## 1장 연습문제

1.

$R=\sqrt{{P_1}^2+{P_2}^2+2P_1\cdot P_2\cdot\cos\alpha}$ 로부터 $10=\sqrt{(8)^2+(5)^2+2(8)(5)\cos\alpha}$ 이므로 $\alpha=82.097^\circ$

2.

(1) $R=\sqrt{{P_1}^2+{P_2}^2+2P_1\cdot P_2\cdot\cos\alpha}=\sqrt{(5)^2+(4)^2+2(5)(4)\cos(60°)}=7.81\text{kN}$

(2) $\theta=\tan^{-1}\left(\dfrac{P_2\cdot\sin\alpha}{P_1+P_2\cdot\cos\alpha}\right)=\tan^{-1}\left(\dfrac{(4)\cdot\sin(60^\circ)}{(5)+(4)\cdot\cos(60^\circ)}\right)=26.3295^\circ$

3.

(1) A점의 합력과 B점의 합력이 같아야 한다.

① $R_A=\sqrt{(30)^2+(60)^2+2(30)(60)\cos(30°)}=87.279\text{kN}$

② $R_B=\sqrt{(40)^2+(50)^2+2(40)(50)\cos\theta}=\sqrt{4,100+4,000\cos\theta}$

(2) $R_A=R_B$ : $\sqrt{4,100+4,000\cos\theta}=87.279\text{kN}$ $\therefore\ \theta=28.429°$

4.

경사의 화살표를 수평분력과 수직분력으로 치환하는 것이 주요 포인트이다.

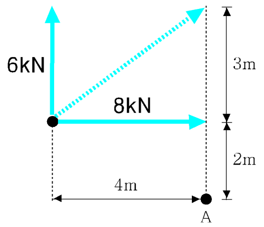
$R=\sqrt{(\Sigma H)^2+(\Sigma V)^2}=\sqrt{(100+200\cos60^\circ)^2+(300+200\sin60^\circ)^2}=513.734\text{kN}$

5. 【정답 부호를 -에서 +로 수정합니다.】

$M_G=+(25)(15)+(30)(30)-(20)(45)+(30)(55)=+2,025\text{kN}\cdot\text{m}(\curvearrowright)$

6.

(1) 역학에서 경사진 힘은 한번에 구할 수 없으므로 반드시 수직(Vertical)과 수평(Horizontal)으로 분력을 구해야만 한다.




$P_H=10\times\dfrac{4}{5}=8\text{kN}$ , $P_V=10\times\dfrac{3}{5}=6\text{kN}$

(2) $M_A=+(8)(2)+(6)(4)=+40\text{kN}\cdot\text{m}\ (\curvearrowright)$

7.

(1) 합력: $R=-(2)+(5)-(1)=+2\text{kN}(\uparrow)$

(2) O점에서 모멘트를 계산한다.

$-(2)(x)=+(2)(4)-(5)(8)+(1)(12)$ $\therefore x=10\text{m}$

8. 【그림수정: 6kN의 화살표를 상향으로 수정합니다.】

(1) 합력: $R = -(8) - (4) + (6) - (10) = -16\text{kN}(\downarrow)$

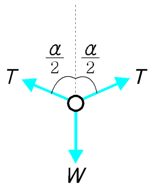
(2) O점에서 모멘트를 계산한다.

$$-(16)(x) = -(8)(9) - (4)(7) + (6)(4) - (10)(2) \qquad \therefore x = 6\text{m}$$

9.

(1) 수직하중이 작용하므로 수직평형조건을 적용한다.

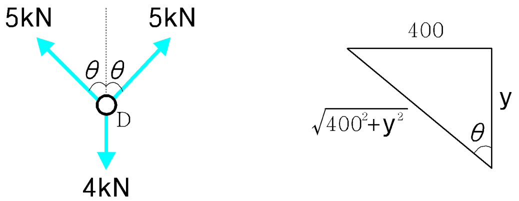
(2)




$$\Sigma V = 0 : -(W) + \left(P \cdot \cos\frac{\alpha}{2}\right) \times 2 = 0 \qquad \therefore P = \frac{W}{2\cos\frac{\alpha}{2}} = \frac{W}{2} \cdot \sec\frac{\alpha}{2}$$

10.

(1) 절점D에서 힘의 수직평형($\Sigma V = 0$) 조건식을 적용한다.




$2(5\cos\theta) = 4$ 이므로 $\cos\theta = \frac{2}{5}$

(2) 직각삼각형에서 $\cos\theta = \frac{y}{\sqrt{400^2 + y^2}}$, 여기에 $\cos\theta = \frac{2}{5}$를 대입하면

$5y = 2\sqrt{400^2 + y^2}$ 에서 $21y^2 = 640000$ $\therefore$ $y = 174.5\text{mm}$

11.

(1) 수평 평형조건($\Sigma H = 0$)을 적용한다. 이때, 구하고자 하는 $P$를 나의 두 눈과 수평으로 일치시키는 것이 포인트다.

(2) $P = P_x \cdot \cos\theta_1 + P_y \cdot \cos\theta_2 = (4)\cos(30°) + (\sqrt{3})\cos(60°) = 4.3\text{kN}$

12.

구조물의 평형조건: $\Sigma H = 0$, $\Sigma V = 0$, $\Sigma M = 0$

(1) $\Sigma H = 0$: 수평하중이 작용하지 않으므로 검토할 필요가 없다.

(2) $\Sigma V = 0$ : $+(10) - (30) + (V_B) = 0$ $\therefore$ $V_B = +20\text{kN}(\uparrow)$

(3) $\Sigma M_A = 0$ : $+(30)(x) - (20)(3) = 0$ $\therefore$ $x = 2\text{m}$

13.

(1) 마찰력은 수직력에 비례하므로 A지점에서의 수직반력 $V_A$ 를 구한다.

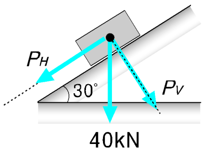
(2) $\Sigma M_B = 0$: $+(10)(30)-(V_A)(10)=0$ $\therefore$ $V_A = +30\text{kN}(\uparrow)$

(3) 수평력 $P$가 수직력 $V_A$ 와 마찰계수 $\mu$의 곱보다 커야 뽑히므로

$\therefore$ $P > V_A \cdot \mu = (30)(0.4) = 12\text{kN}$

14.

(1) $P$는 40kN의 경사방향 분력과 마찰력($F$)을 더한 값보다 커야 한다.




$P_H = 40 \cdot \sin 30° = 20\text{kN}$ , $P_V = 40 \cdot \cos 30° = 34.6\text{kN}$

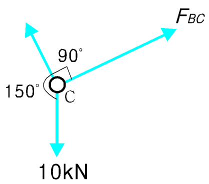
(2) $P > P_H + F = P_H + P_V \cdot \mu$ $= (20)+(34.6)(0.3) = 30.38\text{kN}$

15.

(1) A점에서의 전도(overturn)를 고려하여 회전력을 계산한다.

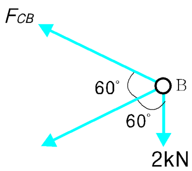
(2) $(P)(7) > (90)(1.2)$ $\therefore P > 15.43\text{kN}$

16.




$\frac{10}{\sin 90°} = \frac{F_{BC}}{\sin 150°}$ $\therefore$ $F_{BC} = +5\text{kN}$(인장)

17.



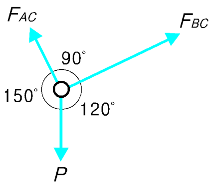

$\frac{2}{\sin 60°} = \frac{F_{CB}}{\sin 60°}$ $\therefore$ $F_{CB} = +2\text{kN}$(인장)

18.

$\frac{10}{\sin 60°} = \frac{F_T}{\sin 180°}$ $\therefore$ $F_T = 0$

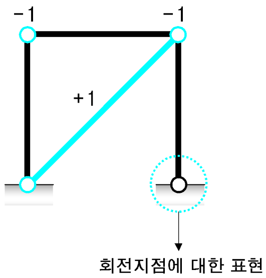
수평력 10kN은 오직 나란한 수평부재로 전달된다는 결과를 잘 관찰해보기 바란다.

19.




$$\frac{P}{\sin 90^\circ} = \frac{F_{AC}}{\sin 120^\circ} = \frac{2}{\sin 150^\circ} \quad \therefore\ F_{AC} = +3.464\text{kN}(\text{인장})$$

20.




(1) $N_e = r - 3 = (2+2) - 3 = 1$

(2) $N_i = (-1) \times 2\text{개} + (+1) \times 1\text{개} = -1$

(3) $N = N_e + N_i = (1) + (-1) = 0$(정정)

(4) 수평하중이나 수직하중에 대해 대각가새(Brace)가 저항할 것이므로 정정이면서 안정한 구조이다.

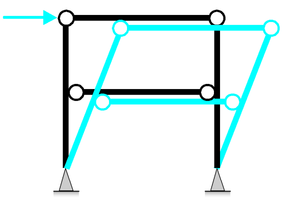
21.

(1) $N_e = r - 3 = (3+3) - 3 = 3$

(2) $N_i = (-1) \times 2\text{개} + (+2) \times 1\text{개} = -0$

(3) $N = N_e + N_i = (3) + (0) = 3$차 부정정

22.



부정정 차수를 계산하면 0이지만 수평하중이 작용하게 되면 과도한 절점 변형을 수반하게 되는 불안정 구조이다.

23.

(1) $N_e = r - 3 = (3+3) - 3 = 3$

(2) $N_i = (-1) \times 1\text{개} = -1$

(3) $N = N_e + N_i = (3) + (-1) = 2$차 부정정

24.

