

<3.9~3.11 >

3.40 [ , , ]

$$x_E = \frac{32 \text{ m}}{2} = 16 \text{ m}, \quad y_E = \frac{16.5 \text{ m} + 7.5 \text{ m}}{2} = 12 \text{ m}, \quad z_E = \frac{-24 \text{ m}}{2} = -12 \text{ m}$$

$$T_{EG} = 178 \text{ N}$$

$$\begin{aligned} \text{(a)} \quad \mathbf{r}_{C/B} &= 32 \mathbf{i} + (7.5 - 16.5) \mathbf{j} - 24 \mathbf{k} \text{ (m)} \\ &= 32 \mathbf{i} - 9 \mathbf{j} - 24 \mathbf{k} \text{ (m)} \end{aligned}$$

$$r_{C/B} = \sqrt{(32)^2 + (-9)^2 + (-24)^2} \text{ m} = 41 \text{ m}$$

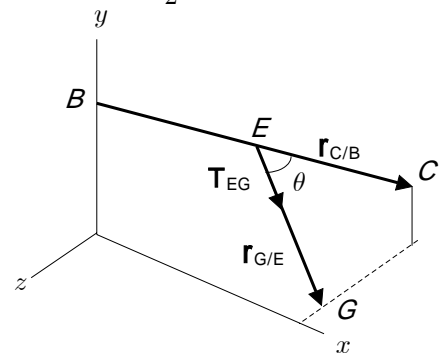
$$\begin{aligned} \mathbf{r}_{G/E} &= (32 - 16) \mathbf{i} + (-12) \mathbf{j} + [-2.25 - (-12)] \mathbf{k} \text{ (m)} \\ &= 16 \mathbf{i} - 12 \mathbf{j} + 9.75 \mathbf{k} \text{ (m)} \end{aligned}$$

$$r_{G/E} = \sqrt{(16)^2 + (-12)^2 + (9.75)^2} \text{ m} = 22.25 \text{ m}$$

$$\begin{aligned} \mathbf{r}_{C/B} \cdot \mathbf{r}_{G/E} &= (32 \mathbf{i} - 9 \mathbf{j} - 24 \mathbf{k}) \cdot (16 \mathbf{i} - 12 \mathbf{j} + 9.75 \mathbf{k}) \text{ (m}^2\text{)} \\ &= (32)(16) + (-9)(-12) + (-24)(9.75) \text{ (m}^2\text{)} = 386 \text{ (m}^2\text{)} \end{aligned}$$

$$\cos \theta = \frac{\mathbf{r}_{C/B} \cdot \mathbf{r}_{G/E}}{r_{C/B} r_{G/E}} = \frac{386 \text{ m}^2}{(41 \text{ m})(22.25 \text{ m})} = 0.4231$$

$$\theta = \cos^{-1}(0.423) = 65.0^\circ$$



$$\text{(b)} \quad (T_{EG})_{BC} = T_{EG} \cos \theta = (178 \text{ N}) 0.4231 = 75.3 \text{ N}$$

3.45 [  $\mathbf{M}_O = \mathbf{r} \times \mathbf{F}$  , ]

$$T_{CE} = 1349 \text{ N}$$

$$\mathbf{r}_{OC} = (2.25 \text{ m}) \mathbf{k}$$

$$\begin{aligned} \lambda_{CE} &= (0.90 \mathbf{i} + 1.50 \mathbf{j} - 2.25 \mathbf{k}) \frac{1}{\sqrt{(0.90)^2 + (1.50)^2 + (-2.25)^2}} \\ &= \frac{1}{2.85} (0.90 \mathbf{i} + 1.50 \mathbf{j} - 2.25 \mathbf{k}) \end{aligned}$$

$$\begin{aligned} \mathbf{T}_{CE} &= T_{CE} \lambda_{CE} = (1349 \text{ N}) \frac{1}{2.85} (0.90 \mathbf{i} + 1.50 \mathbf{j} - 2.25 \mathbf{k}) \\ &= 426 \mathbf{i} + 710 \mathbf{j} - 1065 \mathbf{k} \text{ (N)} \end{aligned}$$

$$\begin{aligned} \mathbf{M}_O &= \mathbf{r}_{OC} \times \mathbf{T}_{CE} = (2.25 \text{ m}) \mathbf{k} \times [426 \mathbf{i} + 710 \mathbf{j} - 1065 \mathbf{k} \text{ (N)}] \\ &= -1597.5 \mathbf{i} + 958.5 \mathbf{j} \text{ (N}\cdot\text{m)} \end{aligned}$$

$$M_x = -1598 \text{ N}\cdot\text{m}, \quad M_y = 959 \text{ N}\cdot\text{m}, \quad M_z = 0$$

$$3.56 \quad [ \quad OL \quad \quad \quad M_{OL} = \lambda_{OL} \cdot (\mathbf{r} \times \mathbf{F}) ]$$

