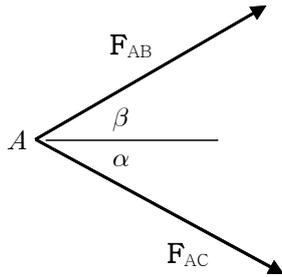


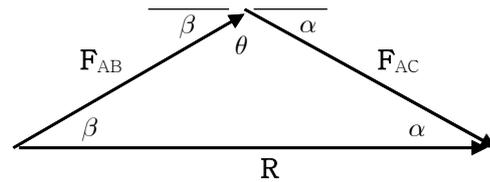
{2.1절}

2.8 [힘의 합성, 삼각법]

자유물체도 (F.B.D.)



힘 삼각형 (force triangle)



$F_{AB} = 2.2 \text{ kN}$, $\alpha = 25^\circ$, $\beta = 30^\circ$, R is horizontal. (a) $F_{AC} = ?$, (b) $R = ?$
 $\theta = 180^\circ - (\alpha + \beta) = 180^\circ - (25^\circ + 30^\circ) = 125^\circ$

(a) S ; known : F_{AB} , α , β , θ , unknown : F_{AC} \Rightarrow sine 공식 사용

M ; 자유물체도 (F.B.D.), 힘 삼각형 (force triangle)

A ;
$$\frac{F_{AC}}{\sin\beta} = \frac{F_{AB}}{\sin\alpha}$$

$$\Rightarrow F_{AC} = F_{AB} \frac{\sin\beta}{\sin\alpha} = (2.2 \text{ kN}) \frac{\sin 30^\circ}{\sin 25^\circ} = 2.603 \text{ kN}$$

$$\Rightarrow F_{AC} = 2.60 \text{ kN}$$

R ; 과정의 타당성 : R 값을 모르므로 cosine 공식을 사용하지 못함

T ; 결과 검토 : β 값이 α 값 보다 크므로, F_{AC} 값이 F_{AB} 값 보다 큼

(b) S ; known : F_{AB} , F_{AC} , α , β , θ , unknown : R \Rightarrow sine 공식, cosine 공식

M ; 자유물체도 (F.B.D.), 힘 삼각형 (force triangle)

A ; <방법 1>
$$\frac{R}{\sin\theta} = \frac{F_{AB}}{\sin\alpha}$$

$$\Rightarrow R = F_{AB} \frac{\sin\theta}{\sin\alpha} = (2.2 \text{ kN}) \frac{\sin 125^\circ}{\sin 25^\circ} = 4.264 \text{ kN}$$

$$\Rightarrow R = 4.26 \text{ kN}$$

<방법 2>
$$R^2 = F_{AB}^2 + F_{AC}^2 - 2 F_{AB} F_{AC} \cos\theta$$

$$= (2.2 \text{ kN})^2 + (2.603 \text{ kN})^2 - 2(2.2 \text{ kN})(2.603 \text{ kN})\cos 125^\circ = 18.1849 \text{ kN}^2$$

$$\Rightarrow R = (18.1849 \text{ kN}^2)^{1/2} = 4.264 \text{ kN} \quad \Rightarrow R = 4.26 \text{ kN}$$

R ; 과정의 타당성 : sine 공식, cosine 공식 모두 사용 가능함

T ; 결과 검토 : θ 값이 α , β 값 보다 크므로, R 값이 F_{AB} , F_{AC} 값 보다 큼
삼각형 성질에 따라 R 값이 $F_{AB} + F_{AC}$ 값 보다 작음

{2.2절}

2.42 [직각성분 합에 의한 힘의 합성]

$$P = 60 \text{ N}, \quad Q = 80 \text{ N}, \quad S = 120 \text{ N}$$

$$\beta = 20^\circ, \quad \phi = 0$$

(a) $\alpha = ?$, (b) $R = ?$

(a) S; (전략)

M; 자유물체도 (F.B.D.)

