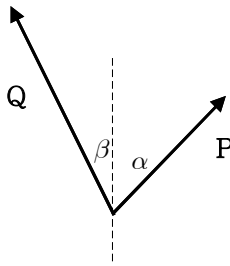


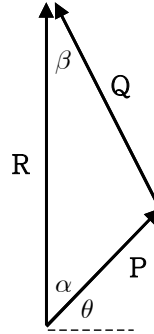
[2.1절]

2.18 S;  $Q = 120 \text{ N}$ ,  $\beta = 25^\circ$ ,  $R = 160 \text{ N} \uparrow$ known :  $Q$ ,  $\beta$ ,  $R$ , unknown :  $P$ (크기, 방향) $\Rightarrow$  삼각법(trigonometry) sine 공식, cosine 공식 사용하여 힘의 합성

M: 자유물체도 (F.B.D.),



힘 삼각형 (force triangle)

A: 힘  $P$ 의 크기 (cosine 공식)

$$\begin{aligned} P^2 &= Q^2 + R^2 - 2QR \cos\beta \\ &= (120 \text{ N})^2 + (160 \text{ N})^2 - 2(120 \text{ N})(160 \text{ N}) \cos 25^\circ = 5,198 \text{ N}^2 \\ &\Rightarrow R = 72.10 \text{ N} \end{aligned}$$

합력의 방향 각도 (sine 공식)

$$\begin{aligned} \frac{Q}{\sin\alpha} &= \frac{P}{\sin\beta} \Rightarrow \sin\alpha = \frac{Q}{P} \sin\beta = \frac{120 \text{ N}}{72.10 \text{ N}} \sin 25^\circ = 0.7034 \\ &\Rightarrow \alpha = \sin^{-1}(0.7034) = 44.70^\circ \\ \theta &= 90^\circ - \alpha = 90^\circ - 44.70^\circ = 45.30^\circ \end{aligned}$$

$$\Rightarrow \mathbf{P} = 72.1 \text{ N} \angle 45.3^\circ$$

R: (과정의 타당성) (가령, 합력의 크기 계산에 sine 공식 대신 cosine 공식을 사용한 사유)

T: (결과의 의미) (가령,  $\beta < \alpha \Rightarrow P < Q$ )

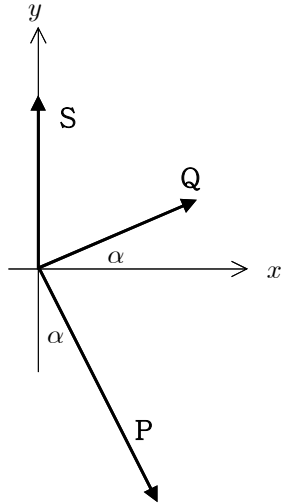
[2.2절]

2.39  $P = 170 \text{ N}$ ,  $Q = 85 \text{ N}$ ,  $S = 110 \text{ N}$

S; known :  $P$ ,  $Q$ ,  $S$ , 합력 성분  $R_y = 0$ , unknown :  $\alpha$ , 합력 성분  $R_x$

$\Rightarrow$  직각성분 합에 의한 힘의 합성

M; 자유물체도 (F.B.D.)



A;

$$(a) R_y = -P \cos\alpha + Q \sin\alpha + S = 0$$

$$\Rightarrow P \cos\alpha = Q \sin\alpha + S$$

$$\Rightarrow P \sqrt{1 - \sin^2\alpha} = Q \sin\alpha + S$$

$$\Rightarrow P^2 (1 - \sin^2\alpha) = (Q \sin\alpha + S)^2$$

$$= Q^2 \sin^2\alpha + 2QS \sin\alpha + S^2$$

$$\Rightarrow (P^2 + Q^2) \sin^2\alpha + 2QS \sin\alpha + (S^2 - P^2) = 0$$

$$\Rightarrow (170^2 + 85^2) \sin^2\alpha + 2(85)(110) \sin\alpha + (110^2 - 170^2) = 0$$

