UNIVERSITY OF GHANA

BSC. MATERIALS SCIENCE AND ENGINEERING SECOND SEMESTER EXAMINATIONS: 2014/2015

COURSE CODE: COURSE TITLE (Credits)
MTEN402: NON-DESTRUCTIVE EVALUATION & FAILURE ANALYSIS (2 Credits)

INSTRUCTION:
ANSWER ALL QUESTIONS

TIME ALLOWED:
TWO HOURS

SECTION A

Choose the correct answer from the following objectives.

Question 1

1. Liquid penetrant testing is based on the principle of:
   a) Polarized sound waves in liquid
   b) Magnetic domains
   c) Absorption of x-rays
   d) Capillary action

2. How is the size of a liquid penetrant indication usually related to the discontinuity it represents:
   a) Larger than
   b) Smaller than
   c) Equal to
   d) Not related to

3. Which of the following statements accurately describes the capabilities of liquid penetrant testing?
   a) Liquid penetrant testing is useful for locating subsurface discontinuities in a test piece
   b) Liquid penetrant testing is useful for locating discontinuities in porous materials
   c) Liquid penetrant testing is useful for locating discontinuities which are open to the surface in non-porous materials
   d) None of the above

4. Subsurface discontinuities can be best detected by:
   a) The post-emulsification penetrant method
   b) The visible dye penetrant method
   c) The fluorescent penetrant method
   d) None of the above will detect subsurface discontinuities

5. What is the function of an emulsifier?
   a) To remove the excess penetrant
   b) To develop indications with a post emulsifiable penetrant system
   c) To assist penetration with a post emulsifiable penetrant system
   d) To make a post emulsifiable penetrant water washable.

6. In order to be detectable by magnetic particle testing, a flaw must:
   a) Be surface breaking
   b) Be no deeper than 1 mm below the surface
   c) Produce a leakage field at the test surface
   d) All of the above

7. Which of the following is not an advantage of magnetic particle testing?
   a) Fast and simple to perform
   b) Can detect discontinuities filled with foreign material
   c) Most reliable for finding surface cracks in all types of materials
   d) Works well through a thin coat of paint

8. The reverse magnetizing force necessary to remove a residual magnetic field from a test piece after it has been magnetically saturated is:
   a) Hysteresis
   b) Coercive force
   c) Demagnetizing flux
   d) Reverse saturation

9. Which of the following produces a circular field?
   a) Coil
   b) Headshot
   c) Yoke
   d) All of the above
10. A leakage field is strongest when a discontinuity interrupts the magnetic flux lines at an angle of:
   a) Zero degrees
   b) 45 degrees
   c) 90 degrees
   d) 180 degrees

11. Which of the following is an isotope not artificially produced for industrial radiographic use?
   a) Ir-192
   b) Ra-226
   c) Co-60
   d) All of the above

12. Most of the energy applied to an x-ray tube is converted into:
   a) X-rays
   b) Light
   c) Heat
   d) Ultraviolet radiations

13. An advantage of a gamma ray source is :
   a) Radiation may be turned on or off at will
   b) Outside power is normally not required
   c) Less shielding is required than for x-rays
   d) All of the above

14. X-rays are produced by:
   a) Radioactive isotopes
   b) The rapid deceleration of electrons
   c) Ultraviolet radiation of unstable atoms
   d) All of the above

15. Explain the difference between x and gamma rays
    a) They are both types of electromagnetic radiation
    b) X-rays are naturally occurring; gamma rays are man made
    c) X- rays are produced electrically; gamma rays are emitted by disintegrating atomic nuclei
    d) There is no difference

16. The smallest detectable flaw by the ultrasonic system or technique is:
    a) Resolution
    b) Detectability
    c) Sensitivity
    d) Wavelength

17. In ultrasonic testing the smallest detectable flaw is :
    a) ½f
    b) ½V
    c) ½λ
    d) None of the above

18. Which of the following compressional probe has the highest sensitivity?
    a) 1 MHz
    b) 2 MHz
    c) 5 MHz
    d) 10 MHz

19. Which of the following sound waves is easily dampened by heavy grease or wet finger?
    a) Longitudinal waves
    b) Transverse waves
    c) Surface waves
    d) Lamb waves

20. Which of the probes below has the longest near zone?
    a) 1 MHz, 10 mm - diameter
    b) 5 MHz, 10 mm - diameter
    c) 1 MHz, 2 mm - diameter
    d) 5 MHz, 2 mm – diameter

(20 marks)

SECTION B

Question 2

a. Why is visible penetrant red and fluorescent penetrant green? **(4 marks)**

b. List four properties of a good penetrant. **(4 marks)**

c. Penetrants can be classified by the method of removing the excess penetrant. List the three classifications. **(4 marks)**

d. How is the excess penetrant removed when solvent removable penetrant is used? **(4 marks)**

Question 3

a. The type of magnetic field established is determined by the method used to magnetize the specimen.
What is:
   1. Longitudinal magnetic field?
   2. Circular magnetic field? **(3 marks)**

b. What type of magnetization is produced by:
   i. Electromagnetic yoke
   ii. Headshot
   iii. Central conductor
   iv. Coil shot
   v. Prods **(4 marks)**

c. A magnetic particle inspector is inspecting a part which is 15 inches long by 3 inches in outside diameter. If a five-turn 12 inches diameter coil or cable is used, calculate the coil current to be used if:
   i. The part is positioned towards the side of the coil
   ii. The part is positioned in the centre of the coil. **(9 marks)**

Question 4

a. Two signals are at 20% and 100% full screen height (FSH). What is the difference between them in decibels (dB's)? **(4 marks)**

b. How much sound is transmitted at a steel to perspex interface if the acoustic impedances of steel (Z_1) and perspex (Z_2) are respectively 46.7×10^6 kg/m^2.s and 3.2×10^6 kg/m^2.s? **(4 marks)**

c. What is the near zone length of a 5 MHz compression probe with a crystal diameter of 15 mm in steel? [Velocity of sound in steel = 5960 m/s]

(4 marks)

d. What is the beam spread at 6 dB of a 15 mm, 5 MHz compression wave probe in steel? [K= 1.08] **(4 marks)**

Question 5

a. X-rays and gamma rays are forms of ionizing radiation. What does this statement mean?

(2 marks)

b. Describe the processes used to produce X-rays for industrial radiography **(6 marks)**

c. What are Image Quality Indicators (IQIs) used for? **(3 marks)**

d. How are IQIs placed on the test specimen? **(2 marks)**

e. What are the three main means of protection to help reduce exposure to radiation?

(3 marks)

Question 6

a. What is failure analysis and what are the main reasons for performing failure analysis?

(5 marks)

b. Outline the major steps that are usually taken when conducting failure analysis.

(5 marks)

c. In failure analysis, why are chemical analysis and fractography important?

(6 marks)

$$Ampere - turns = \frac{45}{L/D}$$

$$dB = 20\ log_{10}\frac{H_0}{H_1}$$

$$Ampere - turns = \frac{43\ x\ coil\_radius}{[(6\ x\ L/D)-5]}$$

$$\left[\frac{Z_1-Z_2}{Z_1+Z_2}\right]^2 x\ 100 = \%\ Reflected$$

$$NZ = \frac{D^2}{4\lambda}$$

$$sin\frac{\theta}{2} = \frac{K\lambda}{D}$$