(1) $N_e = r - 3 = (2+2) - 3 = 1$

(2) $N_i = (+3) \times 1$개 $= 3$

(3) $N = N_e + N_i = (1) + (3) = 4$차 부정정

25.

(1) $N_e = r - 3 = (3+3+3) - 3 = 6$

(2) $N_i = (+3) \times 2$개 $= 6$

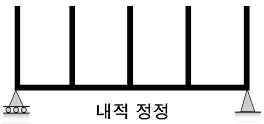
(3) $N = N_e + N_i = (6) + (6) = 12$차 부정정

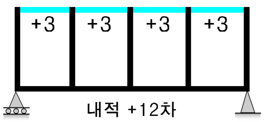
26.

비렌딜 트러스(Vierendeel Truss)

(1) $N_e = r - 3 = (2+1) - 3 = 0$

(2) $N_i = (+3) \times 4 = 12$



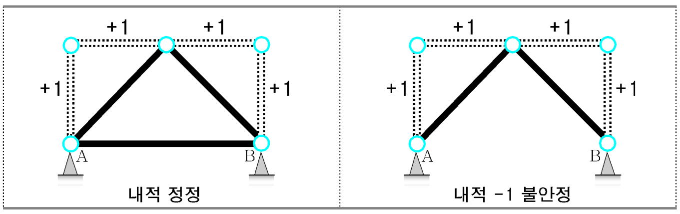




(3) $N = N_e + N_i = (0) + (12) = 12$차 부정정

27.

(1) $N_e = r - 3 = (2+2) - 3 = 1$

(2) $N_i = (+1) \times -1$개 $= -1$(AB 사이에 하나의 +1부재가 하나 부족하다.)

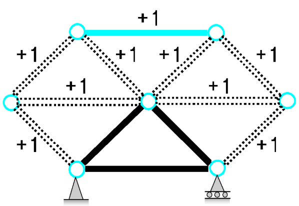



(3) $N = N_e + N_i = (1) + (-1) = 0$(정정, 안정)

28.

(1) $N_e = r - 3 = (2+1) - 3 = 0$

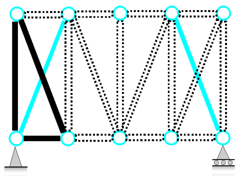
(2) $N_i = (+1) \times 1$개 $= +1$



(3) $N = N_e + N_i = (0) + (1) = 1$차 부정정

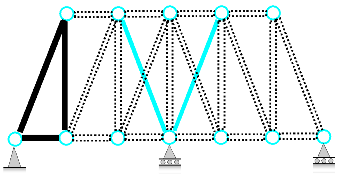
29.
(1) $N_e = r - 3 = (2+1+2) - 3 = 2$
(2) $N_i = 0$
(3) $N = N_e + N_i = (2) + (0) = 2$차 부정정

30.
(1) $N_e = r - 3 = (2+1) - 3 = 0$
(2) $N_i = (+1) \times 2$개 $= 2$



(3) $N = N_e + N_i = (0) + (2) = 2$차 부정정

31.
(1) $N_e = r - 3 = (2+1+1) - 3 = 1$
(2) $N_i = (+1) \times 2$개 $= 2$



(3) $N = N_e + N_i = (1) + (2) = 3$차 부정정

32.
세 번째 격간(Panel)이 사각형이므로 부정정 차수의 계산이 의미 없으며 형태불안정 구조이다.

## 2장 연습문제

1.

$\Sigma M_A = 0 : \ +(9)(x)-(6)(9)=0 \qquad \therefore \ x = 6\text{m}$

2.

(1) $\Sigma M_A = 0 : \ +(40)(3)+(60)(7)-(V_B)(10)=0 \qquad \therefore \ V_B = +54\text{kN}(\uparrow)$

(2) $R_B = V_B = +54\text{kN}(\uparrow)$

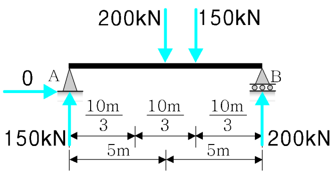
3.

(1) $\Sigma H = 0 : \ H_A = 0$

(2) 사다리꼴 분포하중을 20kN/m 높이의 직사각형 분포하중과 30kN/m 높이의 삼각형 분포하중으로 나누어 계산하면 편리하다.

$\Sigma M_A = 0 : +(20\times10)(5)+\left(\frac{1}{2}\times30\times10\right)\left(\frac{20}{3}\right)-(V_B)(10)=0 \qquad \therefore \ V_B = 200\text{kN}(\uparrow)$

(3) $R_B = V_B = +200\text{kN}(\uparrow)$

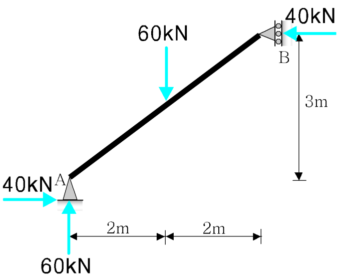



4.

(1) $\Sigma V = 0 : +(V_A)-(60)=0 \qquad \therefore \ V_A = +60\text{kN}(\uparrow)$

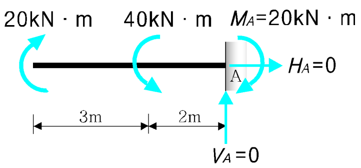
(2) $\Sigma M_A = 0 : \ +(60)(2)+(H_B)(3)=0 \qquad \therefore \ H_B = -40\text{kN}(\leftarrow)$

(3) $R_B = H_B = -40\text{kN}(\leftarrow)$




5.

$\Sigma V = 0 : \ V_A = 0$ ☞ 수직하중이 없으므로 수직반력도 없다.




6.

$\Sigma M_A = 0 \ : \ +(12)-\left(\frac{1}{2}\times3\times2\right)(4)+(M_A)=0 \qquad \therefore \ M_A = 0$

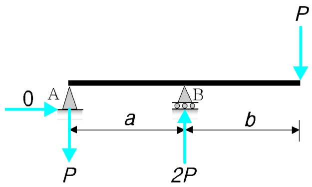
7.

(1) $\Sigma M_A = 0 \ :+\left(\frac{1}{2}\times 9\times 12\right)(3)-(V_B)(6)=0 \qquad \therefore \ V_B = +27\text{kN}(\uparrow)$

(2) $R_B = V_B = +27\text{kN}(\uparrow)$

8.

$\Sigma M_A = 0$: $-(2P)(a)+(P)(a+b)=0$ 에서 $a=b$ 이므로 $\frac{b}{a}=1$

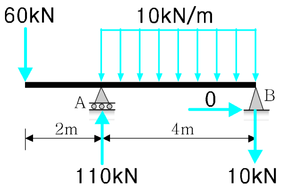



9.

(1) $\Sigma H = 0$ : $\therefore \ H_B = 0$

(2) $\Sigma M_A = 0$: $-(60)(2)+(10\times 4)(2)-(V_B)(4)=0 \qquad \therefore \ V_B = -10\text{kN}(\downarrow)$

(3) $R_B = \sqrt{V_B^2 + H_B^2} = V_B = -10\text{kN}(\downarrow)$




10.

(1) $\Sigma M_A = 0$: $-(20\times 3)(1.5)+(P)(3)-(V_c)(8)=0$

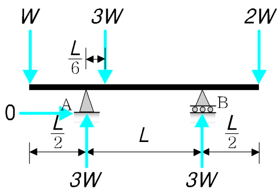
(2) $R_C = V_C$이며, 문제의 조건에서 0이라고 하였으므로 $\therefore \ P = 30\text{kN}$

11.

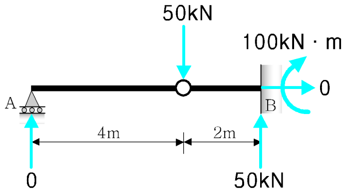
(1) $\Sigma M_A = 0$ : $-(W)\left(\frac{L}{2}\right)+(3W)(x)-(V_B)(L)+(2W)\left(\frac{3L}{2}\right)=0$

(2) $R_B = V_B$ 이며, 문제의 조건에서 $3W$라고 하였으므로

$-\frac{WL}{2}+3W\cdot x-3WL+3WL=0 \qquad \therefore \ x=\frac{L}{6}$



12.
힌지를 h점이라고 하면 Ah구간에 하중이 작용하지 않으므로 A지점의 반력은 존재하지 않는다.



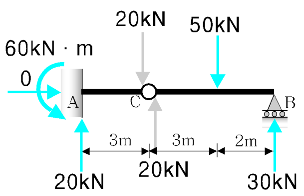

13.

(1) CB구간: $V_C = +50 \times \frac{2}{5} = +20\text{kN}(\uparrow)$

(2) C점은 지점이 아니므로 AC구간의 C점에 하향의 20kN으로 치환한다.

(3) AC구간:

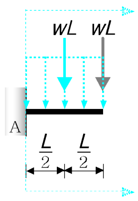
$\Sigma M_A = 0$ : $+(M_A) + (20)(3) = 0$ ∴ $M_A = -60\text{kN} \cdot \text{m}(\curvearrowleft)$




14.

(1) 힌지절점을 C라고 하면, CB구간: $V_C = +wL(\uparrow)$

(2) C점은 지점이 아니므로 AC구간의 C점에 하향의 $wL$로 치환한다.




