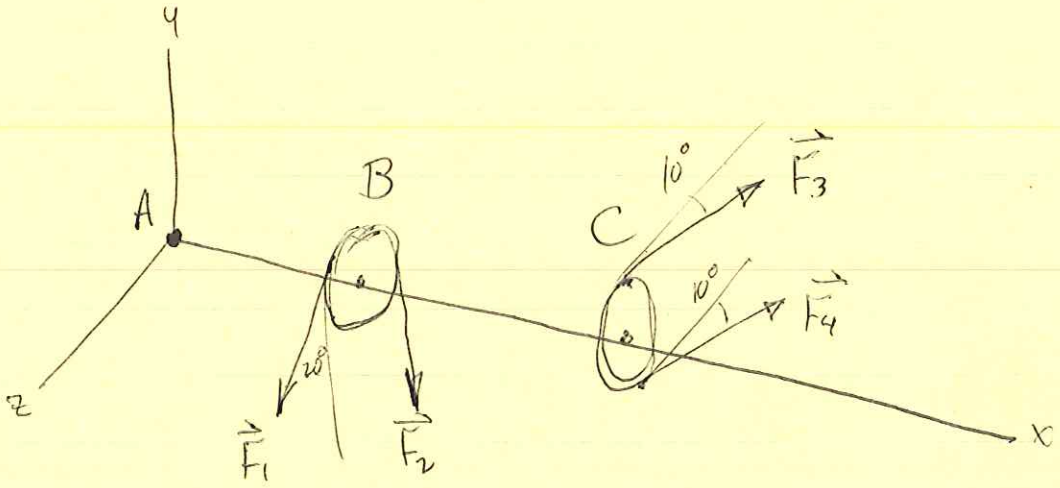
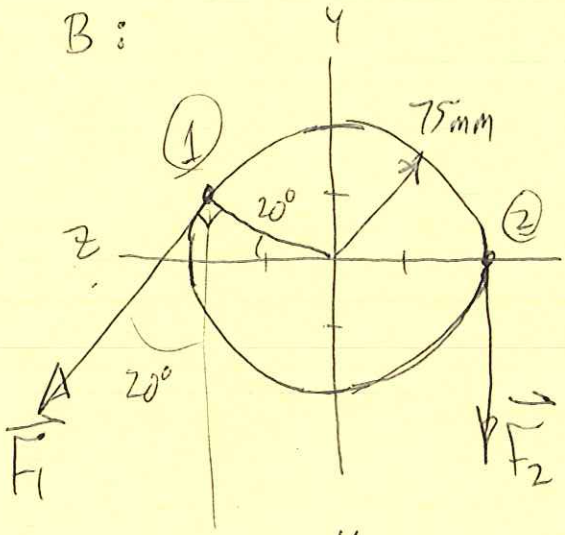
PROB. 3.120



FIND THE EQUIVALENT FORCE-COUPLE SYSTEM AT A

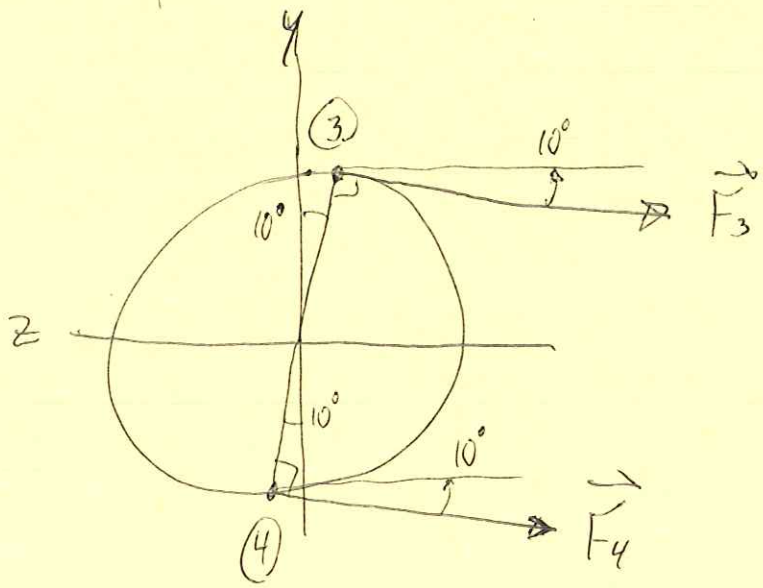
PULLEY B:



$D_B = 150\,mm$

$D_C = 150\,mm$

PULLEY C:



PROB. 3.120 CONT.

FIND COORDINATES:

POINT 1: $X_1 = 225\ mm$, $Y_1 = 75 \sin 20^\circ = 25.6\ mm$

$Z_1 = 75 \cos 20^\circ = 70.5\ mm$

POINT 2: $X_2 = 225\ mm$, $Y_2 = 0$, $Z_2 = -75\ mm$

POINT 3: $X_3 = 450\ mm$, $Y_3 = 75 \cos 10^\circ = 73.9\ mm$

$Z_3 = -75 \sin 10^\circ = -13.0\ mm$

POINT 4: $X_4 = 450\ mm$, $Y_4 = -75 \cos 10^\circ = -73.9\ mm$

$Z_4 = 75 \sin 10^\circ = 13.0\ mm$

FIND POSITION VECTORS FROM POINT A:

$\vec{r}_1 = (225)\hat{i} + (25.6)\hat{j} + (70.5)\hat{k}\ mm$

$\vec{r}_2 = (225)\hat{i} + (0)\hat{j} + (-75)\hat{k}\ mm$

$\vec{r}_3 = (450)\hat{i} + (73.9)\hat{j} + (-13.0)\hat{k}\ mm$

$\vec{r}_4 = (450)\hat{i} + (-73.9)\hat{j} + (13.0)\hat{k}\ mm$

PROB. 3.120 CONT.

