The University of Nottingham

DEPARTMENT OF MECHANICAL, MATERIALS AND MANUFACTURING ENGINEERING

A LEVEL 2 MODULE, SPRING SEMESTER 2012-2013

MECHANICS OF SOLIDS 2

Time allowed ONE Hour and THIRTY Minutes

Candidates may complete the front cover of their answer book and sign their desk card but must NOT write anything else until the start of the examination period is announced

Answer THREE questions

Only silent, self contained calculators with a Single-Line Display or Dual-Line Display are permitted in the examination.

Dictionaries are not allowed with one exception. Those whose first language is not English may use a standard translation dictionary to translate between that language and English provided that neither language is the subject of this examination. Subject specific translation dictionaries are not permitted.

No electronic devices capable of storing and retrieving text, including electronic dictionaries, may be used.

DO NOT turn examination paper over until instructed to do so

ADDITIONAL MATERIAL: Graph Paper

INFORMATION FOR INVIGILATORS:

Question papers should be collected in at the end of the exam – do not allow candidates to take copies from the exam room.

1. For the angle section shown in Fig. Q1, determine:

   (a) The position of the centroid of area

   [10 marks]

   (b) The principal second moments of area

   [16 marks]

   (c) The orientation of the principal axes [illustrate on a sketch of the section]

   [7 marks]

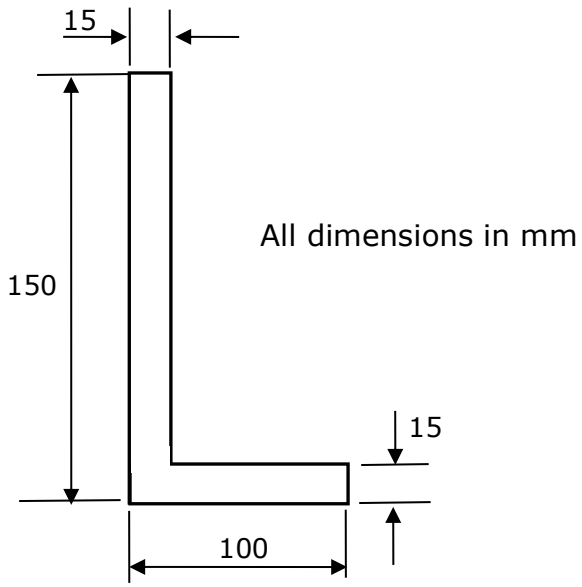

Fig. Q1

2. A thick cylinder, with both ends closed, has an inner radius of 20 mm and outer radius of 40 mm. The cylinder is subjected to an internal pressure of 100 MPa and external pressure of 40 MPa. It may be assumed that end effects can be neglected.

   (a) Determine the hoop stress at the inner radius and outer radius and sketch both the hoop stress and radial stress distribution through the thickness of the cylinder wall.

   [25 marks]

   (b) Determine the axial stress in the cylinder wall.

   [8 marks]

3. A rectangular beam (width, b, depth, d), is built–in (encastré) at both ends. The beam is constrained so that the axial strain $\varepsilon_x = 0$ and the radius of curvature R is constrained so that $1/R = 0$

The beam is subjected to a temperature gradient such that the temperature in the beam varies linearly from $-T_0{}^oC$ at the lower surface ($y=-d/2$) to $+T_0{}^oC$ at the upper surface ($y=+d/2$) and is 0^oC at the centre ($y=0$)

(a) Determine the stress distribution throughout the beam in terms of the Young's modulus E, the coefficient of thermal expansion, α, and the temperature, T_0.

[20 marks]

(b) Determine the forces and moment at the restraints in terms of the Young's modulus E, the coefficient of thermal expansion, α and the temperature, T_0.

[13 marks]

4. A beam, AB, supported by a strut, AC, is subjected to a point load, W, acting halfway along its length, as shown in Fig. Q4. The beam is made from solid square cross-section steel, 40mm x 40mm, and the supporting strut is made from solid circular cross-section steel, 30 mm diameter. All connections are pin joints.

Determine:

(a) The magnitudes and directions of the forces acting at the pin joints A, B and C

[13 marks]

(b) The magnitude of the load, W, which will cause yielding of the beam AB, assuming strut AC does not buckle.

[9 marks]

(c) The magnitude of the load, W, which will cause buckling of the strut AC, assuming beam AB does not yield.

[9 marks]

Identify the mechanism initiating collapse, yielding of the beam or buckling of the strut.

[2 marks]

[assume E_{steel} = 210 GPa, yield stress in tension/compression σ_{ysteel} = 300 MPa]

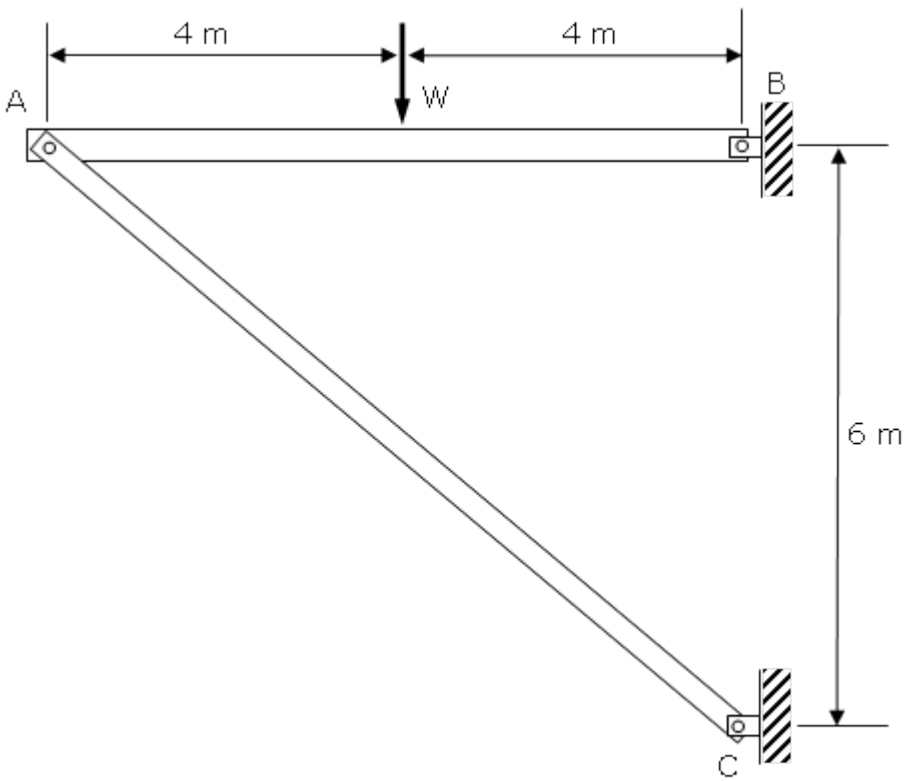

Fig. Q4

5. A cantilever beam has a length L, flexural rigidity EI, and is subjected to an end load P. Using a strain energy approach, show that:

(a) the deflection at the end load is given by $\frac{PL^3}{3EI}$

[20 marks]

(b) the deflection halfway along the beam is given by $\frac{5PL^3}{48EI}$

[13 marks]

End