<문제 해결력을 키우는 정역학>

연습문제 정답

최종 수정일 : 2022. 01. 03.

CHAPTER 01 | 정역학 기초

1.1 15 day

1.2 499 s

1.3 $32.174\ \frac{\text{ft}}{\text{s}^2}$

1.4 14.59 kg

1.5 $1\ \frac{\text{kgf}}{\text{mm}^2}(=9.81\ \text{MPa}) > 1\ \text{psi}(=6.9\ \text{kPa}) > 1\ \text{Pa}$

1.6 단위는 여러 가지로 나타낼 수 있다.

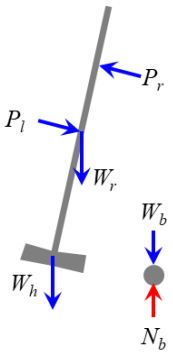
$\text{Pa}\cdot\text{s},\ \frac{\text{kg}}{\text{m}\cdot\text{s}}$

1.7 $y\,^\circ\text{F} = \frac{29}{16}(x\,^\circ\text{C}) + 32$

1.8 밀도, 에너지, 온도, 속력, 압력, 체적, 거리

1.9 $s = 7\ \text{km},\ \mathbf{d} = 4\mathbf{i} + 3\mathbf{j}\ [\text{km}]$

1.10



1.11 ④

1.12 ①

1.13 $b \approx 1.52a,\ c \approx 0.62a,\ d \approx 1.09a$

1.14 ①

1.15 5.98 N

1.16 898.4 N

1.17 수축기 : 0.158 기압, 이완기 : 0.105 기압

1.18

대기 중의 온도(T)는 일정하지 않고 고도(h)attitude에 따라 감소한다. 고도가 0 m인 위치에서의 온도가 15 ℃ 일 때, 고도 11 km까지는 1 km 높아질 때마다 온도는 약 6.5 ℃ 만큼 감소한다. 이를 식으로 나타내면 $\Delta T[℃] = (-)\frac{6.5\ ℃}{1{,}000\ \mathrm{m}} \times (\Delta h\ \mathrm{m})$와 같이 나타낼 수 있으므로 고도 10 km에서의 온도는 약 −50 ℃가 된다.

CHAPTER 02 | 1차원 힘

2.1 $m_1 = 14{,}594\ \mathrm{g}$
$m_2 = 1{,}000\ \mathrm{g}$
$m_3 = 453.6\ \mathrm{g}$
$m_4 = 10^{-3}\ \mathrm{g}$
$m_1 > m_2 > m_3 > m_4$

2.2 $F_1 = 100\ \mathrm{N}$
$F_2 = 981\ \mathrm{N}$
$F_3 = 451\ \mathrm{N}$
$F_4 = 0.00981\ \mathrm{N}$
$F_2 > F_3 > F_1 > F_4$

2.3 $5{,}579{,}983.85\ \mathrm{N} \approx 5{,}580\ \mathrm{kN} \approx 5.6\ \mathrm{MN}$

2.4 $275{,}794.9\ \frac{\mathrm{N}}{\mathrm{m}^2} \approx 275.8\ \mathrm{kPa}$, $276\ \mathrm{kPa}$

2.5 $78.5\ \mathrm{lb}$

2.6 $T_{\mathrm{A}} = 8w$, $T_{\mathrm{B}} = 4w$

2.7 면마찰계수 $\mu_1 \approx 0.61$, 구름마찰계수 $\mu_2 \approx 0.10$

2.8 ③과 ④

2.9 $221.55\ \mathrm{N}$

2.10 $F_1 = 100\ \mathrm{N}$, $s_1 = 1\ \mathrm{m}$

2.11 $F_1 = W/2 = 50\ \mathrm{N}$, $s_2 = 2\ \mathrm{m}$

2.12 $24.2\ \frac{\mathrm{N}}{\mathrm{m}}$, $101.5\ \mathrm{lb}$

2.13 $66{,}135\ \mathrm{lb}$

2.14 $W_1 = 4\,W_2,\ \ W_2 = 0.25\,W_1$

2.15 $246\ \mathrm{N}$

2.16 $F_1 = W$, $F_2 = W/2$, $F_3 = W/2$, $F_4 = W/2$

2.17 $F = 0.075\,W,\ W = \dfrac{40}{3}F$

2.18 $40\ \mathrm{N}$, $s_2 = 3\ \mathrm{m}$

2.19 $32.5\ \mathrm{N}$, $s_2 = 4\ \mathrm{m}$

2.20 $30\ \mathrm{kgf}\,(\approx 294.3\ \mathrm{N})$

CHAPTER 03 | 2차원 힘

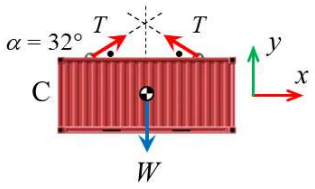
3.1 $(-)6.2\mathbf{i} - 47.2\mathbf{j}$ [kgf]

3.2 82.767 kgf, $(-)8°$

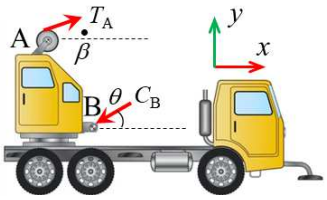
3.3 $\mathbf{R} = (-)22.1\mathbf{i} + 156.1\mathbf{j}$ [N], 157.7 N, 98.1°

3.4 안전하지 않다.

