GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

ROLL NO.	

PRESIDENCY UNIVERSITY, BENGALURU
SCHOOL OF ENGINEERING

Maximum Marks: 80 | Maximum Time: 120 Minutes | Weightage: 40 %

END TERM FINAL EXAMINATION

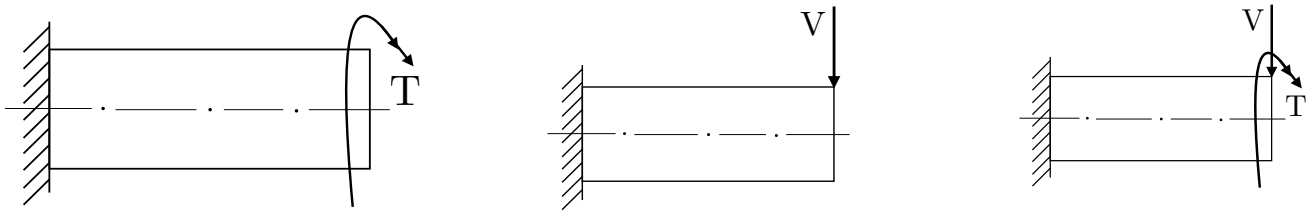
I Semester AY 2017-18 | Course: **MEC 206 Mechanics of Solids** | 20 Dec, 2017

Instructions

i. Read the questions carefully, note what is being asked for and write your answers accordingly.
ii. Use non-programmable scientific calculators to solve the problems in this exam.

Part A **[14 M + 10 M = 24 Marks]**

1. We have seen in class that the normal and shear stresses on an inclined plane in a 2-D stress element are given by $\sigma_\theta = \frac{\sigma_x + \sigma_y}{2} + \frac{\sigma_x - \sigma_y}{2}\cos 2\theta - \tau_{xy}\sin 2\theta$, and, $\tau_\theta = \frac{\sigma_x - \sigma_y}{2}\sin 2\theta + \tau_{xy}\cos 2\theta$, respectively.
   (a) Show that these equations are a representation of a circle.
   (b) What are the radius and the coordinates of the centre of this circle?
2. Sketch the shear stress distributions at the centroidal axis of any cross section for each of the shear loading scenarios shown in Figure 1.



(a) A Bar Subjected to Torsional Shear (b) A Bar Subjected to Transverse Shear (c) A Bar Subjected to Torsional and Transverse Shear

Figure 1: Three Shear Loading Scenarios

Part B **[10 M + 16 M = 26 Marks]**

3. Determine the reaction at the roller joint and the internal axial force at the section AA′ for the member in Figure 2.

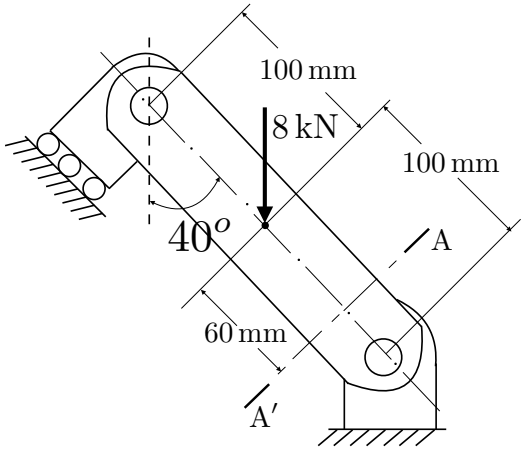


Figure 2: A Member Subjected to a Point Load

4. Determine the axial and maximum bending stresses in the bar shown in Figure 3. Plot the axial stress, bending stress and the resultant normal stress distributions at any cross section in the bar.

