Sample final exam questions

ME 323 – Fall 2021

This is a packet of some sample final exam questions taken from past semesters, semesters for which Weekly Joys does not have posted solutions. These problems may be used by your instructor to assist in exam reviews prior to the final exam this semester.

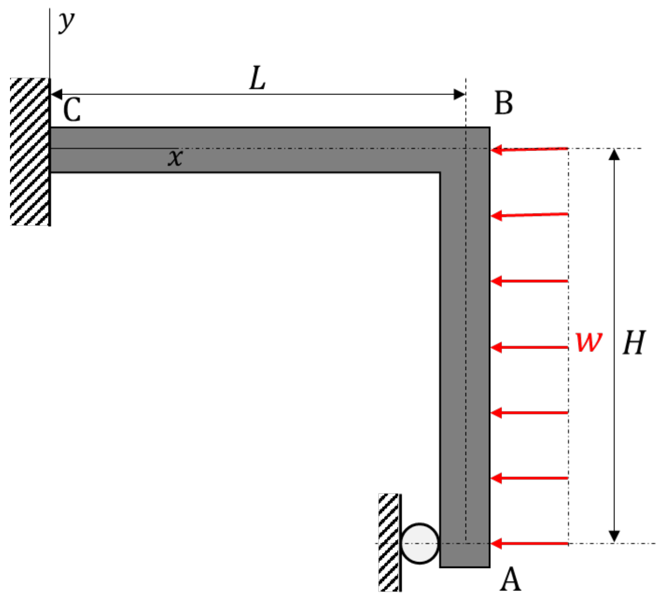
- Please note that these problems are provided to assist you in preparing for the final exam. You should not construe any importance of topics covered in these sample problems in regard to the topics that will be covered on this semester's final exam. That is, the topics covered here may or may not appear on this semester's final, and topics not covered here may appear on your final.
- Please note also that we will not be providing solutions for these problems. These problems are intended to assist your instructor in engaging with you in any review session connected with this semester's final exam. *Weekly Joys has posted detailed solutions for 15 final exams from past semesters*. Please use those Weekly Joys solutions for feedback on your work as you prepare for the final.

ME 323 – Final examination **Name** ________________________________
(Print) (Last) (First)

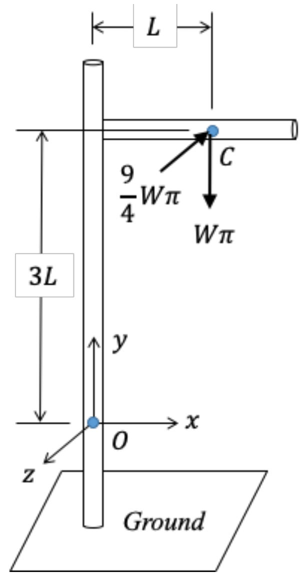
December 14, 2016 **Instructor** ____________________________

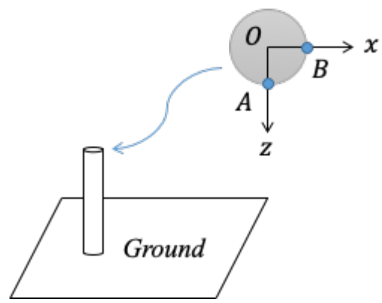
Problem 1 ***(28 points):*** The member shown below is fixed to ground at end C, is supported by a roller at end A, and is subject to a distributed load. It is known that the member has a uniform cross section area A, second area moment I, and a shear shape factor f_s. The member is composed of a material whose Young's modulus is E and shear modulus G.

Using Castigliano's theorem, determine the reaction on the beam at A. Please include the shear, normal and flexural strain energies in your solution. Leave your answer in terms of $w, L, H, E, G, A, I,$ and f_s.



PROBLEM NO. 1 – 25 points max.





Given: The figure above shows a structure acted on by two loads at point C: a load of magnitude $\frac{9}{4}W\pi$ acting in the $-z$-direction, and a load of magnitude $W\pi$ acting in the $-y$ -direction. The support has diameter d, where $L = 3d$. The yield strength of the material is $250\frac{W}{d^2}$.

Find: For this problem:

a) Determine the internal resultant components acting at a cut through point O. Please include an appropriate free body diagram for this analysis.

b) Complete the table on the following page for the internal resultant components at the cross-section shown and the stresses induced by each internal load at point A and at point B.

c) Draw the state of stress at point B on the stress element given on the following page.

d) Draw the in-plane Mohr's circle for point B on the axes given on the following page.

