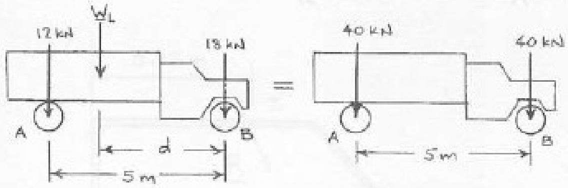
Homework # 5

Solution 3.104:



Have $\Sigma \mathbf{F}$: $-12 \text{ kN} - W_L - 18 \text{ kN} = -40 \text{ kN} - 40 \text{ kN}$

$$W_L = 50 \text{ kN}$$

or $W_L = 50.0 \text{ kN}$

$\Sigma \mathbf{M}_B$: $(12 \text{ kN})(5 \text{ m}) + (50 \text{ kN})d = (40 \text{ kN})(5 \text{ m})$

$$d = 2.8 \text{ m}$$

or heaviest load (50 kN) is located 2.80 m from front axle

Solution 3.118:

Have $\Sigma \mathbf{F}$: $\mathbf{B} + \mathbf{C} = \mathbf{R}$

ΣF_x: $B_x + C_x = 3.9 \text{ lb}$ or $B_x = 3.9 \text{ lb} - C_x$ (1)

ΣF_y: $C_y = R_y$ (2)

ΣF_z: $C_z = -1.1 \text{ lb}$ (3)

Have $\Sigma \mathbf{M}_A$: $\mathbf{r}_{B/A} \times \mathbf{B} + \mathbf{r}_{C/A} \times \mathbf{C} + \mathbf{M}_B = \mathbf{M}_A^R$

$$\therefore \frac{1}{12}\begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ x & 0 & 4.5 \\ B_x & 0 & 0 \end{vmatrix} + \frac{1}{12}\begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ 4 & 0 & 2.0 \\ C_x & C_y & -1.1 \end{vmatrix} + (2 \text{ lb}\cdot\text{ft})\mathbf{i} = M_x\mathbf{i} + (1.5 \text{ lb}\cdot\text{ft})\mathbf{j} - (1.1 \text{ lb}\cdot\text{ft})\mathbf{k}$$

$$(2 - 0.166667C_y)\mathbf{i} + (0.375B_x + 0.166667C_x + 0.36667)\mathbf{j} + (0.33333C_y)\mathbf{k}$$
$$= M_x\mathbf{i} + (1.5)\mathbf{j} - (1.1)\mathbf{k}$$

From **i** - coefficient $2 - 0.166667C_y = M_x$ (4)

j - coefficient $0.375B_x + 0.166667C_x + 0.36667 = 1.5$ (5)

k - coefficient $0.33333C_y = -1.1$ or $C_y = -3.3 \text{ lb}$ (6)

(*a*) From Equations (1) and (5):

$$0.375(3.9 - C_x) + 0.166667C_x = 1.13333$$

$$C_x = \frac{0.32917}{0.20833} = 1.58000 \text{ lb}$$

From Equation (1): $B_x = 3.9 - 1.58000 = 2.32$ lb

$\therefore$ $\mathbf{B} = (2.32 \text{ lb})\mathbf{i}$

$\mathbf{C} = (1.580 \text{ lb})\mathbf{i} - (3.30 \text{ lb})\mathbf{j} - (1.110 \text{ lb})\mathbf{k}$

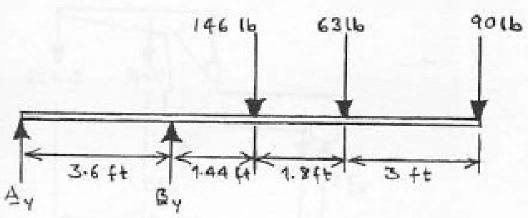
(*b*) From Equation (2): $R_y = C_y = -3.30$ lb or $\mathbf{R}_y = -(3.30 \text{ lb})$

From Equation (4): $M_x = -0.166667(-3.30) + 2.0 = 2.5500$ lb·ft

or $\mathbf{M}_x = (2.55 \text{ lb·ft})$

Solution 4.1:

Free-Body Diagram:



(*a*) $+\circlearrowleft\ \Sigma M_B = 0$: $-A_y(3.6 \text{ ft}) - (146 \text{ lb})(1.44 \text{ ft}) - (63 \text{ lb})(3.24 \text{ ft}) - (90 \text{ lb})(6.24 \text{ ft}) = 0$

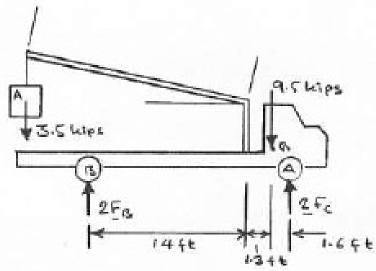
$A_y = -271.10$ lb or $\mathbf{A}_y = 271 \text{ lb} \downarrow$

(*b*) $+\circlearrowleft\ \Sigma M_A = 0$: $B_y(3.6 \text{ ft}) - (146 \text{ lb})(5.04 \text{ ft}) - (63 \text{ lb})(6.84 \text{ ft}) - (90 \text{ lb})(9.84 \text{ ft}) = 0$

