SRM VALLIAMMAI ENGINEERING COLLEGE
(An Autonomous Institution)

SRM Nagar, Kattankulathur – 603 203

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

QUESTION BANK

V SEMESTER

PEC 502 – MEMS DESIGN

Regulation – 2023

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SUBJECT CODE & TITLE: PEC502 – MEMS DESIGN

SEM / YEAR: V / III

UNIT – I: INTRODUCTION TO MEMS AND NEMS				
MEMS and Microsystems, Miniaturization, Typical products, Micro sensors, Micro actuation, MEMS with micro actuators, Micro accelerometers and Micro fluidics, Introduction to NEMS, Nano scaling, classification of nano-structured materials, Applications of nano-materials. Synthesis routes – Bottom up and Top down approaches. Materials for MEMS: Silicon, silicon compounds, polymers, metals				
PART – A				
Q.No.	**Questions**	**CO**	**BT Level**	**Competence**
1	Define MEMS.	CO1	BTL1	Remembering
2	What is a microsystem?	CO1	BTL1	Remembering
3	Mention two key differences between MEMS and Microsystems.	CO1	BTL2	Understanding
4	List two typical applications of MEMS in daily life.	CO1	BTL1	Remembering
5	Explain the significance of miniaturization in MEMS technology.	CO1	BTL2	Understanding
6	What is meant by ‘miniaturization’ in the context of MEMS?	CO1	BTL1	Remembering
7	Name two advantages of miniaturized MEMS devices.	CO1	BTL1	Remembering
8	Give two examples of products that use MEMS sensors.	CO1	BTL1	Remembering
9	Why are MEMS devices preferred in automotive airbag systems?	CO1	BTL2	Understanding
10	Define a micro sensor.	CO1	BTL1	Remembering
11	What is the function of a micro actuator in a MEMS device?	CO1	BTL1	Remembering
12	Explain the difference between a micro sensor and a micro actuator.	CO1	BTL2	Understanding
13	List two physical parameters that can be measured by MEMS sensors.	CO1	BTL1	Remembering
14	What is a MEMS accelerometer?	CO1	BTL1	Remembering
15	State one application of microfluidics in MEMS.	CO1	BTL1	Remembering
16	Describe the role of micro actuators in lab-on-a-chip devices.	CO1	BTL2	Understanding
17	What does NEMS stand for?	CO1	BTL1	Remembering
18	List one major difference between MEMS and NEMS.	CO1	BTL2	Understanding
19	Define nano scaling.	CO1	BTL1	Remembering
20	Classify nano-structured materials into two categories.	CO1	BTL1	Remembering