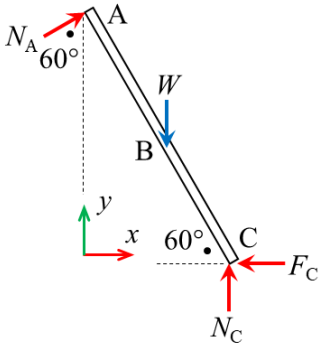
3.5



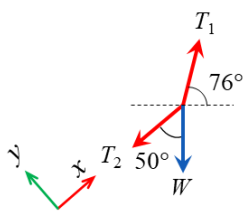
3.6



3.7



3.8 870 N



3.9 $\theta = 60°,\ N = 45.4\ \mathrm{N}$

3.10 $P_1 \approx 44.6\ \mathrm{kN},\ P_2 \approx 62.3\ \mathrm{kN}$
$\mathbf{P}_1 = (-)35.7\mathbf{i} - 26.8\mathbf{j}\ [\mathrm{kN}],\ \mathbf{P}_2 = 55.7\mathbf{i} - 27.9\mathbf{j}\ [\mathrm{kN}]$

3.11 $R_n = 1640.0\ \mathrm{N},\ R_t = (-)480.0\ \mathrm{N}$

3.12 $T = 81.7\ \mathrm{kgf},\ N = 29.9\ \mathrm{kgf}$

3.13 $\alpha = 103.06°,\ F = 205.3\ \mathrm{N}$

3.14 $\beta = 7.589° \approx 7.6°$

3.15 $259.2\ \mathrm{N}$

3.16 $N_{\mathrm{AB}} = 129.9\ \mathrm{N},\ N_1 = 303.1\ \mathrm{N},\ N_2 = 100.0\ \mathrm{N}$

3.17 $P = 304.7\ \mathrm{N}$

3.18 $P = 866.0\ \mathrm{kgf},\ R = 1{,}000\ \mathrm{kgf}$

3.19 $T_{\mathrm{A}} = 30\ \mathrm{kgf},\ T_{\mathrm{E}} = 40\ \mathrm{kgf},\ T_{\mathrm{C}} = 84.6\ \mathrm{kgf},\ T_{\mathrm{D}} = 91.4\ \mathrm{kgf},$
$T_{\mathrm{E}} = 40\ \mathrm{kgf},\ T_{\mathrm{F}} = 20.7\ \mathrm{kgf},\ d_{\mathrm{D}} = 1.745d$

3.20 $F_{\mathrm{BD}} = 7.071\ \mathrm{kN},\ F_{\mathrm{CD}} = 13.660\ \mathrm{kN},\ F_{\mathrm{AC}} = 15.273\ \mathrm{kN},\ F_{\mathrm{BC}} = 6.831\ \mathrm{kN},$
$F_{\mathrm{AB}} = 5.069\ \mathrm{kN},\ R_B = 10.998\ \mathrm{kN}$

CHAPTER 04 | 2차원 모멘트

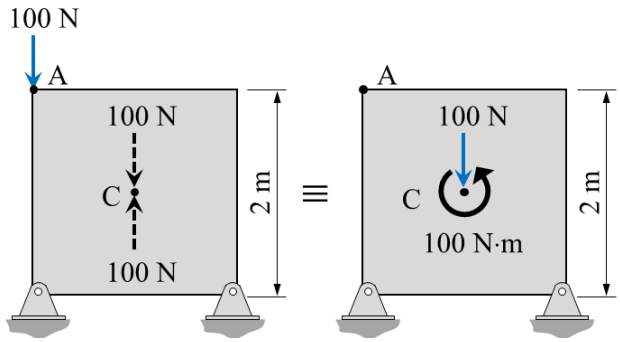
4.1 $\mathbf{M}_O = 196.4\mathbf{k}\ \text{N}\cdot\text{m}$

4.2 $\mathbf{M}_{O1} = (-)500\sqrt{3}\,\mathbf{k}\ \text{N}\cdot\text{m}$, $\mathbf{M}_{O2} = (-)50\sqrt{2}\,\mathbf{k}\ \text{N}\cdot\text{m}$

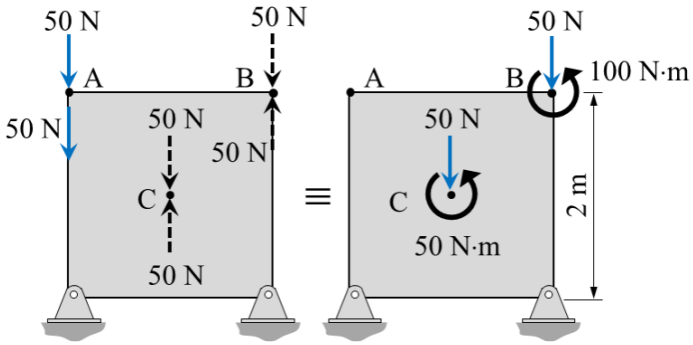
4.3 $9.81\mathbf{k}\ \text{N}\cdot\text{m}$

4.4 $324.6\ \text{N}$

4.5

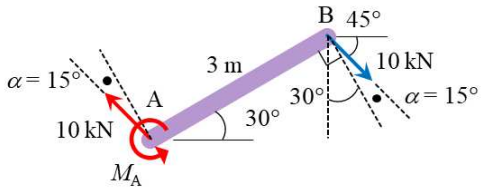


4.6



4.7 $T = 300.46\ \text{kgf}$, $A_x = \dfrac{500}{3}\ \text{kgf} = 166.7\ \text{kgf}$, $A_y = 50\ \text{kgf}$

4.8



$28.98\ \text{kN}\cdot\text{m}$

4.9 $\mathbf{M} = T\mathbf{j}$

4.10 $\mathbf{M}_{\mathrm{A}} = W_{\mathrm{A}} l \cos 22^\circ \, \mathbf{i}$, $\mathbf{M}_{\mathrm{B}} = (-) W_{\mathrm{B}} l \cos 22^\circ \, \mathbf{i}$

4.11 $\mathbf{R}_{\mathrm{O}} = 20 \mathbf{j} \, \mathrm{kN}$, $\mathbf{M}_{\mathrm{O}} = (-) 920 \mathbf{k} \, \mathrm{kN \cdot m}$

4.12 $0.514 \, \mathrm{N}$

4.13 $N_{\mathrm{C}} = 600 \, \mathrm{N}$, $N_{\mathrm{D}} = 700 \, \mathrm{N}$

4.14 $N_{\mathrm{A}} = 15.2 \, \mathrm{kN}$, $N_{\mathrm{B}} = 46.8 \, \mathrm{kN}$, $N_{\mathrm{C}} = 22 \, \mathrm{kN}$, $N_{\mathrm{D}} = 8 \, \mathrm{kN}$

