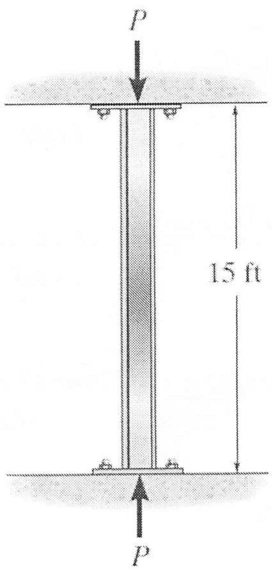
CME 260 – Mechanics of Materials
Exam #9 (04/27/2022)

Tech ID or Star ID: Grading

Do one of the two problems shown below (the second problem is on the back).
Show your work (you will not receive any credit if all you have is a final answer, right or wrong).

(1) The W10 x 45 column is made of A-36 steel. The ends of the column are fixed supported. Will the column fail due to buckling or yielding? (Provide the calculations behind your conclusion.)



W10 x 45

$A = 13.3\ in^2$ (1 pt)

$I_{x-x} = 248\ in^4$

$I_{y-y} = 53.4\ in^4$ (1 pt)

A-36 steel

$E = 29 \times 10^3\ ksi$ (1 pt)

$\sigma_{Y_{comp}} = 36\ ksi$ (1 pt)

fixed - fixed

$K = 0.5$ (1 pt)

$$P_{cr} = \frac{\pi^2 EI}{(KL)^2} = \frac{\pi^2 (29 \times 10^3 \frac{kip}{in^2})(53.4\ in^4)}{((0.5)(180\ in))^2} = 1{,}886.9\ kip \quad (2\ pts)$$

$$\sigma_{Y_{comp}} = \frac{P_Y}{A} \longrightarrow P_{Y_{comp}} = \sigma_{Y_{comp}} A = \left(36\ \frac{kip}{in^2}\right)(13.3\ in^2) = 478.8\ kip \quad (2\ pts)$$

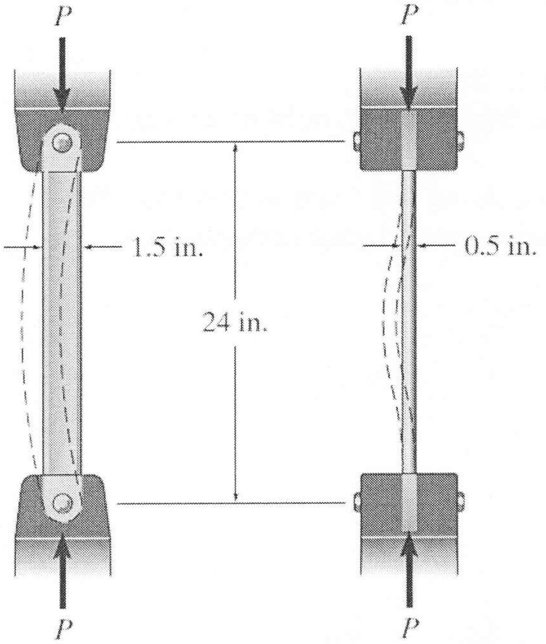
$P_{Y_{comp}} < P_{cr}$, will fail due to yielding (1 pt)

alternate approach:

$$\sigma_{cr} = \frac{P_{cr}}{A} = \frac{1{,}886.9\ kip}{13.3\ in^2} = 141.9\ ksi \quad (2\ pts)$$

$\sigma_{Y_{comp}} < \sigma_{cr}$, will fail due to yielding (1 pt)

(2) An L-2 tool steel member is loaded in compression. In the orientation shown in the left figure the ends are assumed pinned and, in the orientation shown in the right figure the ends are assumed fixed. Determine the maximum load the member can carry without failing (in buckling or by yielding).



L-2 tool steel

$E = 29 \times 10^3$ ksi (0.5 pt)

$\sigma_{y_{comp}} = 102$ ksi (1 pt)

$$P_{cr_L} = \frac{\pi^2 E I_L}{(K_L L)^2} = \frac{\pi^2 (29 \times 10^3 \frac{kip}{in^2})(0.140625\ in^4)}{((1.0)(24\ in))^2} = 69.88\ kip \quad (1\ pt)$$

$$P_{cr_R} = \frac{\pi^2 E I_R}{(K_R L)^2} = \frac{\pi^2 (29 \times 10^3 \frac{kip}{in^2})(0.015625\ in^4)}{((0.5)(24\ in))^2} = 31.06\ kip \quad (1\ pt)$$

$$I_L = \frac{1}{12}(0.5\ in)(1.5\ in)^3 = 0.140625\ in^4 \quad (1\ pt) \qquad I_R = \frac{1}{12}(1.5\ in)(0.5\ in)^3 = 0.015625\ in^4 \quad (1\ pt)$$

$A_L = A_R = A = (0.5\ in)(1.5\ in) = 0.75\ in^2$ (0.5 pt)

$K_L = 1.0$ (1 pt) $\quad K_R = 0.5$ (1 pt)

$$\sigma_{y_{comp}} = \frac{P_{y_{comp}}}{A} \longrightarrow P_{y_{comp}} = \sigma_{y_{comp}} A = (102\ \frac{kip}{in^2})(0.75\ in^2) = 76.5\ kip \quad (1\ pt)$$

max load $= P_{cr_R} = \boxed{31.06\ kip}$ (1 pt)