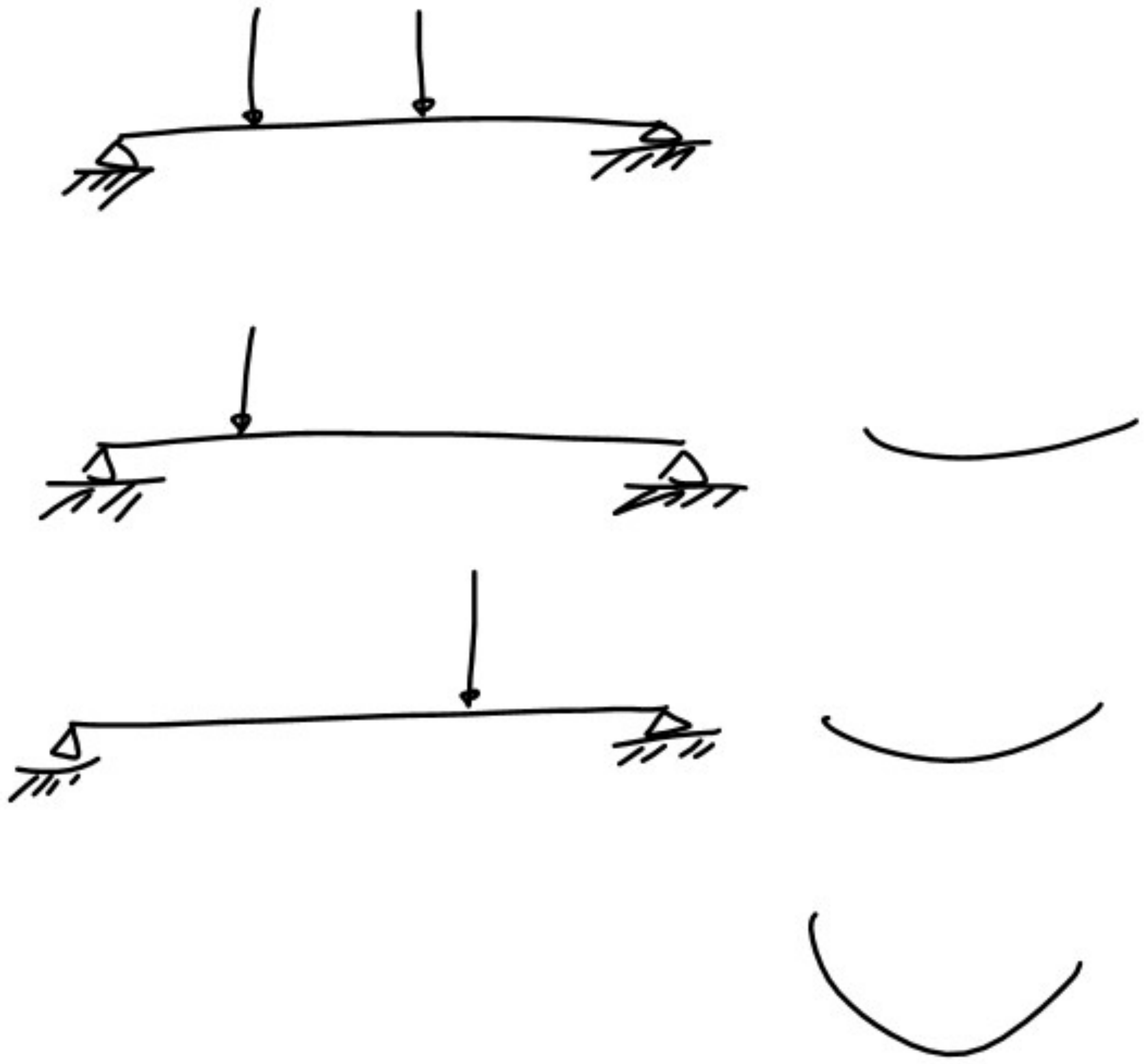
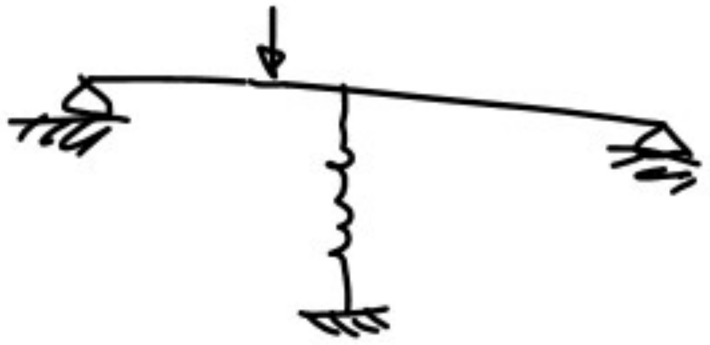
Deflection By Superposition

