9210135 0614

9210-135 JUNE 2014
Level 6 Graduate Diploma in Mechanical Engineering
Mechanics of solids

Monday 30 June 2014
09:30 – 12:30

You should have the following for this examination
- one answer book
- non-programmable calculator
- pen, pencil, drawing instruments

The following is included within the attached booklet
- Worksheets for Q4

General instructions
- This paper consists of **nine** questions.
- Answer any **five** questions.
- A non-programmable electronic calculator may be used but candidates **must** show sufficient steps to justify their answers.
- Drawings should be clear, in good proportion and in pencil. Do not use red ink.
- All questions carry equal marks. The maximum marks for each section within a question are shown.

ST00041540 H1 PO4500098563 10164264

1 a) List out **three** most desirable properties of a strain gauge. (3 marks)

b) What is the basic principle behind strain gauges? (4 marks)

c) State **three** industrial applications of strain gauges. (3 marks)

d) The state of strain at a point is measured using the strain rosette shown in Figure Q1. The readings from the respective strain gauges are:

$\in_a = 60\times10^{-6}$, $\in_b = 135\times10^{-6}$, $\in_c = 264\times10^{-6}$

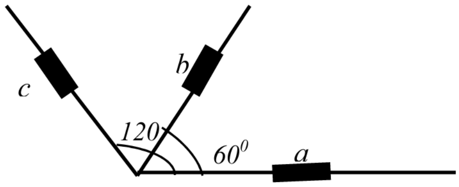

Figure Q1

Determine

i) the in-plane principal strains and the directions along which they act at the point under consideration. (7 marks)

ii) the principal stresses at the point.
The Young's Modulus and the Poisson's ratio of the material are 200 GN/m^2 and 0.3 respectively. (3 marks)

2 A general purpose Finite Element Analysis (FEA) programme used with computers in strength analysis consists of three basic stages.

a) What should be these three basic stages? Briefly explain each stage. (6 marks)

b) Write a brief description of widely used commercially available FEA programmes. (8 marks)

c) Describe the tasks which engineers are able to perform using FEA software programmes. (6 marks)

3 a) A beam AB of length $\boldsymbol{l}$, simply supported at the ends A and B, carries a point load $\boldsymbol{W}$ at a distance $\boldsymbol{a}$ from the left end A and $\boldsymbol{b}$ from the right end B. Show the deflection $\boldsymbol{y_c}$ under the load is

$$y_c = -\frac{Wa^2b^2}{3EIl}$$ (12 marks)

b) A beam with a span of 5.0 m carries a point load of 20 kN at 3 m from the left support. If for the section of the beam, I_{xx} (second moment of area) = 60.0 x 10^{-6} m^4 and for the beam material E (Young's Modulus) = 200 GN/m^2, find

i) the deflection under the load (4 marks)

ii) the position and amount of maximum deflection. (4 marks)

4 Two mutually perpendicular planes of an element of a material are subjected to direct stresses of 10.5 MN/m^2 (tensile) and 3.5 MN/m^2 (compressive) and shear stress of 7 MN/m^2.

Using Mohr's Circle theorem and graphical presentation (Use attached worksheet WSQ4), or otherwise determine the following.

a) The magnitude and direction of each principal stress, and (14 marks)

b) Magnitude of the normal and shear stresses on a plane, where the shear stress is maximum. (6 marks)

If you have used worksheet WSQ4, detach it from the question paper, write your name, centre number and candidate number in the spaces provided and enclose it with your answer book.

5 a) State **five** assumptions, which Lame's theory is based on. (5 marks)

b) A thick walled closed end cylinder made of an Al-alloy with E (Young's Modulus) = 72 GPa, and υ (Poisson's ratio) = 0.33 has inside diameter of 200 mm and outside diameter of 800 mm. The cylinder is subjected to internal fluid pressure of 150 MPa. Determine the principal stresses and maximum shear stress at a point on the inside surface of the cylinder. Also determine the increase in inside diameter due to fluid pressure. (15 marks)

6 a) Derive Euler formula for buckling of struts having two clamped ends. (12 marks)

b) A steel bar with both ends pin-jointed is compressed longitudinally until it buckles. Length of the bar is 1.5 m and cross-section is 20 x 5 mm^2. Using Euler's formula estimate the maximum central deflection before the steel reaches the yield point. Take E = 210 GPa and Yield stress = 320 MPa. (8 marks)

7 a) Define the terms Shear Force and Bending Moment with particular reference to a beam subjected to transverse loads. (6 marks)

b) A simply supported beam of span 2.5 m is subjected to a uniformly distributed load and a clockwise couple as shown in Figure Q7.
Draw the shear force and bending moment diagrams for the beam. (14 marks)

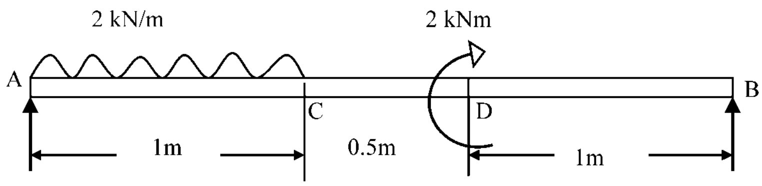

Figure Q7

8 A steel ring of external diameter 300 mm and internal diameter 200 mm is shrunk on to a solid steel shaft. The interference fit is designed such that the radial pressure between the mating surfaces will not fall below 30MN/m^2, whilst the assembly rotates in service. If the maximum circumferential stress on the inside surface of the ring is limited to 240 MN/m^2, determine the maximum speed at which the assembly can be rotated. It may be assumed that no relative slip occurs between the shaft and the ring. For steel, ρ =7470 kg/m^3, υ = 0.3, E = 208 GN/m^2. (20 marks)

9 Describe any **two** of the following:

a) Failure of ductile and brittle materials. (10 marks)

b) Experimental determination of plane strain **Fracture Toughness** (K_{IC}) and the practical difficulties encountered with in such determination. (10 marks)

c) Application of **Fracture Mechanics** in engineering design. (10 marks)