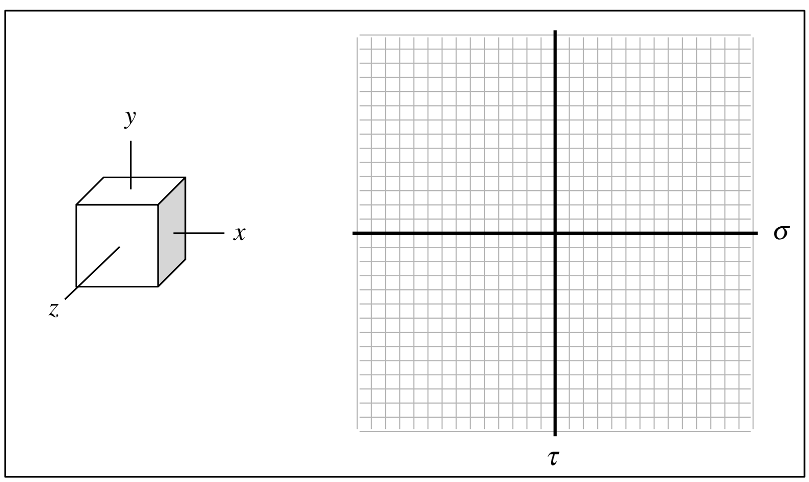
e) Find the principal stresses acting at point B.

f) Using the distortion energy theory, find the factor of safety for point B.

g) Using the maximum shear stress theory, find the factor of safety for point B.

PROBLEM NO. 1 (continued)

Internal Resultant Component	Stress induced by the internal load at point A	Stress induced by the internal load at point B
$V_x =$		
$F_y =$		
$V_z =$		
$M_x =$		
$T_y =$		
$M_z =$		



Point B

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PROBLEM # 2 (25 points)

A thin walled pressure vessel shown on Figure 2A is subjected to an internal pressure which results in an axial normal stress σ_a=70 MPa and a hoop stress σ_h=140 MPa on its outer surface. An accidental event causes a torque to be applied on the entire structure causing a shear stress of magnitude equal to τ_{xy} as shown in Figure 2B.

a) Use the stress element in Figure 2B to draw the **Mohr's circle** on the graph paper.

b) Use the **Mohr's circle** to calculate:

i. The principal stresses at point A.

ii. The maximum in-plane shear stress.

iii. The absolute maximum shear stress.

iv. The angle of rotation from the x-axis to the direction of the in-plane principal stress σ_{p1}.

v. Draw a stress element to show the in-plane principal stresses correctly oriented with respect to the x-axis

vi. Draw a stress element to show the in-plane maximum shear stress correctly oriented with respect to the x-axis

c) Use the **Mohr's circle** to calculate the normal and shear stresses in the x'-y' directions. Draw a stress element to show the calculated stresses, and mark the state of stress in the x'-y' directions on the Mohr's circle. Note: The x'-axis is oriented at 30° from the x-axis as shown in Figure 2A.

d) What would the value of the principal stresses and maximum in-plane shear stresses acting at point A be if the accidental torque could be avoided? Explain your answer.

