2021 FIRST SEMESTER FINAL EXAMINATION

Faculty: **Engineering and the Environment**

Department: **Metallurgical Engineering**

Paper Code/Title: **EMR 2202 SOLID MECHANICS**

Duration: **3 Hours**

Examiner: **Saymore Hobwana**

INSTRUCTIONS TO CANDIDATES

1. Answer **ANY FOUR QUESTIONS.**
2. Start the answer to each question on a fresh page.
3. Each question carries 25 marks.
4. Use of calculators is permissible.

Additional Requirements

List of Formulae

Mark Allocation

Question 1 to 6	**25 marks**
Part Questions	**As shown in each part question**
Total Attainable	**100**

QUESTION 1 **[25]**

A composite beam is made of steel (A) bonded to brass (B) and has the cross section shown
in Figure 1. If the composite beam is subjected to a moment of M = 6.5 kN m,

a) Determine the maximum bending stress in the brass and steel. **(9 marks)**
b) Also, what is the stress in each material at the seam where they are bonded together? **(6 marks)**
c) Make calculations of section properties of the composite beam. **(10 marks)**

The modulus of elasticity for steel, E_{st} is 210 GPa. The modulus of elasticity for brass, E_{br} is 105 GPa.

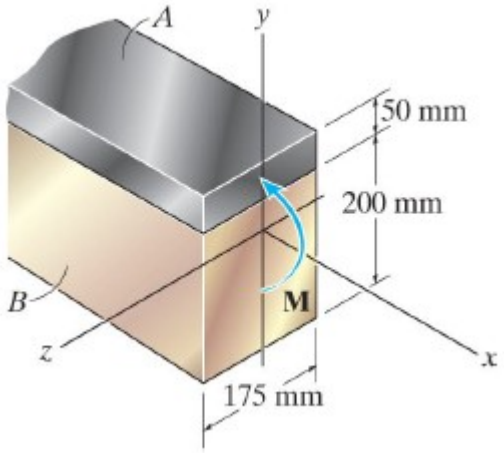
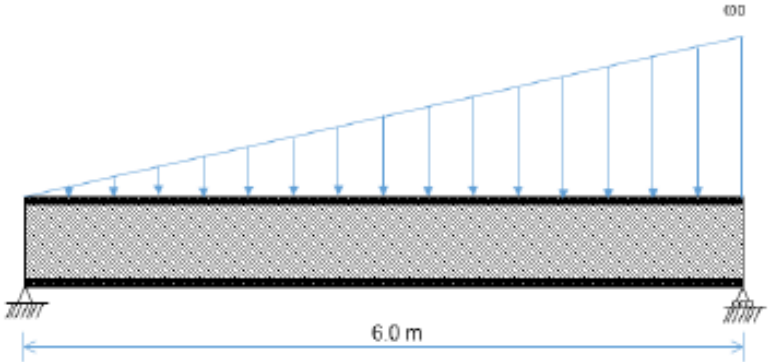


Figure 1

QUESTION 2 **[25]**

A beam is fabricated using a mild steel assumed to be elastic-perfectly plastic. The beam is subjected to distributed load as shown in Figure 2(a). The cross section of beam is shown in Figure 2(b). Consider yield stress σ_y = 175 MPa.

a) Calculate the moment of inertia if the I section **(4 marks)**
b) Determine the maximum intensity of the distributed load that can be applied to the beam when :
(i) yield first occurs **(6 marks)** and
(ii) top and bottom flanges have just become fully plastic. **(15 marks)**



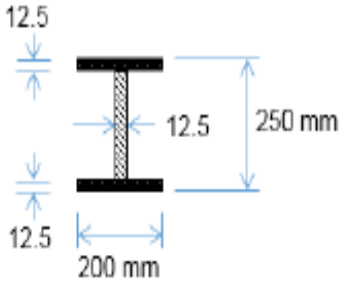


Figure 2(b)

Figure 2(a)

QUESTION 3 **[25]**

i) An aluminum shell is fully bonded to the brass core and the assembly is unstressed at a temperature of 15°C. Considering only axial deformations, determine the stress in the aluminum when the temperature reaches 195°C. **(15 marks)**

