COMMONWEALTH OF AUSTRALIA

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Warning

CHARLES DARWIN UNIVERSITY

Family Name	
Given Names	
Student Number	
Teaching Period	Semester 2, 2016

FINAL EXAMINATION	**DURATION**
ENG212 – Mechanics of Solids	Reading Time: **10** minutes Writing Time: **180** minutes

INSTRUCTIONS TO CANDIDATES

1. The examination has 1 section. Questions must be answered in your answer booklet. This examination paper must be handed in with your answer booklet. Please ensure that your name and student number are clearly indicated on your Answer Booklet and at the top of this examination paper.

2. Note that questions ARE NOT of equal value.

3. Read ALL questions carefully.

4. Answer ALL questions.

EXAM CONDITIONS

You may begin writing from the commencement of the examination session. The reading time indicated above is provided as a guide only.

This is a CLOSED BOOK examination.

Any non-programmable calculator is permitted.

No handwritten notes are permitted.

No dictionaries are permitted.

ADDITIONAL AUTHORISED MATERIALS	EXAMINATION MATERIALS TO BE SUPPLIED
No additional printed material is permitted.	1 x 20 Page Book 1 x Scrap Paper Formula Sheet/s

THIS EXAMINATION IS PRINTED DOUBLE-SIDED.

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Question 1 (14 marks)

The stainless steel shaft shown in Figure 1 (diagram not to scale) is made of three solid circular sections. The shaft is supported by a smooth bearing at *A* (the shaft is free to rotate at *A)* but is fixed at *B.* The two outer sections have a length 0.3 m each and a diameter of 2 cm. The length of the middle section is 0.4 m and the diameter of the middle section is 4 cm. The fillet at each junction of the shafts has a radius of 3 mm. The shear modulus of elasticity, G = 75 GPa.

A torque T_1 = 40 Nm is applied halfway along the length of the first section, a torque T_2 = 60 Nm is applied halfway along the length of the second section, and a torque T_3 = 30 Nm is applied halfway along the length of the third section.

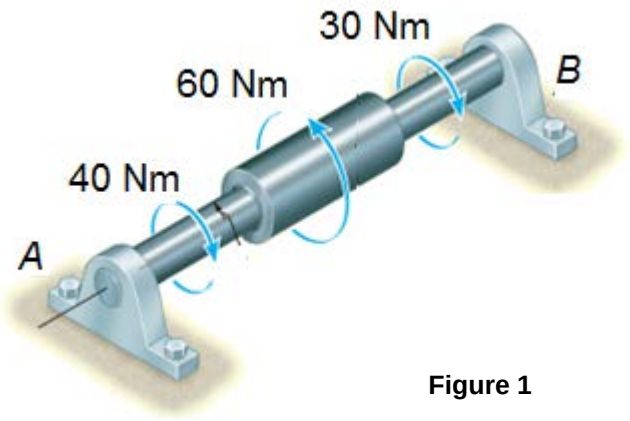

Figure 1

a. Find the maximum and minimum values of the shear stress in the shaft and the locations where these occur, taking stress concentrations into account **(8 marks)**
b. Determine the angle of rotation at *A.* **(6 marks)**

Question 2 (14 marks)

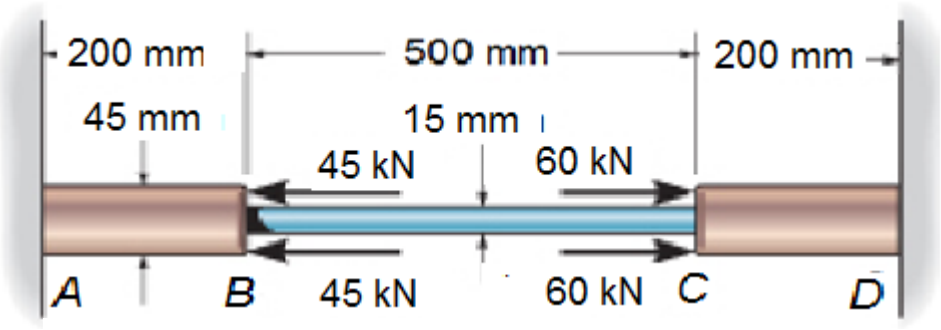

Figure 2

The composite bar shown in Figure 2 consists of a 15 mm diameter steel rod *BC* and 45 mm diameter brass end segments *AB* and *CD.* Two loads of 45 kN and two loads of 60 kN are applied as shown in Figure 2. The bar is fixed to the wall at both ends. Determine the average normal stress in each segment due to the applied load. E_{st} = 200 GPa, E_{br} = 101 GPa.

