



Bharatiya Vidya Bhavan's
SARDAR PATEL COLLEGE OF ENGINEERING

(Government Aided Autonomous Institute)
Munshi Nagar, Andheri (W) Mumbai - 400058



END SEM/RE-EXAM EXAMINATION MAY / JUNE 2026

Program: M Tech Mechanical

Course Code: PC-MTMD201

Course Name: System Modeling & Synthesis of Mechanisms

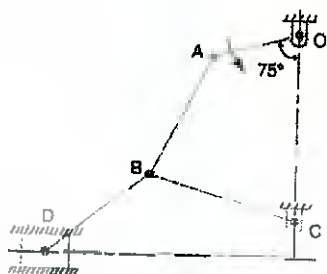
Duration: 3 Hrs

Maximum Points: 100

Semester: II

Notes: Solve ANY FIVE questions

Assume Suitable Data

Q.No	Questions	Points	CO	BL	Module No.
Q.1 a	Explain the concept of system modeling. Discuss physical laws used in mathematical modeling of engineering systems with suitable examples.	10	1	IV	1
b	Derive Mason's Gain Formula for signal flow graphs and explain its application in reduction of complex systems.	10	2	IV	2
Q.2 a	Develop mathematical models for the following mechanical elements: 1. Inertia element 2. Spring element 3. Damper element Discuss their force-displacement and force-velocity relationships.	10	2	VI	2
b	Reduce a multi-subsystem block diagram into a single transfer function using block diagram reduction rules.	10	3	VI	5
Q.3 a	Differentiate between lower pair and higher pair with suitable examples. Explain rigid body, kinematic pair, kinematic chain, and mechanism.	10	3	IV	3
b	As shown in figure, the angular velocity of the crank OA is 600 r.p.m. Determine the linear velocity of the slider D and the angular velocity of the link BD, when the crank is inclined at an angle of 75° to the vertical. The dimensions of various links are : OA = 28 mm ; AB = 44 mm ; BC = 49 mm ; and BD = 46 mm. The centre distance between the centres of rotation O and C is 65 mm. The path of travel of the slider is 11 mm below the fixed point C. The slider moves along a horizontal path and OC is vertical. 	10	4	V	4



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Q.4 a	Explain Type Synthesis, Number Synthesis, and Dimensional Synthesis of mechanisms with suitable examples.	10	4	V	4
b	Discuss accuracy points and spacing of accuracy points in mechanism synthesis. Explain the significance of Chebyshev polynomials.	10	3	VI	6
Q.5 a	Derive the equation of the coupler curve for a four-bar linkage. Explain the significance of double points and symmetry.	10	3	VI	6
b	State and explain Roberts–Chebyshev theorem with neat sketches.	10	3	V	6
Q.6 a	Classify toothed wheels and discuss the different terms used in the gears.	10	4	V	4
b	i) The number of teeth on each of the two equal spur gears in mesh are 40. The teeth have 20° involute profile and the module is 6 mm. If the arc of contact is 1.75 times the circular pitch, find the addendum. ii) A pinion having 30 teeth drives a gear having 80 teeth. The profile of the gears is involute with 20° pressure angle, 12 mm module and 10 mm addendum. Find the length of path of contact, arc of contact and the contact ratio.	10	4	VII	4
Q.7 a	Classify cams and followers and discuss the terms used in radial cams	10	4	VI	7
b	A cam is to be designed for a knife edge follower with the following data: 1. Cam lift = 40 mm during 90° of cam rotation with simple harmonic motion. 2. Dwell for the next 30° . 3. During the next 60° of cam rotation, the follower returns to its original position with simple harmonic motion. 4. Dwell during the remaining 180° . Draw the profile of the cam when (a) the line of stroke of the follower passes through the axis of the cam shaft, and (b) the line of stroke is offset 20 mm from the axis of the cam shaft. The radius of the base circle of the cam is 40 mm. Determine the maximum velocity and acceleration of the follower during its ascent and descent, if the cam rotates at 240 r.p.m.	10	4	VI	7



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END SEM/~~RE-EXAM~~/May/June 2026-1



