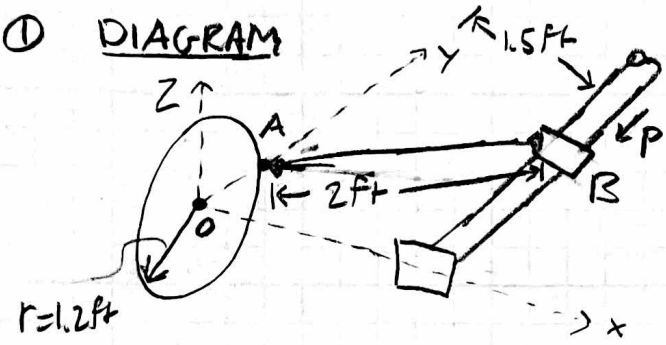
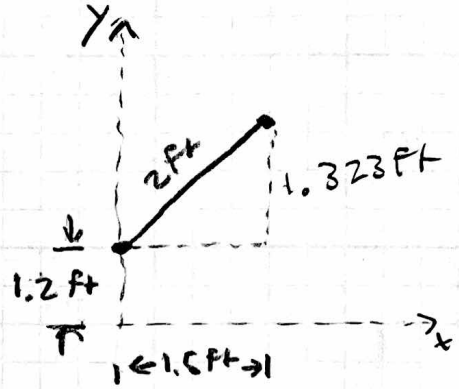
① DIAGRAM





GIVEN

$\vec{\omega}_A = (5 \text{ rad/s})\hat{\imath}$

FIND

$\vec{\omega}_{AB} = ?$

$\vec{V}_B = ?$

SOLVE

$\vec{V}_A = \vec{\omega}_A \times \vec{r}_{A/O} = (5\frac{\text{rad}}{\text{s}})\hat{\imath} \times (1.2\text{ft})\hat{\jmath} = 6\frac{\text{ft}}{\text{s}}\hat{k}$

$\vec{\omega}_{ab} \cdot \vec{r}_{b/a} = (\omega_{abx}\hat{\imath} + \omega_{aby}\hat{\jmath} + \omega_{abz}\hat{k}) \cdot (1.5\hat{\imath} + 1.323\hat{\jmath})\text{ft} = 0$

$(\omega_{abx})(1.5) + (\omega_{aby})(1.323) = 0$ @

$\vec{V}_b = \vec{V}_a + \vec{\omega}_{ab} \times \vec{r}_{b/a}$

$(-P)\hat{\jmath} = (6\frac{\text{ft}}{\text{s}})\hat{k} + (\omega_{abx}\hat{\imath} + \omega_{aby}\hat{\jmath} + \omega_{abz}\hat{k}) \times (1.5\hat{\imath} + 1.323\hat{\jmath})\text{ft}$

$(-P)\hat{\jmath} = (6\frac{\text{ft}}{\text{s}})\hat{k} - (1.323\omega_{abx}\hat{k} - 1.5\omega_{aby}\hat{k} + 1.5\omega_{abz}\hat{\jmath} - 1.323\omega_{abz}\hat{\imath})$

$\hat{\imath}$) $0 = -1.323\omega_{abz} \Rightarrow \omega_{abz} = 0$ rad/s

$\hat{\jmath}$) $-P = 1.5\omega_{abz} \rightarrow P = 0$ ft/s

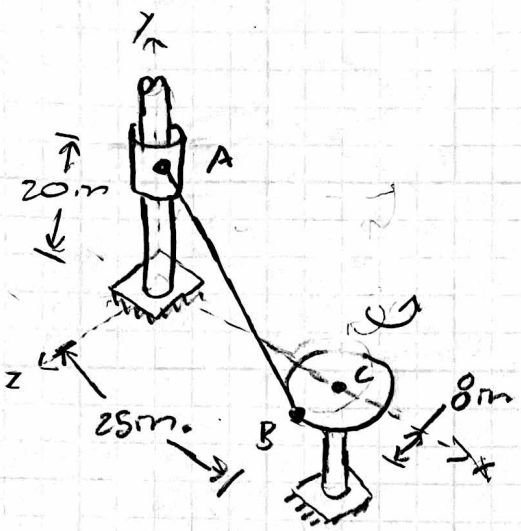
$\hat{k}$) $0 = 6\frac{\text{ft}}{\text{s}} + 1.323\omega_{abx} - 1.5\omega_{aby}$ ①

