The University of Nottingham

DEPARTMENT OF MECHANICAL, MATERIALS AND MANUFACTURING ENGINEERING

A LEVEL 2 MODULE, AUTUMN 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. The angle section shown in Fig. Q1 carries a vertical shear force of 1000N. The 2nd moment of area of the section about the neutral axis XX through the centroid, C, of the section is I = 156, 940 mm^4. Determine:

   (a) The vertical shear stress at positions A, B, C, D and E in the web

   [13 marks]

   (b) The horizontal shear stress at positions F, G and H in the flange

   [13 marks]

   (c) Sketch the shear stress distribution in the web and flange.

   [7 marks]

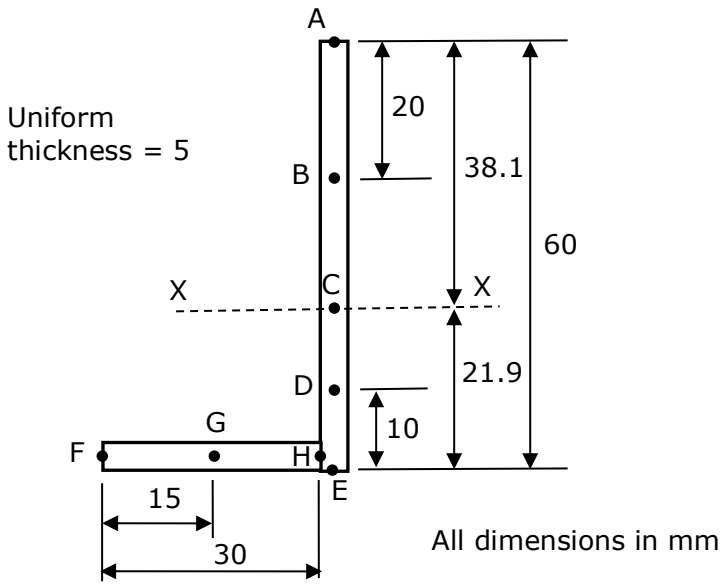

Fig. Q1

2. A simply supported beam is subjected to a point moment couple at the centre of its span, as shown in Fig. Q2. The beam is made from material with a modulus of elasticity E and a second moment of area I.

(a) Determine the reactions at both supports.

[8 marks]

(b) Calculate the vertical deflection and the slope of the beam at point C situated in the middle of the beam.

[13 marks]

(c) Calculate the slopes at both supports and draw schematically the deformation of the beam.

[12 marks]

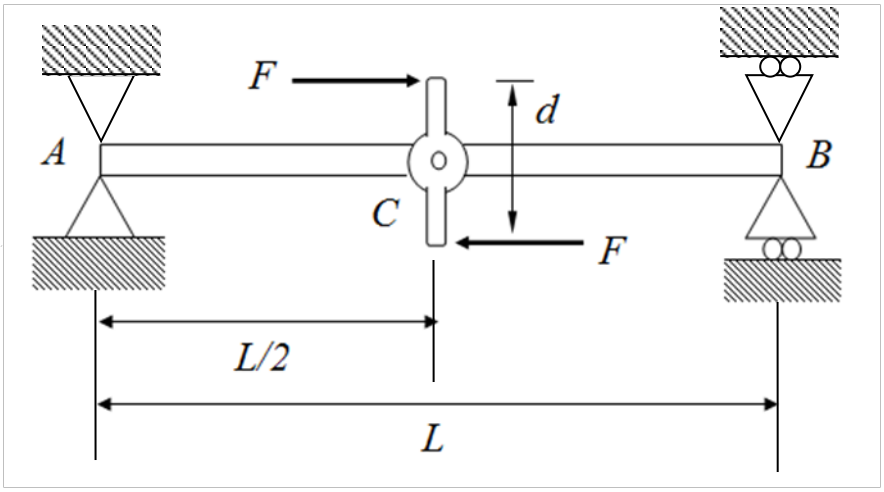

Fig. Q2

3. A structure consisting of two legs, as shown in Figure Q3, is subjected to a uniformly distributed load, q N/m, acting transversely on the leg AB. Each leg has the length *L* and a rectangular cross-section with width *w* and depth *h*. Determine:

(a) the reaction forces at both supports A and C.

[10 marks]

(b) the bending moment distribution along the leg BC.