21	Name two applications of nano-materials.	CO1	BTL1	Remembering
22	Distinguish between 'bottom-up' and 'top-down' approaches in nano-material synthesis.	CO1	BTL2	Understanding
23	List two materials commonly used in MEMS fabrication.	CO1	BTL1	Remembering
24	Explain why silicon is widely used as a material for MEMS devices.	CO1	BTL2	Understanding
	PART – B			
1	Explain the process of miniaturization in MEMS and discuss how it has revolutionized the design and integration of industrial sensors and actuators. Illustrate your answer with suitable examples from industrial or biomedical applications. (16)	CO1	BTL2	Understanding
2	Critically Analyzing the societal and technological impact of MEMS and nano-materials in areas such as healthcare, environmental monitoring, and consumer electronics. Provide case studies or examples to support your analysis. (16)	CO1	BTL4	Analyzing
3	Analyzing the differences between top-down and bottom-up approaches for nano-material synthesis. Discuss the suitability of each method for specific MEMS or NEMS applications. (16)	CO1	BTL4	Analyzing
4	Explain the integration of mechanical, electrical, and software components in a typical MEMS device. How does this integration improve device performance and reliability? (16)	CO1	BTL2	Understanding
5	Examine the classification of nano-structured materials based on their dimensionality (0D, 1D, 2D, 3D). Provide examples and discuss their relevance in MEMS and NEMS applications. (16)	CO1	BTL4	Analyzing
6	Assess the advantages and limitations of using silicon versus polymers as materials for MEMS fabrication in terms of mechanical properties, biocompatibility, and manufacturing processes. (16)	CO1	BTL4	Analyzing
7	Given a scenario where a MEMS pressure sensor is to be used in an automotive airbag system, explain how the sensor detects a collision and triggers airbag deployment. Include the advantages of using MEMS technology in this application. (16)	CO1	BTL3	Applying
8	Describe the working principle of a MEMS accelerometer. How does its miniaturized structure enable high precision and sensitivity in real-world applications? (16)	CO1	BTL3	Understanding
9	A smartphone manufacturer wants to improve motion sensing accuracy. Propose how MEMS accelerometers and gyroscopes can be integrated, and Analyzing the expected improvements in user experience. (16)	CO1	BTL3	Applying
10	Discuss the significance of microfluidics in MEMS. How do microfluidic devices enhance the capabilities of lab-on-chip and biomedical systems? (16)	CO1	BTL2	Understanding
11	Compare and contrast MEMS and NEMS in terms of their scale, fabrication techniques, and potential applications. (16)	CO1	BTL2	Understanding
12	Design a conceptual MEMS-based microfluidic device for rapid disease diagnostics. Describe the components, working principle, and benefits over traditional diagnostic methods. (16)	CO1	BTL3	Applying
13	Applying the concept of batch fabrication in MEMS manufacturing to explain how cost and scalability are addressed in the production of micro sensors. (16)	CO1	BTL3	Applying
14	Discuss the integration challenges when combining MEMS sensors and actuators with conventional electronic circuits. How can these challenges be addressed to ensure optimal system performance? (16)	CO1	BTL4	Analyzing

15	Analyzing the impact of MEMS-based miniaturization on the performance and reliability of industrial automation systems. Discuss both the advantages and potential challenges. (16)	CO1	BTL4	Analyzing
16	Evaluate the role of micro actuators in MEMS devices, specifically in applications like inkjet printheads or micro-mirrors for projectors. How does micro actuation improve functionality and efficiency? (16)	CO1	BTL4	Analyzing
17	Given a requirement for a compact and energy-efficient biomedical implant, Analyzing how MEMS materials (such as silicon and polymers) and miniaturized actuators can be selected and integrated to meet the design goals. (16)	CO1	BTL3	Applying

UNIT - II: MECHANICS FOR MEMS DESIGN

Elasticity, Stress, strain and material properties, Bending of thin plates, Spring configurations, torsional deflection, Mechanical vibration, Resonance, Thermo mechanics – actuators, force and response time, Fracture and thin film mechanics

PART – A

Q.No.	Questions	CO	BT Level	Competence
1	Define stress and strain.	CO2	BTL1	Remembering
2	State Hooke's Law.	CO2	BTL1	Remembering
3	What is Young's modulus?	CO2	BTL1	Remembering
4	List two mechanical properties critical for MEMS materials.	CO2	BTL1	Remembering
5	Explain the difference between elastic and plastic deformation.	CO2	BTL2	Understanding
6	Describe the proportional limit in a stress-strain curve.	CO2	BTL2	Understanding
7	What is Kirchhoff's plate theory?	CO2	BTL1	Remembering
8	Define the elastic limit in bending.	CO2	BTL1	Remembering
9	How does plate thickness affect bending stiffness?	CO2	BTL2	Understanding
10	Compare Kirchhoff and Mindlin plate theories.	CO2	BTL2	Understanding
11	Name two types of springs used in MEMS.	CO2	BTL1	Remembering
12	What is torsional stiffness?	CO2	BTL1	Remembering
13	Explain how deflection in a torsion spring is calculated.	CO2	BTL2	Understanding
14	Why is spring constant critical in MEMS actuators?	CO2	BTL2	Understanding
15	Define resonance frequency.	CO2	BTL1	Remembering
16	List one real-world example of resonance.	CO2	BTL1	Remembering
17	How does damping affect mechanical vibrations?	CO2	BTL2	Understanding
18	Explain why resonance can lead to structural failure.	CO2	BTL2	Understanding
19	What is a thermal actuator?	CO2	BTL1	Remembering
20	Define response time in thermo-mechanical systems.	CO2	BTL1	Remembering
21	How does temperature change influence actuator performance?	CO2	BTL2	Understanding