4.15 $x = 3 \, \mathrm{m}$

4.16 1종 지레, $H = \dfrac{55}{260} N$

4.17 $M_{R,\mathrm{A}} = 1.18 \, \mathrm{N \cdot m}$, $M_{R,\mathrm{B}} = 4.30 \, \mathrm{N \cdot m}$

4.18 $B_y = 11.00 \, \mathrm{kN}$, $A_x = 8.66 \, \mathrm{kN}$, $A_y = 6 \, \mathrm{kN}$

4.19 $T_{\mathrm{D}} = 0.535 \, \mathrm{tonf}$, $N_{\mathrm{C}} = 0.965 \, \mathrm{tonf}$, $N_{\mathrm{F}} = 2.121 \, \mathrm{tonf}$, $N_{\mathrm{E}} = 1.414 \, \mathrm{tonf}$

4.20 $P_{\max} = 0.382 \, \mathrm{kN}$

4.21 $T = 6.6 \, \mathrm{kgf} = 64.7 \, \mathrm{N}$

4.22 $F_{\min} = \dfrac{W}{2\sqrt{3}}$

4.23 $\dfrac{11}{12} l$

CHAPTER 05 | 평면트러스

5.1 AB : 0, AC : 인장, BC & CD : 압축

5.2 부재 BC가 이력부재가 된다.

$F_{BC} = \frac{5\sqrt{2}}{4}\,\mathrm{kN} \approx 1.77\,\mathrm{kN}$

5.3 $F_{AB} = 577.35\,\mathrm{N}$ (압축), $F_{AC} = 288.68\,\mathrm{N}$ (인장)

$F_{BC} = 577.35\,\mathrm{N}$ (인장), $F_{BD} = 577.35\,\mathrm{N}$ (압축)

5.4 $F_{AE} = 0.96\,\mathrm{kN}$ (인장), $F_{AB} = 1.25\,\mathrm{kN}$ (인장), $F_{BE} = 1.0\,\mathrm{kN}$ (압축)

5.5 A와 F에서의 y 방향 반력 : 각각 $1/3\,\mathrm{kN}$, $2/3\,\mathrm{kN}$

$F_{AB} = \frac{\sqrt{2}}{3} \approx 0.471\,\mathrm{kN}$ (압축)

5.6 $F_{BE} = \frac{\sqrt{2}}{3} \approx 0.471\,\mathrm{kN}$ (인장)

5.7 프래트 트러스 또는 수직 부재를 추가한 워렌 트러스

$F_{FG} = 53.9\,\mathrm{N}$ (인장), $F_{DG} = 107.7\,\mathrm{N}$ (인장), $F_{CD} = 7.7\,\mathrm{N}$ (압축)

5.8 하우 트러스

$F_{CD} = 46.2\,\mathrm{N}$ (인장), $F_{CF} = 107.7\,\mathrm{N}$ (압축), $F_{FG} = 107.7\,\mathrm{N}$ (인장)

5.9 파커 트러스

$F_{FG} = 60.0\,\mathrm{N}$ (인장), $F_{CD} = (-)16.9\,\mathrm{N}$ (압축), $F_{DG} = 97.4\,\mathrm{N}$ (인장)

5.10 ※ [그림 5-66]에서 높이 치수(1.8 m)와 치수선 삭제 (치수 충돌)

볼티모어 트러스

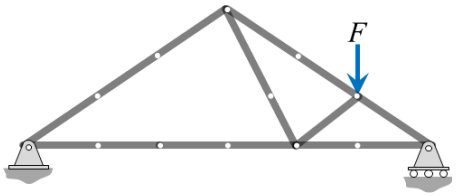
부재 DE: 7.7 N (압축), 부재 KP: 107.7 N (인장), 부재 JK: 53.9 N (인장)

5.11 부재 BG, 부재 CG

5.12 ※ [Hint] 무력부재는 5개이다.

부재 BI, 부재 DJ, 부재 JF, 부재 CJ, 부재 GJ

5.13 10개



5.14 $F_{DE} = F_{CD} = 1{,}000\,\text{N}$ (압축), $F_{EG} = 866\,\text{N}$ (인장), $F_{AG} = F_{EG} = 866\,\text{N}$ (인장),
$F_{CG} = 500\,\text{N}$ (인장), $F_{AB} = F_{BC} = 500\,\text{N}$ (압축), $F_{BG} = F_{DG} = 0\,\text{N}$

5.15 ※ [그림 5-71]에서 $\angle AFB = \angle FEC = 37°$
$F_{CE} = 1{,}143.9\,\text{N}$ (압축), $F_{BF} = 517.8\,\text{N}$ (인장)

5.16 ※ 트러스를 구성하는 모든 부재들의 길이가 같음
$F_{BE} = 0\,\text{N}$, $F_{AB} = 57.7\,\text{N}$ (압축), $F_{AE} = 28.9\,\text{N}$ (인장)

5.17 $F_{JK} = 1{,}077.4\,\text{N}$, $F_{DK} = (-)51.6\,\text{N}$, $F_{CD} = (-)51.6\,\text{N}$

5.18 $F_{CD} = (-)77.4\,\text{N}$, $F_{CJ} = 51.6\,\text{N}$, $F_{JK} = 1{,}051.6\,\text{N}$

5.19 부재 BC: 505 N (압축), 부재 BE: 0 N, 부재 EF: 505 N (압축)

5.20 $W_{min} = 450\,\text{N}$, $F_{EF} = (-)112.5\,\text{N}$, $F_{BC} = (-)246.2\,\text{N}$, $F_{BE} = (-)150.5\,\text{N}$

CHAPTER 06 | 면적 1차 모멘트

6.1 $169{,}765.3\ \mathrm{Pa}$

6.2 $p = 3{,}922.66\ \dfrac{\mathrm{N}}{\mathrm{m}^2},\ w = 98.59\ \dfrac{\mathrm{N}}{\mathrm{m}}$

