Problem 1 $\alpha_A = .5 \text{ rad/s}^2$ $r_A = 6 \text{ in}$ $r_C = 5 \text{ in}$

Q1. $\Delta\theta_A = 5 \text{ rev}$ $r_B = 10 \text{ in}$, $r_D = 15 \text{ in}$

$$\omega_A^2 = \omega_{A,0} + 2\alpha_A(\theta_A - \theta_{A,0}) \quad \omega_{A,0} = 0, \ \theta_{A,0} = 0$$

$$\omega_A = \sqrt{2\alpha_A \theta_A} = \sqrt{2(.5 \text{ rad/s}^2)(5 \cdot 2\pi)} = 5.60 \text{ rad/s}$$

$$r_A \omega_A = r_B \omega_B$$

$$\omega_B = \frac{r_A \omega_A}{r_B} = \frac{6 \text{ in} \cdot 5.6 \text{ rad/s}}{10 \text{ in}} = 3.36 \text{ rad/s}$$

$$\omega_C = \omega_B$$

$$\omega_D = \frac{r_C \omega_C}{r_D} = \frac{5 \text{ in} \cdot 3.36 \text{ rad/s}}{15 \text{ in}} = 1.12 \text{ rad/s}$$

$$a_{A,t} = a_{B,t}$$

$$r_A \alpha_A = r_B \alpha_B$$

$$\alpha_B = \frac{r_A \alpha_A}{r_B} = \frac{6 \text{ in} \cdot .5 \text{ rad/s}^2}{10 \text{ in}} = .3 \text{ rad/s}^2$$

$$\alpha_C = \alpha_B$$

$$\alpha_D = \frac{r_C \alpha_C}{r_D} = \frac{5 \text{ in} \cdot .3 \text{ rad/s}^2}{15 \text{ in}} = .1 \text{ rad/s}^2$$

$$a_{P,t} = r_D \alpha_D = 15 \text{ in} \cdot \frac{1 \text{ ft}}{12 \text{ in}} \cdot .1 \text{ rad/s}^2 = .125 \text{ ft/s}^2$$

$$a_{P,n} = r_D \omega_D = 15 \text{ in} \cdot \frac{1 \text{ ft}}{12 \text{ in}} \cdot (1.12 \text{ rad/s})^2 = 1.568 \text{ ft/s}^2$$

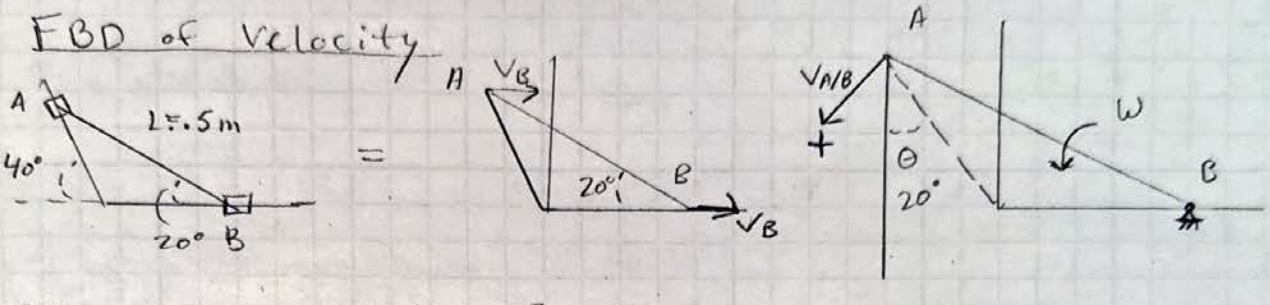
$$a_P = \sqrt{a_{P,t}^2 + a_{P,n}^2} = \sqrt{(.125 \text{ ft/s}^2)^2 + (1.568 \text{ ft/s}^2)^2} = \boxed{1.57 \text{ ft/s}^2}$$