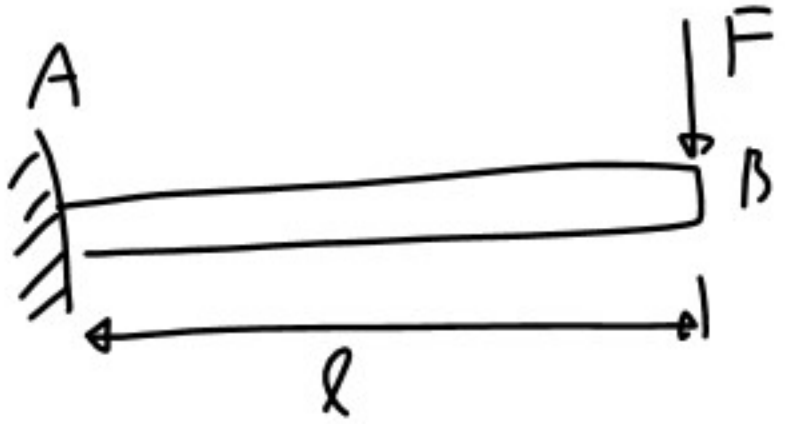


1. deflection is linearly perportional to load

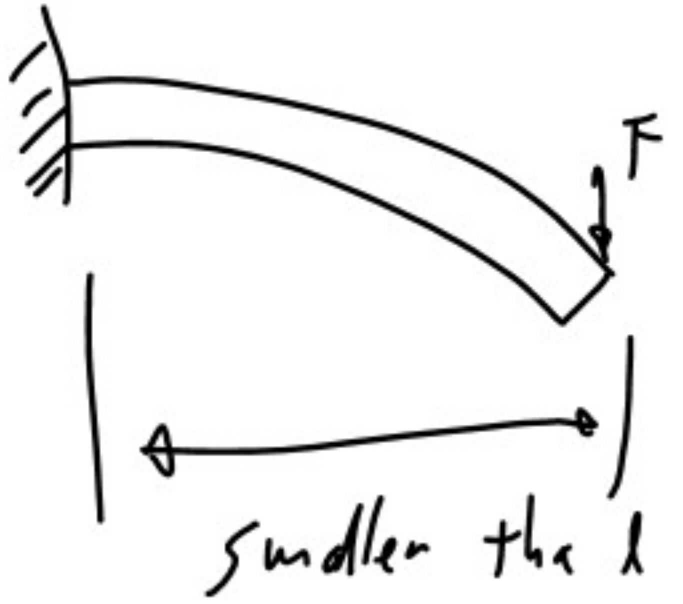
2. one load does not effect another



3. deformations don't appreciably alter the geometry



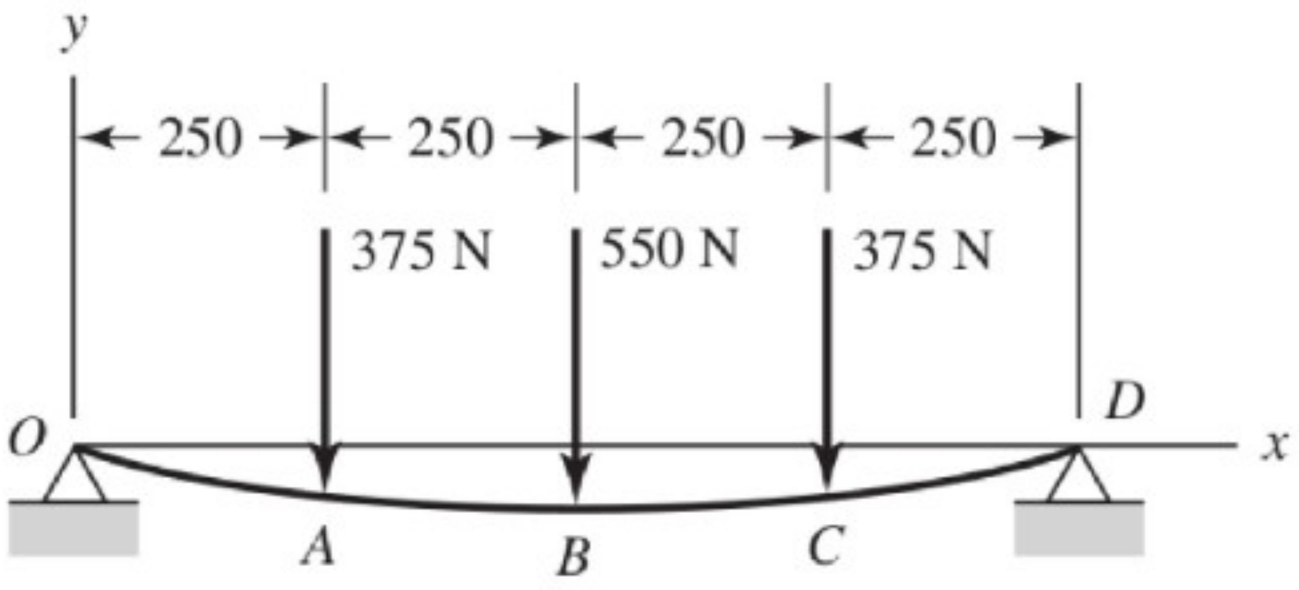
$M_A = F l$

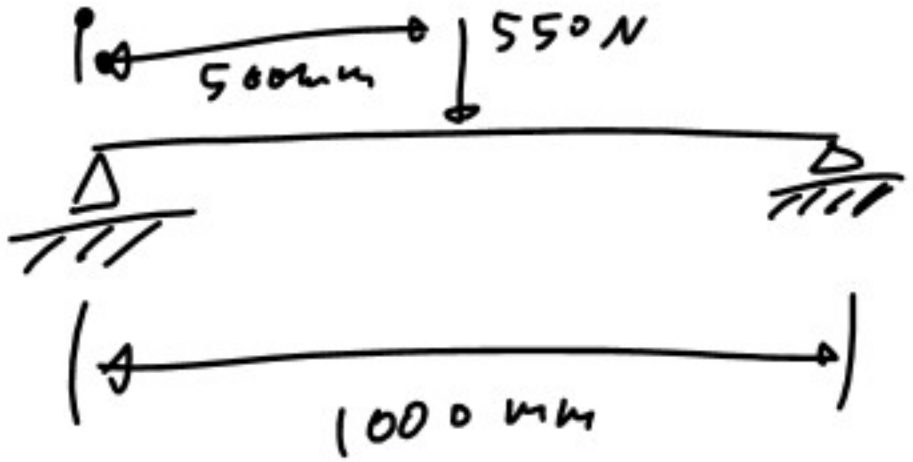


4–16 Using superposition for the bar shown, determine the minimum diameter of a steel shaft for which the maximum deflection is 2 mm.

Problem 4–16

Dimensions in millimeters.