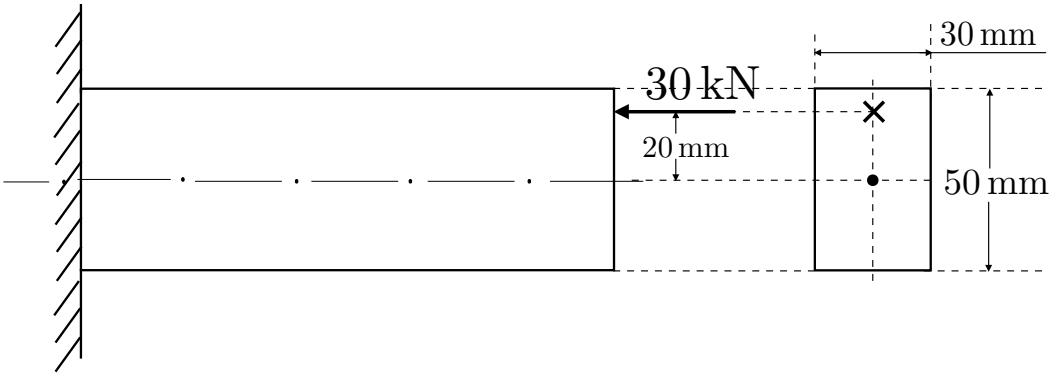


Figure 3: A Bar Subjected to an "Eccentric" Point Load

Part C **[30 Marks]**

5. Figure 4 shows a 2-D stress element.
   (a) Derive expressions for the normal stress σ_θ and the shear stress τ_θ shown in Figure 4.
   (b) Derive expressions for the principal stresses σ_1 and σ_2.
   (c) Suppose $\sigma_x = 8\ \text{N/mm}^2$, $\sigma_y = -2\ \text{N/mm}^2$, and $\tau_{xy} = -5\ \text{N/mm}^2$.
      i) Sketch a 2-D stress element showing these stresses.
      ii) Determine analytically the principal stresses and the maximum shear stresses.
      iii) Determine graphically the principal stresses and the maximum shear stresses by constructing the Mohr's circle.

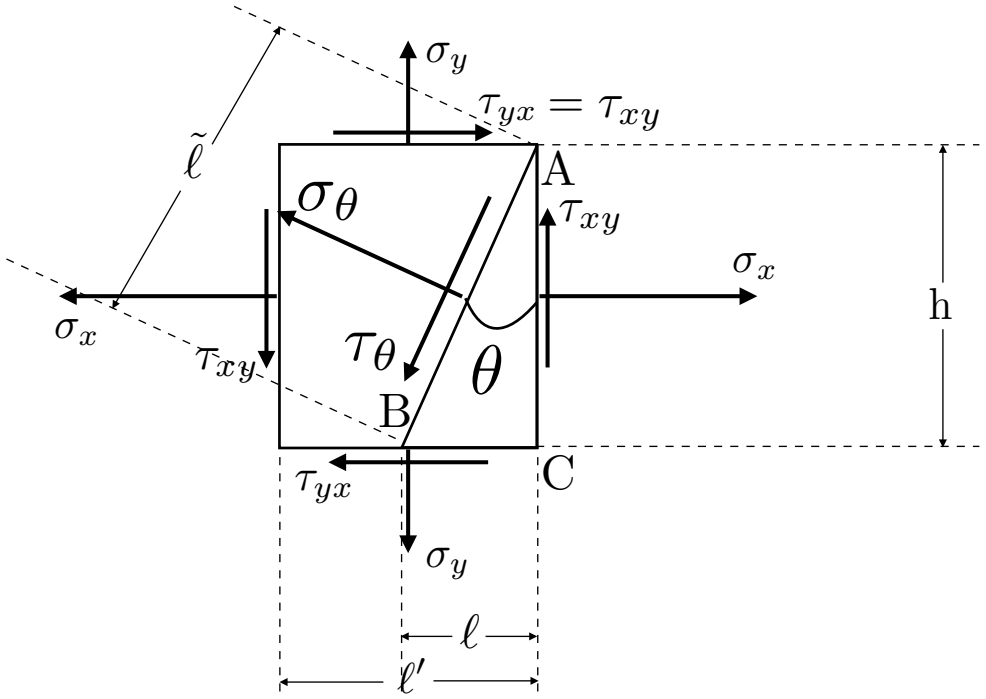


Figure 4: A 2-D Stress Element

The End

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GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