(3) AC구간:

$\Sigma M_A = 0$ : $+(M_A) + (w \cdot L)\left(\frac{L}{2}\right) + (w)(L) = 0$ ∴ $M_A = -\frac{3}{2}wL^2(\curvearrowleft)$

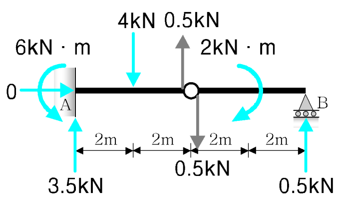
15.

(1) 힌지절점을 C라고 하면, CB구간: $V_C = -\frac{2}{4} = -0.5\text{kN}(\downarrow)$

(2) C점은 지점이 아니므로 AC구간의 C점에 상향의 0.5kN으로 치환한다.

(3) AC구간:

$\Sigma M_A = 0$ : $+(M_A) + (4)(2) - (0.5)(4) = 0$ ∴ $M_A = -6\text{kN} \cdot \text{m}(\curvearrowleft)$



16.

(1) DC구간: $V_C=+\frac{30\times6}{2}=+90\text{kN}(\uparrow)$

(2) D점은 지점이 아니므로 ABD구간의 D점에 하향의 90kN으로 치환한다.

(3) ABD구간:

$\Sigma M_B=0$ : $+(V_A)(6)-(40)(3)+(90)(3)=0$ $\therefore$ $V_A=-25\text{kN}(\downarrow)$

17.

(1) 해석을 위한 EF 단순보 구간: $V_E=+(10)+\frac{(100)}{2}=+60\text{kN}(\uparrow)$, $V_F=+\frac{(100)}{2}=+50\text{kN}(\uparrow)$

(2) E점은 지점이 아니기 때문에 반력이 존재할 수 없으므로 $V_E$를 $60\text{kN}(\downarrow)$의 하중으로 다시 작용시켜 ABE 내민보를 해석한다.

(3) F점은 지점이 아니기 때문에 반력이 존재할 수 없으므로 $V_F$를 $50\text{kN}(\downarrow)$의 하중으로 다시 작용시켜 FCD 내민보를 해석한다.

(4) ABE 내민보 구간:

$\Sigma M_B=0$ : $+(V_A)(3)+(60)(1)=0$ $\therefore V_A=-20\text{kN}(\downarrow)$

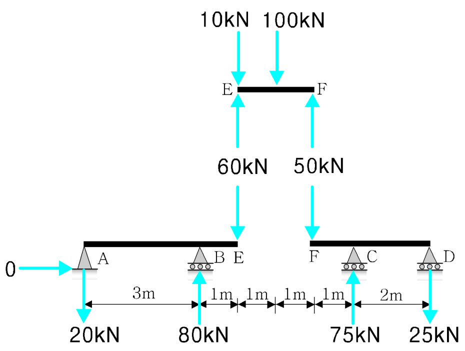
$\Sigma V=0$ : $+(V_A)+(V_B)-(60)=0$ $\therefore V_B=+80\text{kN}(\uparrow)$

(5) FCD 내민보 구간:

$\Sigma M_C=0$ : $-(50)(1)-(V_D)(2)=0$ $\therefore V_D=-25\text{kN}(\downarrow)$

$\Sigma V=0$ : $+(V_C)+(V_D)-(50)=0$ $\therefore V_C=+75\text{kN}(\uparrow)$

(6) B지점의 반력이 최대임을 알 수 있다.




18.

(1) $\Sigma M_A=0$ : $+(6)(8)-(V_C)(12)=0$ $\therefore V_C=+4\text{kN}(\uparrow)$

(2) $V_C=4\text{kN}$을 하향의 수직하중으로 C절점에 치환하면, CB 부재에는 축방향으로 $5\text{kN}$이 작용하는 것이므로 B점의 반력 $R_B$는 $5\text{kN}$이 된다.

19.

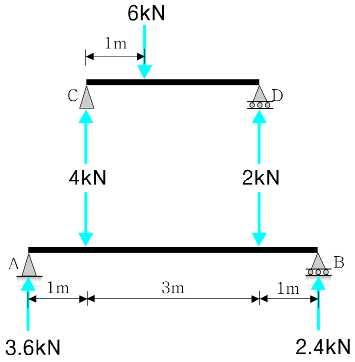
(1) AB보 위에 CD보가 얹혀 있으므로 CD 보를 먼저 해석한다.

(2) $\Sigma M_D = 0$ : $+(V_C)(3) - (6)(2) = 0$ ∴ $V_C = +4\text{kN}(\uparrow)$

(3) $\Sigma V = 0$ : $+(V_C) + (V_D) - (6) = 0$ ∴ $V_D = +2\text{kN}(\uparrow)$

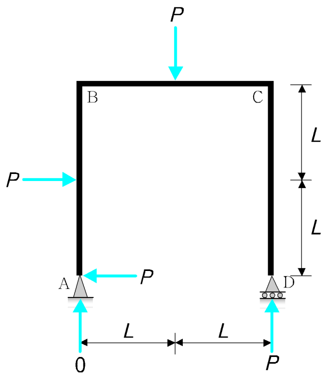
(4) $V_B$와 $V_D$를 AE보 위에 하중으로 치환시켜서 A점의 수직반력을 구한다.

$\Sigma M_B = 0$ : $+(V_A)(5) - (4)(4) - (2)(1) = 0$ ∴ $V_A = +3.6\text{kN}(\uparrow)$



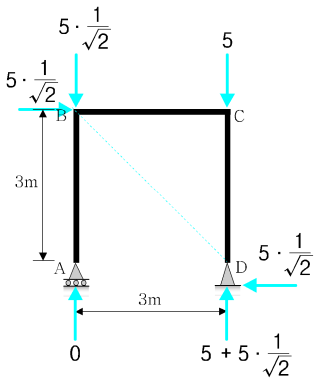

20.

$\Sigma M_A = 0$: $-(V_D)(2L) + (P)(L) + (P)(L) = 0$ ∴ $V_D = +P(\uparrow)$




21.

5kN의 경사하중에 대한 수평분력 $5\text{kN} \times \frac{1}{\sqrt{2}} = 3.535\text{kN}$이 회전지점 D에서 좌향으로 작용되어야 한다.

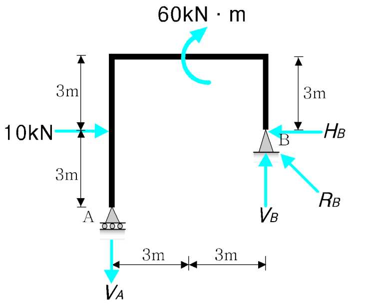


22.

(1) $\Sigma H = 0$ : $+(10)+(H_B)=0$ $\therefore$ $H_B = -10\text{kN}(\leftarrow)$

(2) $\Sigma M_A = 0$ : $+(10)(3)+(60)-(10)(3)-(V_B)(6)=0$ $\therefore$ $V_B = +10\text{kN}(\uparrow)$

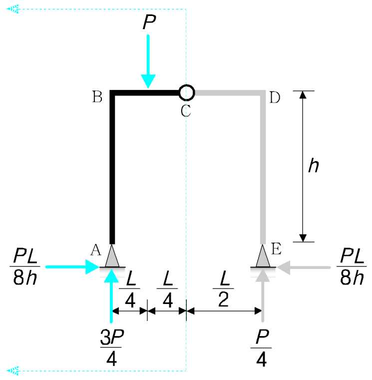
(3) $R_B = \sqrt{V_B^2 + H_B^2} = \sqrt{(10)^2+(10)^2} = +14.142\text{kN}(\nwarrow)$




23.

(1) $\Sigma M_B = 0$ : $+(V_A)(L)-(P)\left(\frac{3L}{4}\right)=0$ $\therefore$ $V_A = +\frac{3P}{4}(\uparrow)$

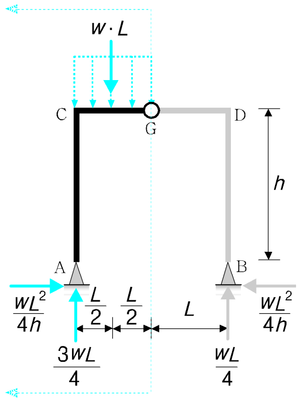
(2) $\Sigma M_{C,Left} = 0$ : $+\left(\frac{3P}{4}\right)\left(\frac{L}{2}\right)-(H_A)(h)-(P)\left(\frac{L}{4}\right)=0$ $\therefore$ $H_A = +\frac{PL}{8h}(\rightarrow)$




24.

(1) $\Sigma M_B = 0$ : $+(V_A)(2L)-(w\cdot L)\left(\frac{3L}{2}\right)=0$ $\therefore$ $V_A = +\frac{3wL}{4}(\uparrow)$

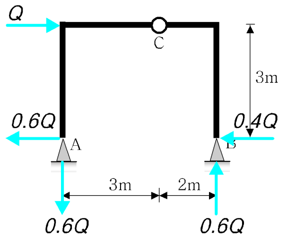
(2) $\Sigma M_{G,Left} = 0$ : $+\left(\frac{3wL}{4}\right)(L)-(H_A)(h)-(w\cdot L)\left(\frac{L}{2}\right)=0$ $\therefore$ $H_A = +\frac{wL^2}{4h}(\rightarrow)$



25.

(1) $\Sigma M_B = 0$ : $+(V_A)(5)+(Q)(3)=0$ $\therefore V_A = -0.6Q(\downarrow)$

(2) $\Sigma M_{C,Left} = 0$ : $+(V_A)(3)-(H_A)(3)=0$ $\therefore H_A = -0.6Q\,(\leftarrow)$

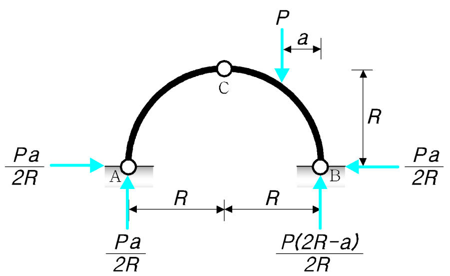



26.

