Solutions

Marking: **M1** a correct method, **A1** the correct answer, **B1** an independent mark.

Each answer shows the steps, then the **result**.

2.1

$F_x = 650\cos 160^\circ = \mathbf{-611\ N}$; $F_y = 650\sin 160^\circ = \mathbf{+222\ N}$

2.2

$R_x = 2.4\cos 25^\circ + 1.6\cos 110^\circ = 2.175 - 0.547 = 1.628$ kN; $R_y = 2.4\sin 25^\circ + 1.6\sin 110^\circ = 1.014 + 1.504 = 2.518$ kN

$R = \sqrt{1.628^2 + 2.518^2} = \mathbf{3.00\ kN}$; both parts positive, so $\theta = \tan^{-1}(2.518/1.628) = \mathbf{57.1^\circ}$ **from** $+x$

2.3

$\vec{r}_{AB} = (3, -2, 6)$ m, $|\vec{r}_{AB}| = \sqrt{9+4+36} = 7$ m; $\hat{u} = (3,-2,6)/7$

$\vec{F} = 1.4\,\hat{u} = (0.6\,\hat{\imath} - 0.4\,\hat{\jmath} + 1.2\,\hat{k})$ **kN**

2.4

$F = \sqrt{200^2 + 300^2 + 600^2} = \mathbf{700\ N}$

$\alpha = \cos^{-1}(-200/700) = \mathbf{106.6^\circ}$, $\beta = \cos^{-1}(300/700) = \mathbf{64.6^\circ}$; $\gamma = \cos^{-1}(600/700) = \mathbf{31.0^\circ}$

3.1

(a) $\vec{F}_2 = \vec{R} - \vec{F}_1$; $F_{2x} = 5.0 - 3.0\cos 30^\circ = 2.402$ kN, $F_{2y} = 0 - 3.0\sin 30^\circ = -1.500$ kN

$F_2 = \sqrt{2.402^2 + 1.500^2} = \mathbf{2.83\ kN}$ at $\tan^{-1}(1.500/2.402) = \mathbf{32.0^\circ}$ **below** $+x$

(b) rope 2 only has to cancel F_{1y}, so it acts along $-y$: **1.50 kN at** 90° **below** $+x$

3.2

$R_x = 563.8 + 232.9 = 796.8$ N, $R_y = 205.2 + 869.3 = 1074.5$ N; $R = \mathbf{1338\ N}$ **at** 53.4°

angles from x' are -10° and 45°: $R_{x'} = 590.9 + 636.4 = 1227.3$ N, $R_{y'} = -104.2 + 636.4 = 532.2$ N

$\sqrt{1227.3^2 + 532.2^2} = 1338$ N, the same; angle $\mathbf{23.4^\circ}$ **from** x' ($= 53.4^\circ - 30^\circ$, so the frames agree)

3.3

(a) $\vec{r}_{AB} = (5, 0, -12)$ m, length 13 m; $\vec{F}_{AB} = 2.6 \times (5,0,-12)/13 = (1.0\,\hat{\imath} - 2.4\,\hat{k})$ **kN**

$\vec{r}_{AC} = (-3, 4, -12)$ and $\vec{r}_{AD} = (-3, -4, -12)$, both 13 m long; $\vec{F}_{AC} = \dfrac{T}{13}(-3,4,-12)$, $\vec{F}_{AD} = \dfrac{T}{13}(-3,-4,-12)$

(b) y: $4T/13 - 4T/13 = 0$ for any T; x: $1.0 - 6T/13 = 0$, so $T = \mathbf{2.17\ kN}$

$R_z = -2.4 - 2 \times \dfrac{12}{13} \times 2.167 = \mathbf{-6.4\ kN}$, so 6.4 kN down

(c) new x balance: $3.9 \times \frac{5}{13} = 1.5$ kN, so $T = 1.5 \times \frac{13}{6} = 3.25$ kN; $R_z = -3.9 \times \frac{12}{13} - 2 \times \frac{12}{13} \times 3.25 = -3.6 - 6.0 = -9.6$ kN; $9.6 > 8.0$ kN, so **the rating is exceeded**

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