

	variations.
2. Phase-modulated optical fiber sensors	B. Used for monitoring the health of civil engineering structures like bridges and dams.
3. Fiber Bragg gratings	C. Utilized for high-precision displacement measurements in dynamic environments.
4. Photo-elasticity	D. An essential tool for assessing internal stress and damage propagation in materials.

- a) 1-C, 2-B, 3-D, 4-A b) 1-A, 2-C, 3-B, 4-D
c) 1-B, 2-D, 3-A, 4-C d) 1-D, 2-A, 3-C, 4-B

6. Match the terms in Column A with their correct applications or features in Column B. CO3 [K1]
Choose the appropriate code for each match from the options provided.

List I	List II
1. Wavelength-based sensors	A. Measures stress distributions by observing changes in light intensity.
2. Intensity-based sensors	B. Used to reflect specific wavelengths for accurate strain measurement.
3. Phase-modulated sensors	C. Applied for detecting changes in the light wavelength to monitor environmental factors.
4. Fiber Bragg gratings	D. Effective for precise measurements of displacement and dynamic strain.

- a) 1-C, 2-A, 3-D, 4-B b) 1-B, 2-C, 3-A, 4-D
c) 1-A, 2-D, 3-B, 4-C d) 1-D, 2-B, 3-C, 4-A

7. Assertion (A): Embedded piezoelectric sensors are effective as acoustic emission (AE) detectors for monitoring structural integrity. CO4 [K2]

Reason (R): Piezoelectric sensors can convert mechanical stress into electrical signals, allowing them to detect and analyze acoustic emissions resulting from material defects

or damage.

- a) Both A and R are true, and R is the correct explanation of A. b) Both A and R are true, but R is not the correct explanation of A.
- c) A is true, but R is false. d) A is false, but R is true.

8. Assertion (A): Electromechanical impedance (E/M impedance) is a useful method for detecting defects in metallic and composite structures. CO4 [K₂]

Reason (R): E/M impedance analysis provides information on the dynamic behavior of a structure, where changes in impedance can indicate the presence of damage or alterations in material properties.

- a) Both A and R are true, and R is the correct explanation of A. b) Both A and R are true, but R is not the correct explanation of A.
- c) A is true, but R is false. d) A is false, but R is true.

9. Instructions: Select all the statements that are true regarding the electrical properties and damage monitoring of composite materials. CO4 [K₂]

1. A. The percolation concept in composite materials refers to the point at which electrical conductivity significantly increases due to the connectivity of conductive paths.
2. B. Anisotropic conduction properties mean that the electrical conductivity of continuous fiber-reinforced polymers is uniform in all directions.
3. C. The influence of temperature can affect the electrical resistance of composites, potentially indicating changes in structural integrity.
4. D. Composite strain and damage monitoring by electrical resistance involves measuring the changes in resistance that occur with the deformation of the material.

- a) 1 and 3. b) 1, 2, and 4.
- c) 2 and 3. d) 1, 3, and 4.

10. Instructions: Select all the statements that are true regarding damage localization and electrical properties in composite materials. CO4 [K₂]

1. Damage localization in composites can be achieved by analyzing changes in electrical resistance across different laminate orientations.
2. Randomly distributed fiber-reinforced polymers exhibit isotropic conduction properties, meaning their electrical conductivity is the same in all directions.
3. 0° uni-directional laminates are designed to carry loads primarily along one direction, making them more susceptible to damage in that direction.
4. Electrical resistance measurements in multidirectional laminates can provide insights into the material's overall structural health and damage state.

- a) 1 and 3. b) 1, 2, and 4
- c) 3 and 4 d) 1, 3, and 4.

PART B (10 x 2 = 20 Marks)

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|--|-----|-------------------|
| 11. Define Structural Health Monitoring (SHM). | CO1 | [K ₁] |
| 12. Differentiate between passive and active SHM. | CO1 | [K ₂] |
| 13. Explain how the principle of using vibrations can be applied in Structural Health Monitoring (SHM) to detect material defects. | CO1 | [K ₂] |
| 14. Define the term "technical diagnosis" in the context of Structural Health Monitoring (SHM). | CO2 | [K ₁] |
| 15. Identify the role of optical fiber sensors in a Structural Health Monitoring (SHM) system. | CO2 | [K ₂] |
| 16. Describe photo-elasticity in the context of fiber-optic sensors. | CO2 | [K ₁] |
| 17. Describe the role of piezoelectric sensors in a Structural Health Monitoring (SHM) system. | CO3 | [K ₂] |
| 18. Explain the Electrical-Mechanical Impedance (EMI) method used in Structural Health Monitoring (SHM). | CO3 | [K ₁] |
| 19. Explain the significance of measuring electrical resistance in unloaded composites. | CO4 | [K ₁] |
| 20. Define multidirectional laminates in composite materials. | CO4 | [K ₁] |

PART C (6 x 5 = 30 Marks)

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|---|---|-----|-------------------|
| 21. Construct a diagram illustrating the organization of a typical structural health monitoring (SHM) system, and explain how SHM can be applied to monitor the structural integrity of a building. | 5 | CO1 | [K ₃] |
| 22. Classify the global and local methods of vibration detection in SHM systems. | 5 | CO2 | [K ₃] |
| 23. Develop a list describing the application of structures with embedded fiber optic sensors and explain how these sensors are utilized for monitoring structural performance. | 5 | CO3 | [K ₄] |
| 24. Identify a new concept in the acoustic emission method and explain how it can be applied to detect and evaluate material defects in structures. | 5 | CO3 | [K ₃] |
| 25. Summarize the notable trends in piezoelectric transducer-based acoustic ultrasonic research and explain how these trends are being applied in structural health monitoring systems. | 5 | CO4 | [K ₄] |

26. Develop a list of the key challenges in implementing Structural Health Monitoring (SHM) in civil engineering, and explain how overcoming these challenges can expand the scope for practical applications in real-world composite structures. 5 CO4 [K₃]

Answer any FOUR Questions

PART D (4 x 10 = 40 Marks)

27. Identify the key characteristics of a Structural Health Monitoring (SHM) system, and explain how these characteristics are applied in various multidisciplinary fields. 10 CO1 [K₃]
28. Examine the statement 'Structural Health Monitoring (SHM) as a way of making materials and structures smart. 10 CO1 [K₃]
29. Illustrate two types of optical sensors categorized by the type of change they detect. 10 CO2 [K₃]
30. Analyze the various techniques and algorithms used to record damage and impacts through acoustic emission sensors with examples. 10 CO3 [K₄]
31. Illustrate the different properties of electrical resistance in unloaded composites, and explain how these properties can be applied to assess the performance and durability of composite materials. 10 CO4 [K₃]
