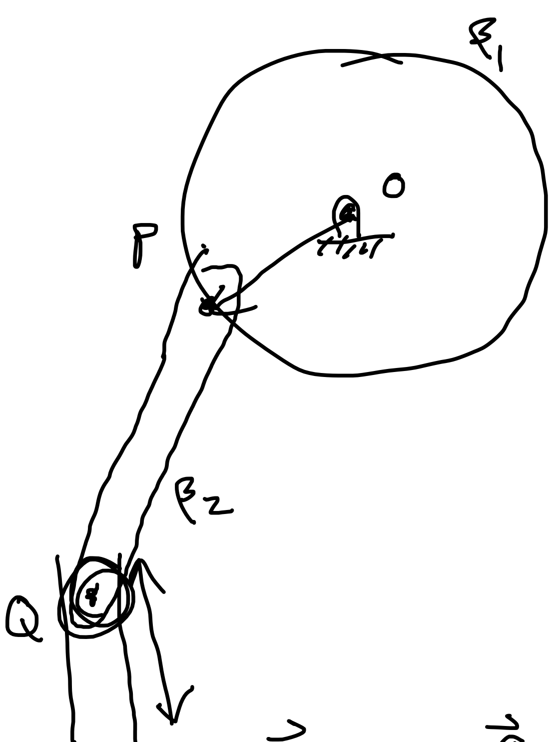
# TAM 212 MidTerm 2 Review

## PL 5-20 Slider CRANK Acceleration




~~At~~ this moment

$\vec{r}_{OP} = -3\hat{i} - \hat{j}$ m

$\vec{\omega}_1 = 24\hat{k}$

$\vec{v}_P = 24\hat{i} - 72\hat{j}$

$\vec{r}_{PQ} = -\hat{i} - 8\hat{j}$ m

$\vec{\omega}_2 = -3\hat{k}$

$\vec{v}_Q = -69\,\hat{j}$ m/s

$\vec{\alpha}_2 = -3\hat{k}$

Find $\vec{a}_Q$

$$\vec{a}_Q = \vec{a}_P + \vec{\alpha}_2 \times \vec{r}_{PQ} - \omega_2^2\,\vec{r}_{PQ}$$

$$\vec{a}_Q = \left(\cancel{\vec{a}_O} + \vec{\alpha}_1 \times \vec{r}_{OP} - \omega_1^2\,\vec{r}_{OP}\right) + \vec{\alpha}_2 \times \vec{r}_{PQ} - \omega_2^2\,\vec{r}_{PQ}$$

Unknowns: $a_{Qx}, a_{Qy}, \alpha_1$

Equations: 2 + constraint = 3

$\boxed{a_{Qx} = 0}$

work through:

$$a_{Qy}\hat{j} = \left[(\alpha_1\hat{k})\times(-3\hat{i}-\hat{j})\right] - (24)^2(-3\hat{i}-\hat{j}) + (-3\hat{k})\times(-\hat{i}-8\hat{j}) - (-3)^2(-\hat{i}-8\hat{j})$$

$$= \left[(-3\alpha_1)(\hat{j}) + (-\alpha_1)(-\hat{i})\right] + (24^2)(3\hat{i}+\cancel{\hat{j}}\,\hat{j}) + (-3)(-1)(\hat{j}) + (-3)(-8)(-\hat{i}) + 9(+\hat{i}+8\hat{j})$$

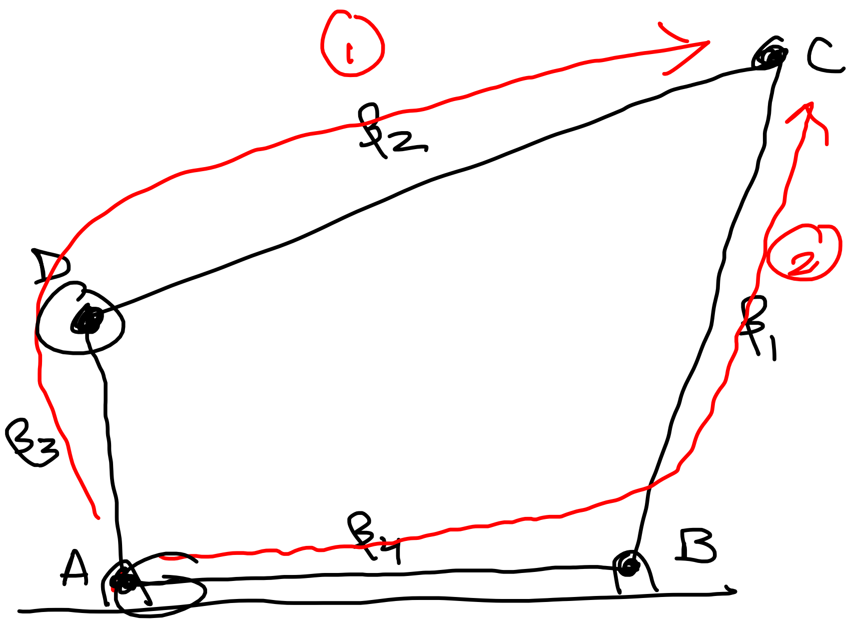
$$a_{Qy}\hat{j} = \left[+\alpha_1 + 3(24^2) - 24 + 9\right]\hat{i} + \left[-3\alpha_1 + 24^2 + 3 + 72\right]\hat{j}$$

