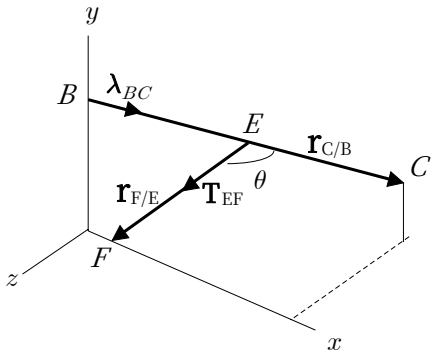
<3.9~3.11절>

3.39 (a) $\mathbf{r}_{F/E} = (1 - 8)\mathbf{i} + (0 - 6)\mathbf{j} + [0 - (-6)]\mathbf{k}$ (m)

$= -7\ \mathbf{i} - 6\ \mathbf{j} + 6\ \mathbf{k}$ (m)

$r_{F/E} = \sqrt{(-7\,\text{m})^2 + (-6\,\text{m})^2 + (6\,\text{m})^2} = 11.0$ m



$\mathbf{r}_{C/B} = (16-0)\mathbf{i} + (3.75-8.25)\mathbf{j} + [(-12)-0]\mathbf{k}$ (m)

$= 16\ \mathbf{i} - 4.5\ \mathbf{j} - 12\ \mathbf{k}$ (m)

$r_{C/B} = \sqrt{(16\,\text{m})^2 + (-4.5\,\text{m})^2 + (-12\,\text{m})^2} = 20.5$ m

$\mathbf{r}_{F/E} \cdot \mathbf{r}_{C/B} = [-7\ \mathbf{i} - 6\ \mathbf{j} + 6\ \mathbf{k}\ (\text{m})] \cdot [16\ \mathbf{i} - 4.5\ \mathbf{j} - 12\ \mathbf{k}\ (\text{m})]$

$= (-7)(16) + (-6)(-4.5) + (6)(-12)\ (\text{m}^2) = -157\ (\text{m}^2)$

$\cos\theta = \dfrac{\mathbf{r}_{F/E} \cdot \mathbf{r}_{C/B}}{r_{F/E}\, r_{C/B}} = \dfrac{(-157\,\text{m}^2)}{(11.0\,\text{m})(20.5\,\text{m})} = -0.6962$

$\theta = \cos^{-1}(-0.6962) = 134.12°$ $\Rightarrow$ $\theta = 134.1°$

(b) $\mathbf{T}_{EF} \cdot \boldsymbol{\lambda}_{BC} = (T_{EF}\ \boldsymbol{\lambda}_{EF}) \cdot \boldsymbol{\lambda}_{BC} = T_{EF}\ (\boldsymbol{\lambda}_{EF} \cdot \boldsymbol{\lambda}_{BC}) = T_{EF} \cos\theta$

$= (330\ \text{N})\ (-0.6962) = -229.7$ N $\Rightarrow$ $\mathbf{T}_{EF} \cdot \boldsymbol{\lambda}_{BC} = -230$ N

3.49 $M_y = 135$ N·m, $M_z = -540$ N·m

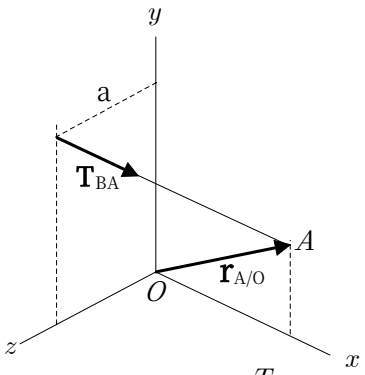
$\mathbf{M}_O = M_x\ \mathbf{i} + M_y\ \mathbf{j} + M_z\ \mathbf{k}$

$= M_x\ \mathbf{i} + (135\ \text{N·m})\ \mathbf{j} + (-540\ \text{N·m})\ \mathbf{k}$