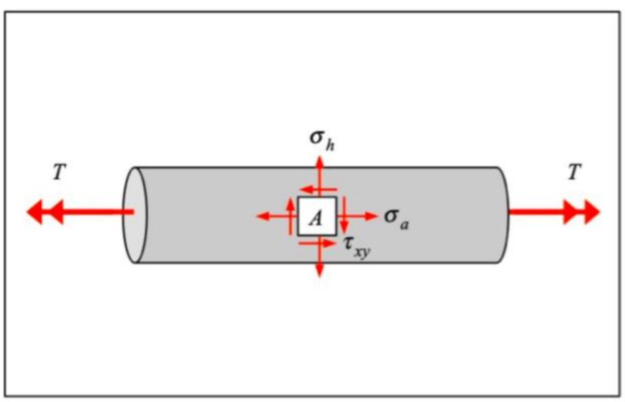


Figure 2A

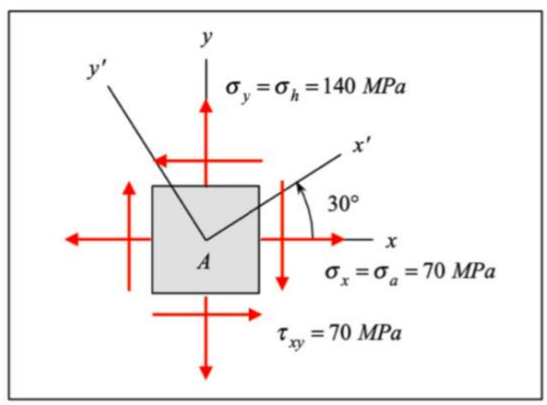
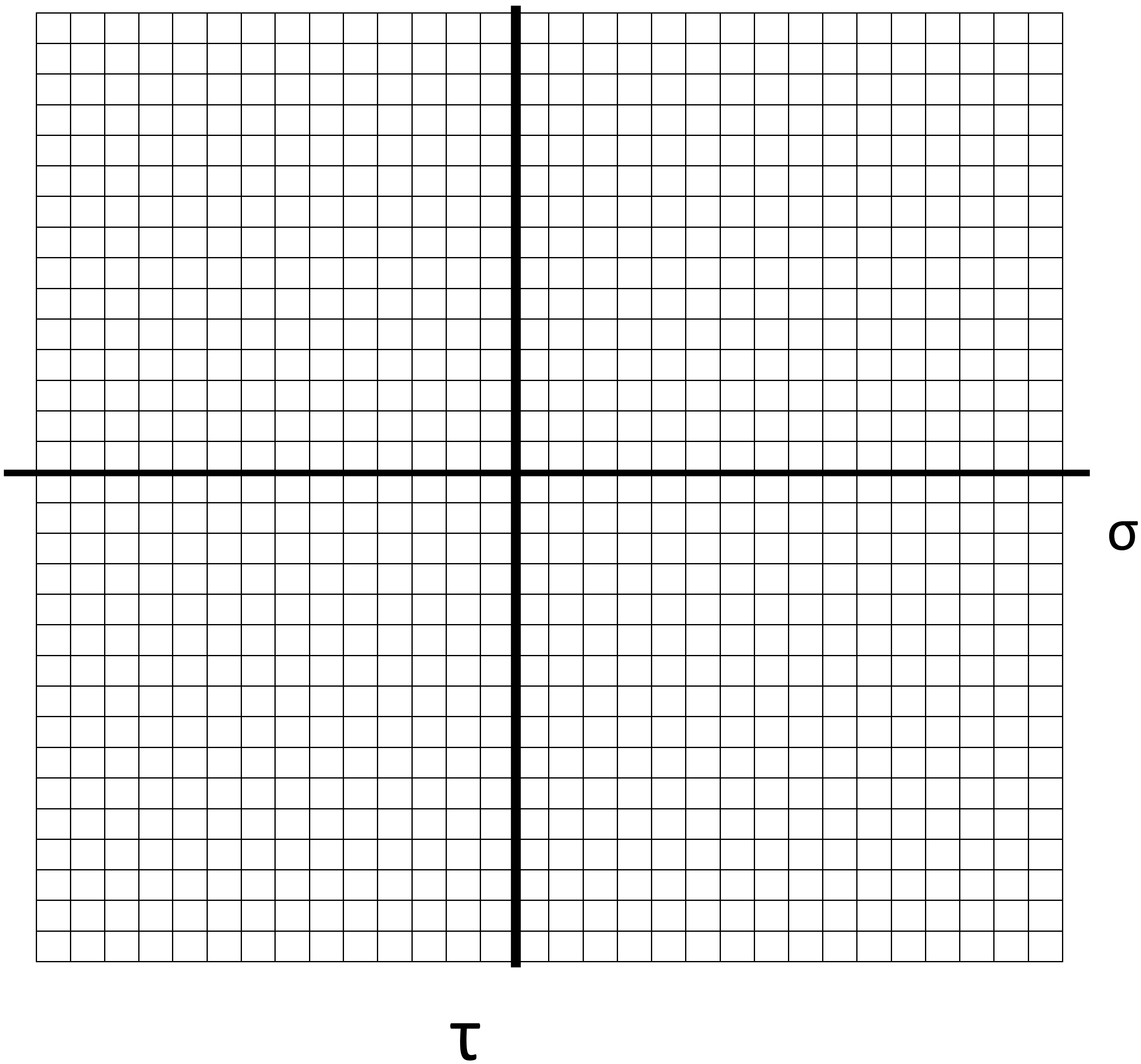


