Ref. No.: Ex/PG/MEC/PE/T/122J/2025

M.E. MECHANICAL ENGINEERING FIRST YEAR, SECOND SEMESTER EXAM 2025
THEORIES OF NON-DESTRUCTIVE TESTING

Time: **Three hours** Full Marks: **100**

Missing data, if any, are to be reasonably assumed.
Different parts of a question must be answered together.
Give sketches wherever applicable.
Answer **Question 1** and any **Five** from the rest

1. Choose the correct answer (write only the correct answer in the answer sheet) [15 × 1]

i. Which defect is best detected by Dye Penetrant Testing?
a) Internal porosity
b) Subsurface cracks
c) Surface-breaking cracks
d) Inclusions

ii. What is the typical frequency range of Ultrasonic Testing?
a) 100–1000 Hz
b) 1–5 MHz
c) 20–100 MHz
d) 10–50 Hz

iii. In ultrasonic testing, the angle beam technique is most useful for detecting:
a) Internal laminar defects
b) Surface pits
c) Lack of fusion in welds
d) Surface roughness

iv. Which one is NOT an Acoustic Emission testing parameter?
a) Energy
b) Duration
c) Frequency
d) Voltage

v. The Kaiser effect refers to:
a) Noise in AE signals
b) First emission during loading
c) No AE activity until previous maximum load is exceeded
d) Corrosion detection

vi. In Magnetic Particle Testing, the best field orientation to detect surface cracks is:
a) Parallel to the defect
b) 45° to the defect
c) Perpendicular to the defect
d) Circular to the defect

vii. Which material is not suitable for Magnetic Particle Testing?
a) Mild steel
b) Nickel alloy
c) Cast iron
d) Copper

viii. Which technique is best for detecting internal voids in thick metal castings?
a) Dye Penetrant Test
b) Ultrasonic Testing
c) Magnetic Particle Testing
d) Visual Inspection

ix. Geometric unsharpness in radiographic testing increases with:
a) Decrease in object-to-film distance
b) Increase in source-to-film distance
c) Use of smaller source size
d) Increase in exposure time

x. The "dead zone" in ultrasonic testing refers to:
a) The region where no sound propagates
b) The region where probe cannot detect near-surface defects
c) Region of maximum defect resolution
d) Probe calibration error

xi. The typical dye used in fluorescent penetrant testing is visible under:
a) Normal daylight
b) Sodium vapor light
c) Infrared light
d) Ultraviolet light

xii. Which of the following can detect progressive crack growth in real-time?
a) Magnetic particle testing
b) Acoustic emission testing
c) Radiographic testing
d) Visual inspection

xiii. In radiographic testing, film density is a measure of:
a) Thickness of material
b) Exposure to light
c) Defect size
d) Amount of silver deposited

xiv. The Felicity Ratio is given by:
a) Maximum load / Load at emission onset
b) Load at emission onset / Previous maximum load
c) Present AE count / Previous AE count
d) Load × Count rate

xv. When a wave encounters an interface at an oblique angle, what takes place at the interface due to the different sound velocities of the two materials?
a) Attenuation
b) Refraction
c) Beam spread
d) Beam impedance

[Turn over

2. (a) List and briefly explain the steps involved in performing a Dye Penetrant Test. [6]

(b) A mechanical engineering workshop is performing a dye penetrant inspection on a batch of aluminum alloy castings used for aircraft components. A particular component has a suspected surface crack. The dimensions of the component are 150 mm × 100 mm, and the dye is applied over the entire surface. The following data are provided: Dye penetrant: Red visible dye; Application area: Full top surface of the component (150 mm × 100 mm); Penetrant dwell time: 20 minutes; Surface crack opening (width): 0.01 mm; Surface crack depth: 0.4 mm; Crack length: 20 mm; Dye penetrant surface tension: 0.03 N/m; Contact angle between dye and surface: 30°; Viscosity of dye: 0.002 Pa-s. Assuming capillary action drives dye into the crack, find out the following:

i. Estimate the capillary pressure driving the dye into the crack.
ii. Calculate the penetration depth after 20 minutes (assume capillary flow using Washburn's equation).
iii. Based on the crack dimensions, determine whether the dye would fully penetrate the crack in 20 minutes.
iv. Comment on whether this crack is likely to be detectable using visible dye penetrant testing. [8]

(c) What are the desired properties of dye/penetrant? [3]

3. (a) Explain the working of angle beam technique in ultrasonic testing with sketch. How does it help in weld inspection? [6]

(b) Explain the concept of dead zone in ultrasonic testing. How can dead zone be avoided/minimized? [3+4]

(c) What is mode conversion and what is its significance in ultrasonic testing? [4]

4. (a) What is the difference between Ultrasonic testing and Acoustic emission testing techniques? [5]

(b) Explain the significance of AE signal parameters – amplitude, duration, energy, rise time. [8]

(c) What are active defects? Explain with the help of examples. [4]

5. (a) What are the steps for Magnetic particle testing? [3]

(b) Explain one contact and one non-contact based magnetization method in relevance to magnetic particle testing. Use suitable sketches. [8]

(c) Compare dry and wet methods of Magnetic Particle Testing. [6]

6. (a) Describe any two absorption mechanisms in case of radiographic testing. [8]

(b) What is film characteristic curve? Explain its significance in radiographic testing. [7]

(c) Define film gradient. [2]

7. (a) An ultrasonic wave strikes a water-steel interface at an angle. Given the velocity of longitudinal wave in steel is 5900 m/s and in water is 1480 m/s, calculate the critical angle beyond which total reflection occurs. What happens when the wave travels from steel to water? [7]

(b) Derive the relation between the intensity of incident radiation (I_0) on a sample and the intensity coming out of it (I_x). [6]

(c) An ultrasonic wave is introduced into a steel plate using a 70° angle beam probe. A surface-breaking crack reflects the wave back to the transducer, and the sound path length is measured as 50 mm. Calculate the horizontal distance (x) to the crack. [4]

8. (a) Write short notes on (any 3) [3 × 5]

i. Construction of ultrasonic testing probe.
ii. Felicity effect.
iii. Pie gauge.
iv. Geometric unsharpness.
v. Demagnetization in radiographic testing.

(b) What are the applications of radiographic testing. [2]