$$A; \quad R_n = Q \sin \alpha - S \cos \alpha = 0$$

$$\Rightarrow \tan \alpha = \frac{S}{Q} = \frac{120 \text{ N}}{80 \text{ N}} = 1.50$$

$$\Rightarrow \alpha = \tan^{-1}(1.50) = 56.3^\circ$$

R; (과정의 타당성)

T; (결과 검토)

(b) S; (전략)

M; 자유물체도 (F.B.D.)

$$A; \quad R_t = P + Q \cos \alpha + S \sin \alpha$$

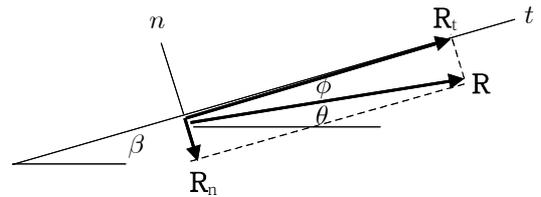
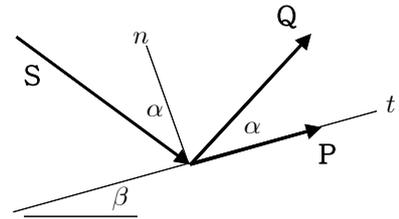
$$= (60 \text{ N}) + (80 \text{ N}) \cos 56.3^\circ + (120 \text{ N}) \sin 56.3^\circ$$

$$= 204.2 \text{ N} \qquad \Rightarrow \quad R = 204 \text{ N}$$

R; (과정의 타당성)

T; (결과 검토)

자유물체도 (F.B.D.)



{2.3절}

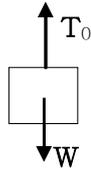
2.62 [질점의 평형 문제]

$W = 800 \text{ N}, P = 200 \text{ N}, d = 600 \text{ mm}, h = ?$

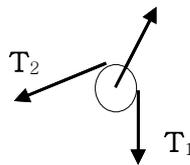
S; (전략)

M; 자유물체도 (F.B.D.)

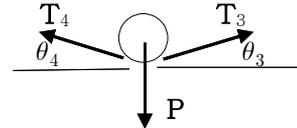
오른쪽 추에서



오른쪽 도르래에서



중앙 도르래에서



장력 $T_0 = T_1 = T_2 = T_3 = T_4 = T$

A; 평형 방정식

오른쪽 추에서 $T - W = 0 \Rightarrow T = W$

중앙 도르래에서 $T_3 = T_4 \Rightarrow \theta_1 = \theta_2 = \theta$

$$2T \sin\theta - P = 0$$

$$\Rightarrow \sin\theta = \frac{P}{2T} = \frac{P}{2W} = \frac{200 \text{ N}}{2(800 \text{ N})} = 0.1250$$

$$\Rightarrow \theta = \sin^{-1}(0.1250) = 7.181^\circ$$

$$\frac{h}{d} = \tan\theta$$

$$h = d \tan\theta = (600 \text{ mm}) \tan(7.181^\circ) = 75.59 \text{ mm} \Rightarrow h = 75.6 \text{ mm}$$

R; (과정의 타당성)

T; (결과 검토)

{2.4절}

2.91

S; (전략)

M; 자유물체도(F.B.D.)

A; ① 힘 **P**의 직각성분

$$P = 300 \text{ N}, \quad \alpha = 30^\circ, \quad \beta = 15^\circ$$

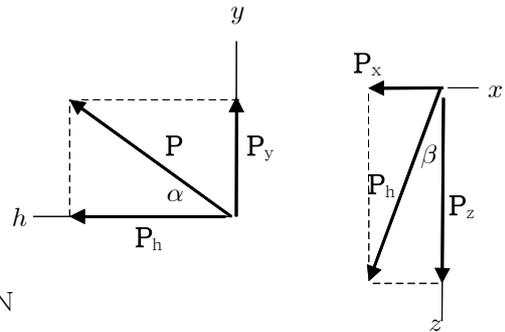
$$P_y = P \sin \alpha = (300 \text{ N}) \sin 30^\circ \\ = 150.0 \text{ N}$$