Question 3 (18 marks)

The beam shown in Figure 3 (cross section not to scale) is constructed from two boards. It is subjected to the loading shown in Figure 3. Please ignore the self weight of the beam.

a. Draw the shear force diagram and the bending moment diagram for the beam and show clearly all important values. **(6 marks)**
b. Find the maximum value of shear stress in the beam and state precisely where this occurs. **(6 marks)**
c. Specify the maximum spacing of nails needed to hold the top board in place for each section (*AB*, *BC* and *CD*) if each nail can safely resist 1.2 kN in shear. **(6 marks)**

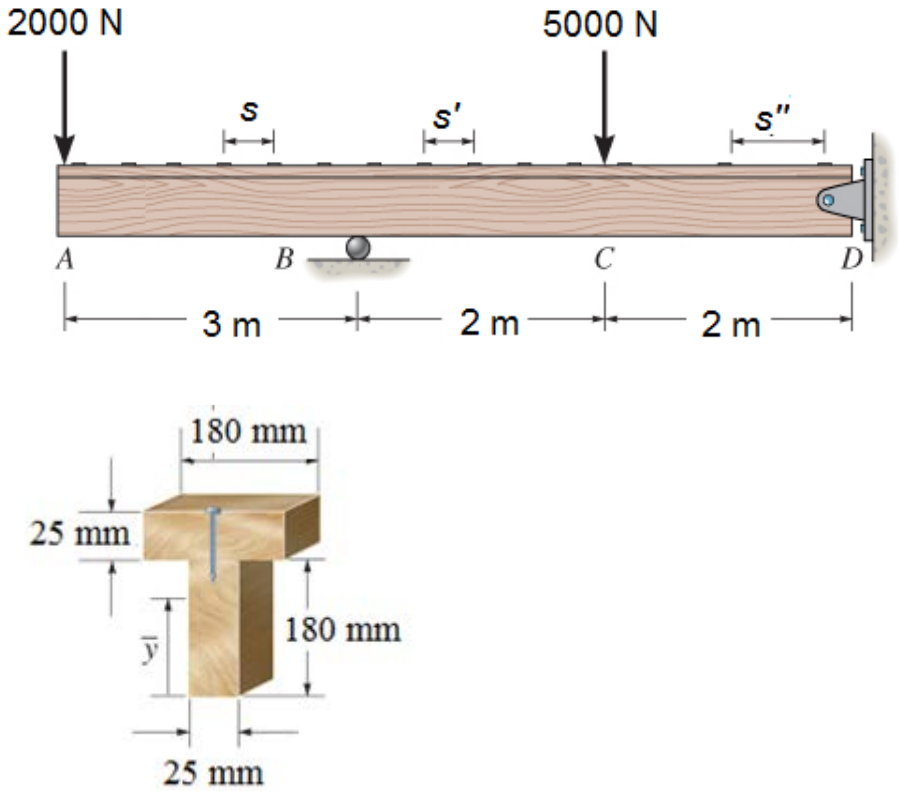

Figure 3

Question 4 (17 marks)

The pressure vessel shown in Figure 4 has an internal diameter of 1.6 m and a wall thickness of 0.65 cm. It is made from steel plates which are welded along the $45°$ seam. The vessel is subjected to an internal pressure P = 10 MPa. E_{st} = 200 GPa, ν_{st} = 0.3.