6.3 $W = 154{,}134.4\ \mathrm{kgf} = 1{,}511{,}542\ \mathrm{N} = 1{,}511.5\ \mathrm{kN},\ 7.122\ \mathrm{m}$

6.4 $(\bar{x},\ \bar{y}) = (0\ \mathrm{cm}, 2.292\ \mathrm{cm})$

6.5 $\dfrac{3R}{8}$

6.6 $\dfrac{a+b}{3}$

6.7 $\dfrac{7}{18}a \approx 0.389a,\ \dfrac{11}{18}a \approx 0.611a$

6.8 $(60\ \mathrm{mm}, 48.5\ \mathrm{mm})$,
$Q_x = 60{,}932\ \mathrm{mm}^3,\ Q_y = 75{,}398\ \mathrm{mm}^3$

6.9 $(0.65\ \mathrm{cm}, 1.46\ \mathrm{cm})$

6.10 $\bar{x} = \bar{y} = \dfrac{4}{3\pi}\dfrac{3R^2 + 3Rt + t^2}{2R + t},\ \overline{x_L} = \overline{y_L} = \dfrac{2R}{\pi}$

6.11 $(\bar{x}, \bar{y}) = (6.20\ \mathrm{cm}, 3.89\ \mathrm{cm})$

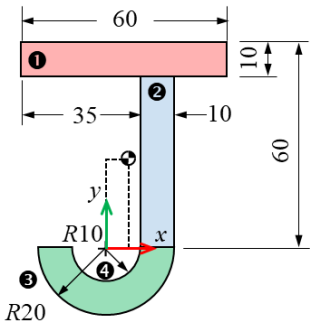
6.12 $\dfrac{4}{3}\pi R^3$

6.13 $(\bar{x}, \bar{y}) = (0\ \mathrm{mm}, 22.8\ \mathrm{mm})$

6.14 $(\bar{x}, \bar{y}) = (0\ \mathrm{mm}, 6.79\ \mathrm{mm})$

6.15 $(\bar{x}, \bar{y}) = (15\ \mathrm{mm}, 10\ \mathrm{mm})$

6.16 $(\bar{x}, \bar{y}) = (6.68\ \text{mm}, 25.99\ \text{mm})$



6.17 ※ 문제 수정: 브라켓의 **체적중심** 좌표를 구하시오. [단위 : mm]

$(\bar{x}, \bar{y}, \bar{z}) = (17.4\ \text{mm}, 55.1\ \text{mm}, -50\ \text{mm})$

6.18 $(\bar{x}, \bar{y}, \bar{z}) = (20.8, 33.3, 7.5)\ [\text{mm}]$

6.19 $Q_{\text{A}-\text{A}} = 634{,}672\ \text{mm}^3$, $\bar{h} = 132.2\ \text{mm}$

6.20 표면적 : $4\pi^2 aR$, 체적 : $2\pi^2 aR^2$

6.21 $m = 31{,}298.4\ \text{g} \approx 31.3\ \text{kg}$

6.22 $(\bar{x}, \bar{y}) = (31.83, 17.44)\ [\text{mm}]$, $V = 196{,}343\ \text{mm}^3 = 196.3\ \text{cm}^3 = 196.3\ \text{cc}$

6.23 3,211,000 원

6.24 $V_f = 999{,}819\ \text{mm}^3 \approx 1{,}000\ \text{cc}$, $h = 39.93\ \text{mm}$

CHAPTER 07 | 면적 2차 모멘트

7.1 $\Delta p = 529.2\,\mathrm{kPa}$

7.2 $\dfrac{1}{12}Ml^2$

7.3 $I_{\bigcirc} = 54.9\,\mathrm{kg\cdot m^2}$

7.4 $29{,}166{,}666.7\,\mathrm{mm^4}$

7.5 $I_c = \pi R^3 t\left(1 - \dfrac{4}{\pi^2}\right) \approx 1.8684R^3t$

7.6 $I_z = 13.5\pi R^4 \approx 42.41R^4,\ \sqrt{13.5}\,R \approx 3.674R$

7.7 $\dfrac{\pi}{4}\left(r_o^4 - r_i^4\right),\ \dfrac{\pi}{64}\left(d_o^4 - d_i^4\right)$

7.8 $d_s = 98.4\,\mathrm{mm}$

7.9 $\overline{I_x} = 161{,}592.1\,\mathrm{mm^4},\ \overline{I_y} = 79{,}068.2\,\mathrm{mm^4}$

7.10 $100\,\mathrm{mm}$

7.11 $\dfrac{R^3t}{2}$

7.12 $\overline{I_{xy}} = I_{xy} - d_x d_y A$

경우	I_{xy}	d_x	d_y	$\overline{I_{xy}}$	$\overline{I_{xy}}\,[\mathrm{cm^4}]$
❶	$b^2h^2/24$	$h/3$	$b/3$	$-b^2h^2/72$	-40.5
❷	$-b^2h^2/24$	$h/3$	$-b/3$	$b^2h^2/72$	40.5
❸	$b^2h^2/24$	$-h/3$	$-b/3$	$-b^2h^2/72$	-40.5
❹	$-b^2h^2/24$	$-h/3$	$b/3$	$b^2h^2/72$	40.5

7.13 $I_{p,\max} = \dfrac{\pi}{8}R^4 \approx 0.3927R^4$

7.14 $2{,}700{,}000\ \text{mm}^4,\ 38.73\ \text{mm}$

7.15 $I_x = 9{,}061{,}839\ \text{mm}^4,\ 40.64\ \text{mm}$

7.16 $I_{\text{A}-\text{A}} = 85{,}973{,}333.3\ \text{mm}^4$

7.17 $I_x = 103{,}750\ \text{mm}^4$

$I_y = 69{,}687.5\ \text{mm}^4$

$I_{xy} = (-)65{,}625\ \text{mm}^4$

7.18 $I_{p,\max} = 154{,}518\ \text{mm}^4,\ I_{p,\min} = 18{,}920\ \text{mm}^4$

7.19 $\sqrt{3}$

7.20 3.2%

CHAPTER 08 | 3차원 힘과 모멘트

8.1 $r_A = 6\,\mathrm{m}$,
$\theta_x = \cos^{-1}(1/3) = 70.5°$, $\theta_y = \cos^{-1}(-2/3) = 131.8°$, $\theta_z = \cos^{-1}(2/3) = 48.2°$