$$\Rightarrow 36,125 \sin^2\alpha + 18,700 \sin\alpha - 16,800 = 0$$

$$\Rightarrow 1,445 \sin^2\alpha + 748 \sin\alpha - 672 = 0$$

$$\Rightarrow \sin\alpha = \frac{-374 \pm \sqrt{374^2 - (1,445)(-672)}}{1,445} = -0.988, 0.4706 \quad (\sin\alpha > 0)$$

$$\Rightarrow \alpha = \sin^{-1}(0.4706) = 28.07^\circ \quad \Rightarrow \quad \alpha = 28.1^\circ$$

$$(b) R_x = P \sin\alpha + Q \cos\alpha$$

$$= (170 \text{ N}) (0.4706) + (85 \text{ N}) \cos 28.07^\circ = 155.00 \text{ N} \quad \Rightarrow \quad R_x = 155.0 \text{ N}$$

R; (과정의 타당성) (가령, 다각형 방법과 비교하면 어떤지?,  $\sin\alpha = -0.988$  이면?)

T; (결과 의미) (가령, 합력의 방향,  $R_x$  방향  $\rightarrow$ )

[2.3절]

2.66  $m = 200 \text{ kg}$

S; known  $W (= mg)$ ,  $\beta$ , unknown  $P$

질점의 평형 문제  $\Rightarrow$  직각성분 방법 또는 힘 삼각형 방법

A;  $W = (200 \text{ kg})(9.806 \text{ m/s}^2) = 1,961.2 \text{ N}$

$$\tan\beta = \frac{0.75}{2.4} = 0.3125$$

$$\beta = \tan^{-1}(0.3125) = 17.35^\circ$$

$$P = Q$$

<방법 1 : 직각 성분>

$$\Sigma F_x = 0 ; P \cos\alpha - 2Q \sin\beta = 0$$

$$\Rightarrow \cos\alpha = 2 \sin\beta = 2 \sin 17.35^\circ = 0.5965$$

$$\alpha = \cos^{-1}(0.5965) = \pm 53.38^\circ$$

(a)  $\alpha = +53.38^\circ$

$$\Sigma F_y = 0 ; P \sin\alpha + 2Q \cos\beta - W = 0$$

$$\Rightarrow P = \frac{W}{\sin\alpha + 2\cos\beta} = \frac{1961.2 \text{ N}}{\sin 53.38^\circ + 2\cos 17.35^\circ} = 723.3 \text{ N}$$

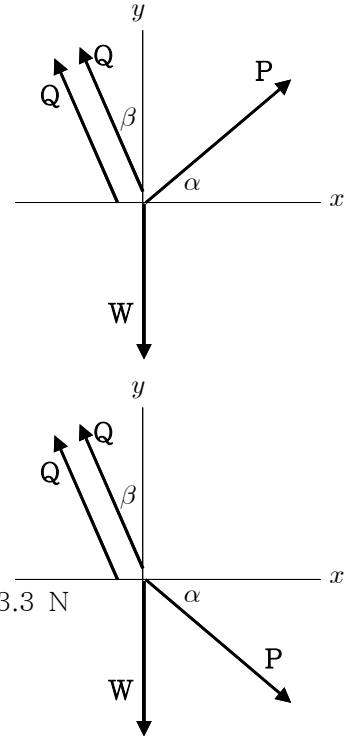
$$\Rightarrow \mathbf{P} = 723 \text{ N } \nearrow 53.4^\circ$$

(b)  $\alpha = -53.38^\circ$

$$\Sigma F_y = 0 ; P \sin\alpha + 2Q \cos\beta - W = 0$$

$$\Rightarrow P = \frac{W}{\sin\alpha + 2\cos\beta} = \frac{1961.2 \text{ N}}{\sin(-53.38^\circ) + 2\cos 17.35^\circ} = 1772.6 \text{ N}$$

M; 자유물체도 (F.B.D.)



