ME 323 – Mechanics of Materials
Midterm #2
March 30th, 2022

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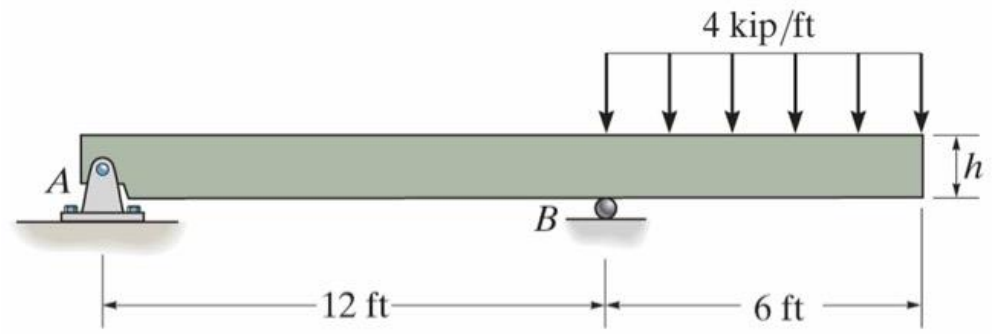
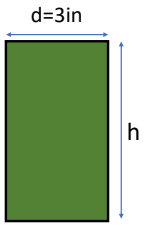
PROBLEM # 1 (25 points)

Find the height *h* of the beam that will safely support the distributed load shown in the figure. The beam has a rectangular cross-section with width *d=3in*. The allowable bending stress is $\sigma_{allow} = 21ksi$ and the allowable shear stress is $\tau_{allow} = 1ksi$.





cross-section

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PROBLEM # 1 CONT.

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PROBLEM # 1 CONT.

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PROBLEM # 2 (25 points)

The beam BCD is fixed to the wall at B and supported by a roller at C. A uniform distributed load ***p0*** is applied between B and C. The beam has Young's modulus ***E*** and second moment of area ***I***.

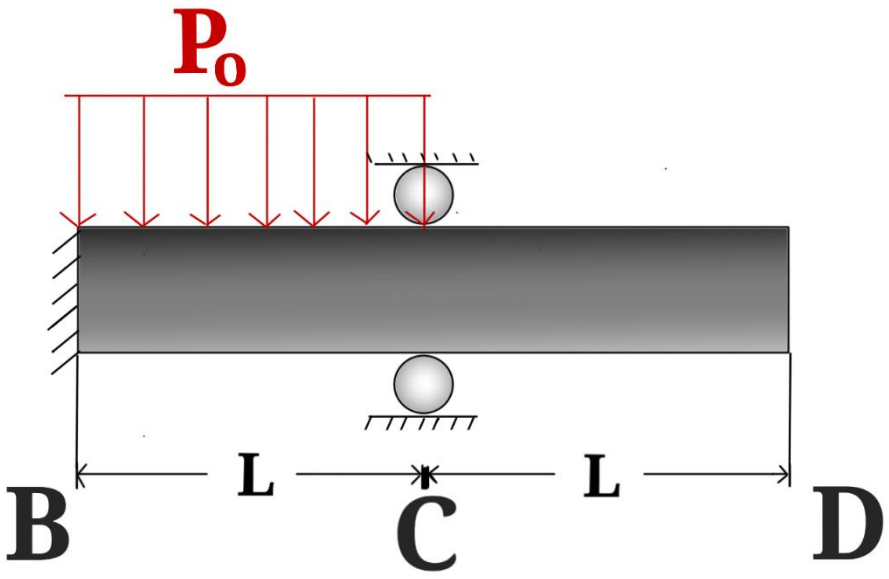
a) Draw a free-body diagram of the entire beam, and write down the equilibrium equations.

b) Use the second-order integration method to find the slope v'(x) and deflection v(x) of each segment of the beam. These can be left in terms of the unknown support reactions.

c) Write down the relevant boundary conditions and continuity conditions for the beam.

d) Use the boundary/continuity conditions to determine the reactions at B and C in terms of ***po and L.***

e) Determine the deflection of the free end D. Sketch the deflection curve over the length of the beam. The sketch does not need to be exact. Show enough detail to clearly indicate the boundary conditions.