$\mathbf{r}_{A/O} = 2.4\ \mathbf{i} + 1.2\ \mathbf{j} + 0\ \mathbf{k}$ (m)

$\mathbf{T}_{BA} = \boldsymbol{\lambda}_{BA}\ T_{BA} = [2.4\ \mathbf{i} + (1.2-4.8)\ \mathbf{j} + (0-a)\ \mathbf{k}]\ \dfrac{T_{BA}}{d_{BA}}$

$= (2.4\ \mathbf{i} - 3.6\ \mathbf{j} - a\ \mathbf{k})\ \dfrac{T_{BA}}{d_{BA}}$



$\mathbf{r}_{A/O} \times \mathbf{T}_{BA} = [2.4\ \mathbf{i} + 1.2\ \mathbf{j} + 0\ \mathbf{k}\ (\text{m})] \times \left\{[(2.4\ \text{m})\ \mathbf{i} + (-3.6\ \text{m})\ \mathbf{j} - a\ \mathbf{k}]\ \dfrac{T_{BA}}{d_{BA}}\right\}$

$= \{[(1.2)(-a) - 0]\ \mathbf{i} + [0 - (2.4)(-a)]\ \mathbf{j} + [(2.4)(-3.6) - (1.2)(2.4)]\ \mathbf{k}\}\ \dfrac{T_{BA}}{d_{BA}}$

$= [(-1.2\ \text{m})\ a\ \mathbf{i} + (2.4\ \text{m})\ a\ \mathbf{j} - (11.52\ \text{m}^2)\ \mathbf{k}]\ \dfrac{T_{BA}}{d_{BA}}$

$\mathbf{M}_O = \mathbf{r}_{A/O} \times \mathbf{T}_{BA}$

$\mathbf{i}$; $M_x = -1.2\ a\ \dfrac{T_{BA}}{d_{BA}}$

$\mathbf{j}$; $(135\ \text{N·m}) = (2.4\ \text{m})\ a\ \dfrac{T_{BA}}{d_{BA}}$ … ①

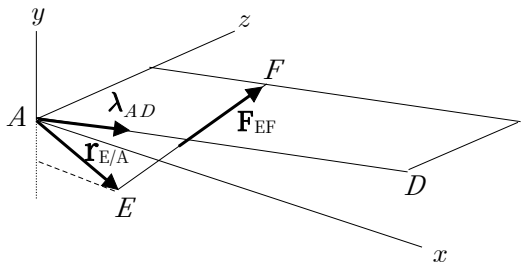
$\mathbf{k}$; $(-540\ \text{N·m}) = (-11.52\ \text{m}^2)\ \dfrac{T_{BA}}{d_{BA}}$ … ②

①÷② $\Rightarrow$ $\dfrac{135}{(-540)} = \dfrac{2.4}{-11.52\,\text{m}}\ a$ $\Rightarrow$ $a = 1.20$ m

3.59 $\boldsymbol{\lambda}_{AD} = \dfrac{(7.2\text{ m})\mathbf{i} + (0.9\text{ m})\mathbf{j}}{\sqrt{(7.2\text{ m})^2 + (0.9\text{ m})^2}}$

$= \dfrac{1}{7.256}[(7.2\text{ m})\mathbf{i} + (0.9\text{ m})\mathbf{j}]$

$= 0.9923\ \mathbf{i} + 0.1240\ \mathbf{j}$



$\mathbf{r}_{E/A} = 2.1\ \mathbf{i} - 0.9\ \mathbf{j}$ (m)

EF ; $d_x = (2.4\text{ m}) - (2.1\text{ m}) = 0.3\text{ m}$

$d_y = (0.9\text{ m})\dfrac{2.4}{7.2} - (-0.9\text{ m}) = 1.2\text{ m}$

$d_z = 2.4\text{ m}$

$\boldsymbol{\lambda}_{EF} = \dfrac{(0.3\text{ m})\mathbf{i} + (1.2\text{ m})\mathbf{j} + (2.4\text{ m})\mathbf{k}}{\sqrt{(0.3\text{ m})^2 + (1.2\text{ m})^2 + (2.4\text{ m})^2}} = \dfrac{1}{2.7}[(0.3\text{ m})\mathbf{i} + (1.2\text{ m})\mathbf{j} + (2.4\text{ m})\mathbf{k}]$