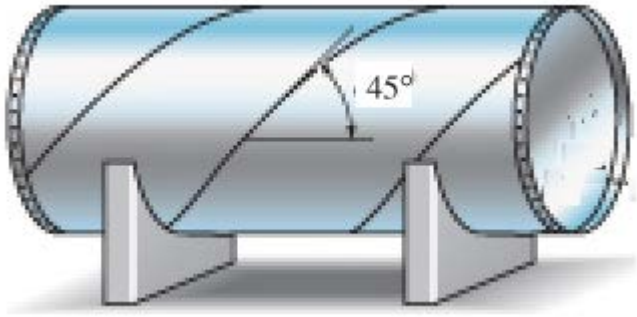

Figure 4

a. Calculate the hoop stress, σ_h, and the longitudinal stress, σ_l. **(4 marks)**
b. Calculate the hoop strain and the longitudinal strain **(4 marks)**
c. Calculate the normal stress and the shear stress where the steel plates are welded together, along the $45°$ seam **(6 marks)**
d. What is the absolute maximum shear strain in the pressure vessel? **(3 marks)**

Question 5 (18 marks)

An aluminium beam is used to support the load w= 15 kN/m as shown in Figure 5. The solid beam is rectangular with a height of 200 mm and a width of 120 mm. The length of the beam L = 4 m. The modulus of elasticity for the beam is E = 70 GPa.

a. Express the bending moment along the length of the beam as a function of x in terms of the reaction force at *B.* **(3 marks)**
b. What is the deflection of the beam at *A?* **(1 mark)**
c. What is the slope of the beam at *A?* **(1 mark)**
d. Draw an exaggerated deflected shape for the beam. **(2 marks)**
e. Determine the value of the slope of the beam at *B.* **(3 marks)**
f. Determine the reaction force at *B.* **(3 marks)**
g. Determine the slope and the deflection of the beam halfway between *A* and *B* (2.5 m from *A).* **(3 marks)**
h. Is this the maximum deflection of the beam? Explain your answer. **(2 marks)**

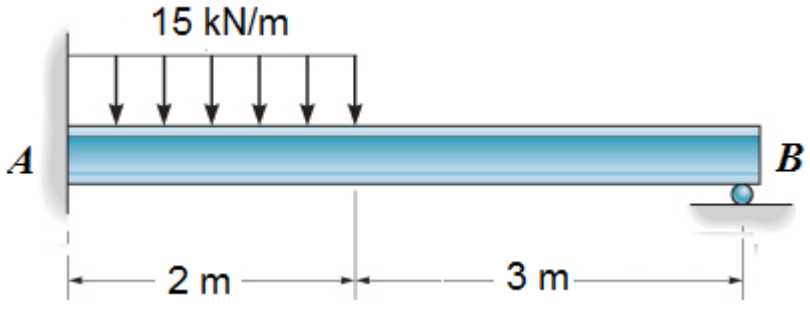

Figure 5

Question 6 (19 marks)

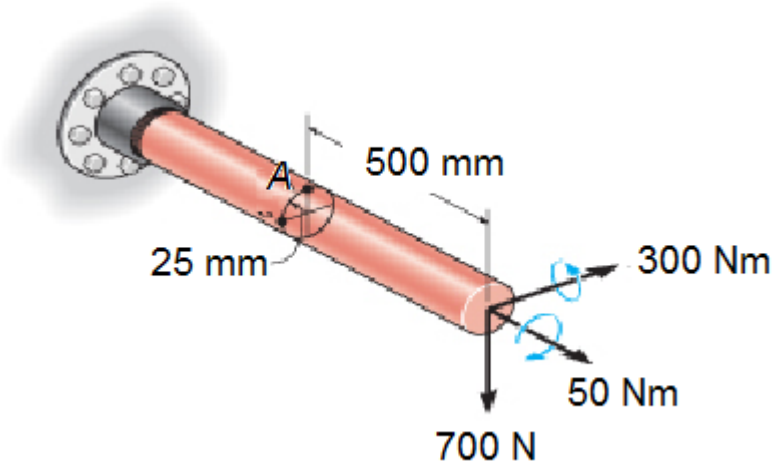

Figure 6

The free end of a solid shaft is subjected to a torque of 50 Nm, a bending moment of 300 Nm and a shear force of 700 N, as shown in Figure 6. The length of the shaft is 90 cm and the diameter of the shaft is 50 mm. The shaft is made of bronze. Point *A* is located on top of the shaft, 500 mm from the free end.

Determine the values of

a. the axial (normal) force, shear force(s), torque and bending moment(s) at point *A* **(4 marks)**
b. the stresses caused by the normal force, torque, shear force(s) and bending moment(s) at point *A.* **(6 marks)**
c. the principal stresses at point *A.* **(6 marks)**
d. the absolute maximum shear stress at point *A.* **(3 marks)**