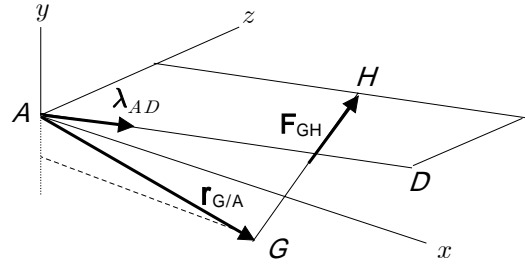
$$F_{GH} = 21.3 \text{ kN}$$

$$A \quad (0, 0, 0)$$

$$D \quad x = 3 (2.4 \text{ m}) = 7.2 \text{ m}$$

$$y = 0.9 \text{ m}, \quad z = 0$$

$$\begin{aligned} \lambda_{AD} &= \frac{(7.2 \text{ m})\mathbf{i} + (0.9 \text{ m})\mathbf{j}}{\sqrt{(7.2 \text{ m})^2 + (0.9 \text{ m})^2}} \\ &= \frac{1}{7.256} [(7.2 \text{ m})\mathbf{i} + (0.9 \text{ m})\mathbf{j}] \\ &= 0.9923 \mathbf{i} + 0.1240 \mathbf{j} \end{aligned}$$



$$G \quad x = (2.1 \text{ m}) + (3.9 \text{ m}) = 6.0 \text{ m}, \quad y = -1.8 \text{ m}, \quad z = 0$$

$$\mathbf{r}_{G/A} = 6.0 \mathbf{i} - 1.8 \mathbf{j} \text{ (m)}$$

$$H \quad x = 2 (2.4 \text{ m}) = 4.8 \text{ m}, \quad y = \frac{2}{3} (0.9 \text{ m}) = 0.6 \text{ m}, \quad z = 2.4 \text{ m}$$

$$GH; \quad d_x = (4.8 \text{ m}) - (6.0 \text{ m}) = -1.2 \text{ m}$$

$$d_y = (0.6 \text{ m}) - (-1.8 \text{ m}) = 2.4 \text{ m}$$

$$d_z = (2.4 \text{ m}) - (0) = 2.4 \text{ m}$$

$$\lambda_{GH} = \frac{(-1.2)\mathbf{i} + (2.4)\mathbf{j} + (2.4)\mathbf{k}}{\sqrt{(-1.2)^2 + (2.4)^2 + (2.4)^2}} = \frac{1}{3.6} [(-1.2)\mathbf{i} + (2.4)\mathbf{j} + (2.4)\mathbf{k}]$$

$$\begin{aligned} \mathbf{F}_{GH} &= F_{GH} \lambda_{GH} = (21.3 \text{ kN}) \frac{1}{3.6} [(-1.2)\mathbf{i} + (2.4)\mathbf{j} + (2.4)\mathbf{k}] \\ &= -7.1 \mathbf{i} + 14.2 \mathbf{j} + 14.2 \mathbf{k} \text{ (kN)} \end{aligned}$$

$$\begin{aligned} \mathbf{r}_{G/A} \times \mathbf{F}_{GH} &= [6.0 \mathbf{i} - 1.8 \mathbf{j} \text{ (m)}] \times [-7.1 \mathbf{i} + 14.2 \mathbf{j} + 14.2 \mathbf{k} \text{ (kN)}] \\ &= [(-1.8)(14.2) - 0] \mathbf{i} + [0 - (6.0)(14.2)] \mathbf{j} \\ &\quad + [(6.0)(14.2) - (-1.8)(-7.1)] \mathbf{k} \quad \text{(kN}\cdot\text{m)} \\ &= (-25.56) \mathbf{i} + (-85.2) \mathbf{j} + (72.42) \mathbf{k} \quad \text{(kN}\cdot\text{m)} \end{aligned}$$

$$\begin{aligned} M_{AD} &= \lambda_{AD} \cdot (\mathbf{r}_{G/A} \times \mathbf{F}_{GH}) \\ &= [0.9923 \mathbf{i} + 0.1240 \mathbf{j}] \cdot [(-25.56) \mathbf{i} + (-85.2) \mathbf{j} + (72.42) \mathbf{k} \text{ (kN}\cdot\text{m)}] \\ &= (0.9923)(-25.56) + (0.1240)(-85.2) + 0 \text{ (kN}\cdot\text{m)} \\ &= -35.928 \text{ (kN}\cdot\text{m)} \quad \quad \quad M_{AD} = -35.9 \text{ kN}\cdot\text{m} \end{aligned}$$