EQ 1 + 2 GIVE THE RESULT:

$\omega_{abx} = -1.98\frac{\text{rad}}{\text{s}}$ $\omega_{aby} = 2.25\frac{\text{rad}}{\text{s}}$

$\boxed{P = 0 \text{ ft/s}}$ $\boxed{\vec{\omega} = (-1.98\hat{\imath} + 2.25\hat{\jmath})\text{ rad/s}}$

② DIAGRAM



GIVEN

$\omega_{BC} = \left(-3\frac{rad}{s}\right)\hat{j}$

FIND

$V_A = ?$

SOLVE

$\vec{V}_B = \vec{\omega}_{BC} \times \vec{r}_{B/C} = (3\hat{j}) \times (8\hat{k}) = -24\hat{i}\ m/s$

$\vec{\omega}_{AB} \cdot \vec{r}_{A/B} = 0 = (\omega_x\hat{i} + \omega_y\hat{j} + \omega_z\hat{k}) \cdot (-25\hat{i} + 20\hat{j} - 8\hat{k})$

$0 = -25\omega_x + 20\omega_y - 8\omega_z \quad (eq\ 1)$

$\vec{V}_B = \vec{V}_A + \vec{\omega}_{AB} \times \vec{r}_{B/A}$

$-24\hat{i} = V_a\hat{j} + (\omega_x\hat{i} + \omega_y\hat{j} + \omega_z\hat{k}) \times (-25\hat{i} + 20\hat{j} - 8\hat{k})$

$-24\hat{i} = V_a\hat{j} + 20\omega_x\hat{k} + 8\omega_x\hat{j} + 25\omega_y\hat{k} - 8\omega_y\hat{i} - 25\omega_z\hat{j} - 20\omega_z\hat{i}$

$\hat{i}) \quad -24 = -8\omega_y - 20\omega_z \quad (eq\ 2)$

$\hat{j}) \quad 0 = V_a + 8\omega_x - 25\omega_z \quad (eq\ 3)$

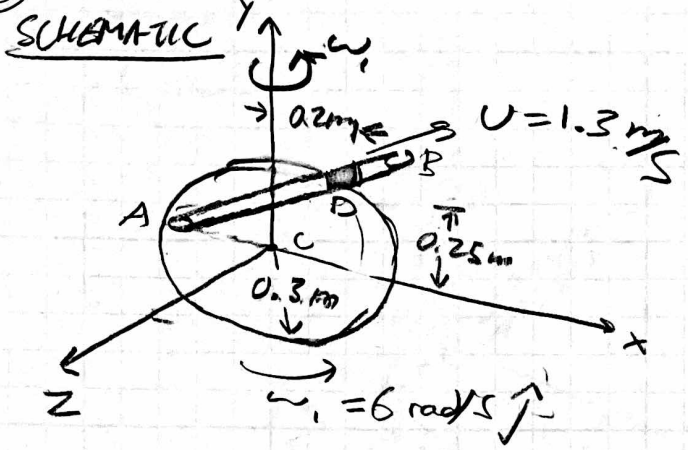
$\hat{k}) \quad 0 = 20\omega_x + 25\omega_y \quad (eq\ 4)$

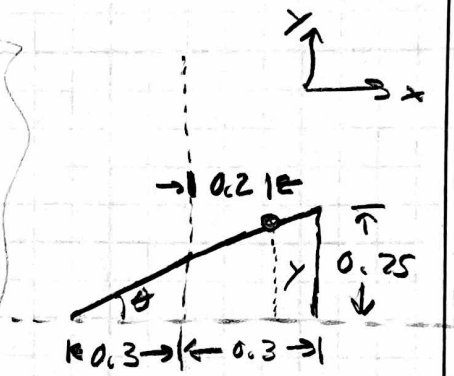
SOLVE EQUATIONS 1-4 WITH COMPUTER

$\boxed{V_a = -30\ m/s}$

(2)