22	Explain the relationship between force and displacement in thermal actuators.	CO2	BTL2	Understanding
23	What is fracture toughness?	CO2	BTL1	Remembering
24	Why are residual stresses critical in thin film mechanics?	CO2	BTL2	Understanding
	PART – B			
1	Explain the concepts of stress and strain in MEMS structures. How do these parameters influence the mechanical behavior of micro-scale devices? (16)	CO2	BTL2	Understanding
2	Given a MEMS micro-mirror actuated by an electrostatic force, Analyzing the mechanical response time and discuss how material properties and geometry affect actuation speed. (16)	CO2	BTL3	Applying
3	Analyzing the impact of thermo-mechanical effects on MEMS actuators. How do temperature changes influence force generation and response time? Provide examples. (16)	CO2	BTL4	Analyzing
4	Explain different spring configurations used in MEMS. What are the advantages and disadvantages of each configuration for specific applications? (16)	CO2	BTL2	Understanding
5	Evaluate the mechanical reliability of MEMS devices under cyclic loading. What failure mechanisms are most critical, and how can they be mitigated in design? (16)	CO2	BTL4	Analyzing
6	Critically Analyzing the role of thin film mechanics in MEMS device performance. How do residual stresses and film thickness variations affect device operation and reliability? (16)	CO2	BTL4	Analyzing
7	Discuss the challenges in modeling and predicting mechanical vibration in MEMS structures with complex geometries. How can finite element analysis assist in overcoming these challenges? (16)	CO2	BTL4	Analyzing
8	Describe the mechanical properties that are critical for materials used in MEMS design. Why are these properties particularly important at the micro-scale? (16)	CO2	BTL2	Understanding
9	Discuss the bending behavior of thin plates in MEMS devices. How does plate thickness affect deflection and stiffness? (16)	CO2	BTL2	Understanding
10	How can the theory of thin plate bending be applied to determine the deflection of a MEMS diaphragm used as a pressure sensor under uniform pressure? (16)	CO2	BTL3	Applying
11	Compare the fracture mechanics of bulk materials and thin films in MEMS. How do scaling effects alter fracture behavior at the micro-scale? (16)	CO2	BTL4	Analyzing
12	Design a MEMS-based accelerometer using a spring-mass system. Illustrate how the mechanical vibration and resonance principles are applied in its operation. (16)	CO2	BTL3	Applying
13	Applying the concept of resonance to optimize the sensitivity of a MEMS gyroscope. What design choices can be made to maximize performance? (16)	CO2	BTL3	Applying
14	Describe the principle of torsional deflection in MEMS beams or plates. How is torsional stiffness calculated and what factors affect it? (16)	CO2	BTL2	Understanding
15	Summarize the basic theory of mechanical vibration in MEMS structures. How do mass, stiffness, and damping influence vibrational behavior? (16)	CO2	BTL2	Understanding
16	Analyzing the trade-offs between stiffness and flexibility in MEMS spring design. How do these trade-offs impact device sensitivity, robustness, and operational bandwidth? (16)	CO2	BTL4	Analyzing

17	Given a MEMS cantilever beam subjected to a point load at its free end, calculate the resulting deflection and maximum stress. Explain the steps and formulas used. (16)	CO2	BTL3	Applying

UNIT - III: MATERIALS AND FABRICATION OF MEMS

Atomic Structures and Quantum Mechanics, Molecular and Nanostructure Dynamics Photolithography, Ion Implantation, Diffusion, Oxidation, Dry and wet etching, Bulk Micromachining, Surface Micromachining, LIGA.

