structural member	06	CO2	4
Q.2 (b)	For pile of 500 mm dia, safe load on pile is 600 kn. Design pile cap for column 300 mm x 300 mm subjected to service load of 1050 Kn Use M 25 concrete and Fe 415 steel. Draw reinforcement placement in pile cap with proper section. Use M 25 grade of concrete and Fe 415 steel	14	CO4	7



Q3	For the 3 equal span continuous beam of each span 4.0 m is subjected to service UDL of 2.0 T/m including self weight. Use load factor 2.0. Size of beam : 23 cm x 45 cm effective depth $\sigma_{cu} = 200 \text{ kg/cm}^2$ $\sigma_{sy} = 2400 \text{ kg/cm}^2$ $\epsilon_{sy} = 0.0012$ Tensile steel 4- 20 dia bars Use Baker's method of design - Calculate EI - Calculate plastic moment - Calculate influence coefficients - Calculate relative rotation and permissible rotation - Check for increase in capacity of section	20	CO2	2
Q4(a)	Using the yield line theory and virtual work method, determine the ultimate resisting moment per linear meter (m) for the isotropic reinforced two-way slab sustaining a uniformly distributed load of 10 kN/m² as shown in the figure below.  The diagram shows a rectangular slab with dimensions 4.8m (width) and 4.39m (depth). The slab is divided into four regions (A, B, C, D) by yield lines. The yield lines are labeled with 'm' and 'm'.	08	CO3	3
Q. 4(b)	Analyze intermediate panel of flat slab and Calculate design bending moments for slab of size 5.0 m x 7.0 m. The slab is subjected to live load of 4.0 Kn/m² in addition to floor load 1 Kn/m² and self-weight The slab is supported by columns of size 500 mm x 500 mm. Provide drop panel. Use direct design method Draw reinforcement in plan Use M 40 grade of concrete and Fe 415 steel	12	CO4	5



Q.5(a).	Draw the yield lines for the slabs shown below 	08	CO3	3
Q.5(b).	For the slab beam arrangement shown calculate design bending moments for Beam 1 and 2 and design beam 1 for flexure and shear. The thickness of slabs is 125 mm and are subjected to live load of 5.0 Kn/m² in addition to floor load 1 Kn/m². Design of slab is not required. Use M 20 grade of concrete and Fe 415 steel 	12	CO2	4
Q.6.	For 16.5 m x 16.5 m raft with 1.0 m Over hang on all four sides is having slab beam arrangement as shown. The extra load of parking from plinth is 10 kn/m² The service load on columns is C1= 1000 Kn , C2= 1800 Kn, C3= 3000Kn SBC of soil at a depth of 4.00 m is 150kn/m² - Perform calculations for load equilibrium . - Design typical slab. - Draw Bending moment and shear force diagram for Beam B4-B5- B6 Beam B7, B8, B9 - Design Beam B4 -B5- B6 - Draw Reinforcement detail for beam in elevation Use M 25 grade of concrete and Fe 415 steel	20	CO4	7



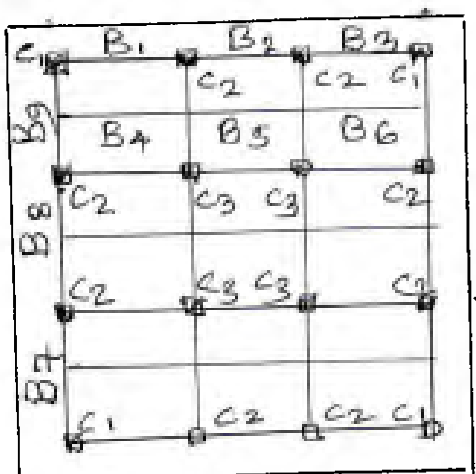
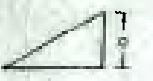
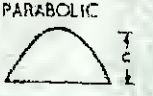
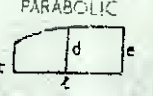
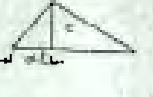
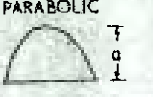
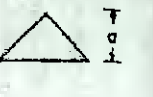
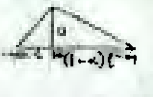
				