Maximum Marks: 40 | Maximum Time: 60 Minutes | Weightage: 20%

TEST 2

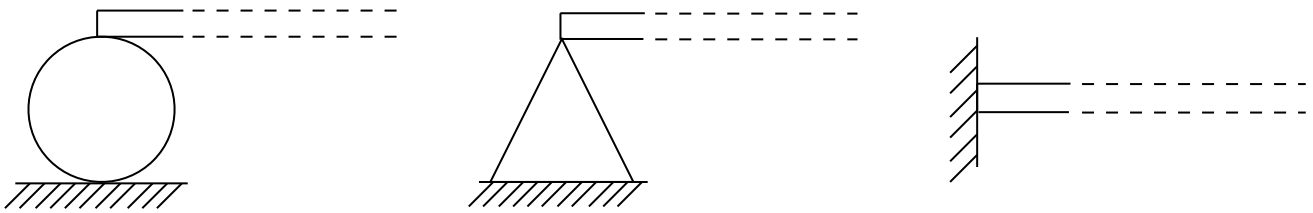
I Semester, 2017-2018 | Course: **MEC 206 Mechanics of Solids** | October 25, 2017

Instructions

i. You have 60 minutes to answer all the questions. Plan your test!
ii. Do not copy entire questions into your answer scripts. Copy only what you need.
iii. Freehand drawings (without rulers!) are encouraged for all diagrams, figures and graphs.
iv. Use only non-programmable scientific calculators for this test.

Part A (6 M + 6 M = 12 Marks)

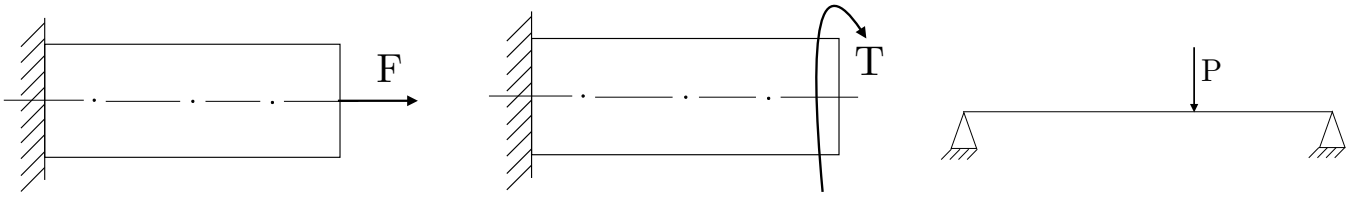
1. Sketch the reactions appropriate to each of the beam supports shown in Figure 1.



(a) Roller Support (b) Pinned Support (c) Fixed Support

Figure 1: A Few Types of Supports for Beams

2. Figure 2 shows some theoretical loading scenarios. For each scenario *just state* whether the stresses in any cross section perpendicular to the axis of the member are normal stresses or shear stresses or both.



(a) An Axially Loaded Bar (b) A Torsionally Loaded Bar (c) A Point Load Acting on a Beam

Figure 2: Some Theoretical Loading Scenarios

Part B (6 M + 5 M = 11 Marks)

3. Figure 3 shows a bar fixed at both ends and acted on by a torque $T_B = 2\,\text{kN}\cdot\text{m}$. Assume the shear modulus of the material of the bar G = 85 GPa.
   (i) Draw a free body diagram of the bar with a coordinate system.
   (ii) Is this a statically determinate or statically indeterminate system? Explain your answer.
   (iii) Find the torque and torsional stress in AB.

