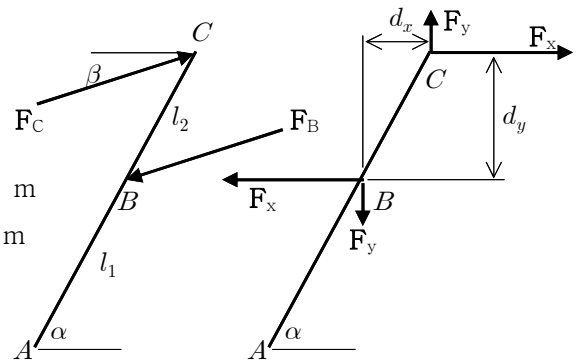
[3.12~3.16절]

3.69 [우력 모멘트, 우력 벡터 합성]

$F_B = F_C = F = 60$ N,

$\alpha = 55°$, $\beta = 20°$,

$l_1 = 0.520$ m, $l_2 = 0.360$ m



(a) $d_x = l_2 \cos\alpha = (0.360\text{ m})\cos 55° = 0.2065$ m

$d_y = l_2 \sin\alpha = (0.360\text{ m})\sin 55° = 0.2949$ m

$F_x = F\cos\beta = (60\text{ N})\cos 20° = 56.38$ N

$F_y = F\sin\beta = (60\text{ N})\sin 20° = 20.52$ N

$M = d_x F_y - d_y F_x$

$= (0.2065\text{ m})(20.52\text{ N}) - (0.2949\text{ m})(56.38\text{ N}) = -12.389$ N·m

$\Rightarrow$ **M** = 12.39 N·m ↺

(b) $\theta = \alpha - \beta = 55° - 20° = 35°$

$d = l_2 \sin\theta = (0.360\text{ m})\sin 35° = 0.2065$ m

$M = -d\ F = -(0.2065\text{ m})(60\text{ N}) = -12.389$ N·m $\Rightarrow$ **M** = 12.39 N·m ↺

(c) $l = l_1 + l_2 = (0.520\text{ m}) + (0.360\text{ m}) = 0.880$ m

$\mathbf{r}_{AB} = l_1(\cos\alpha\ \mathbf{i} + \sin\alpha\ \mathbf{j})$

$= (0.520\text{ m})(\cos 55°\ \mathbf{i} + \sin 55°\ \mathbf{j}) = 0.2983\ \mathbf{i} + 0.4260\ \mathbf{j}$ (m)

$\mathbf{r}_{AC} = l(\cos\alpha\ \mathbf{i} + \sin\alpha\ \mathbf{j})$

$= (0.880\text{ m})(\cos 55°\ \mathbf{i} + \sin 55°\ \mathbf{j}) = 0.5047\ \mathbf{i} + 0.7209\ \mathbf{j}$ (m)

$\mathbf{F}_B = -F_x\ \mathbf{i} - F_y\ \mathbf{j} = -56.38\ \mathbf{i} - 20.52\ \mathbf{j}$ (N)

$\mathbf{F}_C = F_x\ \mathbf{i} + F_y\ \mathbf{j} = 56.38\ \mathbf{i} + 20.52\ \mathbf{j}$ (N)

$\Sigma\mathbf{M}_A = \mathbf{r}_{AB} \times \mathbf{F}_B + \mathbf{r}_{AC} \times \mathbf{F}_C$

$= [0.2983\ \mathbf{i} + 0.4260\ \mathbf{j}\ (\text{m})] \times [-56.38\ \mathbf{i} - 20.52\ \mathbf{j}\ (\text{N})]$

$+ [0.5047\ \mathbf{i} + 0.7209\ \mathbf{j}\ (\text{m})] \times [56.38\ \mathbf{i} + 20.52\ \mathbf{j}\ (\text{N})]$

$= \{[(0.2983)(-20.52) - (0.4260)(-56.38)]$

$+ [(0.5047)(20.52) - (0.7209)(56.38)]\}\ \mathbf{k}$ (N·m)

$= (17.897 - 30.288)\ \mathbf{k}$ (N·m) $= -12.391\ \mathbf{k}$ (N·m) $\Rightarrow$ **M** = 12.39 N·m ↺

<다른 방법>

$\Sigma\mathbf{M}_A = \mathbf{r}_{AB} \times \mathbf{F}_B + \mathbf{r}_{AC} \times \mathbf{F}_C$