[10 marks]

(c) the compressive stress at point P situated at 0.75 *L* distance from C.

[10 marks]

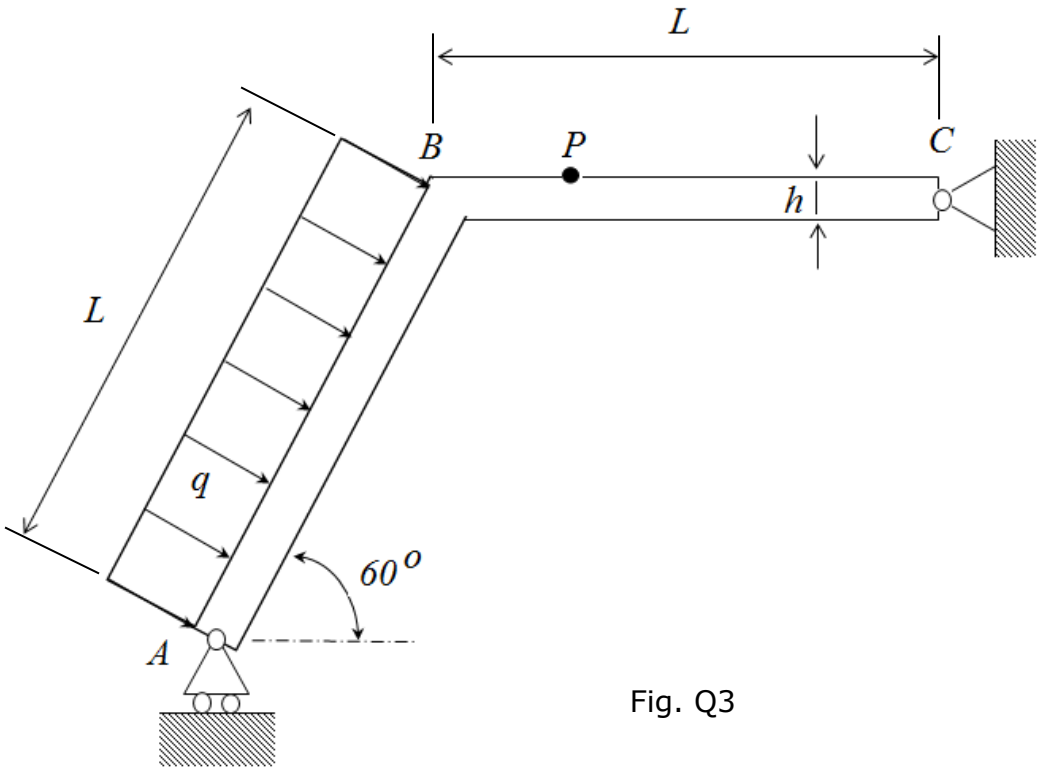

Fig. Q3

4. (a) Explain, with the aid of diagrams, the elastic-perfectly-plastic hardening model of material behaviour. Sketch and label the yield surface in the three dimensional principal stress space.

[7 marks]

(b) A solid circular shaft, of diameter 100mm and length 2m is subjected to a torque, T. The shaft is made from an elastic-perfectly-plastic material with shear yield stress, σ_Y = 100 N/mm^2 and shear modulus, G =70GN/m^2

i) Determine the magnitude of the torque required to cause yielding to occur to a radius of 30mm (and greater) and the angle of twist in the loaded state.

[13 marks]

ii) Determine the residual angle of twist and the residual stress distribution when the shaft is subsequently unloaded.

[13 marks]

5. (a) Describe the *S*-*N* design procedure for fatigue. Your solution should include:

i) a diagram of a typical *S*-*N* curve for an engineering material such as a low strength steel.

ii) a discussion (with the aid of diagrams where appropriate) of the effect of mean stress on the fatigue life of engineering components.

iii) a description of the effect of stress concentrations.

iv) a detailed sketch of the Goodman diagram (or constant-life diagram) showing how this can be used to give safe estimates of fatigue life and load.

[16 marks]

(b) Outline the linear elastic fracture mechanics LEFM approach to fatigue crack growth. Your solution should include;

i) a description (including an equation) of the stress intensity factor.

ii) a sketch showing the 3 modes of stress intensity factor.

iii) a discussion of the Paris Law including the defining equation and a sketch of the (da/dN) versus (ΔK) curve.

[17 marks]

End