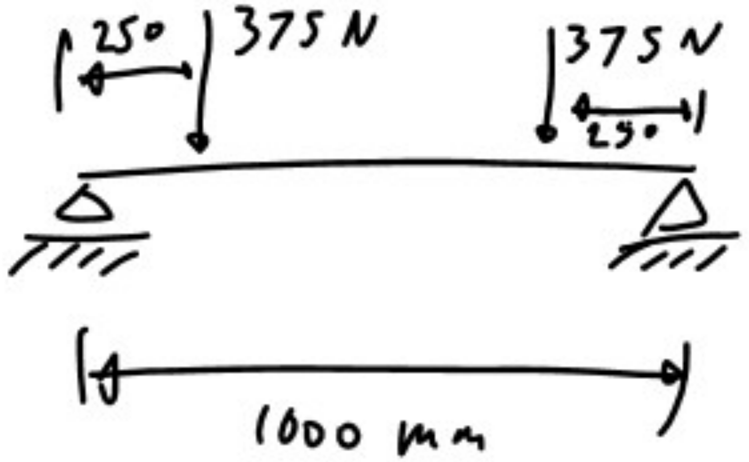




$$y_{max} = \frac{-Fl^3}{48EI}$$

$$= \frac{-550\,(1)^3}{48EI}$$

$$= \frac{-11.46}{EI}$$



$$y_{max} = \frac{Fa}{24EI}(4a^2 - 3l^2)$$

$$= \frac{375(0.25)}{24EI}(4(0.25)^2 - 3(1)^2)$$

$$= \frac{-10.74}{EI}$$

$$y_{max} = \frac{-11.46}{EI} - \frac{10.74}{EI}$$

$$-0.002 = \frac{-22.20}{EI}$$

$$I = \frac{-22.2}{-0.002E} = \frac{11101}{E}$$

$$I = \frac{11101}{207\times10^9} = 5.36\times10^{-8}$$

$$\frac{\pi D^4}{64} = 5.36\times10^{-8}$$

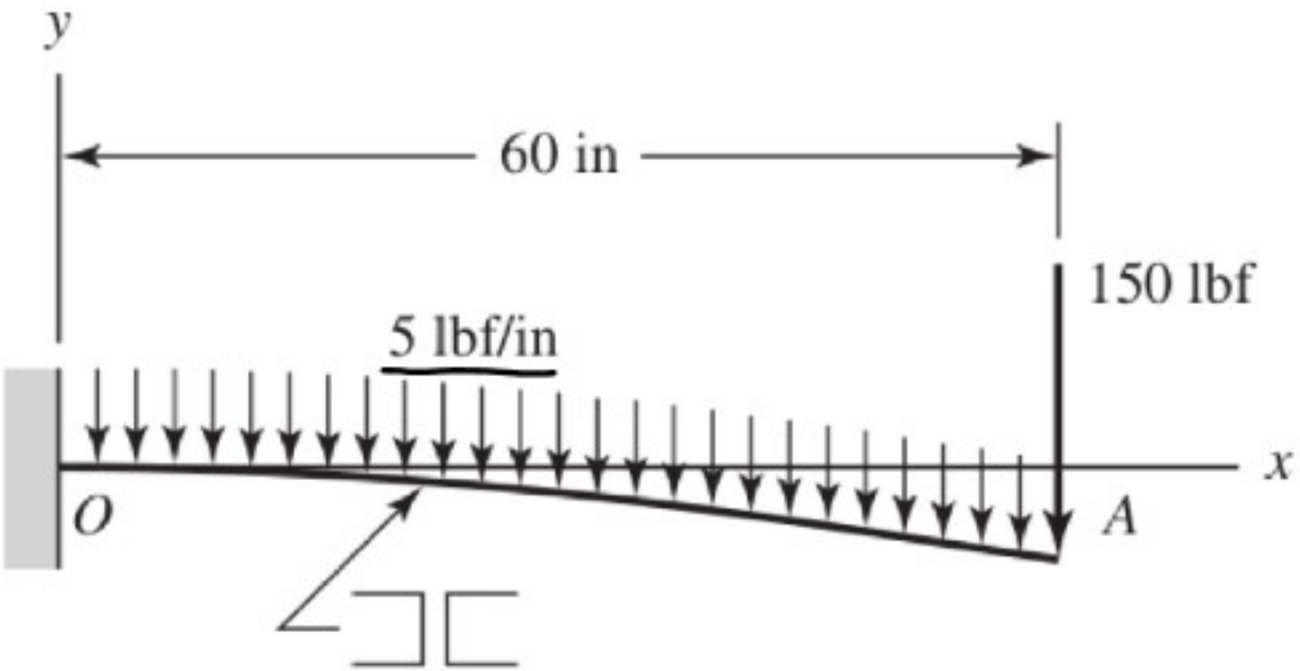
$$D^4 = \frac{64\cdot5.36\times10^{-8}}{\pi} = 1.09\times10^{-6}$$

$$D = 0.032\text{ m} = \boxed{32\text{ mm}}$$

4–15 The cantilever shown in the figure consists of two structural-steel channels size 3 in, 5.0 lbf/ft. Using superposition, find the deflection at A. Include the weight of the channels.