$$P_h = P \cos \alpha$$

$$P_x = -P_h \sin \beta = -P \cos \alpha \sin \beta \\ = -(300 \text{ N}) \cos 30^\circ \sin 15^\circ = -67.2 \text{ N}$$

$$P_z = P_h \cos \beta = P \cos \alpha \cos \beta \\ = (300 \text{ N}) \cos 30^\circ \cos 15^\circ = 251.0 \text{ N}$$

$$\Rightarrow \mathbf{P} = -67.2 \mathbf{i} + 150.0 \mathbf{j} + 251.0 \mathbf{k} \text{ (N)}$$



② 힘 **Q**의 직각성분

$$Q = 400 \text{ N}, \quad \gamma = 50^\circ, \quad \phi = 20^\circ$$

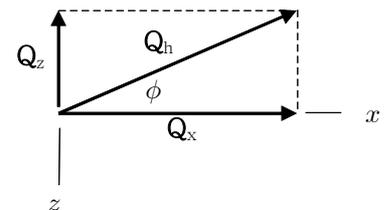
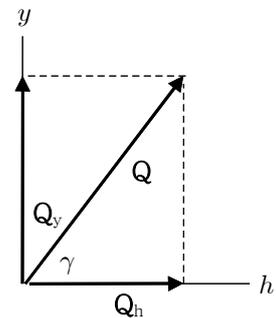
$$Q_y = Q \sin \gamma = (400 \text{ N}) \sin 50^\circ \\ = 306.4 \text{ N}$$

$$Q_h = Q \cos \gamma$$

$$Q_x = Q_h \cos \phi = Q \cos \gamma \cos \phi \\ = (400 \text{ N}) \cos 50^\circ \cos 20^\circ \\ = 241.6 \text{ N}$$

$$Q_z = -Q_h \sin \phi = -Q \cos \gamma \sin \phi \\ = -(400 \text{ N}) \cos 50^\circ \sin 20^\circ = -87.9 \text{ N}$$

$$\Rightarrow \mathbf{Q} = 241.6 \mathbf{i} + 306.4 \mathbf{j} - 87.9 \mathbf{k} \text{ (N)}$$



③ 합력의 크기와 방향

$$\mathbf{R} = \mathbf{P} + \mathbf{Q}$$

$$= (-67.2 \mathbf{i} + 150.0 \mathbf{j} + 251.0 \mathbf{k}) + (241.6 \mathbf{i} + 306.4 \mathbf{j} - 87.9 \mathbf{k}) \text{ (N)} \\ = 174.4 \mathbf{i} + 456.4 \mathbf{j} + 163.1 \mathbf{k} \text{ (N)}$$

$$R = \sqrt{R_x^2 + R_y^2 + R_z^2} \\ = \sqrt{(174.4)^2 + (456.4)^2 + (163.1)^2} \text{ (N)} = 515.1 \text{ (N)} \quad \Rightarrow \quad R = 515 \text{ N}$$

$$\cos \theta_x = \frac{R_x}{R} = \frac{174.4 \text{ N}}{515.1 \text{ N}} = 0.3386 \quad \Rightarrow \quad \theta_x = \cos^{-1}(0.3386) = 70.2^\circ$$

$$\cos \theta_y = \frac{R_y}{R} = \frac{456.4 \text{ N}}{515.1 \text{ N}} = 0.8860 \quad \Rightarrow \quad \theta_y = \cos^{-1}(0.8860) = 27.6^\circ$$

$$\cos \theta_z = \frac{R_z}{R} = \frac{163.1 \text{ N}}{515.1 \text{ N}} = 0.3166 \quad \Rightarrow \quad \theta_z = \cos^{-1}(0.3166) = 71.5^\circ$$

R; (과정의 타당성)

T; (결과 검토)

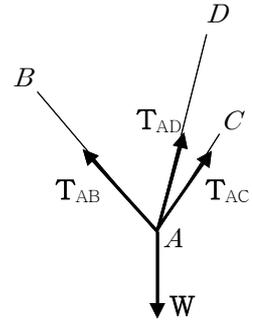
{2.5절}

2.99

S; (전략)

M; 자유물체도(F.B.D.)