$= 0.11111\ \mathbf{i} + 0.44444\ \mathbf{j} + 0.88888\ \mathbf{k}$

$\mathbf{F}_{EF} = \boldsymbol{\lambda}_{EF}\ F_{EF} = (0.11111\ \mathbf{i} + 0.44444\ \mathbf{j} + 0.88888\ \mathbf{k})\ (24\text{ kN})$

$= 2.66667\ \mathbf{i} + 10.6667\ \mathbf{j} + 21.3333\ \mathbf{k}$ (kN)

$\mathbf{r}_{E/A} \times \mathbf{F}_{EF} = [2.1\ \mathbf{i} - 0.9\ \mathbf{j}\ (\text{m})] \times [2.66667\ \mathbf{i} + 10.6667\ \mathbf{j} + 21.3333\ \mathbf{k}\ (\text{kN})]$

$= [(-0.9)(21.3333) - 0]\ \mathbf{i} + [0 - (2.1)(21.3333)]\ \mathbf{j}$

$+ [(2.1)(10.6667) - (-0.9)(2.66667)]\ \mathbf{k}$ (kN·m)

$= (-19.200)\ \mathbf{i} + (-44.800)\ \mathbf{j} + (24.800)\ \mathbf{k}$ (kN·m)

$M_{AD} = \boldsymbol{\lambda}_{AD} \cdot (\mathbf{r}_{E/A} \times \mathbf{F}_{EF})$

$= [0.9923\ \mathbf{i} + 0.1240\ \mathbf{j}] \cdot [(-19.200)\ \mathbf{i} - (44.800)\ \mathbf{j} + (24.800)\ \mathbf{k}\ (\text{kN·m})]$

$= (0.9923)(-19.200) + (0.1240)(-44.800)$ (kN·m)

$= -24.61$ (kN·m) $\Rightarrow$ $M_{AD} = -24.6$ kN·m

<다른 방법>

$\mathbf{r}_{F/A} = 2.4\ \mathbf{i} + 0.3\ \mathbf{j} + 2.4\ \mathbf{k}$ (m)

$\mathbf{r}_{F/A} \times \mathbf{F}_{EF} = [2.4\ \mathbf{i} + 0.3\ \mathbf{j} + 2.4\ \mathbf{k}\ (\text{m})] \times$

$[2.66667\ \mathbf{i} + 10.6667\ \mathbf{j} + 21.3333\ \mathbf{k}\ (\text{kN})]$

$= [(0.3)(21.3333) - (2.4)(10.6667)]\ \mathbf{i} + [(2.4)(2.66667) - (2.4)(21.3333)]\ \mathbf{j}$

$+ [(2.4)(10.6667) - (0.3)(2.66667)]\ \mathbf{k}$ (kN·m)

$= (-19.20)\ \mathbf{i} + (-44.80)\ \mathbf{j} + (24.80)\ \mathbf{k}$ (kN·m)

$M_{AD} = \boldsymbol{\lambda}_{AD} \cdot (\mathbf{r}_{F/A} \times \mathbf{F}_{EF})$

$= [0.9923\ \mathbf{i} + 0.1240\ \mathbf{j}] \cdot [(-19.200)\ \mathbf{i} + (-44.80)\ \mathbf{j} + (24.80)\ \mathbf{k}\ (\text{kN·m})]$

$= (0.9923)(-19.200) + (0.1240)(-44.80)$ (kN·m)

$= -24.61$ (kN·m) $\Rightarrow$ $M_{AD} = -24.6$ kN·m