8.2 $\alpha = \cos^{-1}\dfrac{1}{3} \approx 70.53°$

8.3 $\alpha = \cos^{-1}\dfrac{1}{\sqrt{3}} \approx 54.74°$

8.4 $\mathbf{A}\times\mathbf{B} = 270\mathbf{i} + 60\mathbf{j} - 130\mathbf{k}$, $|\mathbf{A}\times\mathbf{B}| = 305.6$
$\mathbf{B}\times\mathbf{A} = (-)270\mathbf{i} - 60\mathbf{j} + 130\mathbf{k}$, $|\mathbf{B}\times\mathbf{A}| = 305.6$

8.5 $\mathbf{F} = 2\mathbf{i} + 5\mathbf{j}\,[\mathrm{kN}]$, $\mathbf{M}_O = 24\mathbf{j} - 18\mathbf{k}\,[\mathrm{kN\cdot m}]$

8.6 $\mathbf{R} = 1{,}750\mathbf{i}\,[\mathrm{N}]$, $\mathbf{M}_R = (-)23{,}625\mathbf{k}\,[\mathrm{N\cdot m}]$

8.7 $\mathbf{R} = (-)1{,}000\mathbf{j}\,[\mathrm{N}]$, $(x_R, z_R) = (3.25\,\mathrm{m}, 1.4\,\mathrm{m})$

8.8 무력부재: AB, AD, AE, GD, GE, GF

8.9 부재 EF, 부재 EH, 부재 CG

8.10 $\theta = 122.57°$, $\mathbf{M}_O = 60\mathbf{j} - 130\mathbf{k}\,[\mathrm{kN\cdot m}]$

8.11 ※ 조건 추가: [길이 단위 : m]
$\mathbf{M}_C = 3.03\mathbf{i} + 1.50\mathbf{j} - 0.60\mathbf{k}\,[\mathrm{kN\cdot m}]$
$|\mathbf{M}_C| = 3.43\,\mathrm{kN\cdot m}$

8.12 $T_3 = 386.3\,\mathrm{N}$

8.13 $N_C = 424.4\,\mathrm{kgf}$

8.14 ※ 문제 수정: 작업자가 서 있을 때, 기둥 CD가 지지해야 할 힘의 크기를 구하시오.
$N_C = 459.4\,\mathrm{kgf}$

8.15 $F_{BA} = F_{CA} = 3\,\text{kN}$, $T_{AD} = 2\sqrt{5} = 4.472\,\text{kN}$

8.16 (외적으로) 부정정 및 안정 문제, (내적으로) 정정 및 안정
무력부재: AB, BC, DH, EF, EG, EH, FG, GH

8.17 ※ 문제 수정: 무력부재가 아닌 부재들 **중에서 인장 부재를 찾으시오.**
부재 AE, BD, CH

8.18 $M_O = 103\,[\text{N}\cdot\text{m}]$

8.19 $F_{DG} \approx 416.6\,\text{N}$, $F_{DH} \approx (-)117.9\,\text{N}$, $F_{EH} \approx 666.7\,\text{N}$, $F_{FG} \approx (-)408.2\,\text{N}$,
$F_{FH} \approx (-)408.2\,\text{N}$, $F_{FI} \approx (-)166.7\,\text{N}$

8.20 $F_{AD} = F_{AE} \approx 306.2\,\text{N}$, $F_{BE} = 375.0\,\text{N}$, $F_{BC} = 375.0\,\text{N}$, $F_{DH} \approx 250.0\,\text{N}$,
$F_{CH} \approx 707.1\,\text{N}$, $F_{EI} \approx 750.0\,\text{N}$

CHAPTER 09 | 에너지와 마찰

9.1 $W_{A-B} = 50\ \mathrm{J}$, $E_{A-B} = 50\ \mathrm{J}$

9.2 $W_{10} = 50\ \mathrm{J}$, $W_f = (-)150\ \mathrm{J}$, $W_g = 0\ \mathrm{J}$, $E_{A-B} = 200\ \mathrm{J}$

9.3 $W_{A-C} = 3{,}500\ \mathrm{J}$

9.4 $2{,}868\ \mathrm{J}$

9.5 $5{,}230$ 회

9.6 $82\ \mathrm{kJ}$

9.7 $P_{min} = 221.74\ \mathrm{N}$

9.8 $P_{min} = 360.0\ \mathrm{N}$

9.9 $P = 125.0\ \mathrm{N}$

9.10 $P = 53.6\ \mathrm{N}$

9.11 $\frac{2}{7}\cot\alpha$

9.12 $k = 71.9\ \mathrm{N/m}$

9.13 $150{,}021\ \mathrm{N}$

9.14 ※ 문제 수정: 계가 평형을 이루기 위한 최소 무게(W_{min})와
$W_{min} \approx 266.7\ \mathrm{N}$, $328.9\ \mathrm{N}$

9.15 $23.45\ \mathrm{N \cdot m}$

9.16 $M_0 = 31.1\ \mathrm{N \cdot m}$

9.17 $P_{min} = 202.5\ \mathrm{N}$

9.18 $P_{\min} = 1{,}322.4\ \mathrm{N}$

9.19 $\mu_{\min} = 0.325$

9.20 $M_w = 12.28\ \mathrm{N \cdot m}$

9.21 $T_l = 23.51\ \mathrm{N \cdot m}$

CHAPTER 10 | 재료역학

10.1 ※ 문제 수정: 단, 모든 재료는 강체(rigid body)로 가정한다.

