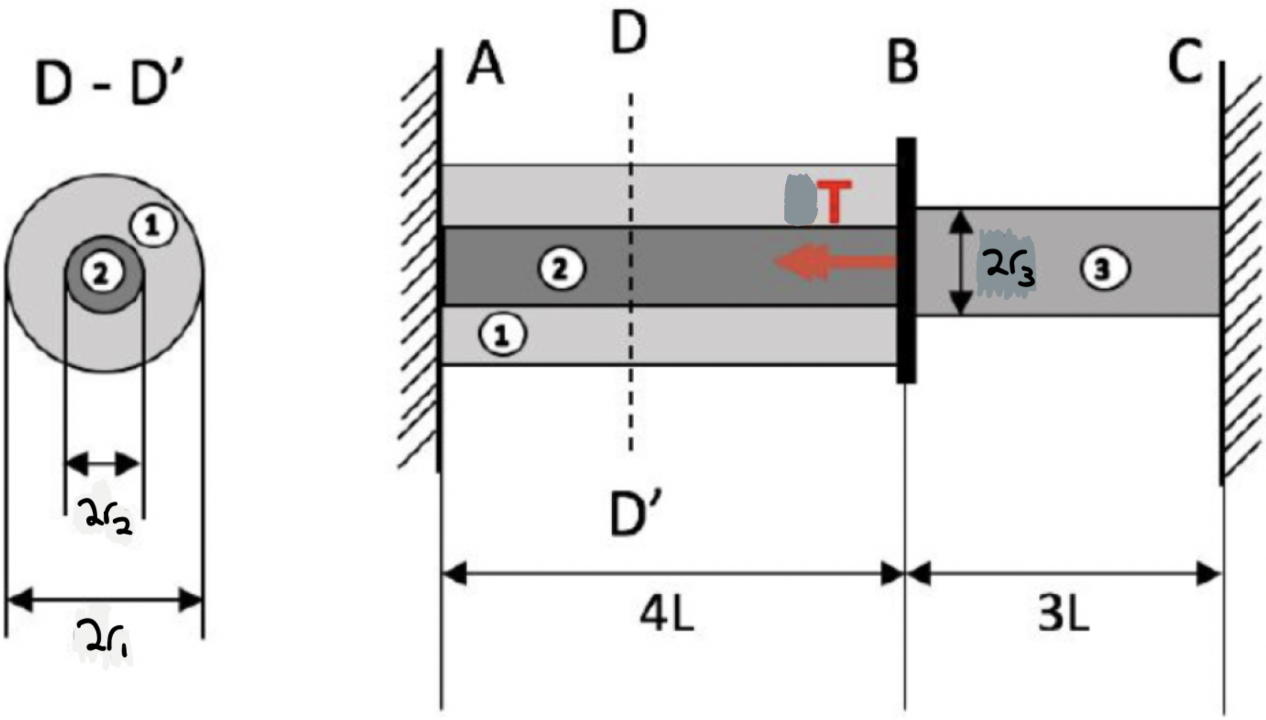
Problem 8.1 ***(10 points)***

A stepped shaft ABC is made of members 1, 2 and 3. Member 1 is a hollow shaft and members 2 and 3 are solid shafts. Members 1 and 2 are fit tightly together. The shear modulus of members 1, 2 and 3 are G, 2G and G respectively.

(a) Determine whether the structure is statically determinate or indeterminate.

(b) Clearly state your choice of redundant load(s) for the problem.
(c) Use Castigliano's theorem to find the torque on each member.
(d) Use Castigliano's theorem to find the angle of rotation at B.