Figure 2B


σ
τ

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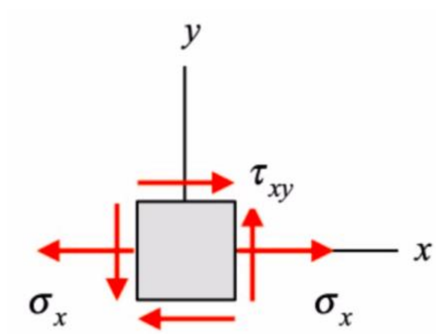
PROBLEM # 3 (25 points)

Consider a state of plane stress in a structural component represented by the stress element provided below where $\sigma_x = 60$ ksi and τ_{xy} is unknown at this point.

a) Suppose that the structural component is made of a *ductile* material with a yield strength of $\sigma_Y = 100$ ksi.
   i. Using the *maximum shear stress theory*, determine the maximum value of $|\tau_{xy}|$ for which the ductile material in the structural component does not fail.
   ii. For the maximum value of $|\tau_{xy}|$ found above, does the *maximum distortional energy theory* predict failure of the material?

b) Suppose now that the structural component is instead made of a *brittle* material with equal ultimate strengths in tension and compression of $\sigma_{UT} = \sigma_{UC} = 100$ ksi. Using *Mohr's failure criteria*, determine the maximum value of $|\tau_{xy}|$ for which the brittle material in the structural component does not fail.



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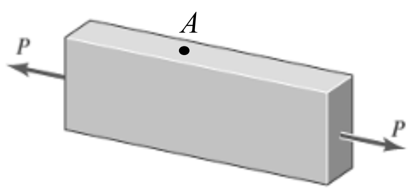
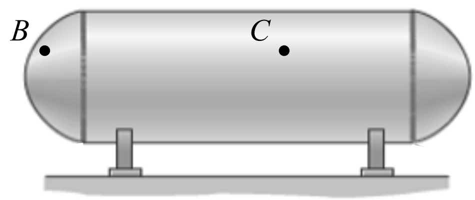
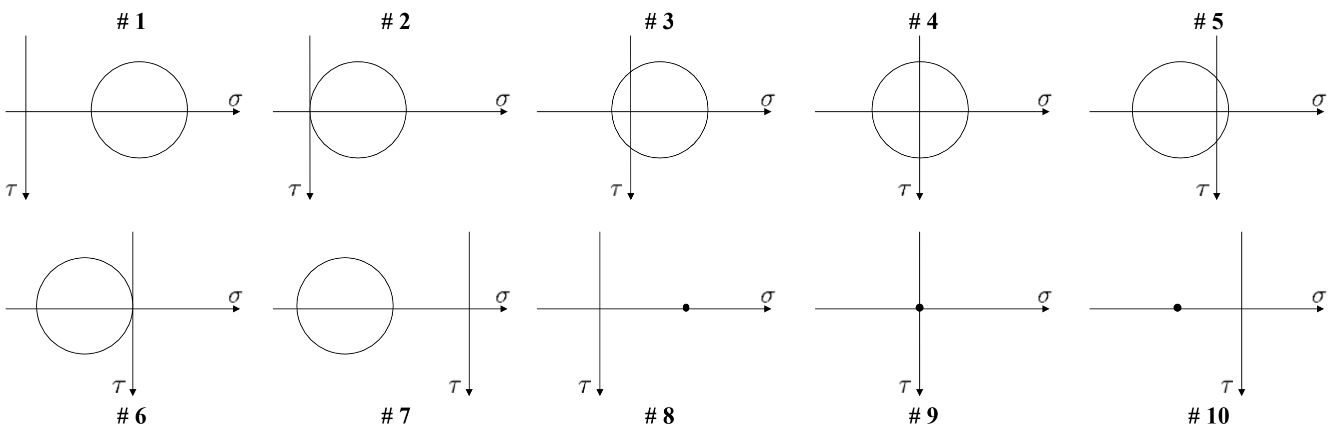
PROBLEM # 4 (25 points)

***Part A* – 9 points**

A rectangular cross-section bar is subjected to an axial force P, and a thin-wall pressure vessel is subjected to internal pressure.







Referring to the ten Mohr's circles shown above, circle the number of the correct **in-plane** Mohr's circle for the state of stress at

- Point A: #1 #2 #3 #4 #5 #6 #7 #8 #9 #10
- Point B: #1 #2 #3 #4 #5 #6 #7 #8 #9 #10
- Point C: #1 #2 #3 #4 #5 #6 #7 #8 #9 #10

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PROBLEM # 4 (cont.)

The schematics shown below correspond to beams with a span L and loading with either a couple at one of the two ends or a sinusoidally distributed load.