PART – A

Q.No.	Questions	CO	BT Level	Competence
1	Define atomic packing factor (APF).	CO3	BTL1	Remembering
2	State the significance of quantum confinement in nanostructures.	CO3	BTL1	Remembering
3	Explain why crystalline materials are preferred in MEMS fabrication.	CO3	BTL2	Understanding
4	What is molecular self-assembly?	CO3	BTL1	Remembering
5	List two methods to synthesize nanostructures.	CO3	BTL1	Remembering
6	How does surface energy influence nanomaterial behavior?	CO3	BTL2	Understanding
7	Define photolithography.	CO3	BTL1	Remembering
8	What is the purpose of a photomask?	CO3	BTL1	Remembering
9	Compare positive and negative photoresists.	CO3	BTL2	Understanding
10	State the principle of ion implantation.	CO3	BTL1	Remembering
11	What is Fick’s first law of diffusion?	CO3	BTL1	Remembering
12	Explain how diffusion is used in doping silicon.	CO3	BTL2	Understanding
13	Name two types of silicon oxide growth methods.	CO3	BTL1	Remembering
14	Why is thermal oxidation critical in MEMS?	CO3	BTL2	Understanding
15	Differentiate isotropic and anisotropic etching.	CO3	BTL2	Understanding
16	List the advantages of dry etching over wet etching.	CO3	BTL1	Remembering
17	Define bulk micromachining.	CO3	BTL1	Remembering
18	What is a sacrificial layer in surface micromachining?	CO3	BTL1	Remembering
19	Compare bulk and surface micromachining.	CO3	BTL2	Understanding
20	What does LIGA stand for?	CO3	BTL1	Remembering
21	List the applications of LIGA in MEMS.	CO3	BTL1	Remembering
22	Explain the role of X-ray lithography in LIGA.	CO3	BTL2	Understanding

23	Name two metals commonly used in MEMS fabrication.	CO3	BTL1	Remembering
24	Why is silicon dioxide used as an insulating layer?	CO3	BTL2	Understanding
PART – B				
1	Explain the significance of atomic structure and quantum mechanics in determining the properties of MEMS materials. (16)	CO3	BTL2	Understanding
2	Describe the process of photolithography and its role in MEMS fabrication. (16)	CO3	BTL2	Understanding
3	Design a process flow for integrating MEMS devices with CMOS circuits using compatible materials and fabrication steps. (16)	CO3	BTL3	Applying
4	Explain the molecular and nanostructure dynamics relevant to MEMS device performance. (16)	CO3	BTL2	Understanding
5	Demonstrate how photolithography and etching can be combined to create a micro-cantilever structure for a MEMS sensor. (16)	CO3	BTL3	Applying
6	Applying the LIGA technique to fabricate a high aspect ratio micro gear. Describe each step and the rationale behind it. (16)	CO3	BTL2	Understanding
7	Discuss the role of oxidation and diffusion in the formation of MEMS structures. (16)	CO3	BTL2	Understanding
8	Given a MEMS pressure sensor design, outline the sequence of fabrication steps using surface micromachining. (16)	CO3	BTL3	Applying
9	Analyzing the impact of material selection on the performance and reliability of MEMS devices fabricated by surface micromachining. (16)	CO3	BTL4	Analyzing
10	Evaluate the challenges in scaling down MEMS structures to the nanoscale, focusing on quantum mechanical effects and surface phenomena. (16)	CO3	BTL4	Analyzing
11	Compare and contrast the etch profiles and selectivity achieved by dry etching versus wet etching in MEMS fabrication. Provide examples. (16)	CO3	BTL4	Analyzing
12	Explain the principles and applications of dry and wet etching techniques in MEMS fabrication. (16)	CO3	BTL2	Understanding
13	Analyzing the process integration challenges when combining ion implantation, diffusion, and oxidation in a single MEMS device fabrication flow. (16)	CO3	BTL4	Analyzing
14	Describe the LIGA process and its importance in MEMS fabrication. (16)	CO3	BTL2	Understanding
15	Assess the advantages and limitations of using LIGA over traditional micromachining techniques for MEMS fabrication, especially for complex 3D structures. (16)	CO3	BTL4	Analyzing
16	Applying the concept of ion implantation to modify the electrical properties of silicon in MEMS devices. Illustrate with a process flow diagram. (16)	CO3	BTL3	Applying
17	Discuss the differences between bulk micromachining and surface micromachining, highlighting their respective advantages and limitations. (16)	CO3	BTL2	Understanding