Use $r_1 = 2R$, $r_2 = R$, $r_3 = R$

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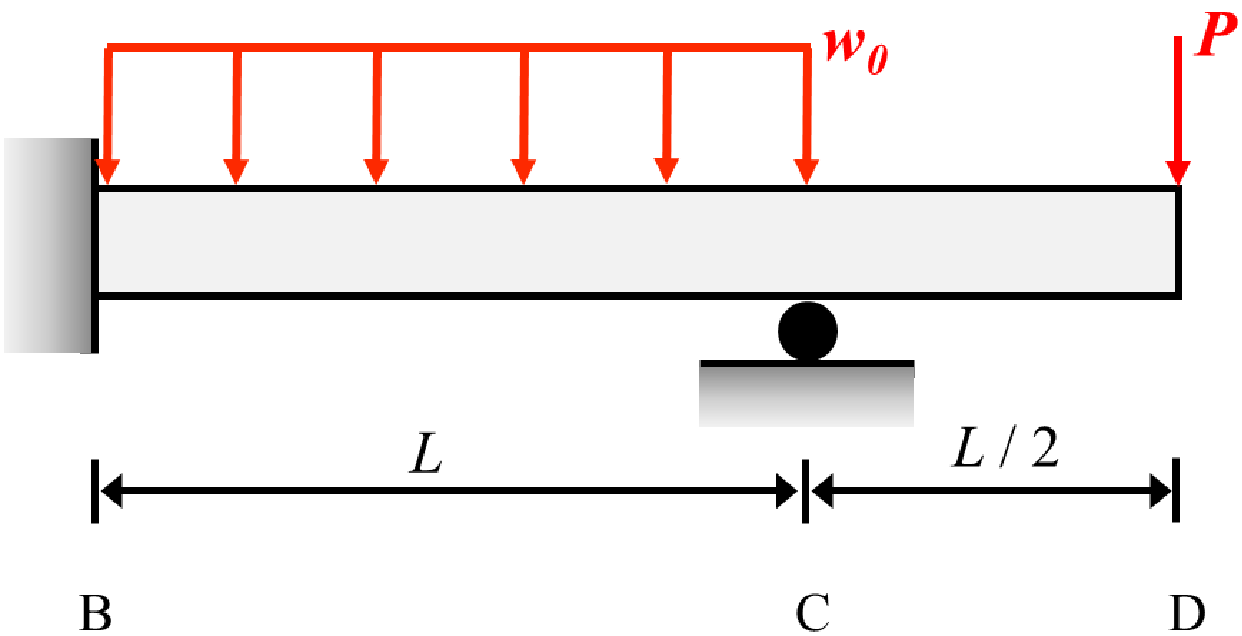
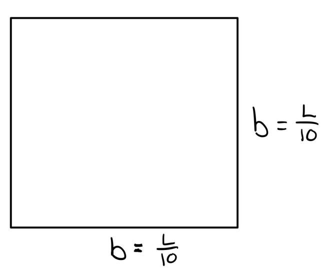
Problem 8.2 ***(10 points)***

A Beam BCD is loaded with a distributed load w_0 between B and C and a point force P at D. The beam has elastic modulus E and has a square cross section with side length $b = L / 10$. Neglect the shear strain energy due to bending.

Using Castigliano's theorem, determine the reactions at the wall at B and the roller at C. Express your answer in terms of w_0, P, L, and E. Explicitly state your choice of redundant load(s).





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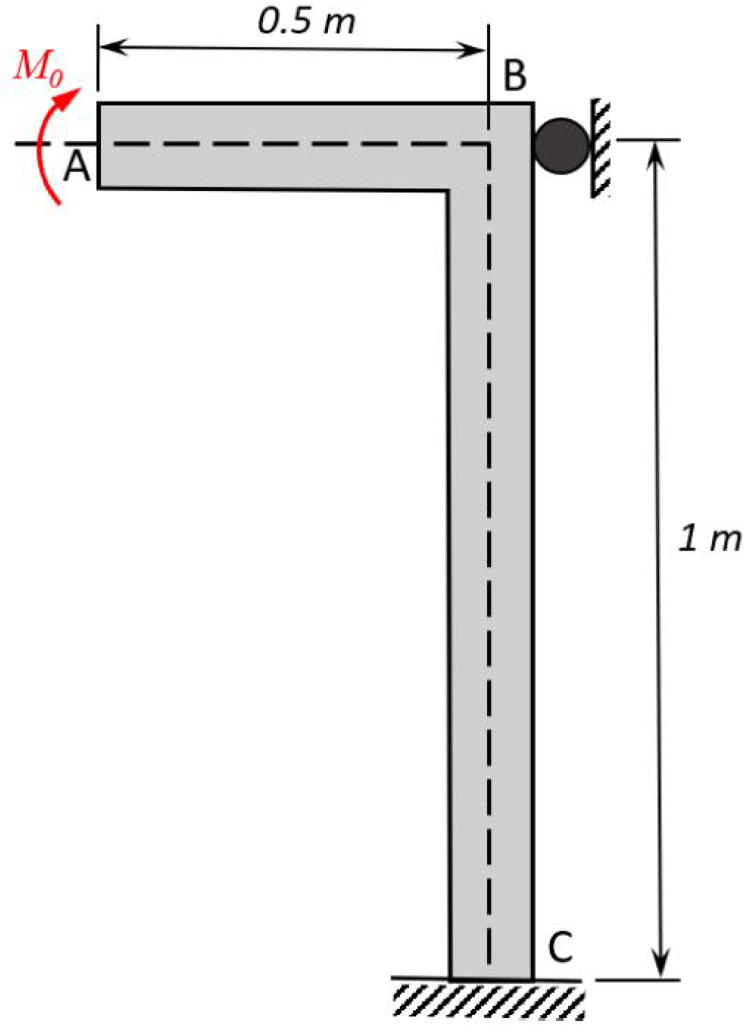
Problem 8.3 ***(10 points)***

