9.7. Use the method of virtual work and determine the vertical displacement of point B. Each steel member has a cross-sectional area of 2 in\(^2\). \(E = 29(10^6)\) ksi.

**Member Real Forces**
As shown on figure (a).

**Member Virtual Forces**
As shown on figure (b).

**Virtual Work Equation:** Applying Eq. 9-15, we have

\[
1 - \Delta = \sum \frac{N\Delta L}{AE}
\]

1 lb \((\Delta_p)_{A} = \frac{1}{AE} \left[ -0.032 \left( \frac{165.67}{10^6} \right) \right] \left( \frac{12}{10} \right) \\
+ \left( -0.032 \left( \frac{165.67}{10^6} \right) \right) \left( \frac{12}{10} \right) \\
1 lb \((\Delta_p)_B = \frac{5000 \text{ in}}{AE} \left( \frac{600}{12} \right) \left[ \frac{0.0911\left( 10^{-2} \right) \text{ in}}{1} \right]
\]

Ans

9.48. Use the method of virtual work and determine the displacement of point C. \(EI\) is constant.

**Real Moment Function** \(M(x)\):
As shown on figure (a).

**Virtual Moment Functions** \(m(x)\): As shown on figure (b).

**Virtual Work Equation:**
For the displacement at point C, apply Eq. 9-48

\[
1 - \Delta = \frac{1}{AE} \int M \, dx
\]

\[
1 = \Delta_{C} = \frac{1}{AE} \int \left( \frac{(45) (P_4) (x_3)}{x_3} \right) \, dx_1 + \frac{1}{AE} \int \left( \frac{(45) (P_4) (x_3)}{x_3} \right) \, dx_1 + \frac{1}{AE} \int \left( \frac{(45) (P_4) (x_3)}{x_3} \right) \, dx_1
\]

Ans


**Internal Moment Function** \(M(x)\): The internal moment function in terms of the load \(P\) and externally applied load are shown on the figure.

Castigliano's Second Theorem: The displacement at C can be determined using Eq. 9-28 with \(\frac{\partial M}{\partial P} = \frac{P}{AE} \), \(\frac{\partial M}{\partial P} = \frac{P}{AE} \),

\[
\Delta (x) = \frac{1}{3} (2x_3 - x_2) \text{ and setting } P = P = 9 - 28
\]