$$\Rightarrow \mathbf{P} = 1,773 \text{ N } \searrow 53.4^\circ$$

<방법 2 : 힘 삼각형>

$$\frac{2Q}{\sin\theta} = \frac{P}{\sin\beta}$$

$$\Rightarrow \sin\theta = 2 \sin\beta = 2 \sin 17.35^\circ = 0.5964$$

$$\Rightarrow \theta = \sin^{-1}(0.5964) = 36.61^\circ, 143.39^\circ$$

(a)  $\theta = 36.61^\circ$

$$\alpha = 90^\circ - \theta = 90^\circ - 36.61^\circ = 53.39^\circ$$

$$\gamma = 180^\circ - (\beta + \theta) = 180^\circ - (17.35^\circ + 36.61^\circ) = 126.04^\circ$$

$$\frac{P}{\sin\beta} = \frac{W}{\sin\gamma} \Rightarrow P = W \frac{\sin\beta}{\sin\gamma} = (1961.2 \text{ N}) \frac{\sin 17.35^\circ}{\sin 126.04^\circ} = 723.3 \text{ N}$$

$$\Rightarrow \mathbf{P} = 723 \text{ N } \nearrow 53.4^\circ$$

(b)  $\theta = 143.39^\circ$

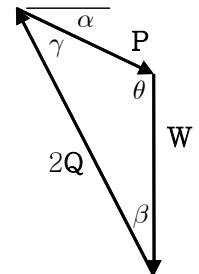
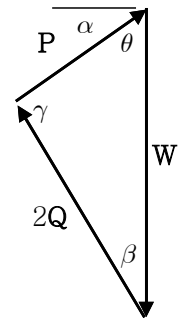
$$\alpha = \theta - 90^\circ = 143.39^\circ - 90^\circ = 53.39^\circ$$

$$\gamma = 180^\circ - (\beta + \theta) = 180^\circ - (17.35^\circ + 143.39^\circ) = 19.26^\circ$$

$$\frac{P}{\sin\beta} = \frac{W}{\sin\gamma}$$

$$\Rightarrow P = W \frac{\sin\beta}{\sin\gamma} = (1961.2 \text{ N}) \frac{\sin 17.35^\circ}{\sin 19.26^\circ} = 1773.0 \text{ N}$$

$$\Rightarrow \mathbf{P} = 1,773 \text{ N } \searrow 53.4^\circ$$



R; (과정의 타당성. 가령, 두 가지 방법 비교)

T; (결과의 의미. 가령, P의 방향  $\nearrow, \searrow$ )

[2.4절]

2.75  $P = 300 \text{ N}$ ,  $\alpha = 20^\circ$ ,  $\beta = 40^\circ$

S; known  $P$ ,  $\alpha$ ,  $\beta$ ,

unknown  $F_x$ ,  $F_y$ ,  $F_z$ ,  $\theta_x$ ,  $\theta_y$ ,  $\theta_z$

⇒ 공간에서 힘의 직각성분 (각도 이용),  
방향여현

A;

(a)  $P_y = P \cos\alpha = (300 \text{ N}) \cos 20^\circ = 281.9 \text{ N}$

$P_h = P \sin\alpha = (300 \text{ N}) \sin 20^\circ = 102.61 \text{ N}$

$P_x = -P_h \cos\beta$

$= -(102.61 \text{ N}) \cos 40^\circ = -78.60 \text{ N}$

$P_z = -P_h \sin\beta$

$= -(102.61 \text{ N}) \sin 40^\circ = -65.96 \text{ N}$

⇒  $P_x = -78.6 \text{ N}$ ,  $P_y = 282 \text{ N}$ ,  $P_z = -66.0 \text{ N}$

(b)  $\cos\theta_x = \frac{P_x}{P} = \frac{-78.60 \text{ N}}{300 \text{ N}} = -0.2620 \Rightarrow$