(1) $\Sigma M_B = 0$: $+(V_A)(2R)-(P)(a)=0$ $\therefore V_A = +\dfrac{Pa}{2R}(\uparrow)$

(2) $\Sigma M_{C,Left} = 0$: $+\left(\dfrac{Pa}{2R}\right)(R)-(H_A)(R)=0$ $\therefore H_A = +\dfrac{Pa}{2R}(\rightarrow)$

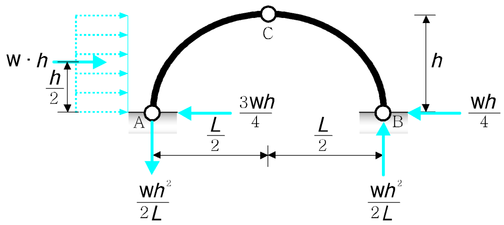
(3) $\Sigma H = 0$: $+(H_A)+(H_B)=0$ 이므로 $\therefore H_B = -\dfrac{Pa}{2R}(\leftarrow)$




27.

(1) $\Sigma M_A = 0$: $+(w\cdot h)\left(\dfrac{h}{2}\right)-(V_B)(L)=0$ $\therefore V_B = +\dfrac{wh^2}{2L}(\uparrow)$

(2) $\Sigma M_{C,Right} = 0$: $-\left(\dfrac{wh^2}{2L}\right)\left(\dfrac{L}{2}\right)-(H_B)(h)=0$ $\therefore H_B = -\dfrac{wh}{4}(\leftarrow)$

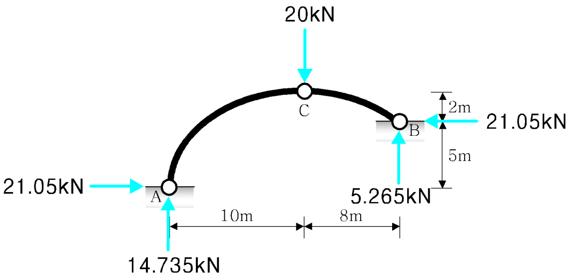


28.

(1) $\Sigma M_B = 0$ : $+(V_A)(18) - (H_A)(5) - (20)(8) = 0$ 에서 $18V_A - 5H_A = 160$ ... ①

(2) $\Sigma M_{C,Left} = 0$ : $+(V_A)(10) - (H_A)(7) = 0$ ... ②

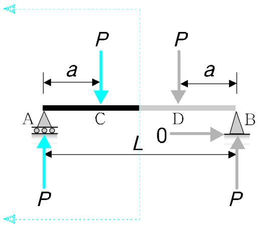
(3) ①, ② 두 식을 연립하면 $H_A = +21.05\text{kN}(\rightarrow)$




29.

(1) 하중이 좌우 대칭이므로 $V_A = V_B = +P(\uparrow)$

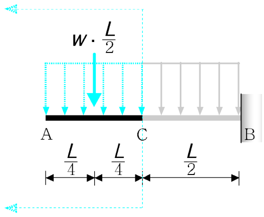
(2) $V_{CD,Left} = +[+(V_A) - (P)] = +[+(P) - (P)] = 0$




30.

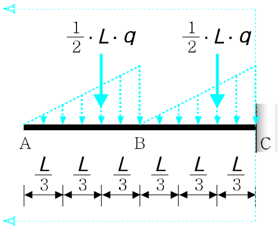
(1) 캔틸레버 구조이므로 AC부재를 수직절단하여 자유단쪽을 계산하면 지점반력을 구할 필요가 없다.

(2) $V_{C,Left} = +[-\left(w \cdot \frac{L}{2}\right)] = -\frac{wL}{2}(\downarrow\uparrow)$




31.

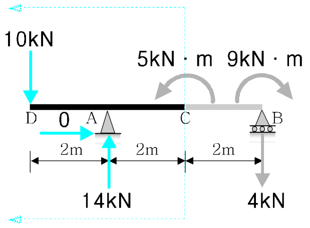
$V_{C,Left} = +[-\left(\frac{1}{2} \cdot L \cdot q\right) - \left(\frac{1}{2} \cdot L \cdot q\right)] = -qL(\downarrow\uparrow)$



32.

(1) $\Sigma M_B=0$: $-(10)(6)+(V_A)(4)-(5)+(9)=0$ ∴ $V_A=+14\text{kN}(\uparrow)$

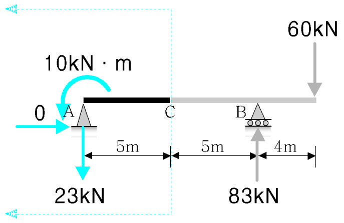
(2) $V_{C,Left}=+[-(10)+(14)]=+4\text{kN}(\uparrow\downarrow)$




33.

(1) $\Sigma M_B=0$ :$+(V_A)(10)-(10)+(60)(4)=0$ ∴ $V_A=-23\text{kN}(\downarrow)$

(2) $V_{C,Left}=+[-(23)]=-23\text{kN}(\downarrow\uparrow)$

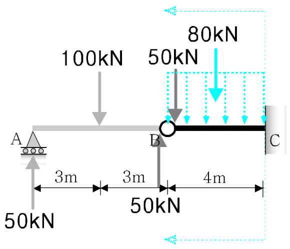



34.

(1) AB구간: $V_A=+50\text{kN}(\uparrow)$, $V_B=+50\text{kN}(\uparrow)$

(2) B점은 지점이 아니기 때문에 반력이 존재할 수 없으므로 $V_B$를 $50\text{kN}(\downarrow)$의 하중으로 다시 작용시킨다.

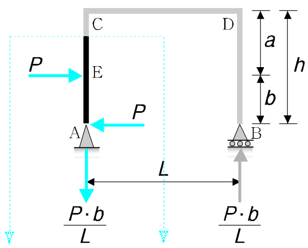
(3) BC구간: $V_{C,Left}=+[-(50)-(20\times4)]=-130\text{kN}(\downarrow\uparrow)$




35.

(1) $\Sigma H=0$: $+(H_A)+(P)=0$ ∴ $H_A=-P(\leftarrow)$

(2) $V_{EC,Left}=+[+(P)-(P)]=0$

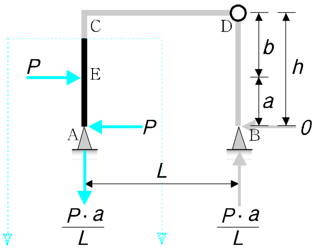


36.

(1) $\Sigma M_B = 0$: $+(V_A)(L)+(P)(a)=0$ $\quad \therefore\ V_A = -\dfrac{Pa}{L}(\downarrow) \Rightarrow V_B = +\dfrac{Pa}{L}(\uparrow)$

(2) $\Sigma M_{D,Right} = 0$: $-[-(H_B)(h)]=0$ $\quad \therefore\ H_B = 0 \Rightarrow H_A = -P(\leftarrow)$

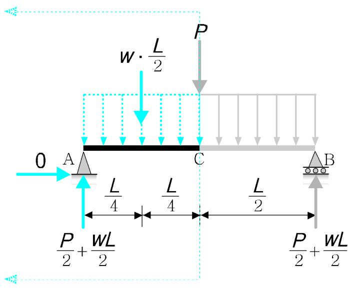
(3) $V_{EC,Left} = +[+(P)-(P)] = 0$




37.

(1) $\Sigma M_B = 0$ : $+(V_A)(L)-(P)\left(\dfrac{L}{2}\right)-(w \cdot L)\left(\dfrac{L}{2}\right)=0$ $\quad \therefore\ V_A = +\dfrac{P}{2}+\dfrac{wL}{2}(\uparrow)$

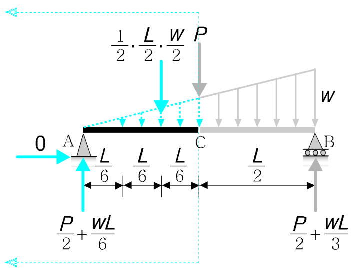
(2) $M_{C,Left} = +\left[+\left(\dfrac{P}{2}+\dfrac{wL}{2}\right)\left(\dfrac{L}{2}\right)-\left(w \cdot \dfrac{L}{2}\right)\left(\dfrac{L}{4}\right)\right] = +\dfrac{PL}{4}+\dfrac{wL^2}{8}(\smile)$




38.

(1) $\Sigma M_B = 0$ : $+(V_A)(L)-(P)\left(\dfrac{L}{2}\right)-\left(\dfrac{1}{2}\cdot L \cdot w\right)\left(\dfrac{L}{3}\right)=0$ $\quad \therefore\ V_A = +\dfrac{P}{2}+\dfrac{wL}{6}(\uparrow)$

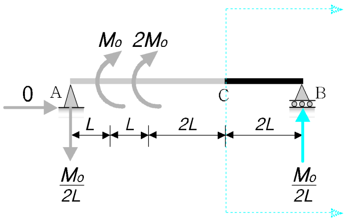
(2) $M_{C,Left} = +[+\left(\dfrac{P}{2}+\dfrac{wL}{6}\right)\left(\dfrac{L}{2}\right)-\left(\dfrac{1}{2}\cdot\dfrac{L}{2}\cdot\dfrac{w}{2}\right)\left(\dfrac{L}{6}\right)] = +\dfrac{PL}{4}+\dfrac{wL^2}{16}(\smile)$



39.