***Part B* – 3 points**

Which schematic corresponds to a beam whose bending moment is equal to

$$M(x) = -\frac{p_0 L^2}{\pi^2}\sin\left(\frac{\pi x}{L}\right) - \frac{2p_0 L^2}{\pi^3}$$

Circle the correct answer (a) (b) (c) (d) (e) (f) (g) (h) (i) (j)

HINT: Identify which supports and loads are compatible with the given bending moment.

***Part C* – 3 points**

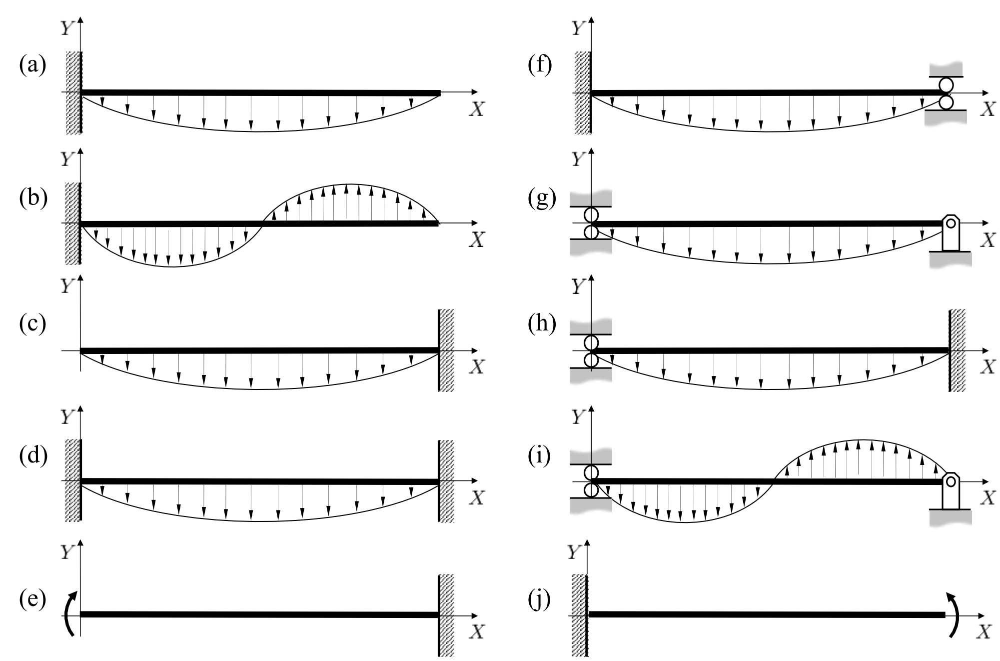
If the deflection at $x = L/2$ is to be determined using Castigliano's second theorem, which schematic(s) correspond to a beam which will require the use of a *redundant load*

Circle the correct answers (a) (b) (c) (d) (e) (f) (g) (h) (i) (j)

***Part D* – 3 points**

If the slope at $x = L$ is to be determined using Castigliano's second theorem, which schematic(s) correspond to a beam which will require the use of a *dummy load*

Circle the correct answers (a) (b) (c) (d) (e) (f) (g) (h) (i) (j)



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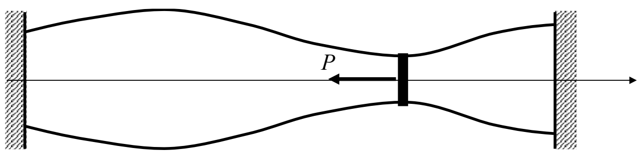
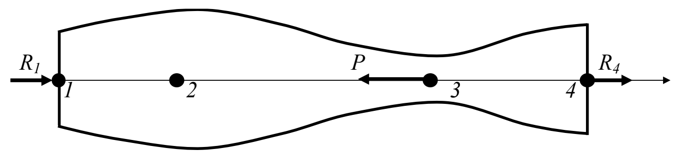
PROBLEM # 4 (cont.)

***Part E* – 7 points**





The rod shown on the left figure has a variable cross section. A finite element model comprised of three rod-elements and four nodes is produced and shown on the right figure. The finite element model has the following stiffness matrix, where only three elements of the matrix are given:

$$[K] = \begin{bmatrix} \underline{\quad\quad} & \underline{\quad\quad} & \underline{\quad\quad} & \underline{\quad\quad} \\ \underline{\quad\quad} & 8 & \underline{\quad\quad} & \underline{\quad\quad} \\ \underline{\quad\quad} & \underline{\quad\quad} & 9 & \underline{\quad\quad} \\ \underline{\quad\quad} & \underline{\quad\quad} & \underline{\quad\quad} & 2 \end{bmatrix}$$

(a) Determine the remaining 13 matrix elements and fill the blank spaces.