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PROBLEM # 2 CONT.

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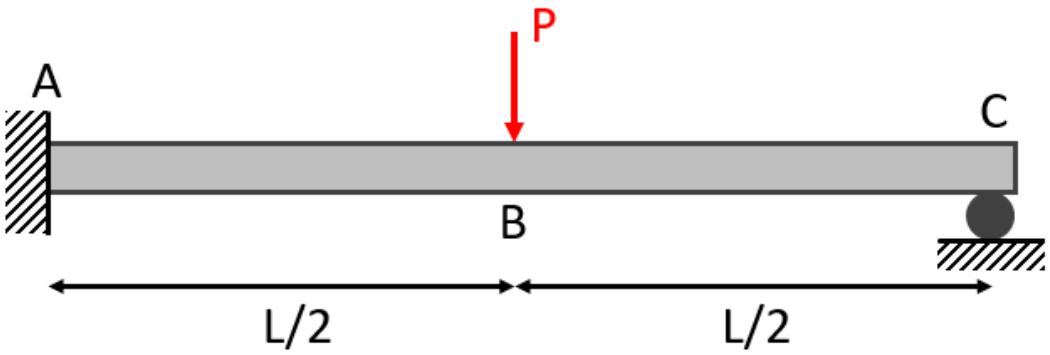
PROBLEM # 3 (25 points)

Cantilever ABC has a Young's modulus of E and a second area moment of I. The cantilever is supported by a roller at C and a force of P is applied at B (L/2). Assume that deformation energy due to shear is negligible.

a) Determine the reactions using Castigliano's Second Theorem.
b) Determine the angle at point C using Castigliano's Second Theorem.



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PROBLEM # 3 CONT.

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PROBLEM # 3 CONT.

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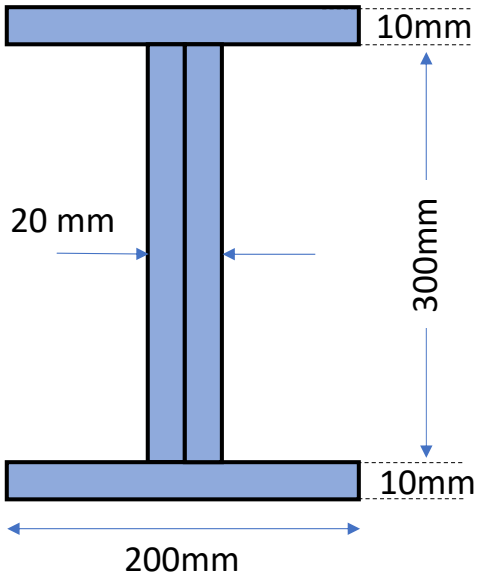
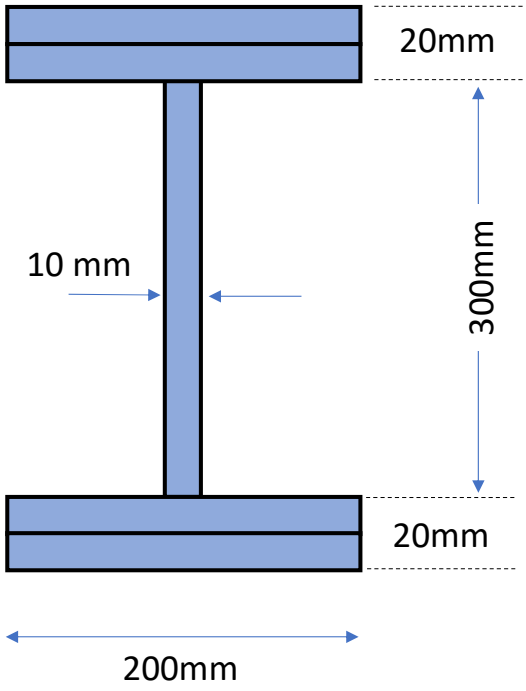
PROBLEM # 4 (25 points)

Part 4.1 (5 points)

Two shapes have been proposed for the design of a beam. Determine which one has the smallest bending stress if a moment M = 100 kN m is applied.