SCHEMATIC





$\theta = \tan^{-1}\left(\frac{0.25}{0.6}\right) = \tan^{-1}\left(\frac{0.5}{1}\right)$
$= 26.199$

$Y = 0.5\left(\frac{0.25}{0.6}\right)$

$Y = 0.2083$

$\vec{r}_{D/A} = (0.5\hat{i} + 0.208\hat{j})$ m

FIND a) $v_D = ?$
b) $a_b = ?$

SOLVE

ATTACH COORD SYSTEM TO A

$\vec{v}_A = \vec{\omega}_1 \times \vec{r}_{A/C} = \left(6\frac{rad}{s}\hat{j}\right) \times (-0.3m\,\hat{i}) = 1.8\hat{k}\,\frac{m}{s}$

$\vec{\Omega} = \vec{\omega} = (6\ rad/s)\hat{j}$

$\vec{v}_b = \vec{v}_A + \vec{\Omega} \times \vec{r}_{D/A} + \vec{r}_{x,y,z}$

$\vec{v}_D = \left(1.8\hat{k}\,\frac{m}{s}\right) + \left(6\frac{rad}{s}\hat{j}\right) \times (0.5\hat{i} + 0.208\hat{j})m + U(\cos(22.6)\hat{i} + \sin(22.6)\hat{j})$

$\vec{v}_D = (1.8\hat{k}\,\frac{m}{s}) - (3\frac{m}{s}\hat{k}) + 1.2\hat{i} + 0.5\hat{j}$

$\boxed{\vec{v}_D = (1.2\hat{i} + 0.5\hat{j} - 1.2\hat{k})\ m/s}$

$\vec{a}_A = \vec{\omega}_1 \times \vec{\omega}_1 \times \vec{r}_{A/C} = 6\hat{j} \times 6\hat{j} \times -0.3\hat{i} = 10.8\hat{i}$

$\vec{a}_b = \vec{a}_A + \cancel{\ddot{\vec{\Omega}} \times \vec{r}_{P/O}}^{\,0} + \vec{\Omega} \times (\vec{\Omega} \times \vec{r}_{D/A}) + 2\vec{\Omega} \times \dot{\vec{r}}_{x,y,z} + \cancel{\ddot{\vec{r}}_{x,y,z}}^{\,0}$

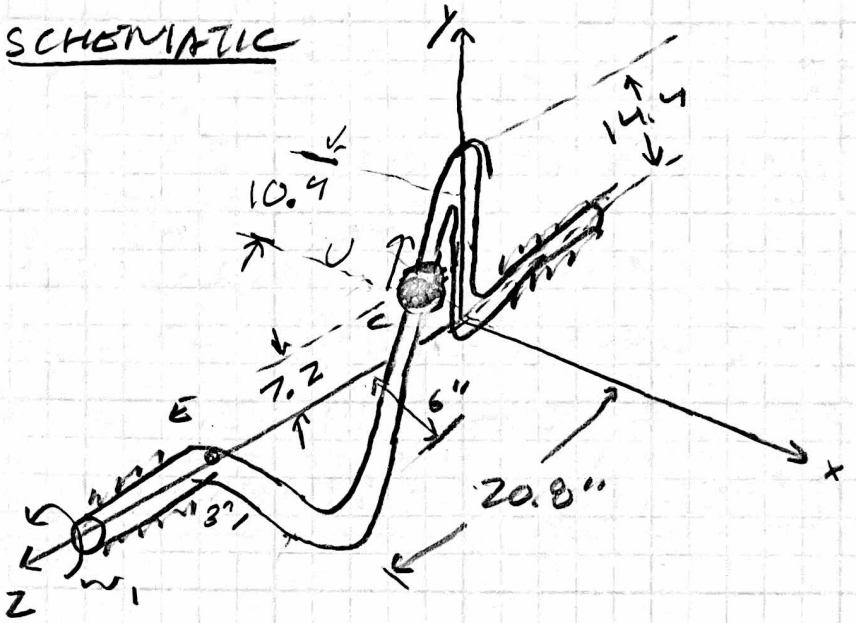
$\vec{a}_D = 10.8\hat{i} + 6\hat{j} \times 6\hat{j} \times (0.5\hat{i} + 0.208\hat{j}) + 2(6\hat{j}) \times 1.3\frac{m}{s}(\cos(22.6)\hat{i} + \sin(22.6)\hat{j})$