$= [l_1(\cos\alpha\ \mathbf{i} + \sin\alpha\ \mathbf{j})] \times [-F_x\ \mathbf{i} - F_y\ \mathbf{j}]$

$+ [l(\cos\alpha\ \mathbf{i} + \sin\alpha\ \mathbf{j})] \times [F_x\ \mathbf{i} + F_y\ \mathbf{j}]$

$= [(l - l_1)(\cos\alpha\ \mathbf{i} + \sin\alpha\ \mathbf{j})] \times [F_x\ \mathbf{i} + F_y\ \mathbf{j}]$

$= (l_2 \cos\alpha\ F_y - l_2 \sin\alpha\ F_x)\ \mathbf{k} = (d_x\ F_y - d_y\ F_x)\ \mathbf{k}$

$= [(0.2065\text{ m})(20.52\text{ N}) - (0.2949\text{ m})(56.38\text{ N})]\ \mathbf{k} = -12.389$ N·m $\mathbf{k}$

$\Rightarrow$ **M** = 12.39 N·m ↺

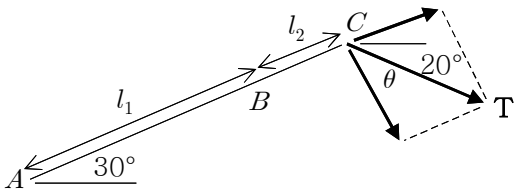
3.80 [등가 우력]

T = 2,240 N, $\mathbf{T}$ = 2,240 N ⌵20°

θ = 90° − (30° + 20°) = 40°

l_1 = 2.4 m, l_2 = 0.3 m,

$l = l_1 + l_2$ = (2.4 m) + (0.3 m) = 2.7 m



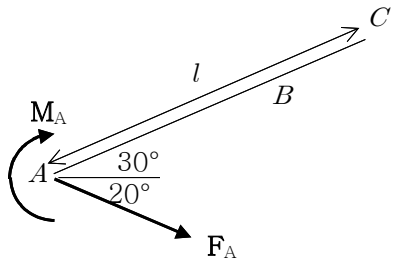
(a) $\Sigma\mathbf{F}$: $\mathbf{F}_A = \mathbf{T}$ ⇒ $\mathbf{F}_A$ = 2,240 N ⌵20°

$\circlearrowleft\Sigma M_A$: $M_A = -l\ (T\cos\theta)$

= −(2.7 m) (2,240 N)cos40°

= −4,633 N·m

⇒ $\mathbf{M}_A$ = 4,630 N·m ↺



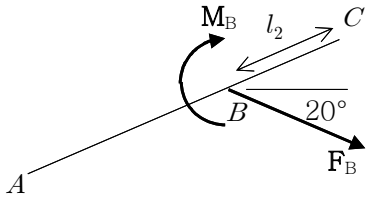
(b) $\Sigma\mathbf{F}$: $\mathbf{F}_B = \mathbf{T}$ ⇒ $\mathbf{F}_B$ = 2,240 N ⌵20°

$\circlearrowleft\Sigma M_B$: $M_B = -l_2\ (T\cos\theta)$

= −(0.3 m) (2,240 N)cos40°

= −514.8 N·m

⇒ $\mathbf{M}_B$ = 515 N·m ↺



3.87 [우력 등가 힘]

$F_{AB} = F_{DE} = F$ = 250 N,

$d_1 = d_2$ = 0.090 m, $d = d_1 + d_2$ = 0.180 m

$\mathbf{F}_{AB}$ = 250 N →, $\mathbf{F}_{DE}$ = 250 N ←, $\mathbf{F}_{BD}$ = 900 ↓

$\Sigma\mathbf{F}$: $\mathbf{F}_C = \mathbf{F}_{AB} + \mathbf{F}_{DE} + \mathbf{F}_{BD}$

= (250 N →) + (250 N ←) + (900 N ↓)

⇒ $\mathbf{F}_C$ = 900 N ↓

$\circlearrowleft\Sigma M_C$: $0 = -d_1\ F_{AB} - d_2\ F_{DE} + x\ F_{BD}$

$= -d\ F + x\ F_{BD}$

$$x = d\frac{F}{F_{BD}} = (0.180\ \text{m})\ \frac{250\ \text{N}}{900\ \text{N}} = 0.050\ \text{m}$$

⇒ x = 50.0 mm