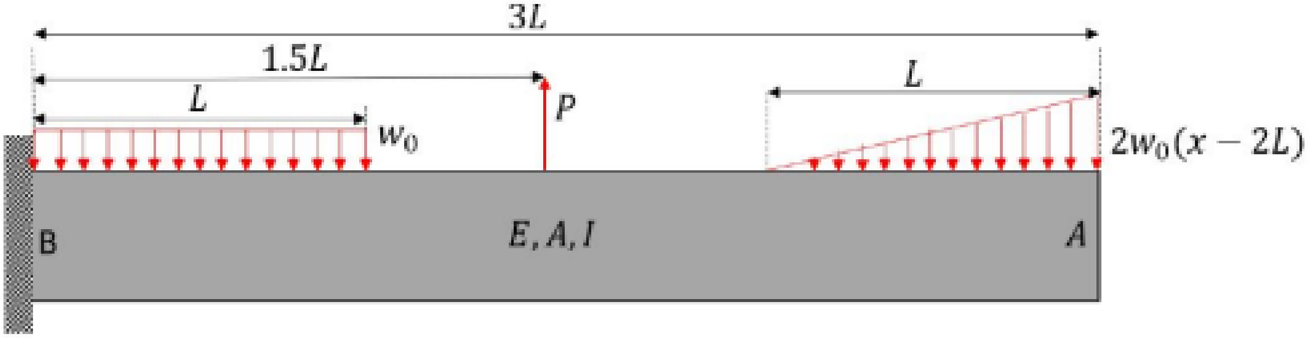
Two segments, AB and BC, with a thin walled hollow circular cross section of outer diameter a and inner diameter 0.8a, are welded together at B to form the L-shaped ABC shown in the figure below. Use the following data in your analysis: E = 280 GPa, G = 120 GPa, a = 20 mm, M_0 = 1000 Nm

(a) Determine the reactions.
(b) Use Castigliano's Second Theorem to determine the slope θ at point A.



Problem 8.4 (5 points)

Consider the cantilevered beam with distributed loads as shown below. Ignoring shear effects:



Select the general form that the equation for flexural energy due to bending will take (note that $f_i(x)$ represents some *continuous* function $M^2(x)/(2EI)$ for the length of integration):

(a) $U = \int_0^L f_1(x)dx + \int_L^{2L} f_2(x)dx + \int_{2L}^{3L} f_3(x)dx$

(b) $U = \int_0^L f_1(x)dx + \int_L^{1.5L} f_2(x)dx + \int_{1.5L}^{3L} f_3(x)dx$

(c) $U = \int_0^L f_1(x)dx + \int_L^{1.5L} f_2(x)dx + \int_{1.5L}^{2L} f_3(x)dx + \int_{2L}^{3L} f_4(x)dx$

(d) $U = \int_0^L f_1(x)dx + \int_0^{1.5L} f_2(x)dx + \int_0^{2L} f_3(x)dx + \int_0^{3L} f_4(x)dx$