$\vec{a}_D = 10.8\hat{i} - 18\hat{i} - 14.4\hat{k}$

$\boxed{\vec{a}_D = -7.2\hat{i} - 14.4\hat{k}}$

PROBLEM 4

SCHEMATIC



GIVEN

$U = 39$ in/s , $\vec{\omega}_1 = 5$ rad/s $\hat{k}$

FIND

v_c, a_c

SOLVE

$\vec{r}_{C/E} = (3\hat{\imath} + 7.2\hat{\jmath} - 10.4\hat{k})$ in

ATTACH ROTATING SYSTEM TO E

$\vec{\Omega} = \vec{\omega}_1$

$\vec{v}_c = \cancel{\vec{v}_E} + \vec{\Omega} \times \vec{r}_{C/E} + \dot{r}_{xyz}$

$\vec{v}_c = \vec{\omega}_1 \times \vec{r}_{C/E} + \dot{r}_{xyz}$

$\vec{r}_{B/D} = (-6\hat{\imath} + 14.4\hat{\jmath} - 20.8\hat{k})$ in

$|\vec{r}_{B/D}| = 26$

$\dot{r}_{xyz} = \dfrac{\vec{r}_{B/D}}{|\vec{r}_{B/D}|} U = 39\frac{\text{in}}{\text{s}}(-0.231\hat{\imath} + .0554\hat{\jmath} - 0.8\hat{k})$

$\dot{r}_{xyz} = (-9\hat{\imath} + 21.6\hat{\jmath} - 31.2\hat{k})\frac{\text{in}}{\text{s}}$

$\vec{v}_c = (5\ rad/s)\hat{k} \times (3\hat{\imath} + 7.2\hat{\jmath} - 10.4\hat{k}) + (-9\hat{\imath} + 21.6\hat{\jmath} - 31.2\hat{k})$

$\vec{v}_c = 15\hat{\jmath} - 36\hat{\imath} - 9\hat{\imath} + 21.6\hat{\jmath} - 31.2\hat{k}$

$\boxed{\vec{v}_c = (-45\hat{\imath} + 36.6\hat{\jmath} - 31.2\hat{k})\ m/s}$

$\vec{a}_c = \cancel{\vec{a}_o} + \cancel{\dot{\vec{\Omega}} \times \vec{r}_{c/o}}^{\,0} + \vec{\Omega} \times \vec{\Omega} \times \vec{r}_{c/o} + 2\vec{\Omega} \times \vec{v}_{rel} + \cancel{\ddot{\vec{r}}_{rel}}$

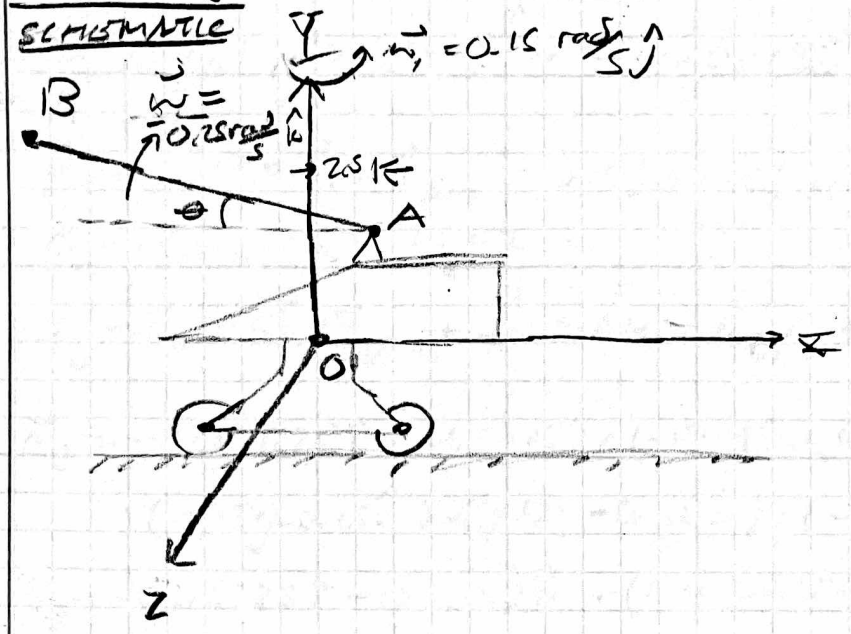
$\vec{a}_c = 5\hat{k} \times 5\hat{k} \times (3\hat{\imath} + 7.2\hat{\jmath} - 10.4\hat{k}) + 2(5\hat{k}) \times (-9\hat{\imath} + 21.6\hat{\jmath} - 31.2\hat{k})$