$\frac{T_A}{T_B} = 1.88$

10.2 $10{,}000\ \mathrm{N} = 10\ \mathrm{kN}$

10.3 $1{,}000\ \mu\varepsilon$

10.4 $127\ \mathrm{GPa}$

10.5 $\delta_A / \delta_B = 0.5$

10.6 $T_0 = 1.155\ \mathrm{kN}$, $T_1 = 1.152\ \mathrm{kN}$

10.7 ※ 문제 수정: [그림 10-37]과 같은 단순 프레임의 BC 부분에 $2\ \mathrm{kN/m}$의 선분포하중이 가해지고 있다. ~~이 프레임에 이력부재가 있는지 찾아보고~~ 지지점 A와 C에서의 반력을 구하시오. 모든 부재는 강체(rigid body)로 가정한다.

※ 점 B에 있는 핀 조인트 제거

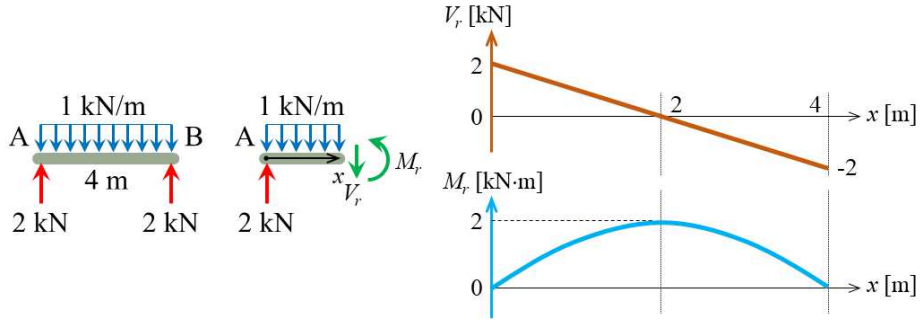
$R_C = 4.2\ \mathrm{kN}$, $R_A = 1.8\ \mathrm{kN}$

10.8 $A_x = 1\ \mathrm{kN}$, $G_y = \frac{21}{16}\ \mathrm{kN} \approx 1.3125\ \mathrm{kN}$, $A_y = G_y = 1.3125\ \mathrm{kN}$, $F_{BE} \approx 2.333\ \mathrm{kN}$

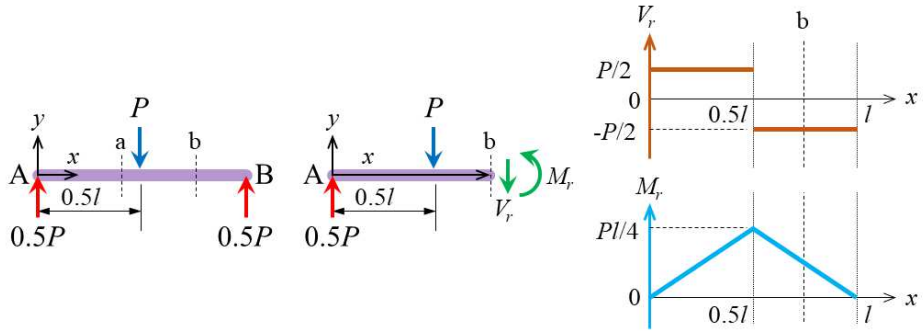
10.9 ※ 문제 수정: [그림 10-39] [길이 : m]

$A_y = 1\ \mathrm{kN}$, $B = 2\sqrt{2}\ \mathrm{kN} \approx 2.828\ \mathrm{kN}$, $A_x = 2\ \mathrm{kN}$

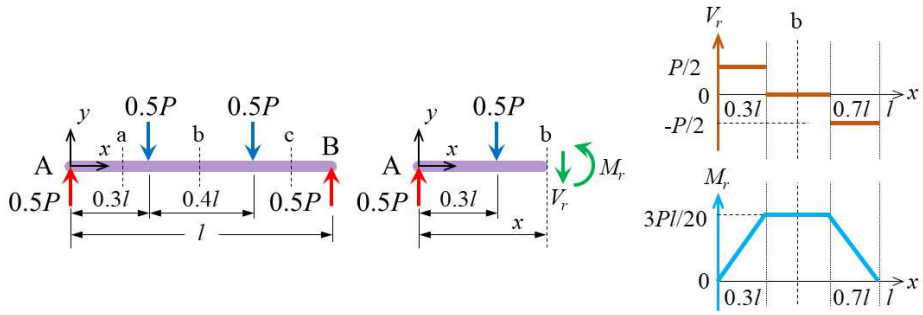
10.10 ※ 문제 수정: [그림 10-40] [길이 : m]



10.11



10.12



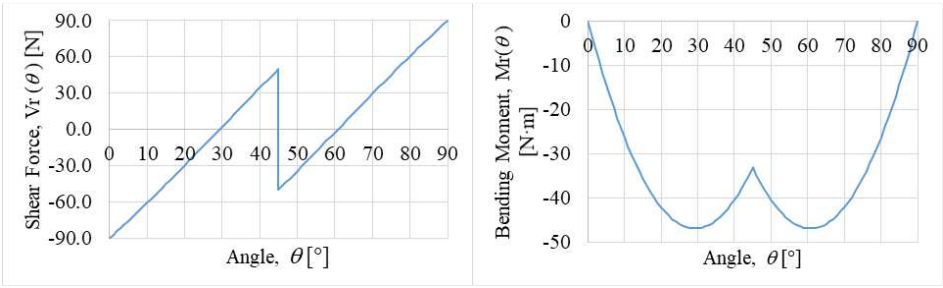
[문제 10.11]의 결과와 비교할 때 가장 두드러진 차이;

- 4PB의 경우 중앙부분($0.3l < x < 0.7l$)에서 전단력은 0이 된다.
- 4PB의 경우 중앙부분에서 굽힘 모멘트는 일정하다.