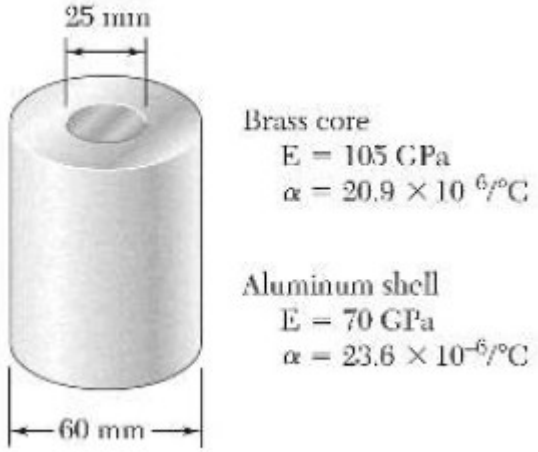


Figure 3(a)

ii) A device for impact testing is shown in Figure 3(b). The swinging arm OG has a mass of 34 kg and a radius of gyration about the axis O of 620 mm. The bearing at O can be assumed to be frictionless. The arm is released from rest when the angle ⚠ 60 .
(a) Draw a free body diagram of the arm OG immediately following release from rest at ⚠ 60 . **(2 marks)**
(b) What is the Moment of Inertia of the arm OG about the axis O? **(1 mark)**
(c) Determine the angular acceleration of the arm OG immediately after it is released from rest at ⚠ 60 ? **(2 marks)**

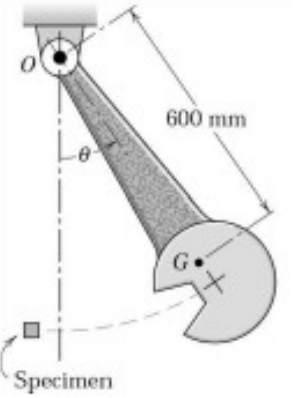


Figure 3(b)

iii) Draw a stress strain diagram for a typical mild steel specimen and name all the points. **(5 marks)**

QUESTION 4 **[25]**

a) For the loading shown in Figure 4(a), calculate stress state (σ_x and σ_{xy}) at point g. Point g is located at the centroid of the rectangular cross-section C which is the midpoint of the beam. **(15 marks)**

Note this problem requires a FBD and cross section diagram. Warning pay attention to units!!

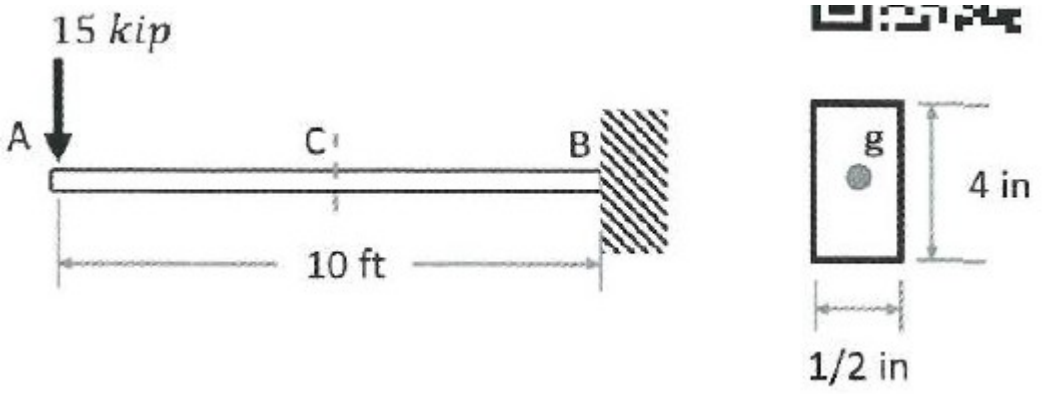
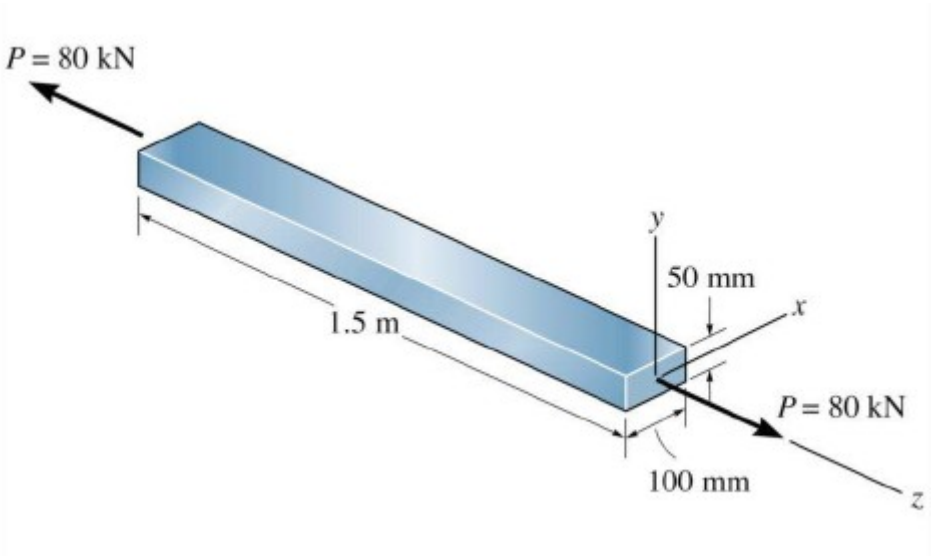