$\vec{a}_c = -75\hat{\imath} - 180\hat{\jmath} - 90\hat{\jmath} - 216.1\hat{\imath}$

$\boxed{\vec{a}_c = (-291.1\hat{\imath} - 270\hat{\jmath})\ m/s^2}$

PROBLEM 5

SCHEMATIC



GIVEN

$\theta = 20°$

$|r_{B/A}| = 16$ ft

FIND

$V_B = ?$ $A_B = ?$

SOLVE

ATTACH ROTATING COORD SYSTEM TO A

$\vec{V}_A = \cancel{\vec{V}_O}^{\,0} + \vec{\omega}_1 \times \vec{r}_{A/O}$

$\vec{r}_{A/O} = (2.5\hat{i} + Y\hat{j})$

$\vec{V}_A = 0.15\hat{j} \times (2.5\hat{i} + Y\hat{j}) = -0.375\hat{k}$

$\vec{\Omega} = \vec{\omega}_1 + \vec{\omega} = 0.15\hat{j} - 0.25\hat{k}$

$\vec{r}_{x,y,z} = 0$, $\vec{\dot{r}}_{x,y,z} = 0$.

$\vec{V}_B = \vec{V}_A + \vec{\Omega} \times \vec{r}_{B/A} + \cancel{\dot{r}_{x,y,z}}^{\,0}$

$\vec{V}_B = (-0.375\hat{k}) + (0.15\hat{j} - 0.25\hat{k}) \times 16(-\cos\theta\,\hat{i} + \sin\theta\,\hat{j})$

$\vec{V}_B = -0.375\hat{k} + (0.15\hat{j} - 0.25\hat{k}) \times (-15.04\hat{i} + 5.47\hat{j})$

$\vec{V}_B = -0.375\hat{k} + 2.256\hat{k} + 3.76\hat{j} + 1.368\hat{i}$

$\boxed{\vec{V}_B = 1.37\hat{i} + 3.76\hat{j} + 1.881\hat{k} \text{ ft/s}}$

$$\vec{\alpha} = 0.15\hat{j} \times (-0.25\hat{k}) = -0.0375\hat{i}\ rad/s^2$$

$$\vec{a}_a = \vec{\omega}_1 + \vec{\omega}_1 \times \vec{r}_{A/O} = 0.15\hat{j} \times 0.1\hat{j} \times (.25\hat{i} + Y\hat{j})$$

$$\vec{a}_a = -.005625\hat{i}\ ft/s^2$$

$$\vec{a}_B = \vec{a}_a + \vec{\alpha} \times \vec{r}_{B/A} + \vec{\omega} \times \vec{\omega} \times r_{B/A} + 2\vec{\omega} \times \vec{v}_{rel} + \vec{a}_{rel}$$

$$\vec{a}_B = -0.005625\hat{i} + -0.0375\hat{i} \times (-15.04\hat{i} + 5.472\hat{j}) +$$

$$(0.15\hat{j} - 0.25\hat{k}) \times (0.15\hat{j} - 0.25\hat{k}) \times (-15.04\hat{i} + 5.472\hat{j})$$