$\hat{i}$: $0 = +\alpha_1 + 3(24^2) - 15$

$\alpha_1 = \boxed{\phantom{xxxx}}$ ✓

$\hat{j}$: $a_{Qy} = -3\alpha_1 + 24^2 + 75$

# 5-21 ~~Gear~~ Accelerations Four Bar Linkage




$\vec{r}_{AB} = 2\hat{i}$

$\vec{r}_{BC} = \hat{i} + 2\hat{j}$

$\vec{r}_{DC} = 3\hat{i} + \hat{j}$

$\vec{r}_{AD} = \hat{j}$

Find $\vec{\alpha}_2$

$\vec{\omega}_1 = \hat{k}$ $\quad$ $\vec{\alpha}_1 = \alpha_1 \hat{k}$

$\vec{\omega}_2 = \omega_2 \hat{k}$ $\quad$ $\vec{\alpha}_2 = \alpha_2 \hat{k}$

$\vec{\omega}_3 = \omega_3 \hat{k}$ $\quad$ $\vec{\alpha}_3 = -2\hat{k}$

$$\left.\begin{aligned} \vec{V}_c &= \cancel{\vec{V}_B} + \vec{\omega}_1 \times \vec{r}_{BC} \\ &= \left(\cancel{\vec{V}_A} + \cancel{\vec{\omega}_4} \times \cancel{\vec{r}_{AB}}\right) + \vec{\omega}_1 \times \vec{r}_{BC} \end{aligned}\right\} \text{one path}$$

$$= \left[\hat{k} \times (\hat{i} + 2\hat{j})\right] = \boxed{\hat{j} - 2\hat{i}} \quad \checkmark$$

Also: $\vec{V}_c = \vec{V}_D + \vec{\omega}_2 \times \vec{r}_{DC}$

$$= \cancel{\vec{V}_A} + \vec{\omega}_3 \times \vec{r}_{AD} + \vec{\omega}_2 \times \vec{r}_{DC}$$

$$= \left[(\omega_3 \hat{k}) \times (\hat{j})\right] + (\omega_2 \hat{k}) \times (3\hat{i} + \hat{j})$$

$$= -\omega_3 \hat{i} + 3\omega_2 \hat{j} - \omega_2 \hat{i}$$

$$= \boxed{(-\omega_3 - \omega_2)\hat{i} + 3\omega_2 \hat{j}}$$

✓

Equate: $\hat{i}: \; -\omega_3 - \omega_2 = -2$ $\qquad \hat{j}: \; 3\omega_2 = 1$

$$-\omega_3 - 1/3 = -2 \qquad \boxed{\omega_2 = 1/3}$$

$$\boxed{\omega_3 = 5/3}$$

Angular Acceleration:

$$\vec{a}_C = \cancel{\vec{a}_B} + \vec{\alpha}_1 \times \vec{r}_{BC} - \omega_1^2 \vec{r}_{BC}$$

$$= (\alpha_1 \hat{k}) \times (\hat{i} + 2\hat{j}) - (1^2)(\hat{i} + 2\hat{j})$$

$$= \alpha_1 \hat{j} - 2\alpha_1 \hat{i} - \hat{i} - 2\hat{j}$$

$$= (-2\alpha_1 - 1)\hat{i} + (\alpha_1 - 2)\hat{j}$$

Also: $\vec{a}_C = \vec{a}_D + \vec{\alpha}_2 \times \vec{r}_{DC} - \omega_2^2 \vec{r}_{DC}$

$$= (\cancel{\vec{a}_A} + \vec{\alpha}_3 \times \vec{r}_{AD} - \omega_3^2 \vec{r}_{AD}) + \vec{\alpha}_2 \times \vec{r}_{DC} - \omega_2^2 \vec{r}_{DC}$$

$$= (-2\hat{k} \times \hat{j}) - \left(\frac{5}{3}\right)^2 (\hat{j}) + (\alpha_2 \hat{k}) \times (3\hat{i} + \hat{j}) - \left(\frac{1}{3}\right)^2 (3\hat{i} + \hat{j})$$

$$= 2\hat{i} - \left(\frac{5}{3}\right)^2 \hat{j} + 3\alpha_2 \hat{j} - \alpha_2 \hat{i} - \frac{1}{3}\hat{i} - \left(\frac{1}{3}\right)^2 \hat{j}$$

$$= \left(\frac{5}{3} - \alpha_2\right)\hat{i} + \left(-\frac{26}{9} + 3\alpha_2\right)\hat{j}$$

Set equal:

$\hat{i}$: $-2\alpha_1 - 1 = \frac{5}{3} - \alpha_2$

$\hat{j}$: $\alpha_1 - 2 = -\frac{26}{9} + 3\alpha_2$

$\alpha_2 = -0.1777\ldots$