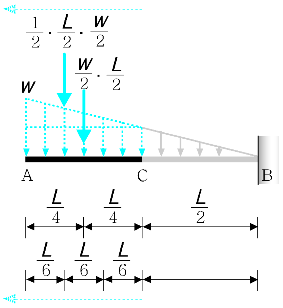
(1) $\Sigma M_A = 0 : +(M_o)+(2M_o)-(V_B)(6L)=0 \qquad \therefore \ V_B = +\frac{M_o}{2L}(\uparrow)$

(2) $M_{C,Right} = -\left[-\left(\frac{M_o}{2L}\right)(2L)\right] = +M_o(\smile)$



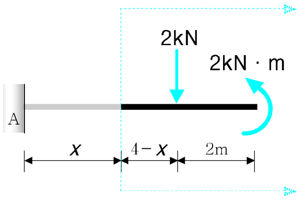

40.

$M_{C,Left} = +[-\left(\frac{w}{2}\cdot\frac{L}{2}\right)\left(\frac{L}{4}\right)-\left(\frac{1}{2}\cdot\frac{L}{2}\cdot\frac{w}{2}\right)\left(\frac{2L}{6}\right)] = -\frac{5wL^2}{48}(\frown)$




41.

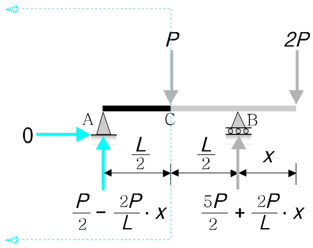
A점으로부터 휨모멘트가 0이 되는 위치까지의 거리를 $x$ 라고 하면 $M_{A,Right} = -[+(2)(4-x)-(2)]=0$ 에서 $x=3\text{m}$




42.

(1) $\Sigma M_B = 0 : \ +(V_A)(L)-(P)\left(\frac{L}{2}\right)+(2P)(x)=0 \qquad \therefore \ V_A = +\frac{P}{2}-\frac{2P}{L}\cdot x(\uparrow)$

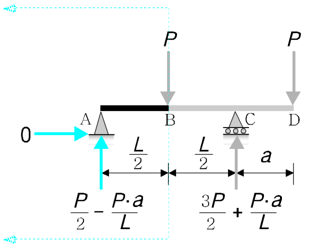
(2) $M_{C,Left} = +[+\left(\frac{P}{2}-\frac{2P}{L}\cdot x\right)\left(\frac{L}{2}\right)]=0$ 이라는 조건에서 $\frac{P}{2}-\frac{2P}{L}\cdot x=0$ 이므로 $x=\frac{L}{4}$



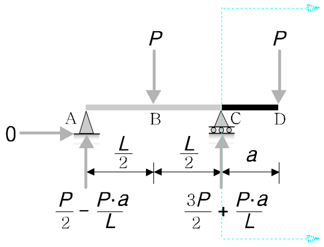
43.

(1) $\Sigma M_C = 0$: $+(V_A)(L) - (P)\left(\frac{L}{2}\right) + (P)(a) = 0$ $\quad\therefore\ V_A = +\frac{P}{2} - \frac{Pa}{L}(\uparrow)$

(2) B점의 휨모멘트: $M_{B,Left} = +[+\left(\frac{P}{2} - \frac{Pa}{L}\right)\left(\frac{L}{2}\right)] = +\frac{PL}{4} - \frac{Pa}{2}$




(3) C점의 휨모멘트: $M_{C,Right} = -[+(P)(a)] = -Pa$



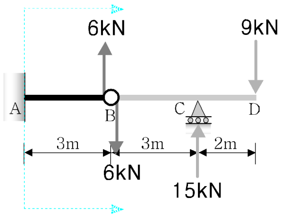

(4) B점의 휨모멘트와 C점의 휨모멘트의 절대값의 크기가 같다는 조건에 의해 $|M_B| = |M_C|$ 에서 $\frac{PL}{4} - \frac{Pa}{2} = Pa$ 이므로 $\quad\therefore\ \frac{L}{a} = 6$

44.

(1) BCD 내민보: $\Sigma M_C = 0$: $+(V_B)(3) + (9)(2) = 0$ $\quad\therefore\ V_B = -6\text{kN}(\downarrow)$

(2) C점은 지점이 아니므로 6kN의 반력을 하중(↑)으로 치환한다.

(3) AB 캔틸레버보: $M_{A,Right} = -[-(6)(3)] = +18\text{kN}\cdot\text{m}(\smile)$

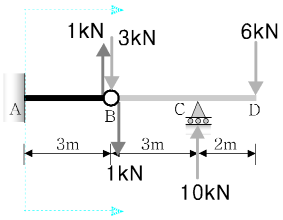



45.

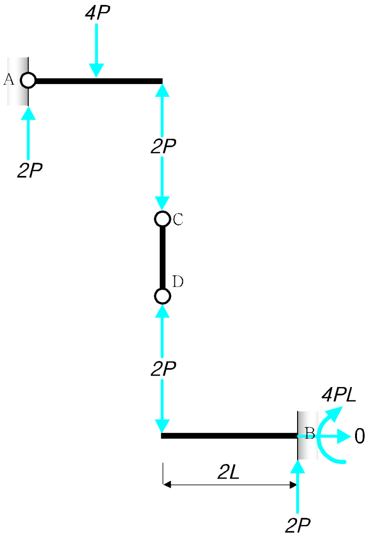
(1) BCD 내민보: $\Sigma M_C = 0$: $+(V_B)(3) - (3)(3) + (6)(2) = 0$ $\quad\therefore\ V_B = -1\text{kN}(\downarrow)$

(2) B점은 지점이 아니므로 1kN의 반력을 하중(↑)으로 치환한다.

(3) AB 캔틸레버보: $M_{A,Right} = -[-(1)(3)] = +3\text{kN}\cdot\text{m}(\smile)$



46. 다음과 같은 힘의 흐름을 잘 관찰해 보도록 한다.

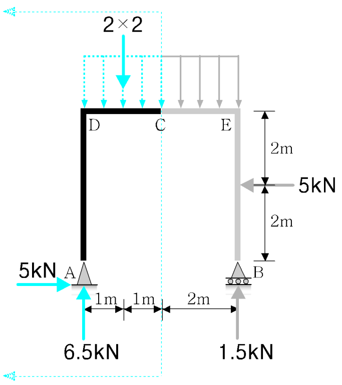



47.

(1) $\Sigma H=0$: $H_A=+5\text{kN}(\rightarrow)$

(2) $\Sigma M_B=0$: $+(V_A)(4)-(2\times4)(2)-(5)(2)=0$ $\quad\therefore\ V_A=+6.5\text{kN}(\uparrow)$

(3) $M_{C,Left}=+[+(6.5)(2)-(5)(4)-(2\times2)(1)]=-11\text{kN}\cdot\text{m}(\frown)$

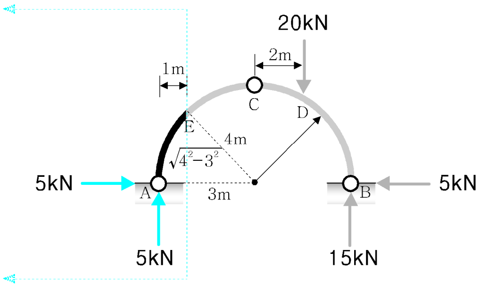



48.

(1) $\Sigma M_B=0$: $+(V_A)(8)-(20)(2)=0$ $\quad\therefore\ V_A=+5\text{kN}(\uparrow)$

(2) $\Sigma M_{C,Left}=0$: $+(V_A)(4)-(H_A)(4)=0$ $\quad\therefore\ H_A=+5\text{kN}(\rightarrow)$

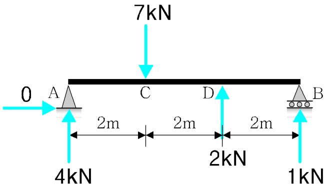
(3) $M_{E,Left}=+[+(5)(1)-(5)(\sqrt{4^2-3^2})]=-8.23\text{kN}\cdot\text{m}(\frown)$



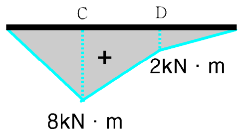
49.

(1) $\Sigma M_B = 0$: $+(V_A)(6)-(7)(4)+(2)(2)=0$ $\quad \therefore\ V_A = +4\text{kN}(\uparrow)$ $\quad \Rightarrow \quad \therefore\ V_B = +1\text{kN}(\uparrow)$

(2) 하중과 지점반력, 휨모멘트도(BMD)

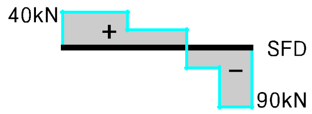
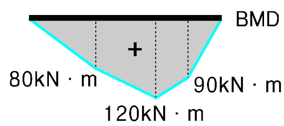



하중과 지점반력

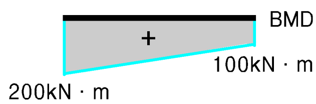



개략적인 휨모멘트도

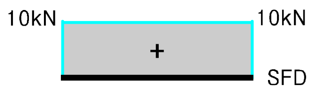
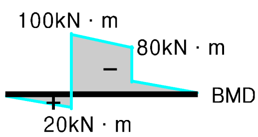
50.

| 전단력도(SFD) | 휨모멘트도(BMD) |
|---|---|
|  |  |

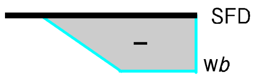
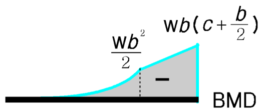
51.

| 전단력도(SFD) | 휨모멘트도(BMD) |
|---|---|
|  |  |

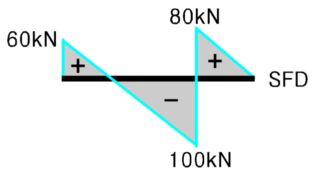
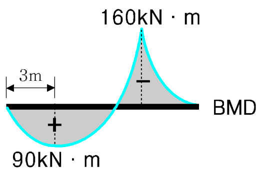
52.

| 전단력도(SFD) | 휨모멘트도(BMD) |
|---|---|
|  |  |

53.

| 전단력도(SFD) | 휨모멘트도(BMD) |
| --- | --- |
|  |  |

54.