Problem 2

$V_B = 3\ m/s$ $a_B = 1.8\ m/s^2 \rightarrow$

$\beta = 40°$ $\theta = 20°$ $L = 500\ mm$ or $.5\ m$

FBD of Velocity



Collar A x dir: $V_A \cos\beta = V_B - V_{A/B} \sin\theta$

$V_{A/B} = L\omega$ $\quad V_A \cos\beta = V_B - L\omega \sin\theta$ ①

Collar A y-dir: $-V_A \sin\beta = -V_{A/B} \cos\theta$

$V_A \sin\beta = L\omega \cos\theta$ ②

① $V_A \cos 40° = 3\ m/s - .5\,\omega \sin 20°$

② $V_A \sin 40° = .5\,\omega \cos 20°$

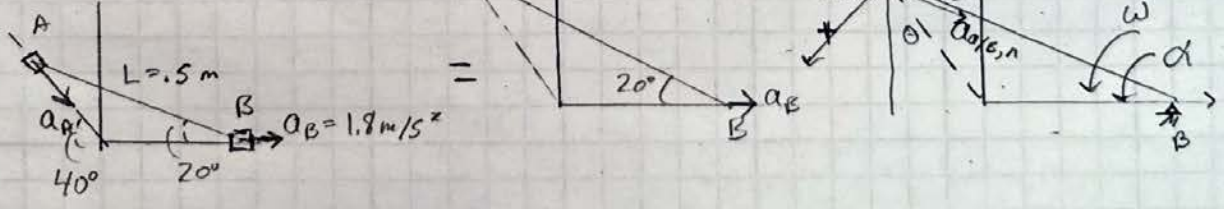
$$V_A = \frac{.5 \cdot \cos 20°\ \omega}{\sin 40°} = .731\,\omega$$

$$.731\omega \cos 40° + .5\,\omega \sin 20 = 3\ m/s$$

$$\omega = \frac{3\ m/s}{.731 \cos 40 + .5 \cdot \sin 20} = 4.1\ rad/s$$

$V_A = .731 \cdot 4.1\ rad/s = 3.00\ m/s$

FBD Accel



Collar A x-dir: $a_A \cos\beta = a_B - a_{A/B,t} \sin\theta + a_{A/B,n} \cos\theta$ ③

y-dir: $-a_A \sin\beta = -a_{A/B,t} \cos\theta - a_{A/B,n} \sin\theta$ ④

$a_{A/B,t} = L\alpha$

$a_{A/B,n} = L\omega^2$

③ $a_A \cos\beta = a_B - L\alpha \sin\theta + L\omega^2 \cos\theta$

④ $a_A \sin\beta = L\alpha \cos\theta + L\omega^2 \sin\theta$

$a_A \cos 40° = 1.8 - .5 \sin 20\,\alpha + .5(4.1)^2 \cos 20$

$.766\, a_A + .171\,\alpha = 9.698$

$a_A \sin 40° = .5\,\alpha \cos 20 + .5(4.1)^2 \sin 20$

$.643\, a_A - .4698\,\alpha = 2.875$

$$A \begin{bmatrix} .766 & .171 \\ .643 & -.4698 \end{bmatrix} \qquad B \begin{bmatrix} 9.698 \\ 2.875 \end{bmatrix}$$

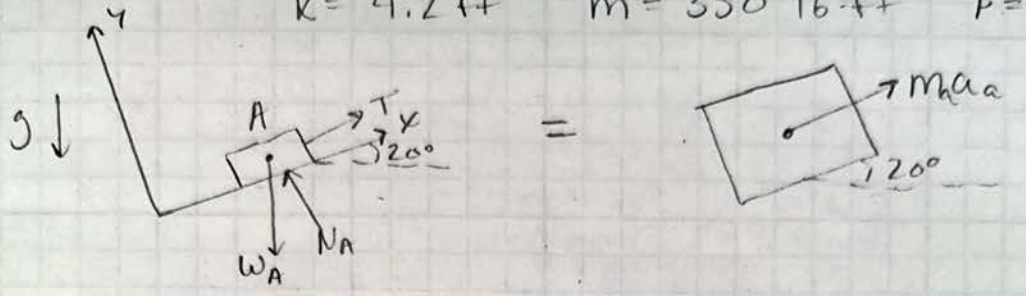
$$A^{-1} \cdot B = \begin{bmatrix} 10.744 \\ 8.585 \end{bmatrix}$$