FIND FORCE VECTORS

FOR $\vec{F}_1$: $|\vec{F}_1| = 145$ N

$F_x = 0$

$F_y = -145 \cos 20^\circ = -136$ N

$F_z = 145 \sin 20^\circ = 49.6$ N

$$\vec{F}_1 = (0)\hat{i} + (-136)\hat{j} + (49.6)\hat{k} \text{ N}$$

FOR $\vec{F}_2$:

$$\vec{F}_2 = (-215)\hat{j} \text{ N} = (0)\hat{i} + (-215)\hat{j} + (0)\hat{k} \text{ N}$$

FOR $\vec{F}_3$: $|\vec{F}_3| = 155$ N

$F_x = 0$

$F_y = -155 \sin 10^\circ = -26.9$ N

$F_z = -155 \cos 10^\circ = -153$ N

$$\vec{F}_3 = (0)\hat{i} + (-26.9)\hat{j} + (-153)\hat{k} \text{ N}$$

PROB. 3.120 CONT.

FOR $\vec{F}_4$: $|\vec{F}_4| = 240\ N$

$F_x = 0$

$F_y = -240 \sin 10^\circ = -41.7\ N$

$F_z = -240 \cos 10^\circ = -236\ N$

$$\vec{F}_4 = (0)\,\hat{i} + (-41.7)\,\hat{j} + (-236)\,\hat{k}\ N$$

FIND MOMENTS ABOUT A:

$$\vec{M}_A = \vec{M}_1 + \vec{M}_2 + \vec{M}_3 + M_4$$

$$= \vec{r}_1 \times \vec{F}_1 + \vec{r}_2 \times \vec{F}_2 + \vec{r}_3 \times \vec{F}_3 + \vec{r}_4 \times \vec{F}_4$$

$$\vec{M}_1 = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 225 & 25.6 & 70.5 \\ 0 & -136 & 49.6 \end{vmatrix}$$

$$= [(25.6)(49.6) - (70.5)(-136)]\,\hat{i}$$

$$- [(225)(49.6) - (70.5)(0)]\,\hat{j}$$

$$+ [(225)(-136) - (25.6)(0)]\,\hat{k} \quad N\text{-}mm$$

$$\vec{M}_1 = (10800)\,\hat{i} + (-11200)\,\hat{j} + (-30600)\,\hat{k}\ N\text{-}mm$$

PROB. 3.120 CONT.

$$\vec{M}_2 = \vec{r}_2 \times \vec{F}_2 = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 225 & 0 & -75 \\ 0 & -215 & 0 \end{vmatrix}$$

$$\vec{M}_2 = [(0)(0) - (-75)(-215)]\,\hat{i} - [(225)(0) - (-75)(0)]\,\hat{j} + [(225)(-215) - (0)(0)]\,\hat{k}$$

$$\vec{M}_2 = (-16100)\,\hat{i} + (0)\,\hat{j} + (-48400)\,\hat{k} \text{ N-mm}$$

$$\vec{M}_3 = \vec{r}_3 \times \vec{F}_3 = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 450 & 73.9 & -13.0 \\ 0 & -26.9 & -153 \end{vmatrix}$$

$$\vec{M}_3 = [(73.9)(-153) - (-13)(-26.9)]\,\hat{i} - [(450)(-153) - (-13)(0)]\,\hat{j} + [(450)(-26.9) - (73.9)(0)]\,\hat{k} \text{ N-mm}$$

$$\vec{M}_3 = (-11600)\,\hat{i} + (68800)\,\hat{j} + (-12100)\,\hat{k} \text{ N-mm}$$

PROB. 3.120 CONT.

$$\vec{M}_4 = \vec{r}_4 \times \vec{F}_4 = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 450 & -73.9 & 13.0 \\ 0 & -41.7 & -236 \end{vmatrix}$$

$$\vec{M}_4 = [(-73.9)(-236) - (13)(-41.7)]\,\hat{i}$$

$$-[(450)(-236) - (13)(0)]\,\hat{j}$$

$$+[(450)(-41.7) - (-73.9)(0)]\,\hat{k} \quad N\text{-}mm$$

$$\vec{M}_4 = (18000)\,\hat{i} + (106000)\,\hat{j} + (-18800)\,\hat{k} \quad N\text{-}mm$$

$$\vec{M}_A = [(10800) + (-16100) + (-11600) + (18000)]\,\hat{i}$$

$$+[(-11200) + (0) + (68800) + (106000)]\,\hat{j}$$

$$+[(-30600) + (-48400) + (-12100) + (-18800)]\,\hat{k} \; N\text{-}mm$$

$$\vec{M}_A = (1100)\,\hat{i} + (164000)\,\hat{j} + (-110000)\,\hat{k} \quad N\text{-}mm$$

$$\vec{M}_A = (1.1)\,\hat{i} + (164)\,\hat{j} + (-110)\,\hat{k} \quad N\text{-}m$$

PROB. 3.120 CONT.

FIND RESULTANT FORCE:

$$\vec{R} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \vec{F}_4$$

$$\vec{R} = [(0) + (0) + (0) + (0)]\,\hat{i}$$

$$+ [(-136) + (-215) + (-26.9) + (-41.7)]\,\hat{i}$$

$$+ [(49.6) + (0) + (-153) + (-236)]\,\hat{k} \text{ N}$$

$$\vec{R} = (0)\,\hat{i} + (-420)\,\hat{j} + (-339)\,\hat{k} \text{ N}$$