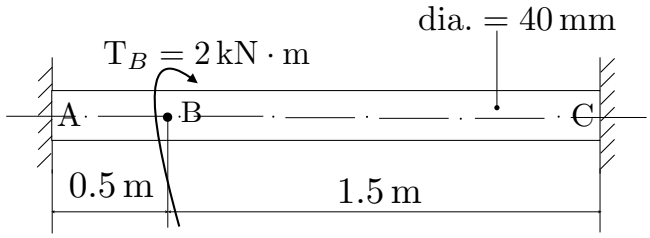
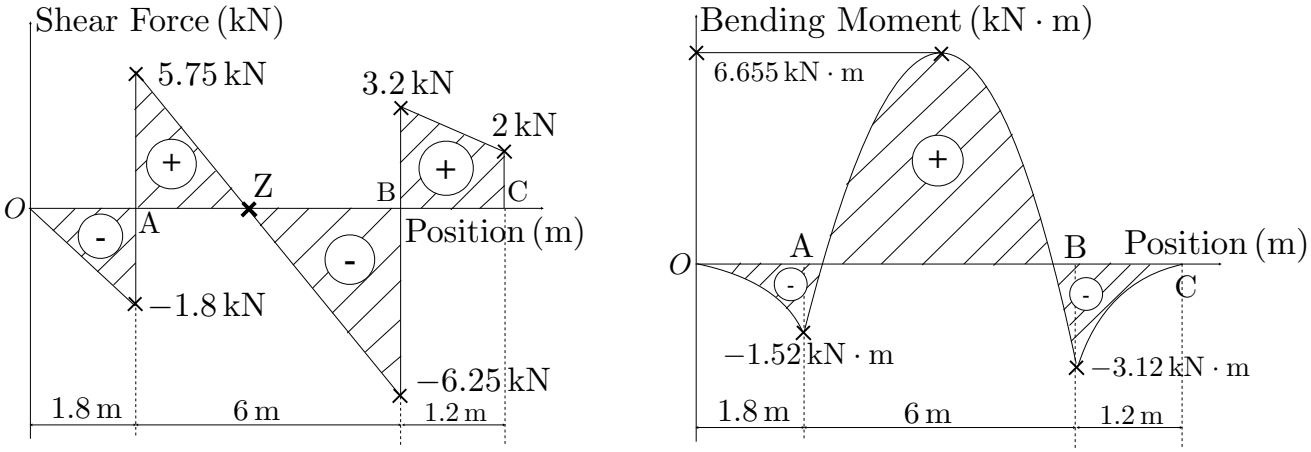


Figure 3: A Bar Fixed at Both Ends and Subjected to a Twisting Moment

4. (DO NOT COPY THE SFD AND BMD INTO YOUR ANSWER SCRIPT!) Figure 4 shows the shear force diagram (SFD) and the bending moment diagram (BMD) for a beam of 60-mm diameter subjected to external loads. Answer the following questions using the SFD and BMD.
   (i) What is the maximum shear *force* acting on the beam?
   (ii) What is the shear *stress* at C?
   (iii) What is the maximum bending *stress* in the beam?



(a) Shear Force Diagram (b) Bending Moment Diagram

Figure 4: Shear Force and Bending Moment Diagrams for a Beam

Part C (5 M + 12 M = 17 Marks)

5. Fig. 5 shows a cantilever beam loaded within the elastic limit of the material it is made of. *Use the method of direct integration* to obtain a mathematical expression for y(x), the deflection of the beam as a function of its length. Assume the Young's Modulus of the material of the shaft E = 220 GPa.

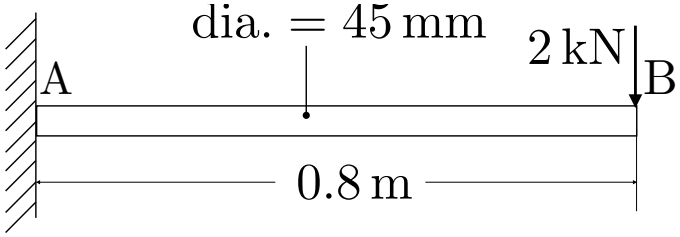


Fig. 5: A Cantilever Beam Subjected to a Point Load

6. Answer the following questions for the beam shown in Figure 6.
   (i) Draw the free body diagram of the beam and determine all the reactions at the supports A and D.
   (ii) Obtain mathematical expressions for the shear forces in AB, BC and CD. Plot the SFD.
   (iii) Obtain mathematical expressions for the bending moments in AB, BC, and CD. Plot the BMD.