Q2. $\alpha_{A/B} = 8.585 \text{ rad/s}^2$

Q3. $a_A = 10.744 \text{ m/s}^2$

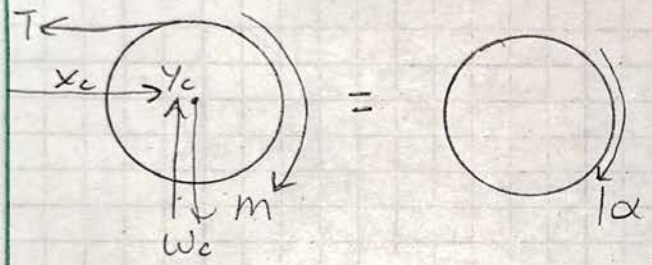
Problem 3 $W_A = 250$ lb $W_C = 150$ lb $r = 2.3$ ft

$K = 4.2$ ft $m = 350$ lb-ft $\beta = 20°$



x dir : $-W_a \sin\beta + T = m_a a_a$ $\quad a_a = r\alpha$

y dir : $N_A - W_a \cos\beta = 0$



x dir : $X_c - T = 0$

y dir : $y_c - W_c = 0$

M : $Tr - m = -I\alpha$ $\quad I = m_c k^2$

$Tr - m = -m_c k^2 \alpha$

$-W_A \sin\beta + T = m_A r \alpha$

$\alpha = \dfrac{-W_A \sin\beta + T}{m_A r}$

$Tr - m = -\dfrac{m_c k^2 (-W_A \sin\beta + T)}{m_A r}$

$Tr + \dfrac{m_c k^2}{m_A r} T = \dfrac{m_c k^2}{m_A r} \cdot W_A \sin\beta + m$

$T = \dfrac{1}{r + \frac{m_c k^2}{m_A r}} \cdot \dfrac{m_c k^2}{m_A r} W_A \sin B + m$

Q5. $T = \dfrac{1}{2.3 + \dfrac{\frac{150}{32.2}\cdot 4.2^2}{\frac{250}{32.2}\cdot 2.3}} \cdot \dfrac{\frac{150}{32.2}\cdot 4.2^2}{\frac{250}{32.2}\cdot 2.3} \cdot 2.50\sin 20 + 350 =$

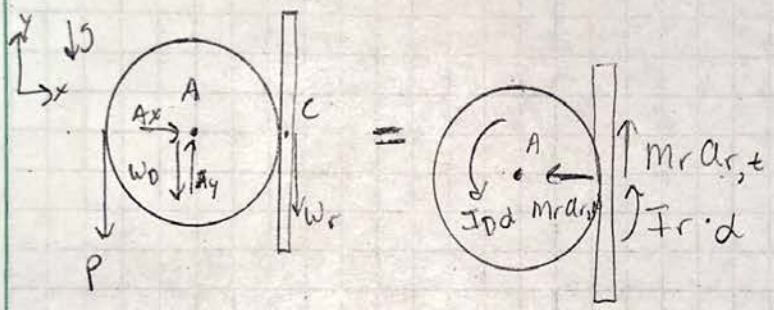
107.72 lb

Q4. $a_A = \frac{1}{m_a}(-W_a \sin\beta + T) = \frac{1}{\frac{250}{32.2}}(-250\sin 20 + 107.72) =$

2.86 ft/s²

Problem 4 $m_r = 5$ kg $L = 750$ mm or .75 m $m_d = 18$ kg
$r_d = 380$ mm or .38 m

$P = 300$ N $\omega_A = 12$ rad/s



$\bar{I}_D = \frac{1}{2} m_D r^2 = \frac{1}{2}\cdot 18\text{ kg}\cdot(.38\text{m})^2 = 1.2996\ \text{kg m}^2$

$\bar{I}_r = \frac{1}{12} m_r L^2 = \frac{1}{12}\cdot 5\text{ kg}\cdot(.75\text{m})^2 = .2344\ \text{kg m}^2$

$a_{r,t} = r\alpha = .38\alpha$

$a_{r,n} = r\omega^2 = .38\omega^2$

$+\circlearrowleft;\ \overset{+\circlearrowleft}{\Sigma} M_A = \overset{+\circlearrowleft}{\Sigma}(M_A)_{eff}$

$P\cdot r - W_r\cdot r = I_D\alpha + I_r\alpha + m_r a_{r,t}\cdot r$ ($a_{r,t} = .38\alpha$)