A; $T_{AB} = 6 \text{ kN}$, $\mathbf{W} = -W \mathbf{j}$



$$d_{AB} = \sqrt{(-450 \text{ mm})^2 + (600 \text{ mm})^2 + 0} = 750 \text{ mm}$$

$$\begin{aligned}\lambda_{AB} &= \frac{1}{750}(-450 \mathbf{i} + 600 \mathbf{j}) \\ &= -0.60 \mathbf{i} + 0.80 \mathbf{j}\end{aligned}$$

$$\begin{aligned}\mathbf{T}_{AB} &= T_{AB} \lambda_{AB} = (6 \text{ kN})(-0.60 \mathbf{i} + 0.80 \mathbf{j}) \\ &= (-3.60 \text{ kN}) \mathbf{i} + (4.80 \text{ kN}) \mathbf{j}\end{aligned}$$

$$d_{AC} = \sqrt{0 + (600 \text{ mm})^2 + (-320 \text{ mm})^2} = 680 \text{ mm}$$

$$\lambda_{AC} = \frac{1}{680}(600 \mathbf{j} - 320 \mathbf{k}) = 0.8823 \mathbf{j} - 0.4705 \mathbf{k}$$

$$\mathbf{T}_{AC} = T_{AC} \lambda_{AC} = T_{AC} (0.8823 \mathbf{j} - 0.4705 \mathbf{k})$$

$$d_{AD} = \sqrt{(500 \text{ mm})^2 + (600 \text{ mm})^2 + (360 \text{ mm})^2} = 860 \text{ mm}$$

$$\lambda_{AD} = \frac{1}{860}(500 \mathbf{i} + 600 \mathbf{j} + 360 \mathbf{k}) = 0.5813 \mathbf{i} + 0.6976 \mathbf{j} + 0.4186 \mathbf{k}$$

$$\mathbf{T}_{AD} = T_{AD} \lambda_{AD} = T_{AD} (0.5813 \mathbf{i} + 0.6976 \mathbf{j} + 0.4186 \mathbf{k})$$

$$\Sigma \mathbf{F} = 0 \Rightarrow \mathbf{T}_{AB} + \mathbf{T}_{AC} + \mathbf{T}_{AD} + \mathbf{W} = 0$$

$$\Sigma F_x = 0 ; (-3.60 \text{ kN}) + 0 + 0.5813 T_{AD} = 0 \quad \dots \textcircled{1}$$

$$\Sigma F_y = 0 ; (4.80 \text{ kN}) + 0.8823 T_{AC} + 0.6976 T_{AD} - W = 0 \quad \dots \textcircled{2}$$

$$\Sigma F_z = 0 ; 0 - 0.4705 T_{AC} + 0.4186 T_{AD} = 0 \quad \dots \textcircled{3}$$

$$\textcircled{1} \Rightarrow T_{AD} = \frac{3.60 \text{ kN}}{0.5813} = 6.193 \text{ kN}$$

$$\textcircled{3} \Rightarrow T_{AC} = \frac{1}{0.4705} [0.4186 (6.193 \text{ kN})] = 5.509 \text{ kN}$$

$$\begin{aligned}\textcircled{2} \Rightarrow W &= (4.80 \text{ kN}) + 0.8823 (5.509 \text{ kN}) + 0.6976 (6.193 \text{ kN}) = 13.980 \text{ kN} \\ &\Rightarrow W = 13.98 \text{ kN}\end{aligned}$$

R; (과정의 타당성)

T; (결과 검토)