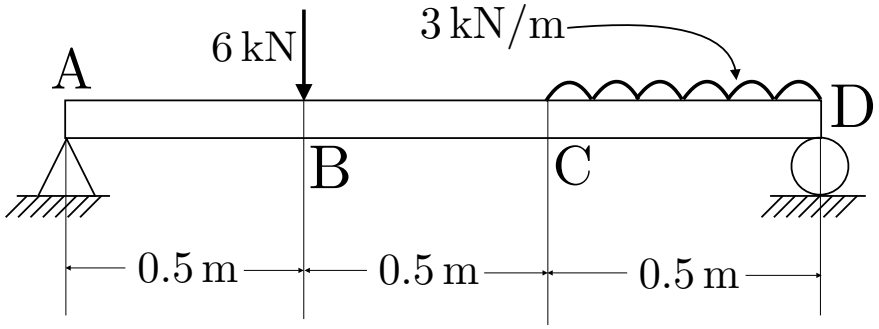


Figure 6: A Beam Acted on by a Point Load and a Uniformly Distributed Load

The End

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Maximum Marks: 40 | Maximum Time: 60 Minutes | Weightage: 20%

TEST 1

I Semester 2017-2018 | Course: **MEC 206 Mechanics of Solids** | September 20, 2017

Instructions

i. Read the questions carefully. Your answers must contain only what the questions ask for.
ii. Each graph must have axes labels and its "origin" must be marked.
iii. Free body diagrams will help you get "partial credit". Draw them!
iv. It is your duty to make your work understood to the evaluator of your test. Write legibly!
v. You are permitted to use non-programmable scientific calculators.

Part A

(6 M + 3 M + 3 M = 12 Marks)

1. Define and state an S. I. unit for stress, deformation in bars subjected to purely axial loads, and normal strain.
2. Draw the stress-strain curve for a brittle material. Show the yield point, the point of ultimate stress and the fracture point on this curve. (Draw the curve, mark the points on it. Don't explain anything!)
3. Figure 1 shows a bar attached to a "ceiling." This bar is subjected to an increase in temperature ΔT degrees Celsius. Draw a figure showing the elongation δ_T due to this increase in temperature. Write down the expressions for thermal strain ϵ_T and the elongation δ_T. (No explanations needed!)

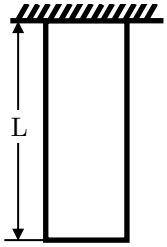

Figure 1: A Bar Undergoing Free Expansion

Part B

(2 Q x 8 M = 16 Marks)

4. Assume the bar in Figure 2 remains in the linear elastic region when acted upon by F. The Young's Modulus of the material of the bar is $E = 200 \times 10^3$ N/mm^2.
   (a) Draw a free body diagram of the bar showing all relevant forces and reactions. Neglect gravitational forces.
   (b) Find the normal stress and normal strain.
   (c) Now suppose $F = -5000N$. Find the normal stress and normal strain in the bar.

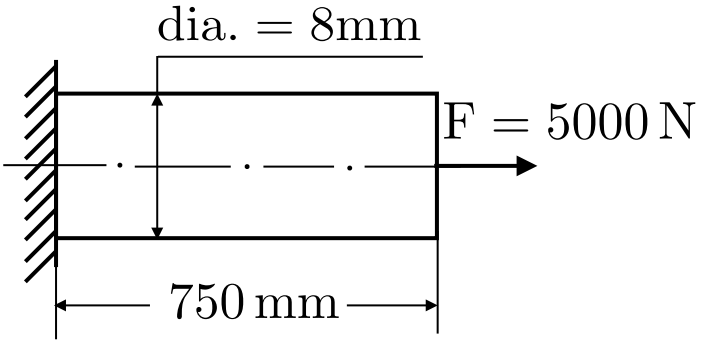

Figure 2: An Axially Loaded Bar

5. The bar shown in Figure 3 is acted upon by a torque $T = 20\,N \cdot m$. Answer the following questions assuming G = 80 GPa.
   (a) Draw a free body diagram showing all torques and reactions. Neglect all gravitational loads.
   (b) Determine the magnitude and direction of the reaction torque at the "wall".
   (c) Calculate the torsional shear stress in the bar.
   (d) Find the angle of twist of the cross section at the free end A with respect to the cross section at O.