Program: MTech Mechanical engg

m/c Design

Duration: 3 hr

Course Code: PC-MTMD202

Maximum Points: 100

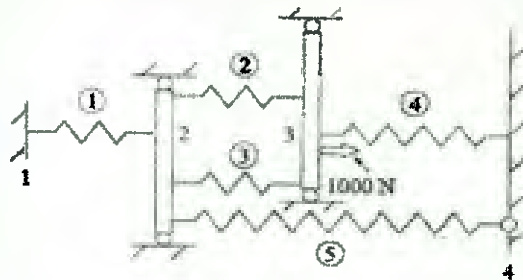
Course Name: Adv FEM

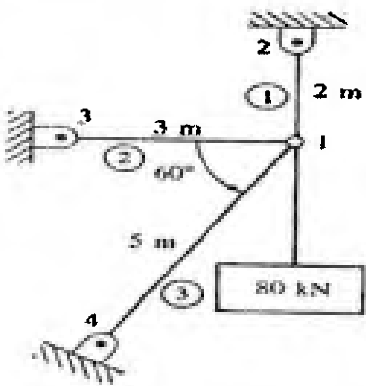
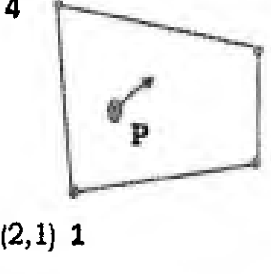
Semester: II

Notes:

1. Question 1 is compulsory, solve any 4 out of remaining.
2. Answers to each sub-questions are grouped together
3. Use of scientific calculator is allowed
4. Begin answer to each question on new page.
5. Keep some margin on left side of answer paper

Q.No	Question Description	Pts	CO	BL
1	a) Explain the general steps involved in the Finite Element Analysis (FEA) process, from discretization to post-processing. b) Derive the strain-displacement matrix [B] for 2D triangular matrix.	10 10	1,2	3,4
2	a) For the five-spring assemblage shown in figure, determine: I. The assembled stiffness matrix. II. Nodal displacement (Assume the rigid vertical bars at nodes 2 and 3 connecting the springs remain horizontal at all times but are free to slide or displace left or right. There is an applied force at node 3 of 1000 N to the right; and ($K_1 = K_4 = 800 \text{ N/m}$ $K_5 = 500 \text{ N/m}$ $K_2 = K_3 = 400 \text{ N/m}$) b) Derive the expression of weak formulation for simply supported beam element with udl.	10 10	2,3	2,3
3	a) A stepped metallic bar is subjected to an axial load of 200kN at small end; Section 1: $L=300\text{mm}$, $A=600\text{mm}^2$, $E=200\text{GPa}$ Section 2: $L=200\text{mm}$, $A=300\text{mm}^2$, $E=70\text{GPa}$ Obtain :- assembled stiffness matrix, nodal displacement and stress in each section.	20	3	2,3



4	For the truss shown in fig. obtain: - Elements stiffness matrix - Displacement of node 1 - Stress in each element $E = 210 \text{ GPa}$, $A = 4 \times 10^{-4} \text{ m}^2$ 	10 5 5	2,3	2,3
5	The pin-fin used for heat dissipation, has 60 mm long and circular c/s area of $81\pi \text{ mm}^2$. At one end of fin temperature is 250°C. (take $k = 100 \text{ watt/cm } ^\circ\text{C}$, $h = 10 \text{ watt/cm}^2 ^\circ\text{C}$, use 2 linear elements, consider convection from free end also) Find: - Conductive and convective matrix for each element - Final assembled matrix - Thermal load vector - Temperature at the other end of pin.	6 4 4 6	1,2,3	3,4
6	a) The element shown in Fig., $P(3, 4)$ is the point on which the load of 10kN in the directions of 60 degrees with horizontal is applied. Determine its nodal equivalent forces. b) Obtain the jacobian matrix for quadrilateral element shown in fig. 	10 10	2,3	2,3
7	- List and elaborate the characteristics of the stiffness matrix. - Explain the concept of Natural Coordinates, Derive the shape functions for a 1D quadratic bar element in natural coordinates.	10 10	1,2,3	2,3



