Section 1: Multiple Choice (4 points each, 40 points total)

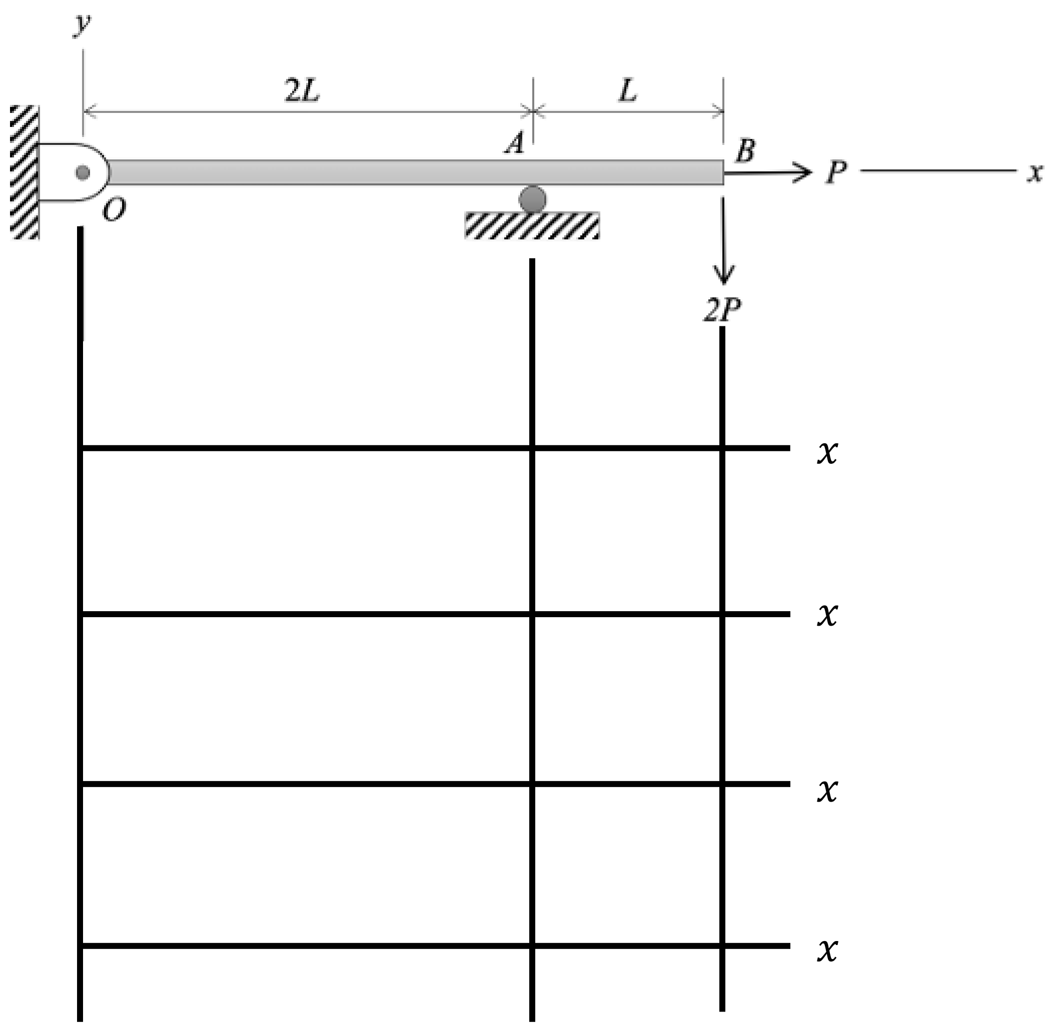
1. Which of the following best describes the purpose of using factors of safety in mechanical design?
   - O To optimize material usage
   - O To ensure that a design can withstand more load than expected
   - O To reduce production costs
   - O To minimize the weight of the design
2. Which of the following best describes the Maximum Normal Stress (MNS) theory?
   - O Failure occurs when the maximum shear stress exceeds a critical value.
   - O Failure occurs when the maximum normal stress exceeds the ultimate tensile strength.
   - O Failure occurs when the strain energy density exceeds the failure threshold.
   - O Failure occurs when the von Mises stress exceeds the yield strength.
3. Which failure criterion is typically used for ductile materials in static loading?
   - O Modified Mohr theory
   - O Distortion Energy Theory
   - O Maximum Principal Stress Theory
   - O Brittle Coulomb-Mohr theory
4. When analyzing a beam subjected to torsion, which of the following stresses must be evaluated?
   - O Normal stress
   - O Shear stress
   - O Bending stress
   - O Hoop stress
5. Which of the following best describes the purpose of conceptual design?
   - O To generate detailed design drawings
   - O To develop initial ideas and possible solutions
   - O To select final materials
   - O To test prototypes
6. The critical stress intensity factor, K_{IC}, is also known as the:
   - O Tensile strength
   - O Fracture energy
   - O Fracture toughness
   - O Geometry
7. Which of the following is NOT an assumption of static failure analysis?
   - O Material exhibits linear elastic behavior up to failure.
   - O Stresses are time dependent.
   - O The loading is applied gradually and remains constant.
   - O Failure is governed by a single, instantaneous load event.