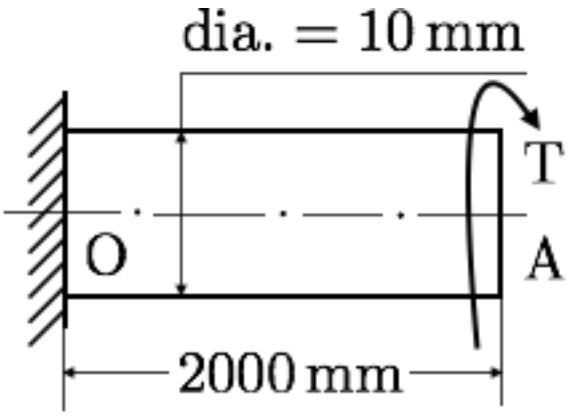

Figure 3: A Bar Subjected to a Torque

Part C

(5 M + 7 M = 12 Marks)

6. Figure 4 shows a steel bar restrained by "walls" at both ends. Its temperature is raised from $27^o C$ to $82^o C$. Assume the Young's Modulus of steel to be $E = 230\,GPa$ and its linear coefficient of thermal expansion to be $\alpha = 11.7 \times 10^{-6}\ /^o C$.
   (a) Determine the thermal stress in the bar.
   (b) Is this thermal stress tensile or compressive? Explain your answer.

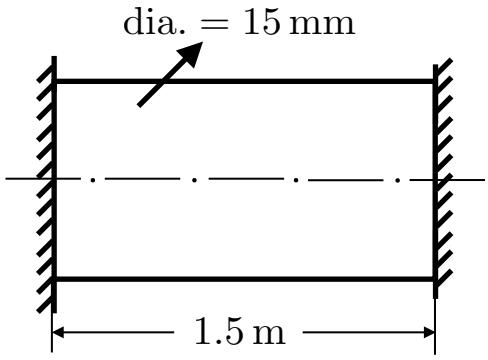

Figure 4: A Bar Subjected to an Increase in Temperature

7. Answer the following questions for the rotating shaft shown in Figure 5.
   (a) What are the force and torque on Pulley 2? Determine their magnitudes and directions.
   (b) Choose any section between the points A and B on the shaft. Determine the magnitude and direction of the torque acting at this section?
   (c) What is the maximum torsional shear stress in the shaft?

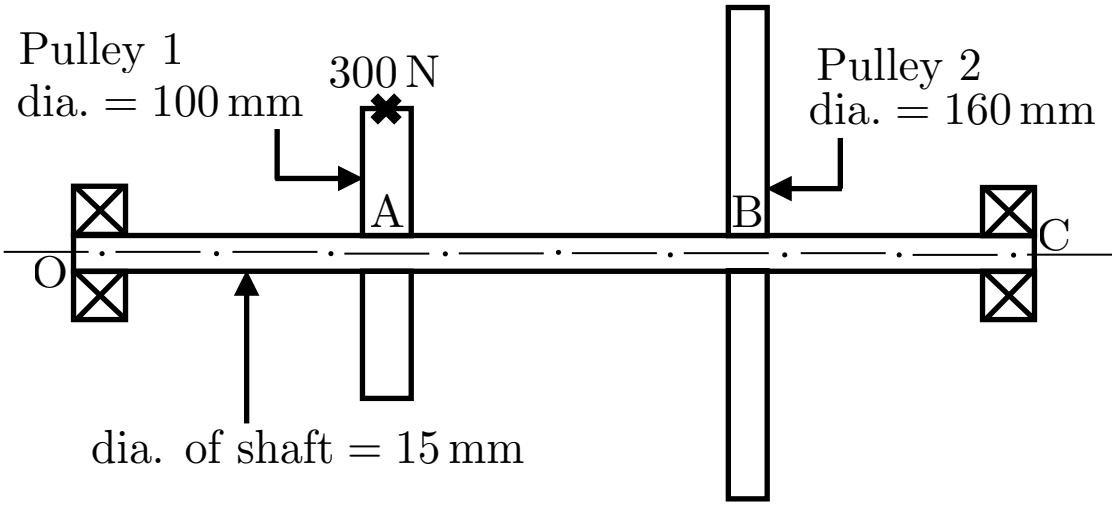

Figure 5: A Rotating Shaft with Two Pulleys

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