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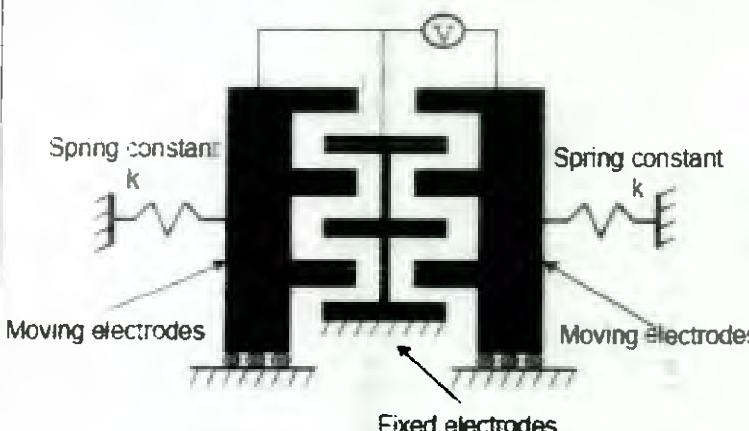
END SEMESTER EXAMINATION MAY 2026 / RE - EXAM JULY 2026

Program: M.Tech Machine Design *Sum II*
Course Code: PE-MTMD08
Course Name: Micro-Electro Mechanical Systems

Duration: 03 Hours. *26/5/26*
Maximum Points: 100
Semester: II

Notes:

1. Question no 1 is compulsory
2. Attempt any four questions from the remaining six questions.
3. If necessary assume suitable data with justification
4. Draw neatly labeled sketches wherever required.

Q. No.	Questions	Points	CO	BL	Module No.
1A	For the micro-griper shown in Figure B, determine the voltage supply required to pull the moving electrode 10 microns from the unstretched position of the spring. The spring constant k is 0.05 N/m. The comb drive is operated in air. The gap d between the electrodes and the width W of the electrodes are 2 microns and 5 microns respectively. 	10	1,4	2,3	2
1B	Analyze the structure and classification of Carbon Nanotubes (CNTs). Compare SWCNT and MWCNT, and differentiate between Armchair, Zigzag, and Chiral CNTs. Evaluate how chirality influences the electrical properties of CNTs and justify its importance in nanoelectronic applications.	10	2,3	4	7
2A	Analyze the suitability of MEMS technology for implantable medical devices compared to macro-scale instrumentation. Explain its role in improving performance, biocompatibility, manufacturing cost, and long-term stability.	10	1,2	4,5	1



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END SEMESTER EXAMINATION MAY 2026 / RE - EXAM JULY 2026

2B	In Microstereolithography, different scanning schemes influence the fabrication quality, accuracy, and dimensional precision of microstructures. Analyze the working of pre-objective, post-objective, and off-axis scanning systems. Also explain which scanning scheme is more suitable for obtaining uniform spot size and high precision, with proper justification.	10	2,4	3,4	4
3 A	Evaluate the feasibility of replacing traditional sensors with MEMS-based sensors in aircraft structural monitoring systems. Justify your answer by considering reliability, cost, redundancy, fabrication complexity, and safety certification requirements.	10(6 +4)	2,4	4	1
3B	Estimate the resolution and depth of focus of a state-of-the-art excimer laser stepper using a KrF light source with wavelength $\lambda = 248$ nm and numerical aperture $NA = 0.6$. Assume $k_1 = 0.75$ and $k_2 = 0.5$. Use the standard lithography equations for resolution and depth of focus. Explain the working principle of photolithography and discuss how patterns from a mask are transferred to the photoresist layer.	10	4	4,5	3
4A	Analyze the suitability of wet etching and dry etching processes for fabricating high-aspect-ratio microstructures in MEMS. Explain which process is more appropriate with proper justification.	10	1,3	4	3
4B	A MEMS designer needs to fabricate high-aspect-ratio metallic microstructures with an aspect ratio greater than 100:1 and nearly vertical sidewalls for inertial sensor applications. Analyze the most suitable fabrication technique for this requirement and explain your selection based on process physics, resolution capability, and infrastructure requirements. Also explain the working mechanism of the selected fabrication process.	10	2	3,4	4
5A	Analyze the concept of scaling laws in MEMS and explain how important physical quantities such as mass, electrostatic force, and gravitational force change with characteristic length. Discuss why surface forces become more dominant than body forces at the micro-scale.	10	3,2	4	5
5B	A researcher needs to characterize a MEMS device operating in a liquid environment with nanometer-level resolution. Evaluate why conventional SEM is not suitable for this application. Compare the suitability of AFM and SPM techniques for liquid-environment characterization, and justify the most appropriate approach based on resolution, operating medium, sample compatibility, and measurement accuracy.	10	3,1	4	6
6A	Evaluate the role of governing equations in MEMS modelling by comparing the equations used in mechanical, thermal, and fluid domains. Justify the significance of each equation in predicting	10	2	4	5



