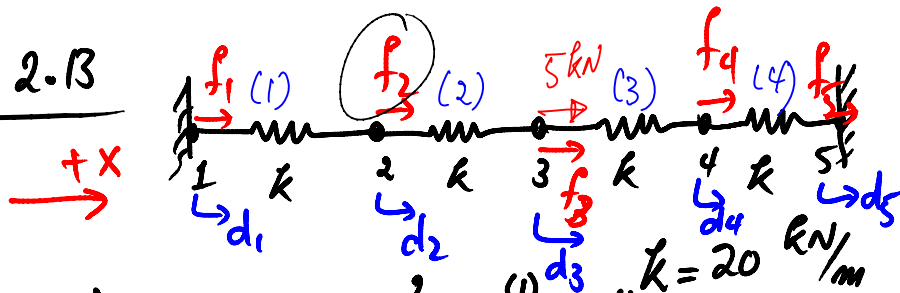


PROB. 2-13



$$\Pi_p^{(1)} = \frac{1}{2} k_1 (d_2 - d_1)^2 - d_1 f_1^{(1)} - d_2 f_2^{(1)}$$

$$\Pi_p^{(2)} = \frac{1}{2} k_2 (d_3 - d_2)^2 - d_2 f_2^{(2)} - d_3 f_3^{(2)}$$

$$\Pi_p^{(3)} = \frac{1}{2} k_3 (d_4 - d_3)^2 - d_3 f_3^{(3)} - d_4 f_4^{(3)}$$

$$\Pi_p^{(4)} = \frac{1}{2} k_4 (d_5 - d_4)^2 - d_4 f_4^{(4)} - d_5 f_5^{(4)}$$

$$\Pi_{\text{TOTAL}} = \Pi_p^{(1)} + \dots + \Pi_p^{(4)}$$

$$\frac{\partial \Pi_{\text{TOT}}}{\partial d_1} = 0 \Rightarrow -k_1 (d_2 - d_1) - f_1^{(1)} = 0$$

$$\frac{\partial \Pi_{\text{TOT}}}{\partial d_2} = 0 \Rightarrow k_1 (d_2 - d_1) - f_2^{(1)} - k_2 (d_3 - d_2) - f_2^{(2)} = 0$$

$$\frac{\partial \Pi_{\text{TOT}}}{\partial d_3} = 0 \Rightarrow k_2 (d_3 - d_2) - f_3^{(2)} - k_3 (d_4 - d_3) - f_3^{(3)} = 0$$

$$\frac{\partial \Pi_{\text{TOT}}}{\partial d_4} = 0 \Rightarrow k_3 (d_4 - d_3) - f_4^{(3)} - k_4 (d_5 - d_4) - f_4^{(4)} = 0$$

$$\frac{\partial \Pi_{\text{TOT}}}{\partial d_5} = 0 \Rightarrow k_4 (d_5 - d_4) - f_5^{(4)} = 0$$

$$f_1 = -k_1 (d_2 - d_1)$$

$$(f_1^{(1)} + f_2^{(2)}) = f_2 = k_1 (d_2 - d_1) - k_2 (d_3 - d_2)$$

$$(f_2^{(1)} + f_2^{(2)}) = f_2 = k_1 (d_2 - d_1) - k_2 (d_3 - d_2)$$

$$f_3 = k_2 (d_3 - d_2) - k_3 (d_4 - d_3)$$

$$f_4 = k_3 (d_4 - d_3) - k_4 (d_5 - d_4)$$

$$f_5 = k_4 (d_5 - d_4)$$

$$\begin{Bmatrix} F_1 \\ F_2 \\ F_3 \\ F_4 \\ F_5 \end{Bmatrix} = \begin{bmatrix} k_1 & -k_1 & 0 & 0 & 0 \\ -k_1 & k_1+k_2 & -k_2 & 0 & 0 \\ 0 & -k_2 & k_2+k_3 & -k_3 & 0 \\ 0 & 0 & -k_3 & k_3+k_4 & -k_4 \\ 0 & 0 & 0 & -k_4 & k_4 \end{bmatrix} \begin{Bmatrix} d_1=0 \\ d_2 \\ d_3 \\ d_4 \\ d_5=0 \end{Bmatrix}$$

$$\begin{Bmatrix} F_2=0 \\ F_3=5 \text{ kN} \\ F_4=0 \end{Bmatrix} = \begin{bmatrix} k_1+k_2 & -k_2 & 0 \\ -k_2 & k_2+k_3 & -k_3 \\ 0 & -k_3 & k_3+k_4 \end{bmatrix} \begin{Bmatrix} d_2 \\ d_3 \\ d_4 \end{Bmatrix}$$

$$\begin{Bmatrix} 0 \\ 5 \\ 0 \end{Bmatrix} = \begin{bmatrix} 40 & -20 & 0 \\ -20 & 40 & -20 \\ 0 & -20 & 40 \end{bmatrix} \begin{Bmatrix} d_2 \\ d_3 \\ d_4 \end{Bmatrix}$$