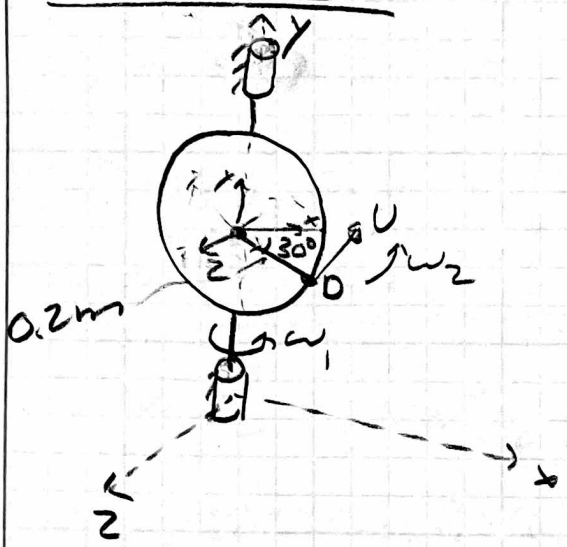
$$\vec{a}_B = -0.005625\hat{i} - 0.2052\hat{k} + (0.15\hat{j} - 0.25\hat{k}) \times (2.256\hat{k} + 3.76\hat{j} + 1.368\hat{i})$$

$$\vec{a}_B = -0.005625\hat{i} - 0.2052\hat{k} + (0.3384\hat{i} - 0.2052\hat{k} + 0.44\hat{i} - 0.342\hat{j})$$

$$\boxed{\vec{a}_b = (1.22\hat{i} - 0.342\hat{j} - 0.408\hat{k})\ ft/s^2}$$

PROBLEM #6

SCHEMATIC



GIVEN

$\omega_1 = 10$ rad/s $\hat{\jmath}$

$\dot{\omega}_1 = -25$ rad/s $\hat{\jmath}$

$U = 1.5$ m/s

$\dot{U} = -3$ m/s^2

FIND

a) v_D

b) a_D

SOLVE

ATTACH SYS AT C

$v_C = 0$

$\vec{\Omega} = \vec{\omega}_1 + \vec{\omega}_2$

$U = r\omega_2$

$\omega_2 = \frac{1.5 \text{ m/s}}{0.2 \text{ m}} = 7.5 \text{ rad/s } \hat{k}$

$\vec{\Omega} = 10\hat{\jmath} + 7.5\hat{k}$

$\dot{\vec{\omega}}_2 = \vec{\omega}_1 \times \vec{\omega}_2 + \dot{\vec{\omega}}_{2\,rel} = 10\hat{\jmath} \times 7.5\hat{k} + \left(\frac{-3 \text{ m/s}^2}{0.2 \text{ m}}\right)\hat{k}$

$\dot{\omega}_2 = 75\hat{\imath} - 15\hat{k}$

$\vec{\Omega}_2 = (-25 \text{ rad/s } \hat{\jmath}) + 75\hat{\imath} - 15\hat{k}$

$\vec{\Omega}_2 = 75\hat{\imath} - 25\hat{\jmath} - 15\hat{k}$

$$v_b = \cancel{v_c} + \vec{\Omega} \times \vec{r}_{b/c} + \cancel{\dot{r}_{xyz}}^{\,0}$$

$$v_b = (10\hat{j} + 7.5\hat{k}) \times 0.2(\cos(20)\hat{\imath} - \sin(30)\hat{j})$$

$$= (10\hat{j} + 7.5\hat{k}) \times (0.173\hat{\imath} - 0.1\hat{j})$$

$$\boxed{v_b = -1.73\hat{k} + 1.298\hat{j} + 0.75\hat{\imath}}$$

$$a_b = \cancel{a_c} + \dot{\vec{\Omega}} \times \vec{r}_{b/c} + \vec{\Omega} \times \vec{\Omega} \times \vec{r}_{b/c} + \cancel{2\vec{\Omega} \times \dot{r}_{b/z}} + \cancel{\ddot{r}_{xyz}}$$

$$a_b = (25\hat{\imath} - 25\hat{j} - 15\hat{k}) \times (0.173\hat{\imath} - 0.1\hat{j}) + (10\hat{j} + 7.5\hat{k}) \times (0.75\hat{\imath} + 1.298\hat{j} - 1.73\hat{k})$$

$$a_b = (-7.5\hat{k} + 4.325\hat{k} - 2.595\hat{j} - 1.5\hat{\imath}) + (-7.5\hat{\imath} - 17.3\hat{\imath} + 5.625\hat{j} - 9.735\hat{\imath})$$

$$\boxed{a_b = (-28.54\hat{\imath} + 3.03\hat{j} - 10.68\hat{k})\ m/s^2}$$