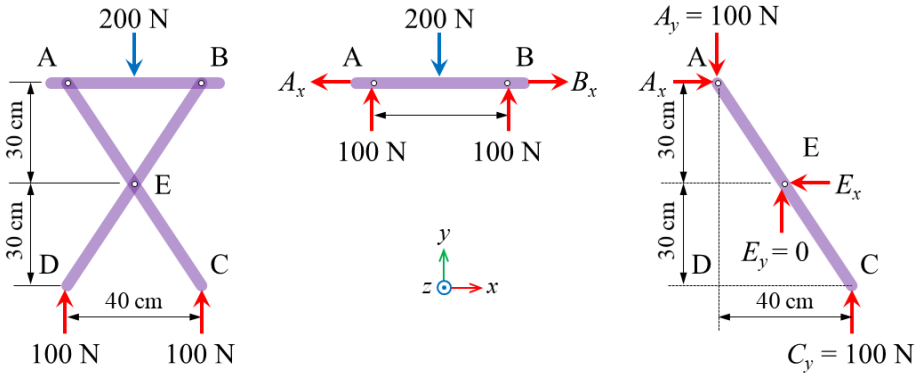
10.13 ※ 문제 수정: [그림 10-43] [길이 : m]

$A_x = 160.7\,\mathrm{N}$, $A_y = 60\,\mathrm{N}$, $C_x = 90\,\mathrm{N}$, $C_y = (90 + 50\sqrt{2})\,\mathrm{N} \approx 160.7\,\mathrm{N}$

10.14



10.15 ※ 문제 수정: …분포된다고 가정했을 때 부재 AC에 대한 자유물체도를 그리고 모든 반력의 크기를 결정하시오.

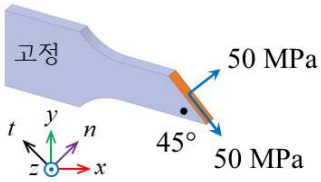


$A_x = E_x = \frac{400}{3}$ N, $A_y = C_y = 100$ N, $E_y = 0$

10.16 $y_{\mathrm{E}} \approx (-)2.60$ mm,

$\sigma_{\mathrm{AB}} = \frac{400}{3}$ MPa ≈ 133.3 MPa (압축), $\sigma_{\mathrm{CD}} = \frac{700}{3}$ MPa ≈ 233.3 MPa (인장)

10.17 $\sigma_{nn} = 50$ MPa, $\tau_{nt} = (-)50$ MPa



10.18 $|\tau_{\max}| = 133.3$

10.19 $\sigma_{xx,\mathrm{A}} = 30$ N/mm^2 $= 30$ MPa

$\sigma_{xx,\mathrm{B}} = (-)30$ MPa

10.20 $v_{\max} \approx 1.3$ mm

10.21 $\tau_{\max} = 40.7$ N/mm^2 $= 40.7$ MPa

CHAPTER 11 | 동역학

11.1 $t = 3\ \mathrm{s}$

11.2 $x_{\max} = 201.3\ \mathrm{m}$

11.3 $T_{\mathrm{A}} = 20\ \mathrm{N},\ T_{\mathrm{B}} = 50\ \mathrm{N}$

11.4 $a = 0.2g$

11.5 $s \approx 67.7\ \mathrm{m}$

11.6 $a \approx 0.287g \approx 2.82\ \mathrm{m/s^2},\ T_1 \approx 238.8\ \mathrm{N}$

11.7 $a \approx 1.415\ \mathrm{m/s^2}\ (+y\ \text{방향}),\ T \approx 11.44g \approx 112.2\ \mathrm{N}$

11.8 $a_{\mathrm{A}} \approx 2.15\ \mathrm{m/s^2},\ a_{\mathrm{B}} = (-)0.24\ \mathrm{m/s^2},\ a_{\mathrm{C}} = 4.54\ \mathrm{m/s^2},\ T \approx 57.4\ \mathrm{N}$

11.9 $P_{\min} \approx 118.1\ \mathrm{N}$

11.10 $t_{\min} \approx 1.7\ \mathrm{s}$

11.11 힘 T는 트레일러를 왼쪽으로 미는 방향으로 작용한다.
$T = 25{,}200\ \mathrm{N} = 25.2\ \mathrm{kN}$

11.12 $\omega_{\mathrm{B}2} \approx 5.8\ \mathrm{rad/s}$

11.13 $h_{\max} \approx 2.55\ \mathrm{m},\ v \approx 7.07\ \mathrm{m/s}$

11.14 $I_{\mathrm{O}} = 38.69\ \mathrm{kg \cdot m^2},\ k_{\mathrm{O}} \approx 2.54\ \mathrm{m}$

11.15 $a_{\mathrm{G}} \approx 0.981\ \mathrm{m/s^2},\ \alpha_{\mathrm{G}} \approx 1.96\ \mathrm{rad/s^2}$

11.16 $\mathbf{v}_{\mathrm{A}} = (-)325\mathbf{i} - 75\sqrt{3}\mathbf{j}\ [\mathrm{mm/s}] \approx (-)325\mathbf{i} - 130\mathbf{j}\ [\mathrm{mm/s}]$

11.17 $s = 0.0725\ \mathrm{m} = 72.5\ \mathrm{mm}$

11.18 $\omega_2 \approx 100.7\,\mathrm{rad/s}$

11.19 $\omega_B = 12.36\,\mathrm{rad/s}$, $\omega_C = 8.92\,\mathrm{rad/s}$

11.20 $\omega_2 \approx 2.914\,\mathrm{rad/s}$

CHAPTER 12 | 진동학

12.1 $f = 54.2\,\mathrm{Hz}$

12.2 $T = 0.02\,\mathrm{s},\ f = 50\,\mathrm{Hz}$

12.3 $k = 8{,}041\,\mathrm{N/m}$

12.4 $c = 2{,}000\,\dfrac{\mathrm{N\cdot s}}{\mathrm{m}}$

12.5 $\delta \approx 21.45\,\mathrm{mm}$

12.6 $k_{\mathrm{eq}} = 5k$

12.7 $m\ddot{x} + kx = 0$

12.8 $ml^2\ddot{\theta} + mgl\sin\theta + kl^2\sin\theta\cos\theta = 0$ 또는 $ml^2\ddot{\theta} + (mgl + kl^2)\theta = 0$