UNIT- IV : DESIGN OF MEMS SENSORS AND ACTUATORS
Acoustic sensor – Quartz crystal microbalance, Surface acoustic wave, Flexural plate wave, shear horizontal; Vibratory gyroscope, Pressure sensors, Electrostatic actuators, piezoelectric actuators, Thermal actuators, Actuators using shape memory alloys, Micro grippers, Micro motors, Micro valves, Micro pumps, Packaging.
PART – A

Q.No.	Questions	CO	BT Level	Competence
1	Define a quartz crystal microbalance sensor.	CO4	BTL1	Remembering
2	What is the principle of surface acoustic wave (SAW) sensors?	CO4	BTL1	Remembering
3	List two applications of flexural plate wave sensors.	CO4	BTL1	Remembering
4	What is a shear horizontal acoustic sensor used for?	CO4	BTL1	Remembering
5	State the working principle of a vibratory gyroscope.	CO4	BTL1	Remembering
6	Explain the basic function of a MEMS pressure sensor.	CO4	BTL2	Understanding
7	What is an electrostatic actuator?	CO4	BTL1	Remembering
8	List two advantages of piezoelectric actuators in MEMS.	CO4	BTL1	Remembering
9	Describe how a thermal actuator generates movement.	CO4	BTL2	Understanding
10	What is the main property of shape memory alloys used in actuators?	CO4	BTL1	Remembering
11	Name one application of micro grippers in MEMS.	CO4	BTL1	Remembering
12	What is the function of a MEMS micro motor?	CO4	BTL1	Remembering
13	Explain the role of micro valves in microfluidic systems.	CO4	BTL2	Understanding
14	List two uses of micro pumps in biomedical devices.	CO4	BTL1	Remembering
15	What is the importance of packaging in MEMS devices?	CO4	BTL2	Understanding
16	Compare electrostatic and thermal actuators in terms of energy efficiency.	CO4	BTL2	Understanding
17	What is the output signal of a quartz crystal microbalance sensor?	CO4	BTL1	Remembering
18	How does a piezoelectric actuator convert energy?	CO4	BTL2	Understanding
19	State one limitation of electrostatic actuators.	CO4	BTL1	Remembering
20	Describe the function of a displacement sensor integrated with an electrostatic actuator.	CO4	BTL2	Understanding
21	What is the principle behind micro pump operation?	CO4	BTL1	Remembering
22	List two critical considerations in MEMS packaging.	CO4	BTL1	Remembering
23	Explain why material selection is important for MEMS actuators.	CO4	BTL2	Understanding
24	What is the significance of frequency response in MEMS sensors?	CO4	BTL2	Understanding
PART – B				
1	Explain the working principles of quartz crystal microbalance and surface acoustic wave sensors. Compare their applications and limitations. (16)	CO4	BTL2	Understanding
2	Explain the design considerations for packaging MEMS sensors and actuators. How does packaging affect device performance and reliability? (16)	CO4	BTL2	Understanding