$E = 30$ Mpsi $\qquad I = 3.7\ \text{in}^4$

Problem 4–15



$w = 5\ \text{lbf/in} + 2.5\ \text{lbf/ft}\left(\frac{1\ \text{ft}}{12\ \text{in}}\right)$

$= 5.83\ \text{lbf/in}$

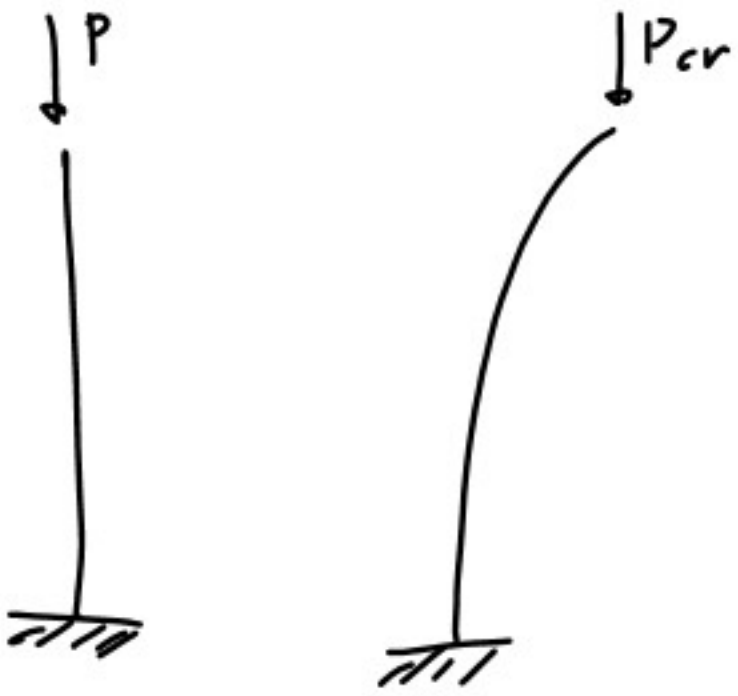
distributed $\quad y_{max} = -\frac{wl^4}{8EI}$

point load $\quad y_{max} = -\frac{Fl^3}{3EI}$

$$y_{max} = -\frac{wl^4}{8EI} - \frac{Fl^3}{3EI} = \frac{-1}{EI}\left(\frac{5.83(60)^4}{8} + \frac{150(60)^3}{3}\right) = \frac{-20.2\times10^6}{EI}$$