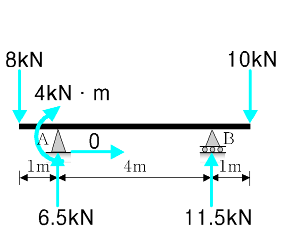
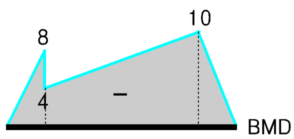
| 전단력도(SFD) | 휨모멘트도(BMD) |
| --- | --- |
|  |  |

55.

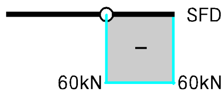
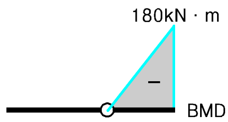
(1) $\Sigma M_B=0$ : $-(8)(5)+(4)+(V_A)(4)+(10)(1)=0$ ∴ $V_A=+6.5\text{kN}(\uparrow)$

(2) $\Sigma V=0$ : $+(V_A)+(V_B)-(8)-(10)=0$ ∴ $V_B=+11.5\text{kN}(\uparrow)$

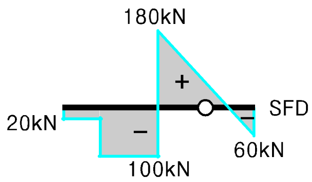
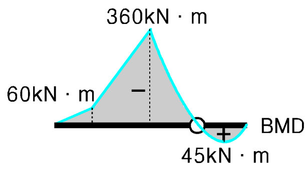
(3) $M_{max}=M_B=-10\text{kN}\cdot\text{m}(\frown)$

| 하중과 지점반력 | 개략적인 휨모멘트도(BMD) |
| --- | --- |
|  |  |

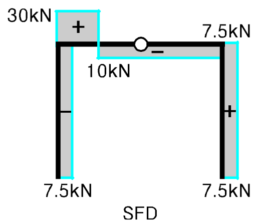
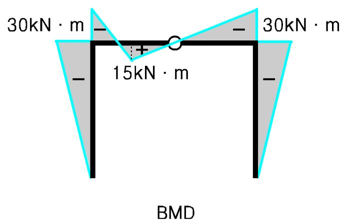
56.

| 전단력도(SFD) | 휨모멘트도(BMD) |
| --- | --- |
|  |  |

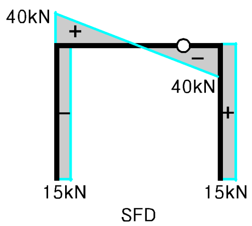
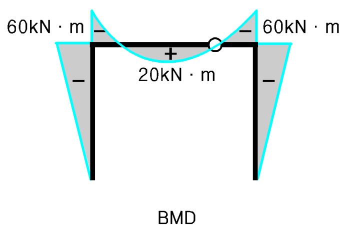
57.

| 전단력도(SFD) | 휨모멘트도(BMD) |
|---|---|
|  |  |

58.

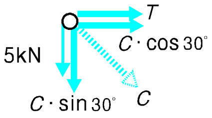
| 전단력도(SFD) | 휨모멘트도(BMD) |
|---|---|
|  |  |

59.

| 전단력도(SFD) | 휨모멘트도(BMD) |
|---|---|
|  |  |

## 3장 연습문제

1.



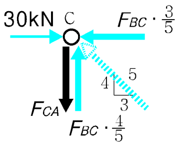

(1) $\Sigma V=0$: $-(5)-(F_C \cdot \sin 30^\circ)=0$ $\therefore F_C=-10\text{kN}$(압축)

(2) $\Sigma H=0$: $+(F_T)+(F_C \cdot \cos 30^\circ)=0$ $\therefore F_T=+8.66\text{kN}$(인장)

2.

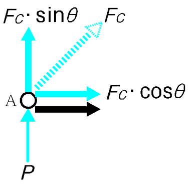
(1) 하중 30kN이 작용하는 절점에서 $\Sigma H=0$ 조건을 적용한다.

(2) 절점 C




$\Sigma H=0$: $+(30)+\left(F_{BC} \cdot \frac{3}{5}\right)=0$ $\therefore F_{BC}=-50\text{kN}$(압축)

3.




(1) 하중과 경간이 좌우 대칭이므로 $\therefore V_A=+P(\uparrow)$

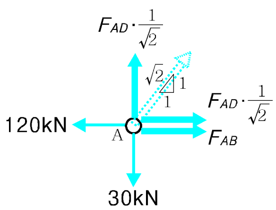
(2) 절점A: $+(P)+(F_C \cdot \sin\theta)=0$ $\therefore F_C=-\dfrac{P}{\sin\theta}=-P \cdot \text{cosec}\theta$

4.

(1) $\Sigma H=0$: $+(H_A)+(120)=0$ $\therefore H_A=-120\text{kN}(\leftarrow)$

(2) $\Sigma M_C=0$: $+(V_A)(10)+(120)(5)-(60)(5)=0$ $\therefore V_A=-30\text{kN}(\downarrow)$

(3) 절점A에서 절점법을 적용



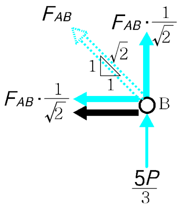

① $\Sigma V=0$: $-(30)+\left(F_{AD} \cdot \frac{1}{\sqrt{2}}\right)=0$ $\therefore F_{AD}=+30\sqrt{2}\text{kN}$ (인장)

② $\Sigma H=0$: $-(120)+\left(F_{AD} \cdot \frac{1}{\sqrt{2}}\right)+(F_{AB})=0$ $\therefore F_{AB}=+90\text{kN}$ (인장)

5.

(1) $\Sigma M_A = 0$ : $+(P)(4)+(2P)(8)-(V_B)(12)=0$ $\therefore V_B = +\frac{5P}{3}(\uparrow)$

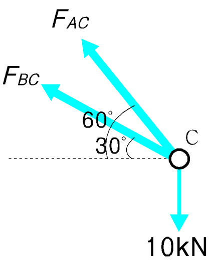
(2) 절점B




$\Sigma V = 0 : +\left(\frac{5P}{3}\right)+\left(F_{AB}\cdot\frac{1}{\sqrt{2}}\right)=0$ $\therefore F_{AB} = -\frac{5\sqrt{2}}{3}P = -2.357P$ (압축)

6.

(1) 절점 C에서 절점법을 적용



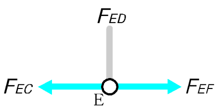

① $\Sigma V = 0$: $-(10)+(F_{AC}\cdot\sin 60^\circ)+(F_{BC}\cdot\sin 30^\circ)=0$

② $\Sigma H = 0$: $-(F_{AC}\cdot\cos 60^\circ)-(F_{BC}\cdot\cos 30^\circ)=0$

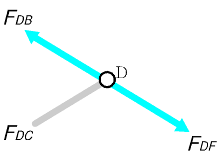
(2) ①, ② 두 식을 연립하면 $F_{AC} = +10\sqrt{3}$ kN (인장), $F_{BC} = -10$ kN (압축)

7.

(1) 3개의 부재가 모이는 E절점에 외력이 작용하지 않는 경우이므로 CE부재, EF부재의 부재력은 서로 같고 DE부재의 부재력은 0이다.

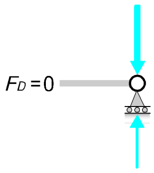



(2) D절점에서 DE부재력은 0이므로 CD부재력은 0이 된다.

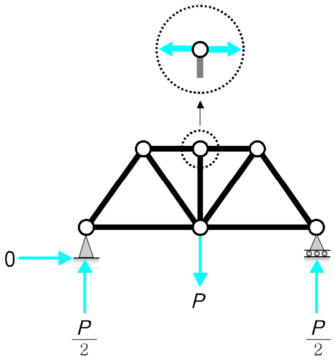


8.

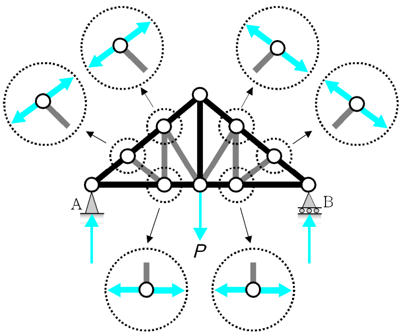
이동지점에서는 수직반력만 발생하고 수평반력은 없으므로 D부재는 0이다.



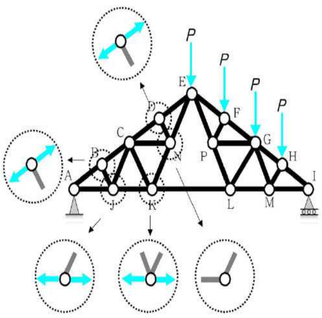

9.



