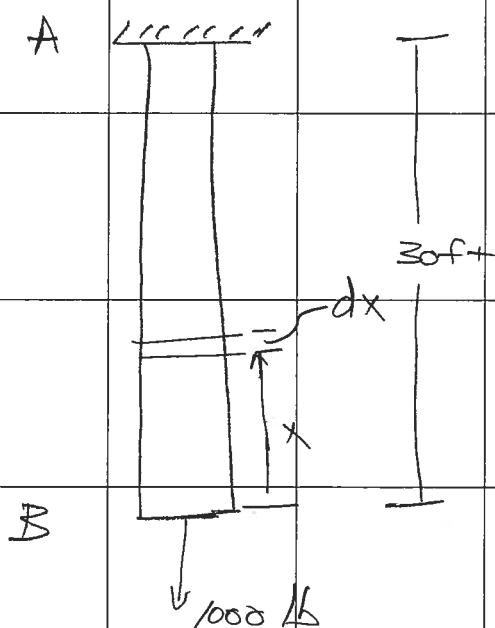


A steel bar is suspended from the ceiling of a structure. The cross-sectional area of the bar is 5 in^2 . There is a 1000 lb force applied at the bottom end of the bar as shown. Assume that the modulus of elasticity of steel is equal to $30 \times 10^6 \text{ psi}$ and that it has a unit weight of $490 \frac{\text{lb}}{\text{ft}^3}$.

Calculate the maximum deflection at B.



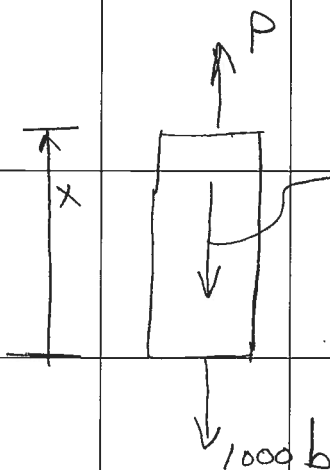
$$A = 5 \text{ in}^2$$

$$E = 30 \times 10^6 \frac{\text{lb}}{\text{in}^2}$$

$$\gamma = 490 \frac{\text{lb}}{\text{ft}^3}$$

$$\text{or } 12836 \frac{\text{lb}}{\text{in}^3}$$

First it is necessary to develop an expression that gives the internal force as a function of position x measured from the bottom of the bar



$$W = (x)(5)(1.2836) \quad (1)$$

$$W = 1.418 x \text{ lb} \quad (2)$$

where x is in inches

$$+\uparrow \sum F_y = 0$$

$$+P - 1.418 x - 1000 = 0 \quad (3)$$

$$P = 1000 + 1.418 x \quad (4)$$

The total deflection is then given as follows

$$\Delta_{AB} = \int_0^{(30)(12)} \frac{P(x)}{AE} dx \quad (5)$$

$$\Delta_{AB} = \frac{1}{AE} \int_0^{360} (1000 + 1.418x) dx \quad (6)$$

$$\Delta_{AB} = \frac{1}{AE} \left[1000x \Big|_0^{360} + \frac{1.418}{2} x^2 \Big|_0^{360} \right] \quad (7)$$

$$S_{AB} = \frac{1}{AE} [360000 + 91,886] \quad (8)$$

$$S_{AB} = \frac{451,886}{(5)(30 \times 10^6)} \quad (9)$$

$$S_{AB} = 3.01 \times 10^{-3} \text{ in} \quad (10)$$

The normal stress at any point X is
given as follows

$$\sigma(x) = \frac{1000 + 1.418x}{5 \text{ in}^2} \quad (11)$$

$$\sigma(x) = 200 + .2836x \quad \frac{\text{lb}}{\text{in}^2} \quad (12)$$

The maximum stress occurs at point
A where x will be equal to 360 in.

$$\sigma_{\max} = 200 + .2836(360) \quad (13)$$

$$\sigma_{\max} = 302.1 \quad \frac{\text{lb}}{\text{in}^2} \quad (14)$$