12.9 $k_{\mathrm{eq}} = k_1\left(\dfrac{l_1}{l_0}\right)^2 + k_2\left(\dfrac{l_2}{l_0}\right)^2$

12.10 $\ddot{\theta} + \dfrac{6kl - 3mg}{2ml}\theta = 0$

12.11 $\ddot{y} + \dfrac{2T}{ml}y + g = 0$ 또는 $\ddot{y} + \dfrac{2T}{ml}y = 0$

12.12 $m\ddot{y} + 4ky = F(t)$

12.13 $\ddot{y} + \dfrac{c}{m}\dot{y} + \dfrac{k_1k_2}{4m(k_1+k_2)}y = 0$

12.14 $\begin{bmatrix} m_1 & 0 \\ 0 & m_2 \end{bmatrix}\begin{Bmatrix} \ddot{x}_1 \\ \ddot{x}_2 \end{Bmatrix} + \begin{bmatrix} c & -c \\ -c & c \end{bmatrix}\begin{Bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{Bmatrix} + \begin{bmatrix} 3k & -2k \\ -2k & 5k \end{bmatrix}\begin{Bmatrix} x_1 \\ x_2 \end{Bmatrix} = \begin{Bmatrix} 0 \\ 0 \end{Bmatrix}$

12.15 $\begin{bmatrix} (m_1+m_2)l_1 & m_2l_2 \\ m_2l_1 & m_2l_2 \end{bmatrix}\begin{Bmatrix} \ddot{\theta}_1 \\ \ddot{\theta}_2 \end{Bmatrix} + \begin{bmatrix} (m_1+m_2)g & 0 \\ 0 & m_2g \end{bmatrix}\begin{Bmatrix} \theta_1 \\ \theta_2 \end{Bmatrix} = \begin{Bmatrix} 0 \\ 0 \end{Bmatrix}$

12.16 $$\begin{bmatrix} m_1 & 0 \\ 0 & m_2 \end{bmatrix} \begin{Bmatrix} \ddot{y}_1 \\ \ddot{y}_2 \end{Bmatrix} + T \begin{bmatrix} \frac{1}{l_1} + \frac{1}{l_2} & -\frac{1}{l_2} \\ -\frac{1}{l_2} & \frac{1}{l_2} + \frac{1}{l_3} \end{bmatrix} \begin{Bmatrix} y_1 \\ y_2 \end{Bmatrix} = \begin{Bmatrix} 0 \\ 0 \end{Bmatrix}$$

12.17 $$\begin{bmatrix} m_1 l_1^2 & 0 \\ 0 & m_2 l_2^2 \end{bmatrix} \begin{Bmatrix} \ddot{\theta}_1 \\ \ddot{\theta}_2 \end{Bmatrix} + \begin{bmatrix} ka^2 + m_1 g l_1 & -ka^2 \\ -ka^2 & ka^2 + m_2 g l_2 \end{bmatrix} \begin{Bmatrix} \theta_1 \\ \theta_2 \end{Bmatrix} = \begin{Bmatrix} 0 \\ 0 \end{Bmatrix}$$

12.18 $$\begin{bmatrix} m & 0 \\ 0 & m \end{bmatrix} \begin{Bmatrix} \ddot{x} \\ \ddot{y} \end{Bmatrix} + \begin{bmatrix} c & 0 \\ 0 & 2c \end{bmatrix} \begin{Bmatrix} \dot{x} \\ \dot{y} \end{Bmatrix} + \begin{bmatrix} 5k & 0 \\ 0 & 4k \end{bmatrix} \begin{Bmatrix} x \\ y \end{Bmatrix} = \begin{Bmatrix} F(t) \\ 0 \end{Bmatrix}$$

12.19 $$\begin{bmatrix} m_1 & 0 \\ 0 & m_2 \end{bmatrix} \begin{Bmatrix} \ddot{y}_1 \\ \ddot{y}_2 \end{Bmatrix} + \begin{bmatrix} 2k_1 & -2k_1 \\ -2k_1 & 2k_1 + k_2 \end{bmatrix} \begin{Bmatrix} y_1 \\ y_2 \end{Bmatrix} = \begin{Bmatrix} 0 \\ 0 \end{Bmatrix}$$

12.20 $$\begin{bmatrix} m_1 & 0 \\ 0 & m_2 \end{bmatrix} \begin{Bmatrix} \ddot{y}_1 \\ \ddot{y}_2 \end{Bmatrix} + \begin{bmatrix} 2(c_1 + c_2) & -2c_2 \\ -2c_2 & 2c_2 \end{bmatrix} \begin{Bmatrix} \dot{y}_1 \\ \dot{y}_2 \end{Bmatrix} + \begin{bmatrix} 2(k_1 + k_2) & -2k_2 \\ -2k_2 & 2k_2 \end{bmatrix} \begin{Bmatrix} y_1 \\ y_2 \end{Bmatrix} = \begin{Bmatrix} 0 \\ 0 \end{Bmatrix}$$

12.21 $$\begin{bmatrix} m_1 & 0 & 0 \\ 0 & m_2 & 0 \\ 0 & 0 & m_3 \end{bmatrix} \begin{Bmatrix} \ddot{x}_1 \\ \ddot{x}_2 \\ \ddot{x}_3 \end{Bmatrix} + \begin{bmatrix} k_1 + k_2 + k_4 & -k_2 & -k_4 \\ -k_2 & k_2 + k_3 & -k_3 \\ -k_4 & -k_3 & k_3 + k_4 + k_5 \end{bmatrix} \begin{Bmatrix} x_1 \\ x_2 \\ x_3 \end{Bmatrix} = \begin{Bmatrix} F_1 \\ F_2 \\ F_3 \end{Bmatrix}$$