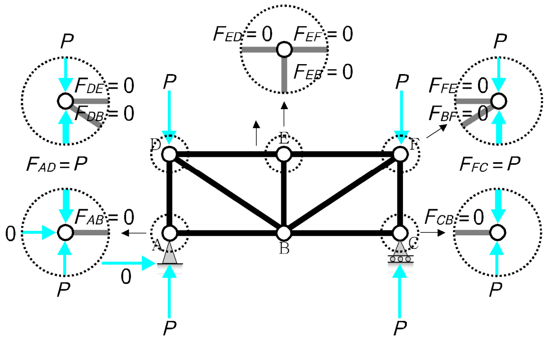

10.



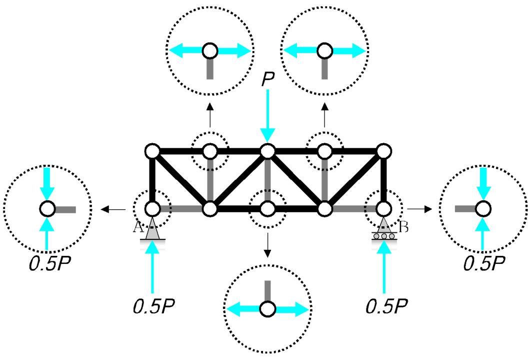

11.



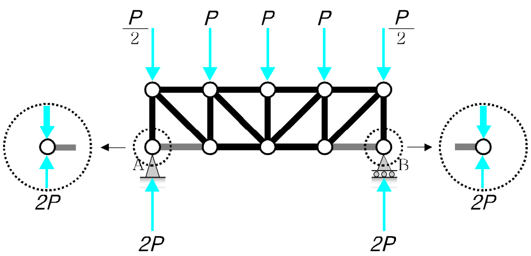
12.


P
F_ED = 0
F_EF = 0
F_EB = 0
F_DE = 0
F_DB = 0
F_FE = 0
F_BF = 0
F_AD = P
F_FC = P
F_AB = 0
F_CB = 0
0
P
D
E
F
A
B
C

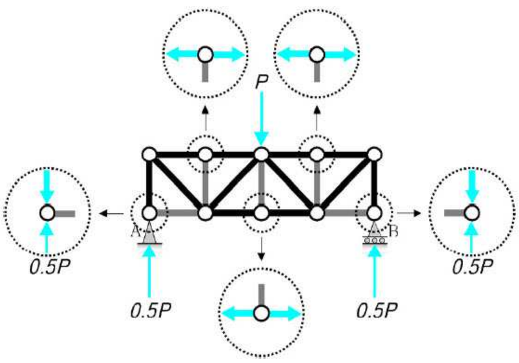
13.


P
A
B
0.5P

14.


P/2
P
A
B
2P

15.

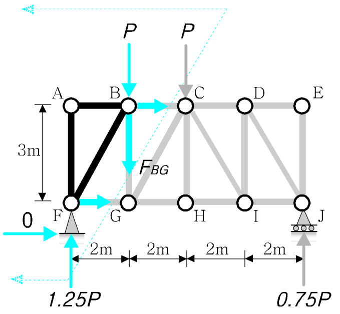

P
A
B
0.5P

16.

(1) $\Sigma M_J = 0$: $+(V_F)(8) - (P)(6) - (P)(4) = 0$ $\therefore V_F = +1.25P(\uparrow)$

(2) B-G 부재가 지나가도록 단면을 3개로 절단한다.

(3) $\Sigma V = 0$ : $+(1.25P) - (P) - (F_{BG}) = 0$ $\therefore F_{BG} = +0.25P$(인장)

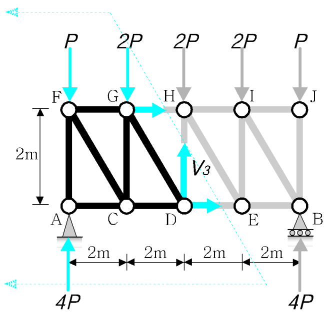



17.

(1) 하중과 경간이 좌우 대칭이므로 $\therefore V_A = +4P(\uparrow)$

(2)

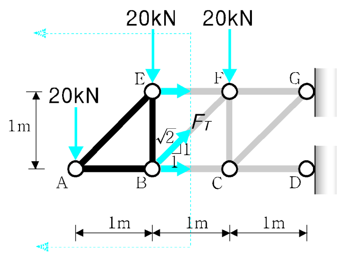
$V = 0$: $+(V_A) - (P) - (2P) + (F_{V_3}) = 0$ $\therefore F_{V_3} = -P$(압축)




18.

(1) 캔틸레버 트러스이므로 지점반력을 구할 필요가 없이 구하고자 하는 $T$를 포함하여 3개 이내로 수직절단한 후 자유단쪽을 계산한다.

(2) $V = 0$: $-(20) - (20) + (F_T \cdot \sin 45) = 0$ $\therefore F_T = +40\sqrt{2}\,\mathrm{kN}$(인장)

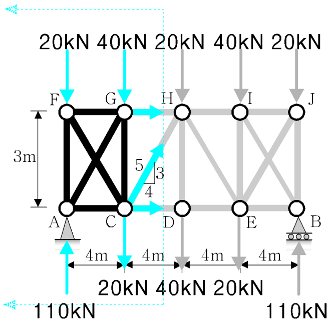


19.

(1) 하중과 경간이 대칭이므로 $V_A = +110\text{kN}(\uparrow)$

(2) CH 부재의 부재력을 구하기 위해 CH부재가 지나가도록 수직절단한다.

(3) $\Sigma V = 0$ : $+(110)-(20)-(40)-(20)+\left(F_{CH}\cdot\frac{3}{5}\right)=0$ $\quad\therefore\ F_{CH} = -50\text{kN}$(압축)

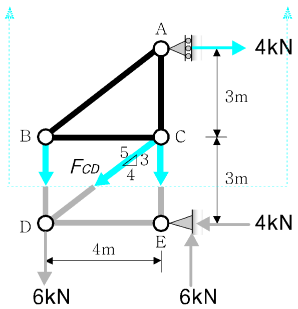



20.

(1) $\Sigma M_E = 0$: $-(6)(4)+(H_A)(6)=0$ $\quad\therefore\ H_A = +4\text{kN}(\rightarrow)$

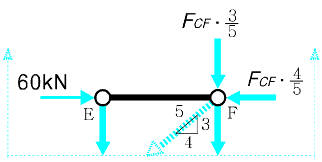
(2) CD부재가 지나가도록 수평절단하여 위쪽을 고려한다.

$\Sigma H = 0$ : $+(4)-\left(F_{CD}\cdot\frac{4}{5}\right)=0$ $\quad\therefore\ F_{CD} = +5\text{kN}$(인장)




21.

(1) CF부재가 지나가도록 수평으로 절단해서 위쪽을 고려한다.

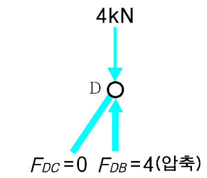


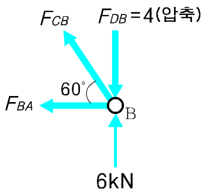

(2) $V=0$ : $+(60)-\left(F_{CF}\cdot\frac{4}{5}\right)=0$ $\quad\therefore\ F_{CF} = +75\text{kN}$(인장)

22.

(1) 지점반력: $V_B = + \frac{4+4+4}{2} = +6\text{kN}(\uparrow)$

(2) 절점 D에서




① $\Sigma H = 0$: $-(F_{DC} \cdot \sin 30^\circ) = 0$ $\quad \therefore\ F_{DC} = 0$

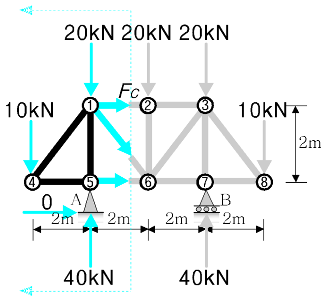
② $\Sigma V = 0$: $-(4) - (F_{DB}) = 0$ $\quad \therefore\ F_{DB} = -4\text{kN}$(압축)

(3) 절점 B에서 $\Sigma V = 0$: $+(6) - (4) + (F_{CB} \cdot \sin 60^\circ) = 0$ $\quad \therefore\ F_{CB} = -2.309\text{kN}$(압축)

23.

(1) 하중과 경간이 좌우 대칭이므로 $\therefore\ V_A = +40\text{kN}(\uparrow)$

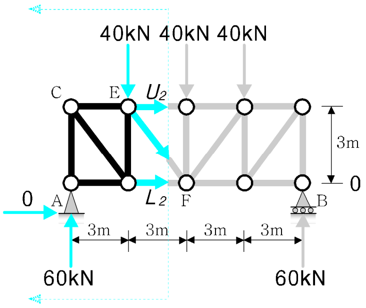
(2) $C$부재의 부재력을 구하기 위해 하현재 세 번째 절점⑥에서 모멘트를 계산한다.




$M_{⑥,Left} = 0$ : $-(10)(4) - (20)(2) + (40)(2) + (F_C)(2) = 0$ $\quad \therefore\ F_C = 0$

24.

(1) $V_A = \frac{(40)+(40)+(40)}{2} = +60\text{kN}(\uparrow)$




(2) $M_F = 0$ : $+(60)(6)-(40)(3)+(U_2)(3) = 0$ $\therefore$ $U_2 = -80\text{kN}$(압축)

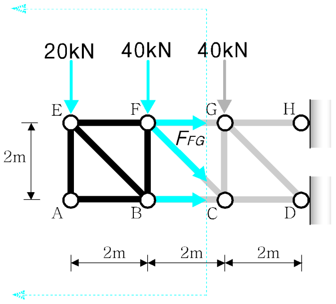
(3) $M_E = 0$ : $+(60)(3)-(L_2)(3) = 0$ $\therefore$ $L_2 = +60\text{kN}$(인장)

25.