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END SEMESTER EXAMINATION MAY 2026 /RE - EXAM JULY 2026

	MEMS device behavior, performance, and application suitability.				
6B	Evaluate the use of Laser Doppler Vibrometry for MEMS vibration analysis. Justify its suitability by explaining the working principle, measurement of velocity and displacement using the Doppler effect, and its significance in dynamic characterization of MEMS devices.	10	1,2	3	6
7A	A capacitive MEMS pressure sensor consists of two square parallel plates of dimensions $L = W = 900 \mu\text{m}$ separated initially by an air gap of $2.2 \mu\text{m}$. The dielectric medium between the plates is air with $\epsilon_r = 1$, and the permittivity of free space is $\epsilon_0 = 8.85 \text{ pF/m}$. During operation, the gap between the electrodes changes to 2.5, 2.2, 1.8, 1.4, 1.0, and $0.6 \mu\text{m}$ due to diaphragm deflection. Determine the voltage ratio V_o/V_i for each gap value. Carefully justify the unit conversion, capacitance variation, and the effect of decreasing gap on sensor output.	10	4	4,5	2
7B	Evaluate the concept of nanotechnology by defining the nanoscale and its significance in engineering applications. Compare MEMS and NEMS in terms of feature size, dominant physical effects, fabrication techniques, and operating frequency, and justify how miniaturization influences their performance and applications.	10	2,4	3,4	7



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2026 Examinations – END-SEM

SET B

Semester: II

M.Tech

29/5/26

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

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	L4

	• 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



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

Max. Marks: 100

Class: F.Y. (M)

Semester: II

Duration: 3hrs

Program: F.Y.M.Tech. in
Mechanical Engineering

Name of the Course: Waste to Energy

Course Code : OE-MTMD204

Instructions:

1. Question 1 is compulsory.
2. Solve any 4 questions from remaining.
3. Assume Suitable Data wherever required.

Question No		Maximum Marks	Course Outcome Number	Module No.
Q1A	Analyze industrial waste as fuel: categorize types, challenges like heterogeneity, and integration with incineration systems. Provide a case study.	10	CO1	M1
Q1B	Propose a waste-to-energy scheme for mixed MSW in India, integrating classification, device selection, and policy incentives.	10	CO1	M1
Q2A	Discuss catalytic pyrolysis for upgraded pyrolytic oils: select catalysts, predict yields, and evaluate fuel properties	10	CO2	M2
Q2B	Quantify economic feasibility of charcoal production via earth-pit vs. metal kilns; include lifecycle emissions	10	CO4	M2
Q3A	Perform mass-energy balance for a 100 kW gasifier-engine system; include standby provisions.	10	CO2	M3
Q3B	Analyze kinetic vs. equilibrium approaches in gasifier modeling; validate with experimental data for biomass blends	10	CO2	M3
Q4A	Classify improved chullahs (types, efficiency); design an exotic rocket stove with heat transfer analysis	10	CO3	M4