Q.7	Design Silo with conical hopper bottom to store wheat. The dimensions of silo are as shown in the figure. Design ring beam also. Use Airy's theory Assume unit weight of wheat as 8340 N/m³. Use M20 grade of concrete and mild steel reinforcement Fe 250. Height of silo cylinder 16 m , Internal diameter of silo 4.0 m, conical bottom height = 2.25m. , opening at bottom of silo 0.5 m Perform calculations at h = 4 m, 8m, 12m, and 16m Use $\mu = 0.46$, $\mu' = 0.43$ Draw reinforcement in section $P_h = \gamma h \left[\frac{1}{\sqrt{1+\mu^2}} + \sqrt{\mu(\mu+\mu')} \right]^2$ $P_w = P_h \times \frac{h}{2}$ $P_h = \frac{\gamma b}{(\mu+\mu')} \left[1 - \frac{\sqrt{1+\mu^2}}{\sqrt{\frac{2h}{b}(\mu+\mu') + (1-\mu\mu')}} \right]$ $P_h = \frac{\gamma b^2}{2(\mu+\mu')^2} \left[\sqrt{\frac{2h}{b}(\mu+\mu') + (1-\mu\mu')} - \sqrt{1+\mu^2} \right]$	20	CO4	6

TABLE 8.1 PRODUCT

M_k	M_t		
			
	lac	$\frac{1}{2} lac$	$\frac{1}{2} lac$
	$\frac{1}{2} lac$	$\frac{1}{2} lac$	$\frac{1}{2} lac$
	$\frac{1}{2} lac$	$\frac{1}{2} lac$	$\frac{1}{2} lac$
	$\frac{2}{3} lac$	$\frac{1}{3} lac$	$\frac{1}{3} lac$
	$\frac{1}{2} lac$	$\frac{1}{2} lac$	$\frac{1}{2} lac$
	$\frac{1}{2} la(c+d)$	$\frac{1}{2} la(2c+d)$	$\frac{1}{2} la(c+2d)$
	$\frac{1}{6} la(c+4d+e)$ $d = \text{central ordinate}$	$\frac{1}{6} la(c+2d)$	$\frac{1}{6} la(2d+e)$
	$\frac{1}{2} lac$	$\frac{1}{2} lac(2-\alpha)$	$\frac{1}{2} lac(1+\alpha)$

INTEGRALS— $\int M_1 M_2 ds$ Values

PARABOLIC			
			
$\frac{1}{12} lac$	$\frac{1}{2} lac$	$\frac{1}{2} l(a+b)c$	$\frac{1}{2} lac$
$\frac{1}{3} lac$	$\frac{1}{2} lac$	$\frac{1}{2} l(2a+b)c$	$\frac{1}{2} lac(2-\alpha)$
$\frac{1}{3} lac$	$\frac{1}{2} lac$	$\frac{1}{2} l(a+2b)c$	$\frac{1}{2} lac(1+\alpha)$
$\frac{1}{12} lac$	$\frac{1}{12} lac$	$\frac{1}{2} l(a+b)c$	$\frac{1}{2} lac(\alpha+1-\alpha^2)$
$\frac{1}{12} lac$	$\frac{1}{2} lac$	$\frac{1}{2} l(a+b)c$	$\frac{1}{2} lac \frac{(3-4\alpha^2)}{(1-\alpha)}$ If $\alpha > 0.5$ $\frac{lac}{12\alpha} (8\alpha - 4\alpha^2 - 1)$
$\frac{1}{2} lac(c+d)$	$\frac{1}{2} la(c+d)$	$\frac{1}{2} l[a(2c+d) + b(2d+c)]$	$\frac{1}{2} al[d(1+\alpha) + c(2-\alpha)]$
$\frac{la}{15} (c+c+8d)$	$\frac{la}{24} (c+10d+e)$	$\frac{1}{6} la(2d+c) + \frac{1}{6} lb(2d+e)$	$\frac{1}{6} al \left[\frac{2a^2(c-2d+e)}{+4\alpha(d-c)} + 2c+4d \right]$
$\frac{1}{2} lac(1+\alpha-\alpha^2)$	$\frac{1}{12} lac \frac{(3-4\alpha^2)}{1-\alpha}$ $\alpha > 0.5$ $\frac{lac}{12\alpha} (8\alpha - 4\alpha^2 - 1)$	$\frac{1}{2} lc[b(1+\alpha) + a(2-\alpha)]$	$\frac{1}{2} lac$