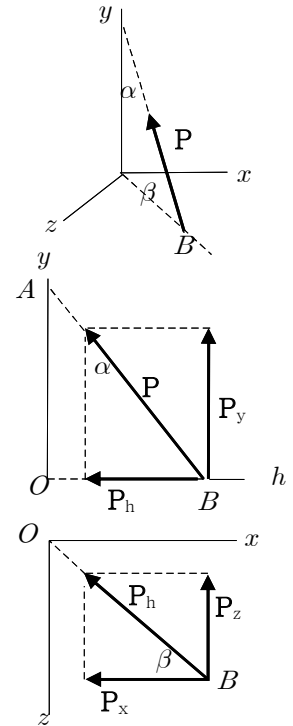
$\theta_x = \cos^{-1}(-0.2620) = 105.2^\circ$

$\theta_y = \alpha = 20.0^\circ$

$\cos\theta_z = \frac{P_z}{P} = \frac{-65.96 \text{ N}}{300 \text{ N}} = -0.2199 \Rightarrow$

$\theta_z = \cos^{-1}(-0.2199) = 102.7^\circ$

M;



R; 과정의 타당성 (가령, 수직성분, 수평성분)

T; 결과 검토 (가령, 힘 성분의 부호와 방향 각도의 범위)

[2.5절]

2.123  $W = 376 \text{ N}$ ,  $\mathbf{P} = P \mathbf{i}$ ,  $\mathbf{Q} = Q \mathbf{k}$

S; known  $W$ ,  $T_{AB} = T_{AC} (= T)$ , 좌표들

unknown  $P$ ,  $Q$

⇒ 공간에서 힘의 직각성분 (좌표 이용), 평형

A;  $\mathbf{W} = -W \mathbf{j}$

$$d_{AB} = \sqrt{(-130 \text{ mm})^2 + (400 \text{ mm})^2 + (160 \text{ mm})^2} \\ = 450 \text{ mm}$$

$$\lambda_{AB} = \frac{1}{450}(-130 \mathbf{i} + 400 \mathbf{j} + 160 \mathbf{k}) \\ = -0.2889 \mathbf{i} + 0.8889 \mathbf{j} + 0.3556 \mathbf{k}$$

$$\mathbf{T}_{AB} = T \lambda_{AB} = T(-0.2889 \mathbf{i} + 0.8889 \mathbf{j} + 0.3556 \mathbf{k})$$

$$d_{AC} = \sqrt{(-150 \text{ mm})^2 + (400 \text{ mm})^2 + (-240 \text{ mm})^2} = 490 \text{ mm}$$

$$\lambda_{AC} = \frac{1}{490}(-150 \mathbf{i} + 400 \mathbf{j} - 240 \mathbf{k}) = 0.3061 \mathbf{i} + 0.8163 \mathbf{j} - 0.4898 \mathbf{k}$$

$$\mathbf{T}_{AC} = T \lambda_{AC} = T(-0.3061 \mathbf{i} + 0.8163 \mathbf{j} - 0.4898 \mathbf{k})$$

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

$$\Sigma F_x = 0 ; -0.2889 T - 0.3061 T + P = 0 \quad \dots \textcircled{1}$$

$$\Sigma F_y = 0 ; 0.8889 T + 0.8163 T - W = 0 \quad \dots \textcircled{2}$$

$$\Sigma F_z = 0 ; 0.3556 T - 0.4898 T + Q = 0 \quad \dots \textcircled{3}$$

$$\textcircled{2} \Rightarrow (0.8889 + 0.8163) T = W \quad \Rightarrow \quad T = \frac{376 \text{ N}}{1.7052} = 220.5 \text{ N}$$

$$\textcircled{1} \Rightarrow P = (0.2889 + 0.3061) T = 0.5950 (220.5 \text{ N}) = 131.20 \text{ N}$$

$$\textcircled{3} \Rightarrow Q = (-0.3556 + 0.4898) T = 0.1342 (220.5 \text{ N}) = 29.59 \text{ N} \\ \Rightarrow P = 131.2 \text{ N}, Q = 29.6 \text{ N}$$

R; 과정의 타당성 (가령, 공간에서 힘의 직각성분)

T; 결과 검토 (가령, 두 줄이 A에 가하는 힘의 합력의  $x, y, z$  성분)