Q4B	Analyze operation of inclined grate combustors: model fuel bed combustion zones and ash handling	10	CO3	M4
Q5A	Discuss bioenergy systems status in India; evaluate KVIC vs. Deenbandhu models economically	10	CO4	M5
Q5B	Compute biogas potential from MSW; integrate with urban waste-to-energy frameworks.	10	CO4	M5
Q6A	Design liquefaction process for algae biomass; compare hydrothermal vs. pyrolysis routes	10	CO3	M6
Q6B	Integrate biochemical (digestion) and thermochemical (gasification) for hybrid bioenergy plants.	10	CO2	M6
Q7A	Review biomass energy programs (National Bioenergy Mission); critique achievements to 2026	10	CO4	M7
A7B	Detail alcohol production from biomass (ethanol via fermentation); compute yields from sugarcane.	10	CO4	M7



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END SEMESTER EXAMINATION MAY 2026 / ~~RE~~ - EXAM JULY 2026

Program: F.Y. Mechanical (M. Tech) Machine Design

Duration: 3 Hour

Course Code: PE-MTMD09

Maximum Points: 100

Course Name: Entrepreneurship Development and Management

Semester: II

Notes:-

1. Attempt any five questions out of seven.
2. Each question carries 20 marks.
3. Draw neat and labelled diagrams wherever required.
4. State suitable assumptions clearly wherever necessary.

Q.No.	Questions	Points	CO	BL	Module No.
Q1)	a) Analyze the role of entrepreneurship in promoting innovation, employment generation, and economic growth in the present business environment.	10	01	04	01
	b) Evaluate the suitability of different forms of business ownership such as sole proprietorship, partnership, and company form for a new entrepreneurial venture.	10	01	05	01
Q2)	a) Analyze the importance of a well-structured business plan for a new venture with respect to finance, risk management, and business growth.	10	01	04	02
	b) Explain how entrepreneurs estimate start-up costs and financing requirements. Compare different sources of start-up finance for a new business.	10	01	04	02
Q3)	a) What systematic steps should an entrepreneur follow while converting a business idea into a market-ready venture? Highlight the major difficulties faced during the early stage of launch.	10	01,04	03	03
	b) Why is legal compliance important for the stability of an entrepreneurial venture? Comment with reference to contracts, licensing, taxation, and intellectual property.	10	02	04	03
Q4)	a) Why is women's entrepreneurship important for inclusive economic development in India? Identify the major barriers faced by women entrepreneurs and suggest practical measures to	10	03,04	04	04



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END SEMESTER EXAMINATION MAY 2026 / RE - EXAM JULY 2026

	improve their participation in business.				
	b) In what way can Entrepreneurship Development Programme cells in educational institutions convert student ideas into startup opportunities? Comment on their role in training, mentoring, innovation support, and industry linkage.	10	03	03	04
Q5)	a) How do regulatory and legal requirements influence the formation and smooth operation of an entrepreneurial venture in India? Comment with reference to registration, compliance, and operational efficiency.	10	02	04	05
	b) What support does the MSMED Act, 2006 provide to micro, small, and medium enterprises? Justify its importance with respect to registration benefits, protection, and growth opportunities.	10	02,04	03	05
Q6)	a) What are the major operational and managerial difficulties faced by micro and small enterprises in India? Examine how finance, competition, and regulatory pressure affect their survival and growth.	10	04	04	06
	b) How can technology innovation, better supply chain practices, and linkages with large industries improve the competitiveness of micro and small enterprises? Support your answer with suitable examples.	10	04	04	06
Q7)	a) How does the managerial focus of a small business change from start-up stage to growth, maturity, and decline stage? Map the key challenges and decisions required at each stage.	10	04	04	07
	b) When a small business reaches maturity, what options should an entrepreneur consider for the future? Comment on harvesting, restructuring, succession, and closure decisions.	10	04	05	07



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END SEM/RE-EXAM/May/June 2026-2



17/26

Program: MTech Mechanical engg

Course Code: PC-MTMD202

Course Name: Adv.FEM

Duration: 3 hr

Maximum Points: 100

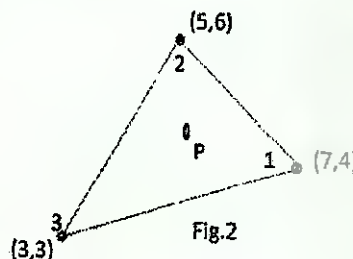
Semester: II

First Year (Machine Design)
Sem-II

Notes:

1. Question 1 is compulsory, solve any 4 out of remaining.
2. Answers to each sub-questions are grouped together
3. Use of scientific calculator is allowed
4. Begin answer to each question on new page.
5. Keep some margin on left side of answer paper

Q.No	Question Description	Pts	CO	BL
1	a) Explain the general steps involved in the Finite Element Analysis (FEA) process, from discretization to post-processing. b) What are the mesh refinement methods? Explain with suitable sketches.	10 10	1,2	3,4
2	a) Obtain the equation of temperature T_p for 2D-triangular element shown in fig.2. Given the nodal temperatures $T_1 = 55^\circ \text{C}$, $T_2 = 40^\circ \text{C}$, $T_3 = 30^\circ \text{C}$. P(5,5) b) Derive the expression of weak formulation for simply supported beam element with udl.	12 8	2,3	2,3
3	A stepped metallic bar is subjected to an axial load of 200kN at small end; Section 1: $L=450\text{mm}$, $A= 500\text{mm}^2$, $E = 200\text{GPa}$ Section 2: $L=300\text{mm}$, $A= 300\text{mm}^2$, $E = 70\text{GPa}$ Obtain :- assembled stiffness matrix, nodal displacement and stress in each section.	20	3	2,3



4	For the truss shown in fig. obtain: a) Elements stiffness matrix b) Displacement of node 1 c) Stress in each element $E = 210 \text{ GPa}$, $A = 4 \times 10^{-4} \text{ m}^2$.		10 5 5	2,3	2,3
5	a) What are the mesh revision methods? Discuss. b) Evaluate $\iint (3y^2 + 2x) dx dy$ using gauss quadrature, take limits of integration as 0 to 2 for both x and y.		8 12	1,2,3	3,4
6	a) The element shown in Fig., $P(5, 4)$ is the point on which the load of 10kN in the directions of 45 degrees with horizontal is applied. Determine its nodal equivalent forces. b) Obtain the jacobian matrix for quadrilateral element shown in fig.		10 10	2,3	2,3
7	a) List and elaborate the characteristics of the stiffness matrix. b) What is Gaussian Quadrature and why is it used in FEM? Explain in detail.		10 10	1,2,3	2,3



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END SEMESTER EXAMINATION MAY 2026 / RE - EXAM JULY 2026

15/07/26

Program: M.Tech Machine Design

Course Code: PE-MTMD08

Course Name: Micro-Electro Mechanical Systems

Sem - II

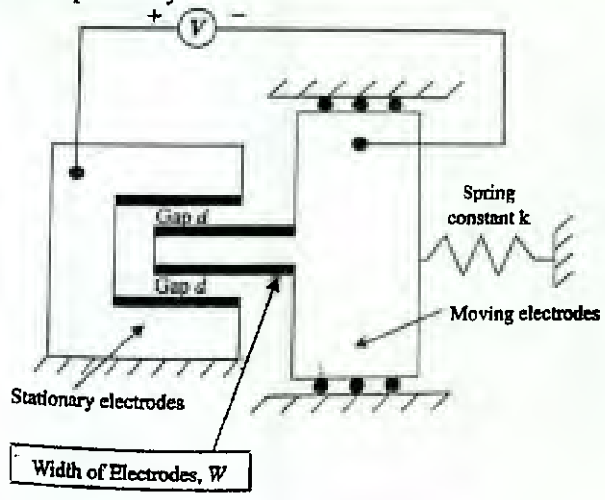
Duration: 03 Hours.

Maximum Points: 100

Semester: II

Notes:

1. Question no 1 is compulsory
2. Attempt any four questions from the remaining six questions.
3. If necessary assume suitable data with justification
4. Draw neatly labeled sketches wherever required.