Figure 4(a)

b) A steel bar has the dimensions shown in the Figure (4b). If an axial force of P=80 kN is applied to the bar,
   i) determine the normal stress, change in its length (axial elongation) and (contraction strains) **(8 marks)**
   ii) the change in the dimensions of its cross section after applying the load. **(2 marks)**

   The material behaves elastically. The modulus of elasticity E of steel is 200 GPa and the Poisson's ratio u of the steel is 0.32



Figure(4b)

QUESTION 5 **[25]**

i) In Figure 5 determine:

(a) The principal stresses and **(4 marks)**

(b) Maximum in-plane shear stress and average normal stress at the point. **(7 marks)**

(c) Specify the orientation of the element in each case in (b) **(4 marks)**

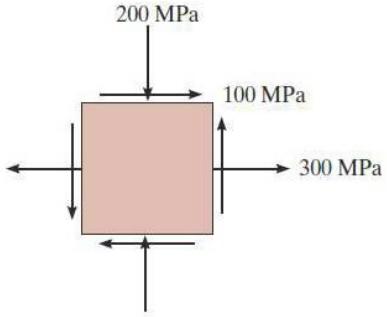


Figure 5(a)

ii) The solid cylindrical shaft of variable size as shown in mm in Figure 5(b) is acted upon by the torque indicated. Find the maximum shear stress developed in the shaft, and indicate between which two pulleys it occurs. **(6 marks)** Also determine the relative twist between the end pulleys. Take G = 80 GPa. **(4 marks)**

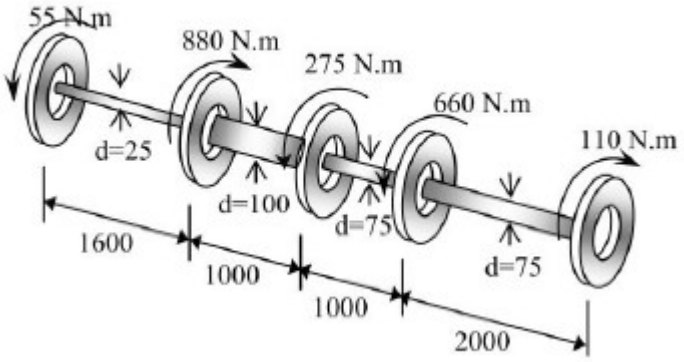


Figure 5(b)

QUESTION 6 **[25]**

a. Describe the maximum principal stress criterion? What type of material is it useful for? **(3marks)**
b. What is the definition of the Tresca failure criterion? What type of material is it useful for? **(3 marks)**
c. What is the definition of the von Mises failure criterion? What type of material is it useful for? **(3 marks)**
d. What is necking? **(1 mark)**

e. Determine the centroid of the section of the concrete tailings dam shown in Figure 6. **(15 marks)**

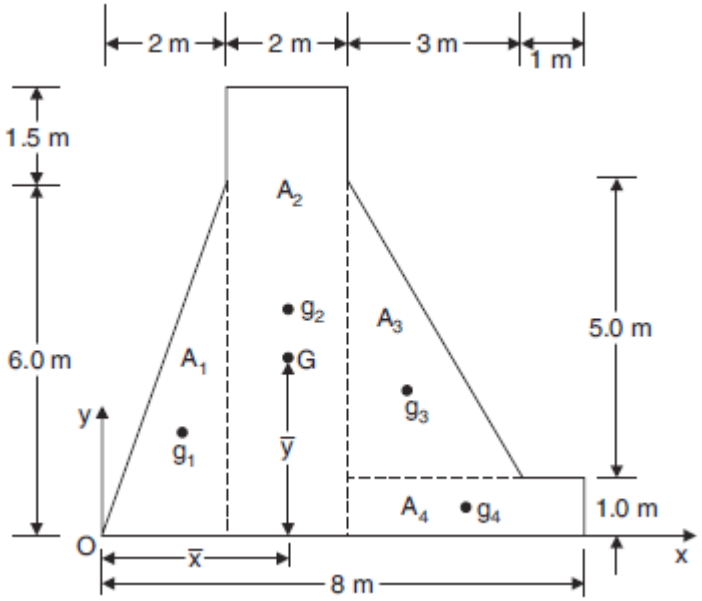


Figure 6.

************************************END OF QUESTION PAPER************************************