8. What does the slope of the linear portion of a stress-strain curve represent for a material?
    - O Yield strength
    - O Modulus of elasticity (Young's modulus)
    - O Ultimate tensile strength
    - O Toughness
9. Which of the following failure criteria is most appropriate for analyzing the failure of a ductile material under static loading?
    - O Modified Mohr (MM) theory
    - O Maximum Shear Stress (MSS) Theory
    - O Maximum Normal Stress (MNS) Theory
    - O Brittle Coulomb-Mohr (BCM) theory
10. In a beam subject to pure bending, which type of stress is experienced along the length of the beam?
    - O Shear stress
    - O Normal stress
    - O Torsional stress
    - O Hoop stress

Section 2: Problem-Solving (60 points total)

11. (20 points) A circular shaft with a diameter of 30 mm is subjected to a bending moment of 600 N·m and a torsional moment of 200 N·m. The shaft is made of a brittle material with an ultimate strength in tension of 100 MPa, and an ultimate strength in compression of 400 MPa. Using the Modified-Mohr theory, determine whether the shaft will fail. Show all calculations.

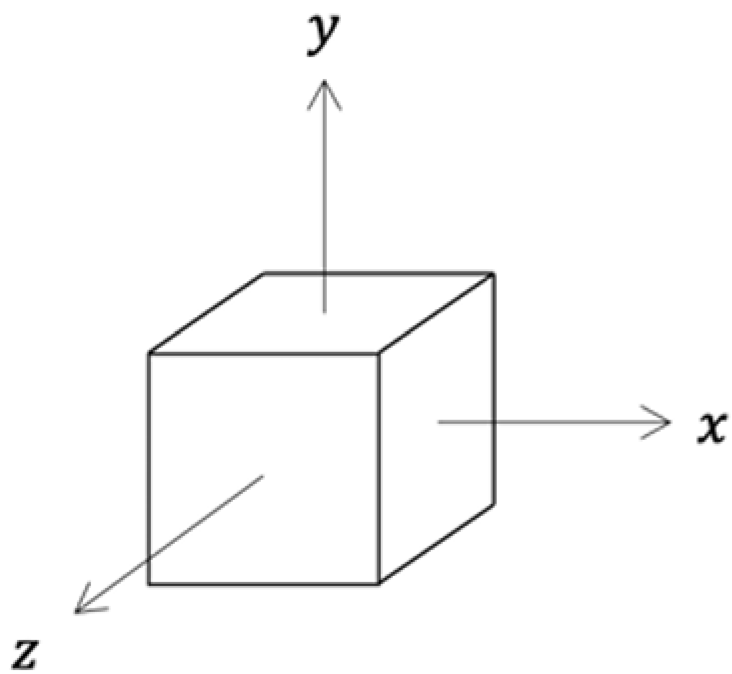
12. (40 points total) Rod *OAB* has length $3L$ and diameter $d = L/6$.
The rod is supported by a pin joint at *O* and by a roller at *A*.
Axial load *P* and transverse load *2P* act at *B*.
The rod is made of a ductile material with yield strength S_y.
Determine the following:
    a) (5 points) Solve for the reactions at *O* and *A*.
    b) (10 points) Sketch and label diagrams of the internal loads on the axes provided.
    c) (5 points) Identify the critical cross-section of rod *OAB*.
    d) (5 points) Identify the critical element on the cross-section identified in part (c). You may use the attached Combined Stress Analysis Worksheet to aid your analysis.
    e) (5 points) Show the state of stress on a stress element for the critical element.
    f) (10 points) The factor of safety for the critical element in terms of variables *P*, *L*, and S_y. Use both the distortion energy (DE) and maximum shear stress (MSS) failure theories. If needed, axes to draw Mohr's circle are provided on the next page.



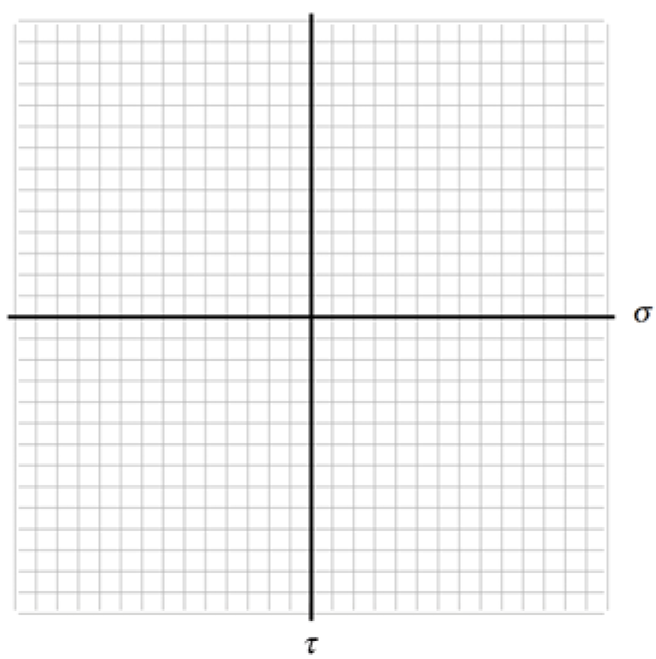
[Problem 12 continued]

[Problem 12 continued]

Stress element for the critical element:



Axes to draw Mohr's circle:



In this box,

- Draw the critical cross-section
- Identify and label the potential locations for the critical element(s) (e.g. top, bottom, left, right, and center)

Potential location of critical element						
Internal load	Axial 					
	Torsion 					
	Transverse shear 					
	Bending 					
Stress element