(a)



(b)

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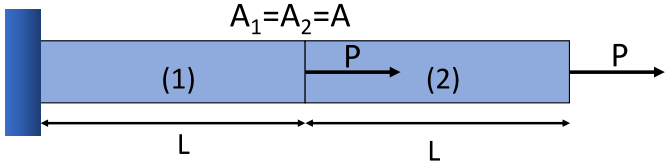
Part 4.2 (10 points)

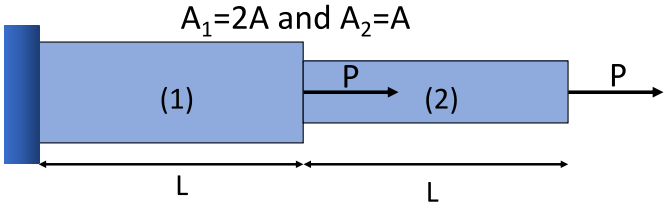
The strain energy of the system (A) is $\mathcal{U}_A$. Compare the strain energy $\mathcal{U}_A$ to the following three systems and circle the correct answer. The Young's modulus is *E* for both members, the cross sectional areas and lengths are given in each figure.

(A)



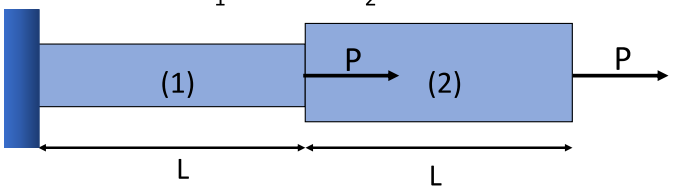
$\mathcal{U}_A$

(B)



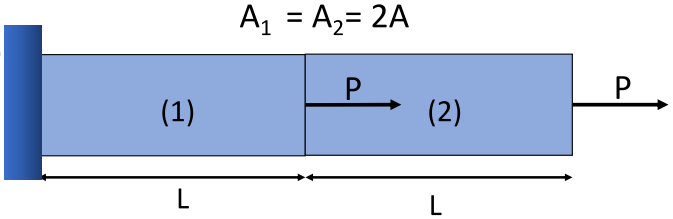
$\mathcal{U}_B < \mathcal{U}_A$
$\mathcal{U}_B > \mathcal{U}_A$
$\mathcal{U}_B = \mathcal{U}_A$

(C)



$\mathcal{U}_C < \mathcal{U}_A$
$\mathcal{U}_C > \mathcal{U}_A$
$\mathcal{U}_C = \mathcal{U}_A$

(D)



$\mathcal{U}_D < \mathcal{U}_A$
$\mathcal{U}_D > \mathcal{U}_A$
$\mathcal{U}_D = \mathcal{U}_A$

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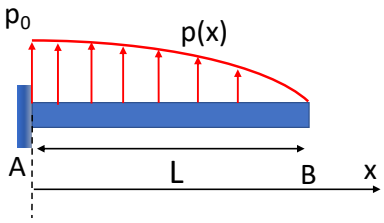
Part 4.3 (10 points)

For the cantilever beam shown in the figure the equation of deflection is

$$u(x) = \frac{p_0 L}{3\,\pi^4 EI}\left(48L^3\, cos\left(\frac{\pi x}{2L}\right) - 48L^3 + 3\pi^3 L x^2 - \pi^3 x^3\right)$$



a) Find the distributed force p(x) in terms of p_0, L and x

p(x)=

b) Find the rotation of the beam at A and B

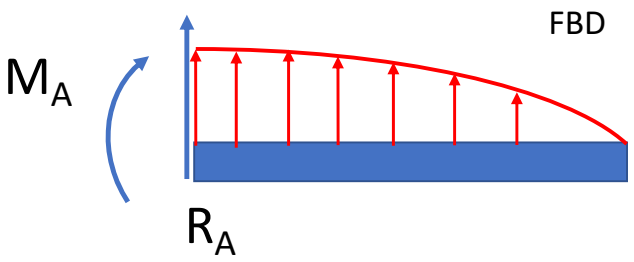
$\theta_A =$

$\theta_B =$

c) Find the reactions R_A and M_A. Use the directions in the FBD shown below

R_A=

M_A=



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