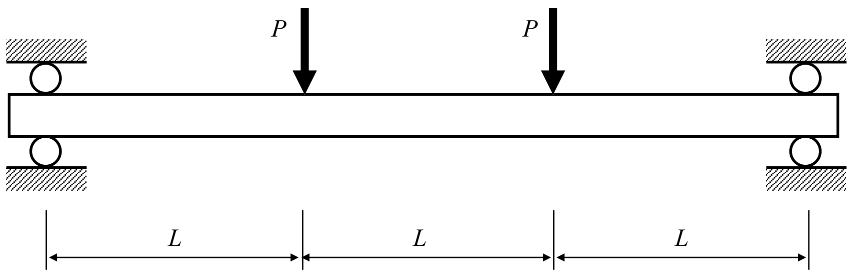
The two ends of rod are attached to fixed walls, and one concentrated force of value P is applied to node 3, as shown on the right figure.

(b) Determine the displacement of node 3.

(c) Determine the reaction force on the rod due to the wall at node 4.

PROBLEM NO. 4 - PART A: 10 points max.

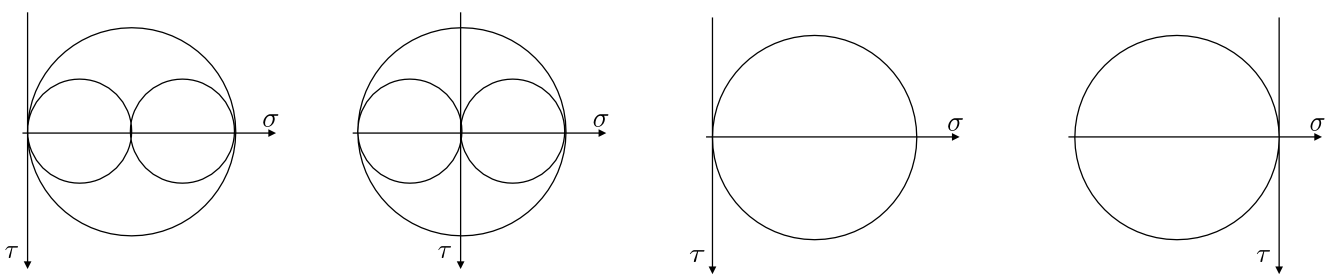
A slab is brought to failure subjected to the loading configuration depicted in the following figure.



Circle the correct answer in the following statements:

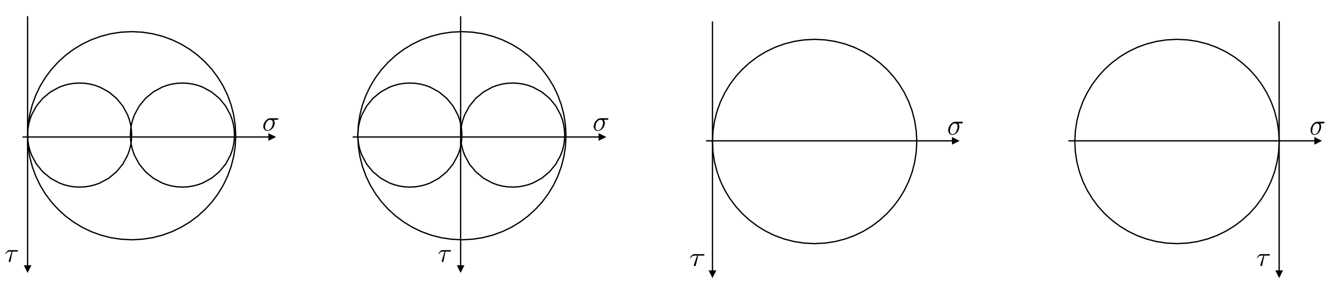
(a) The internal resultant for cross section between the two applied loads correspond to:
- (i) An unloaded configuration
- (ii) Pure bending
- (iii) Axial loading
- (iv) Pure shear
- (v) A combined loading condition comprised of shear force and bending moment

(b) For any cross section between the two loads, the state of stress of a point on the *top face* of the slab is represented by the following Mohr's circle:



(i) (ii) (iii) (iv)

(c) For any cross section between the two loads, the state of stress of a point on the *bottom face* of the specimen is represented by the following Mohr's circle:



(i) (ii) (iii) (iv)