Q. No.	Questions	Points	CO	BL	Module No.
1A	For the comb-driven actuator shown in Figure A, determine the voltage supply required to pull the moving electrode 10 microns from the unstretched position of the spring. The spring constant k is 0.05 N/m. The comb drive is operated in air. The gap d between the electrodes and the width W of the electrodes are 2 microns and 5 microns respectively. 	10	1,4	2,3	2
1B	Analyze the structure and classification of Carbon Nanotubes (CNTs). Compare SWCNT and MWCNT, and differentiate between Armchair, Zigzag, and Chiral CNTs. Evaluate how chirality influences the electrical properties of CNTs and justify its importance in nanoelectronic applications.	10	2,3	4	7



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2A	Evaluate the suitability of MEMS technology for implantable medical devices compared to macro-scale instrumentation. Discuss performance, biocompatibility, manufacturing cost, and long-term stability.	10	1,2	4,5	1
2B	Focused Ion Beam lithography is widely used in MEMS prototyping but is generally not preferred for mass production. Analyze the reasons for this limitation by considering factors such as throughput, fabrication cost, serial writing nature, and process complexity. Also suggest suitable improvements or hybrid fabrication approaches that can help overcome these limitations.	10	2,4	3,4	4
3 A	Analyze why MEMS devices are often integrated with electronic circuitry. Explain how this integration helps in improving signal processing, control operation, and overall system performance with suitable examples.	10	2,4	4	1
3B	Explain the working principle of photolithography and discuss how patterns from a mask are transferred to the photoresist layer. Estimate the resolution and depth of focus of a state-of-the-art excimer laser stepper using a KrF light source with wavelength $\lambda = 248$ nm and numerical aperture $NA = 0.6$. Assume $k_1 = 0.75$ and $k_2 = 0.5$. Use the standard lithography equations for resolution and depth of focus.	10	4	4,5	3
4A	During lithography, improper spin coating speed may result in non-uniform photoresist thickness. Explain how this problem can affect pattern resolution and fabrication accuracy.	10	1,3	4	3
4B	A MEMS designer needs to fabricate high-aspect-ratio metallic microstructures with an aspect ratio greater than 100:1 and nearly vertical sidewalls for inertial sensor applications. Analyze the most suitable fabrication technique for this requirement and explain your selection based on process physics, resolution capability, and infrastructure requirements. Also explain the working mechanism of the selected fabrication process.	10	2	3,4	4
5A	Analyze the concept of scaling laws in MEMS and explain how important physical quantities such as mass, electrostatic force, and gravitational force change with characteristic length. Discuss why surface forces become more dominant than body forces at the micro-scale.	10	3,2	4	5
5B	A MEMS device fabricated using SiO_2 and polysilicon layers requires surface roughness measurement and nanoscale imaging. Analyze the suitability of STM, SEM, AFM, and SPM techniques	10	3,1	4	6



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	for this application. Evaluate the most appropriate microscopy technique and justify your selection based on working principle, resolution, surface roughness measurement capability, and material compatibility.				
6A	Analyze the differences between Lumped Parameter Modelling and Distributed Parameter Modelling in MEMS system analysis. Explain their governing equations, computational cost, accuracy, and suitable applications where each modelling approach is preferred.	10	2	4	5
6B	Evaluate the use of Laser Doppler Vibrometry for MEMS vibration analysis. Justify its suitability by explaining the working principle, measurement of velocity and displacement using the Doppler effect, and its significance in dynamic characterization of MEMS devices.	10	1,2	3	6
7A	A capacitive MEMS pressure sensor consists of two square parallel plates of dimensions $L = W = 800 \mu\text{m}$ separated initially by an air gap of $2.5 \mu\text{m}$. The dielectric medium between the plates is air with $\epsilon_r = 1$, and the permittivity of free space is $\epsilon_0 = 8.85 \text{ pF/m}$. During operation, the gap between the electrodes changes to 2.5, 2.2, 1.8, 1.4, 1.0, and $0.6 \mu\text{m}$ due to diaphragm deflection. Determine the voltage ratio V_0/V_i for each gap value. Carefully justify the unit conversion, capacitance variation, and the effect of decreasing gap on sensor output.	10	4	4,5	2
7B	Explain the working principle of NEMS resonators. Derive the significance of mass sensitivity and explain why NEMS devices can detect extremely small masses (zeptogram level).	10	2,4	3,4	7