3	A MEMS micro pump is required to deliver precise fluid volumes in a biomedical device. Propose a design and discuss how actuator selection impacts accuracy and reliability. (16)	CO4	BTL3	Applying
4	Compare electrostatic, piezoelectric, and thermal actuators in MEMS. Discuss their advantages, disadvantages, and typical applications. (16)	CO4	BTL2	Understanding
5	Analyzing the impact of material properties (e.g., silicon, polymers, metals) on the performance and longevity of MEMS actuators and sensors. Provide examples from current technologies. (16)	CO4	BTL4	Analyzing
6	Describe the design and operation of a flexural plate wave sensor. How does its structure influence sensitivity and selectivity? (16)	CO4	BTL2	Understanding
7	Applying the principles of piezoelectric actuation to develop a MEMS-based acoustic sensor. Illustrate the transduction mechanism and potential use cases. (16)	CO4	BTL3	Applying
8	Explain the operating principles of MEMS pressure sensors. Illustrate with sketches the typical structure and signal transduction mechanism. (16)	CO4	BTL2	Understanding
9	Discuss the role of frequency response and resonance in the design of MEMS gyroscopes and acoustic sensors. How can these factors be optimized for specific applications? (16)	CO4	BTL4	Analyzing
10	Compare and contrast the control strategies for electrostatic and thermal actuators in MEMS. How do nonlinearities and dynamic response affect system design? (16)	CO4	BTL4	Analyzing
11	Analyzing the trade-offs between micro motors and micro valves in terms of energy consumption, speed, and control complexity in MEMS systems. (16)	CO4	BTL4	Analyzing
12	Discuss the integration of displacement sensors with electrostatic actuators. How does feedback improve actuator performance in closed-loop systems? (16)	CO4	BTL4	Analyzing
13	Discuss the dynamics of a vibratory gyroscope. How does Coriolis force enable angular rate measurement in MEMS gyroscopes? (16)	CO4	BTL2	Understanding
14	Applying the concept of electrostatic actuation to design a MEMS micro gripper. Discuss the key design parameters and control strategies. (16)	CO4	BTL3	Applying
15	Design a micro pump for lab-on-chip applications. Specify the actuator type, working principle, and discuss the challenges in miniaturization. (16)	CO4	BTL3	Applying
16	A MEMS pressure sensor must operate reliably in a harsh environment. Analyzing the material and packaging choices needed to ensure performance and durability. (16)	CO4	BTL4	Analyzing
17	Evaluate the use of shape memory alloy actuators in MEMS. Discuss their actuation mechanism, response time, and reliability issues. (16)	CO4	BTL4	Analyzing

UNIT - V: OPTICAL AND RF MEMS

Optical MEMS, - System design basics – Gaussian optics, matrix operations, resolution. Case studies, MEMS scanners and retinal scanning display, Digital Micro mirror devices. RF MEMS-design, RF MEMS switch, performance issues. Packaging.

PART – A

Q.No.	Questions	CO	BT Level	Competence
1	Define Optical MEMS.	CO5	BTL1	Remembering