$B_y = 570.10$ lb or $\mathbf{B}_y = 570 \text{ lb} \uparrow$

Solution 4.2:

Free-Body Diagram:



(*a*)

$$+\circlearrowleft\ \Sigma M_C = 0: \quad (3.5\text{ kips})\left[\left(1.6 + 1.3 + 19.5\cos 15^\circ\right)\text{ft}\right] - 2F_B\left[(1.6 + 1.3 + 14)\text{ft}\right] + (9.5\text{ kips})(1.6\text{ ft}) = 0$$

$$2F_B = 5.4009\text{ kips}$$

or $\mathbf{F}_B = 2.70\text{ kips}\uparrow$

(*b*)

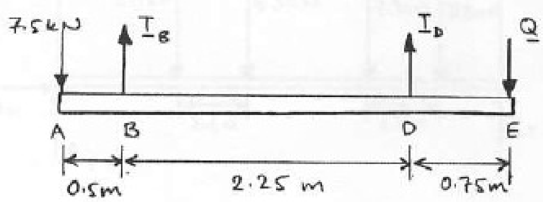
$$+\circlearrowleft\ \Sigma M_B = 0: \quad (3.5\text{ kips})\left[\left(19.5\cos 15^\circ - 14\right)\text{ft}\right] - (9.5\text{ kips})\left[(14 + 1.3)\text{ft}\right] + 2F_C\left[(14 + 1.3 + 1.6)\text{ft}\right] = 0$$

$$2F_C = 7.5991\text{ kips, or}$$

or $\mathbf{F}_C = 3.80\text{ kips}\uparrow$

Solution 4.10:

Free-Body Diagram:



For $Q_{\min}$, $T_D = 0$

$$+\circlearrowleft\ \Sigma M_B = 0: \quad (7.5\text{ kN})(0.5\text{ m}) - Q_{\min}(3\text{ m}) = 0$$

$$Q_{\min} = 1.250\text{ kN}$$

For $Q_{\max}$, $T_B = 0$

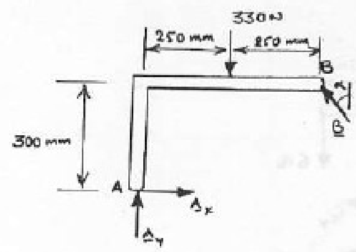
$$+\circlearrowleft\ \Sigma M_D = 0: \quad (7.5\text{ kN})(2.75\text{ m}) - Q_{\max}(0.75\text{ m}) = 0$$

$$Q_{\max} = 27.5\text{ kN}$$

Therefore: $1.250\text{ kN} \le Q \le 27.5\text{ kN}$

Solution 4.17:

Free-Body Diagram:



Equations of equilibrium:

$+\circlearrowleft\ \Sigma M_A = 0$: $\quad -(330\text{ N})(0.25\text{ m}) + B\sin\alpha(0.3\text{ m}) + B\cos\alpha(0.5\text{ m}) = 0$

$\xrightarrow{+}\ \Sigma F_x = 0$: $\quad A_x - B\sin\alpha = 0$

$+\uparrow\ \Sigma F_y = 0$: $\quad A_y - (330\text{ N}) + B\cos\alpha = 0$

(*a*) Substitution $\alpha = 0$ into (1), (2), and (3) and solving for A and B:

$$B = 165.000\text{ N},\ A_x = 0,\ A_y = 165.0\text{ N}$$

or $\mathbf{A} = 165.0\text{ N} \uparrow$, $\mathbf{B} = 165.0\text{ N} \uparrow$

(*b*) Substituting $\alpha = 90°$ into (1), (2), and (3) and solving for A and B:

$$B = 275.00\text{ N},\ A_x = 275.00\text{ N},\ A_y = 330.00\text{ N}$$

$$A = \sqrt{A_x^2 + A_y^2} = \sqrt{(275)^2 + (330)^2} = 429.56\text{ N}$$

$$\theta = \tan^{-1}\frac{A_y}{A_x} = \tan^{-1}\frac{330}{275} = 50.194°$$

$\therefore\ \mathbf{A} = 430\text{ N} \measuredangle 50.2°$, $\mathbf{B} = 275\text{ N} \longleftarrow$

(*c*) Substituting $\alpha = 30°$ into (1), (2), and (3) and solving for A and B:

$$B = 141.506\text{ N},\ A_x = 70.753\text{ N},\ A_y = 207.45\text{ N}, \Rightarrow$$

$$A = \sqrt{A_x^2 + A_y^2} = \sqrt{(70.753)^2 + (207.45)^2} = 219.18\text{ N}$$

$$\theta = \tan^{-1}\frac{A_y}{A_x} = \tan^{-1}\frac{207.45}{70.753} = 71.168°$$

$\therefore\ \mathbf{A} = 219\text{ N} \measuredangle 71.2°$, $\mathbf{B} = 141.5\text{ N} \searrow 60°$