(1) 캔틸레버 구조이므로 지점반력을 구할 필요가 없이 구하고자 하는 FG 부재를 포함하여 3개 이내로 수직절단한 후 자유단쪽을 계산한다.

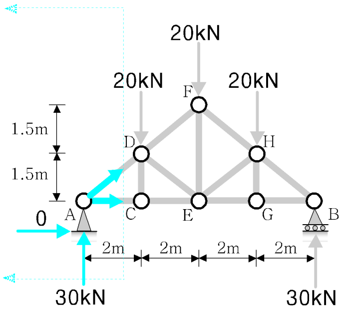
(2) 상현재 FG부재가 지나가도록 경사재 FC, 하현재 BC를 수직절단한 후 절점 C에서 $M=0$을 계산하면 경사재 FC, 하현재 BC는 미지수가 소거되어 FG부재의 부재력만이 계산된다.

(3) $M_{C,Left} = 0$ : $-(20)(4)-(40)(2)+(F_{FG})(2) = 0$ $\therefore$ $F_{FG} = +80\text{kN}$ (인장)




26.

(1) 하중과 경간이 대칭이므로 $\therefore$ $V_A = +30\text{kN}(\uparrow)$



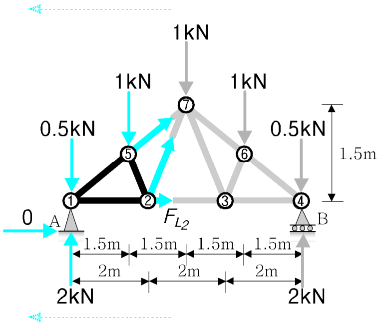

(2) $M_{D,Left} = +[+(30)(2)-(F_{AC})(1.5)] = 0$ $\therefore$ $F_{AC} = +40\text{kN}$(인장)

27.

(1) 하중과 경간이 좌우 대칭이므로 $\therefore\ V_A = +2\text{kN}(\uparrow)$

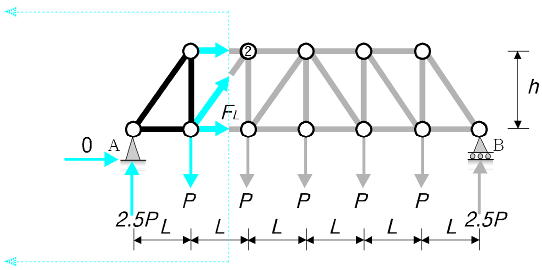
(2) $L_2$부재의 부재력을 구하기 위해 최상단 중앙점(⑦)에서 모멘트를  계산한다.

$\Sigma M_{⑦,Left} = 0:\quad +(2)(3)-(0.5)(3)-(1)(1.5)-(F_{L_2})(1.5)=0 \quad \therefore\ F_{L_2} = +2\text{kN}$(인장)




28.

(1) 지점반력: $V_B = +\dfrac{P+P+P+P+P}{2} = +2.5P(\uparrow)$



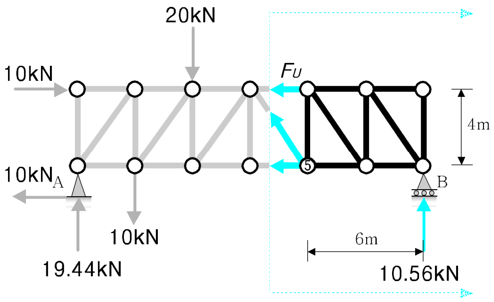

(2) $M_{②} = 0:\ +(2.5P)(2L)-(P)(L)-(F_L)(h)=0$

$\therefore\ F_L = +\dfrac{4PL}{h}$(인장)

29.

(1) $\Sigma M_A = 0:\ +(10)(4)+(10)(3)+(20)(6)-(V_B)(18)=0 \quad \therefore\ V_B = +10.56\text{kN}(\uparrow)$

(2) $M_{⑤} = 0:\ -(F_U)(4)-(10.56)(6)=0 \qquad \therefore\ F_U = -15.84\text{kN}$(압축)

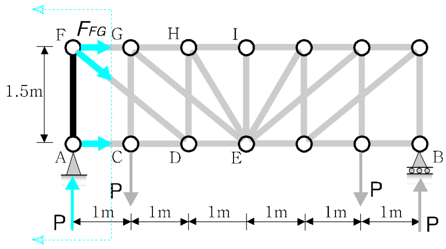


30

(1) 하중과 경간이 대칭이므로 $\therefore\ V_A = +P(\uparrow)$

(2) 상현재 FG부재가 지나가도록 경사재 FD, 하현재 AC를 수직절단한 후 절점 D에서 $\Sigma M = 0$ 을 계산하면 경사재 FD, 하현재 AC는 미지수가 소거되어 FG부재의 부재력만이 계산된다.

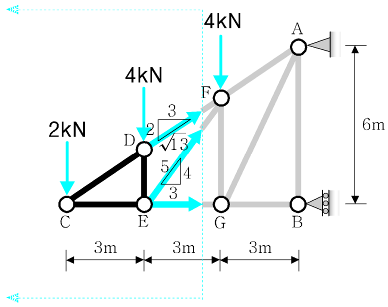
(3) $M_{G,Left} = 0$: $+[+(P)(2) + (F_{FG})(1.5)] = 0 \qquad \therefore\ F_{FG} = -\frac{4}{3}P$(압축)




31

(1) EF부재가 지나가도록 수직절단하여 좌측을 고려하면 지점반력을 구할 필요가 없다.

(2) EF부재, DF부재, EG부재가 절단된 상태에서 DF부재의 부재력을 먼저 구하기 위해 E절점에서 모멘트법을 적용하면 EF부재 및 EG부재는 미지수가 소거된다.




$\Sigma M_{E,Left} = 0$ : $-(2)(3) + \left(F_{DF} \cdot \frac{3}{\sqrt{13}}\right)(2) = 0 \ \therefore\ F_{DF} = +3.605\text{kN}$(인장)

(3) EF부재의 부재력을 구하기 위해 전단력법을 적용하면 EG부재는 미지수가 소거된다.

$V = 0$: $-(2) - (4) + \left(F_{DF} \cdot \frac{2}{\sqrt{13}}\right) + \left(F_{EF} \cdot \frac{4}{5}\right) = 0 \qquad \therefore\ F_{EF} = +5\text{tf}$(인장)

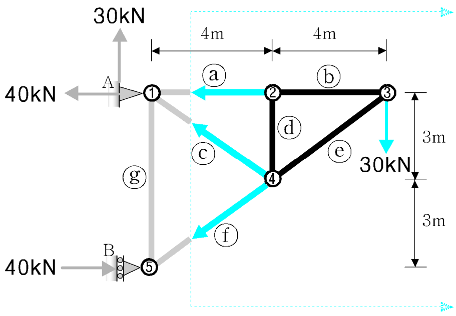
32

(1) 지점반력

① $\Sigma V=0$: ∴ $V_A=+30\text{kN}(\uparrow)$

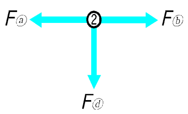
② $\Sigma M_A=0$: $+(30)(8)-(H_B)(6)=0$ ∴ $H_B=+40\text{kN}(\rightarrow)$

(2) ⓐ부재가 지나가도록 수직절단하여 우측을 고려하며, ④절점에서 모멘트법을 적용한다.



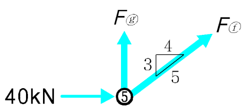

$M_{④}=0$: $-(F_{ⓐ})(3)+(30)(4)=0$ ∴ $F_{ⓐ}=+40\text{kN}$(인장)

(3) ②절점에서 절점법을 적용:




$\Sigma V=0$: ∴ $F_{ⓓ}=0$

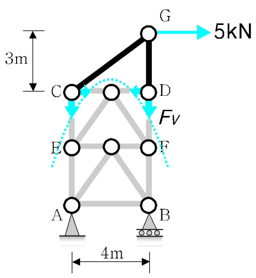
(4) ⑤절점에서 절점법을 적용:




$\Sigma H=0$: $+(40)+\left(F_{ⓕ}\cdot\frac{4}{5}\right)=0$ ∴ $F_{ⓕ}=-50\text{kN}$(압축)

33

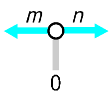
(1) K트러스에서 $DF$의 부재력을 구하기 위해 다음 그림과 같이 절단한 후 C점에서 모멘트법을 적용한다.



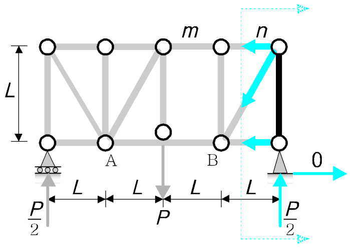

(2) $M_C=0$: $+(5)(3)+(F_V)(4)=0$ ∴ $F_V=-3.75\text{kN}$(압축)

34.

(1) 부재력에 관한 성질을 이용하면 m부재와 n부재의 부재력은 같다.




(2) n부재를 중심으로 절단법을 이용한다.




(3) 절단된 3개의 부재 중 경사재와 하현재가 만나는 B점을 모멘트 원점으로 하여 모멘트법을 적용하면 경사재와 하현재는 미지수가 소거되어 n부재의 부재력만이 계산된다.

(4) $M_{B,Right} = -\left[-\left(\frac{P}{2}\right)(L)-(F_n)(L)\right]=0$

$\therefore F_n = -\frac{P}{2}$(압축) $\Rightarrow F_m = -\frac{P}{2}$(압축)