2	What is Gaussian optics, and why is it important in optical MEMS design?	CO5	BTL1	Remembering
3	State the function of a MEMS scanner.	CO5	BTL1	Remembering
4	What is a retinal scanning display?	CO5	BTL1	Remembering
5	List two applications of Digital Micromirror Devices (DMDs).	CO5	BTL1	Remembering
6	Explain the term 'matrix operations' in the context of optical system design.	CO5	BTL2	Understanding
7	What does 'resolution' mean in optical MEMS?	CO5	BTL1	Remembering
8	Describe a common packaging challenge for optical MEMS devices.	CO5	BTL2	Understanding
9	What is the main function of an RF MEMS switch?	CO5	BTL1	Remembering
10	List two performance issues in RF MEMS devices.	CO5	BTL1	Remembering
11	Explain the principle of free-space optical MEMS switching.	CO5	BTL2	Understanding
12	What is the significance of surface quality in optical MEMS devices?	CO5	BTL2	Understanding
13	Define the term 'fill factor' in MEMS mirror arrays.	CO5	BTL1	Remembering
14	What is the role of electrostatic actuation in MEMS mirrors?	CO5	BTL2	Understanding
15	Name a typical material used for MEMS mirrors.	CO5	BTL1	Remembering
16	How does Gaussian beam propagation affect MEMS system design?	CO5	BTL2	Understanding
17	What is meant by 'system-level modeling' in optical MEMS?	CO5	BTL1	Remembering
18	List two components commonly found in an optical MEMS system.	CO5	BTL1	Remembering
19	Explain the importance of alignment tolerances in optical MEMS packaging.	CO5	BTL2	Understanding
20	What is the function of a beam splitter in an optical MEMS device?	CO5	BTL1	Remembering
21	Describe a typical application of RF MEMS in telecommunications.	CO5	BTL2	Understanding
22	What is the basic principle behind a digital micromirror device?	CO5	BTL1	Remembering
23	State one advantage of using MEMS in optical cross-connects.	CO5	BTL2	Understanding
24	Explain how packaging can affect the performance of RF MEMS switches.	CO5	BTL2	Understanding
PART – B				
1	Explain the fundamentals of Gaussian optics and matrix operations in the design of optical MEMS systems. Illustrate with examples how these principles are applied to optimize system resolution and performance. (16)	CO5	BTL2	Understanding
2	Describe the working principle of a MEMS scanner and its application in retinal scanning displays. Discuss the key design considerations for achieving high-resolution scanning. (16)	CO5	BTL2	Understanding
3	Discuss the architecture and operation of Digital Micromirror Devices (DMDs). Analyzing their role in projection systems and highlight the main challenges in their MEMS design. (16)	CO5	BTL2	Understanding

4	Compare and contrast the system-level modeling approaches for optical MEMS, focusing on the integration of Gaussian beam optics with electromechanical simulation. (16)	CO5	BTL4	Analyzing
5	Applying the concept of Gaussian beam propagation to design an optical MEMS cross-connect switch. Include considerations for mirror size, beam waist, and alignment tolerances. (16)	CO5	BTL3	Applying
6	Analyzing the impact of surface deformation and residual stress on the optical performance of MEMS mirrors. How do these factors influence cavity loss and linewidth? (16)	CO5	BTL4	Analyzing
7	Evaluate the packaging requirements for optical MEMS devices. Discuss how packaging influences optical alignment, signal integrity, and device reliability. (16)	CO5	BTL4	Analyzing
8	Explain the design and operation of an RF MEMS switch. What are the critical performance parameters, and how do they affect switch reliability and speed? (16)	CO5	BTL2	Understanding
9	Discuss the main performance issues in RF MEMS devices, such as insertion loss, isolation, and power handling. Propose solutions to mitigate these issues. (16)	CO5	BTL4	Analyzing
10	Applying system-level simulation tools to optimize an optical MEMS noise suppression system. Describe the integration of optical and electromechanical models in your approach. (16)	CO5	BTL3	Applying
11	Analyzing the trade-offs between using electrostatic and piezoelectric actuation in MEMS mirrors for optical switching applications. (16)	CO5	BTL4	Analyzing
12	Design a MEMS-based optical beam steering system for telecommunications. Discuss the challenges in achieving precise control and high-speed operation. (16)	CO5	BTL3	Applying
13	Evaluate the role of fill factor and actuator density in the performance of MEMS mirror arrays for optical cross-connects. (16)	CO5	BTL4	Analyzing
14	Explain the significance of resolution and alignment tolerances in the packaging of optical MEMS systems. How can these factors be optimized during the design phase? (16)	CO5	BTL2	Understanding
15	Discuss the fabrication steps involved in creating a MEMS vertical mirror array for free-space optical switching. Analyzing the impact of process variations on device performance. (16)	CO5	BTL3	Applying
16	Applying Gaussian beam analysis to assess the optical losses in a MEMS-based variable optical attenuator. How do beam size and mirror curvature affect attenuation? (16)	CO5	BTL3	Applying
17	Critically assess the future trends and emerging challenges in the integration of optical and RF MEMS for next-generation communication systems. (16)	CO5	BTL4	Analyzing