$$= \frac{-20.2\times10^6}{30\times10^6\cdot3.7} = \boxed{-0.182\ \text{in}}$$

Column Buckling



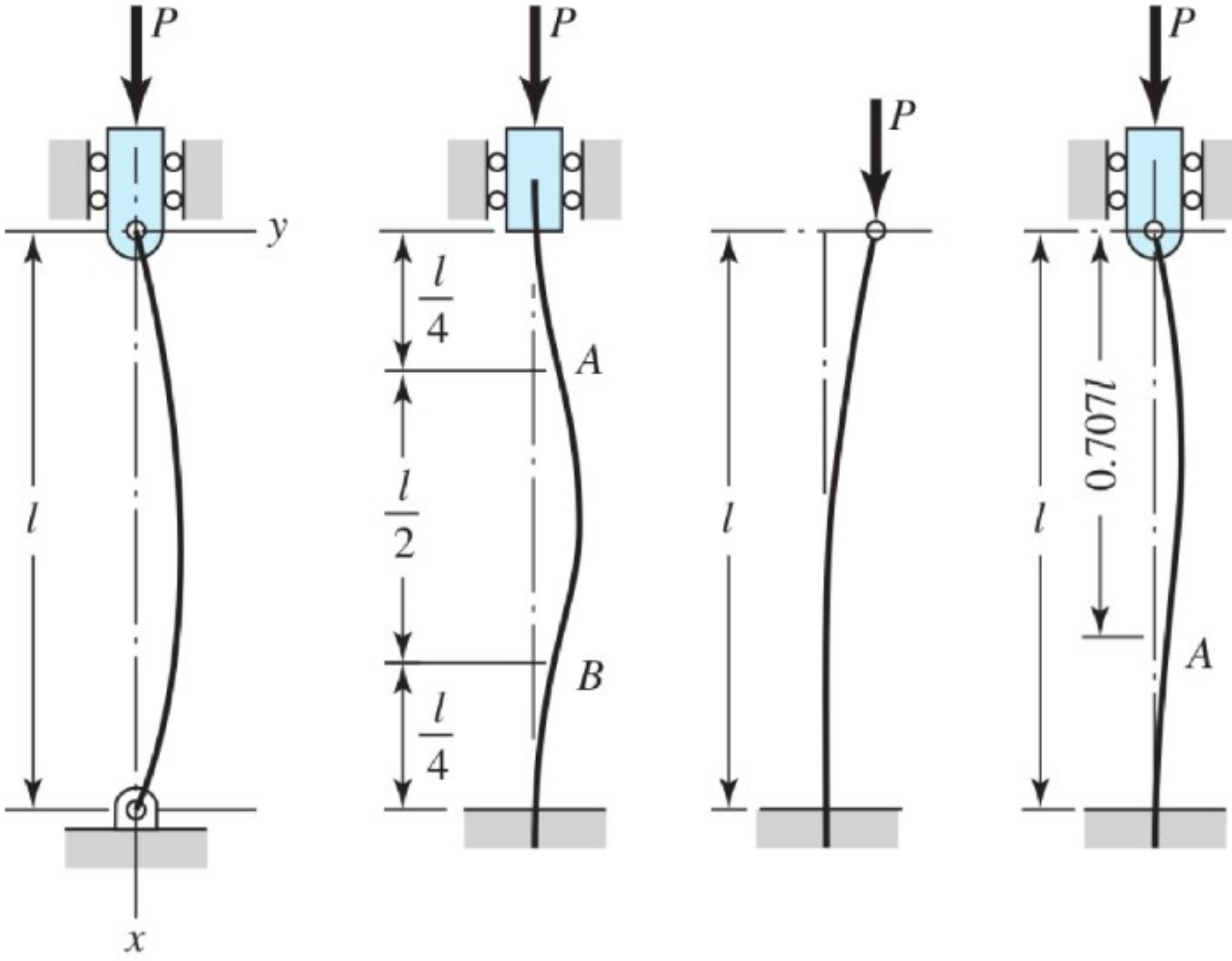
$$P_{cr} = \frac{C\pi^2 EI}{l^2}$$

$$\frac{P_{cr}}{A} = \frac{C\pi^2 E}{(l/K)^2}$$

K radius of gyration

$I = AK^2$

l/K slenderness ratio



(a) $C = 1$ (b) $C = 4$ (c) $C = \frac{1}{4}$ (d) $C = 2$

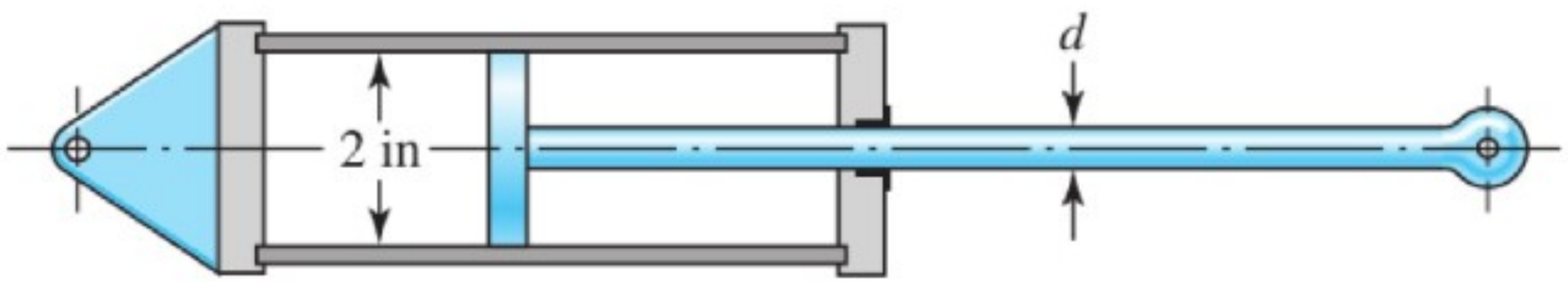
Table 4–2 End-Condition Constants for Euler Columns [to Be Used with Equation (4–43)]

	End-Condition Constant C		
Column End Conditions	**Theoretical Value**	**Conservative Value**	**Recommended Value***
Fixed-free	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$
Rounded-rounded	1	1	1
Fixed-rounded	2	1	1.2
Fixed-fixed	4	1	1.2

*To be used only with liberal factors of safety when the column load is accurately known.

4–131 The hydraulic cylinder shown in the figure has a 2-in bore and is to operate at a pressure of 1500 psi. With the clevis mount shown, the piston rod should be sized as a column with both ends rounded for any plane of buckling. The rod is to be made of forged AISI 1030 steel without further heat treatment.

Problem 4–131



(*a*) Use a design factor $n_d = 2.5$ and select a preferred size for the rod diameter if the column length is 50 in.

(*b*) Repeat part (*a*) but for a column length of 16 in.

(*c*) What factor of safety actually results for each of the cases above?