$\alpha = \dfrac{P\cdot r - W_r\cdot r}{I_D + I_r + .38 m_r\cdot r} = \dfrac{(300\cdot .38\text{m}) - (5\cdot 9.81\cdot .38\text{m})}{1.2996 + .2344 + (.38\cdot 5\cdot .38)}$

Q6. **= 42.27 rad/s²**

Q7. $\underset{+\rightarrow}{x}$ dir: $\Sigma F_x = \Sigma (F_x)_{eff}$

$$A_x = -m_r \cdot a_{r,n} = -5\,kg \cdot .38 \cdot (12\ rad/s)^2$$

$a_{r,n} = r\omega^2$

$$|A_x| = -273.6 = \boxed{273.6\,N}$$

Q8 $\underset{+\uparrow}{y}$ dir: $\Sigma F_y = \Sigma (F_y)_{eff}$

$$A_y - P - m_D \cdot g - m_r \cdot g = m_r a_{r,t}$$

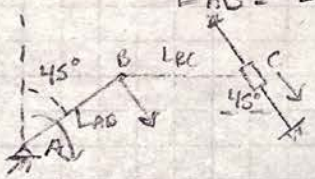
$$A_y = P + m_D \cdot g + m_r \cdot g + m_r \cdot r\alpha$$

$$A_y = 300N + (18kg \cdot 9.81) + (5kg \cdot 9.81) + (5kg \cdot .38 \cdot 42.27)$$

$$\boxed{= 605.943\ N}$$

Problem #5 $\omega_{AB} = 3.2\ rad/s$ $\alpha = .8\ rad/s^2$ $W_C = 12\ lbs$

$L_{AC} = 2.5\ ft$ $L_{BC} = 1.8\ ft$ $\beta = 45°$ $\theta = 45°$



$\omega_{AB} = 3.2\ rad/s$

$\alpha_{AB} = .8\ rad/s^2$

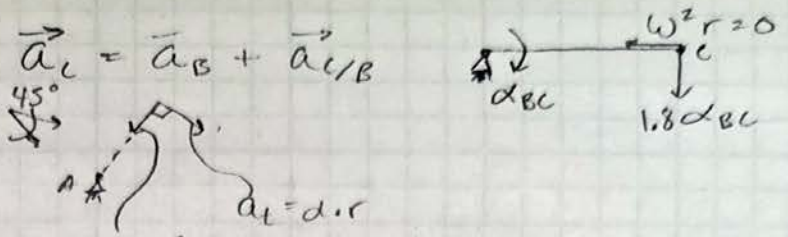
Velocities: $\vec{V}_C = \vec{V}_B + \vec{V}_{C/B}$

45° 45° w_r

$V_B = V_C = r \cdot \omega = 2.5 \cdot 3.2\ rad/s = \boxed{8\ ft/s}$ Q11

$\boxed{\omega_{BC} = 0}$ Q9

accels: $\vec{a}_C = \vec{a}_B + \vec{a}_{C/B}$



$a_n = \omega^2 r = .8 \cdot 2.5$
$= 2 \text{ ft/s}^2$
$= 3.2^2 \cdot 2.5$
$= 25.6 \text{ ft/s}^2$

$\vec{+}$ x dir: $a_C \cos 45° = -25.6 \sin 45 + 2 \cos 45$

$a_C = -23.6 \text{ ft/s}$

Q12 $\boxed{|a_C| = 23.6 \text{ ft/s}}$

$\downarrow +$ y dir: $a_C \sin 45 = 25.6 \cos 45 + 2 \sin 45 + 1.8\alpha_{BC}$

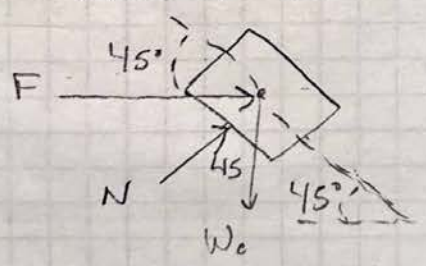
$$\alpha_{BC} = \frac{(-23.6 \sin 45) - (25.6 \cos 45) + (2 \sin 45)}{1.8}$$

$\alpha_{BC} = -18.54 \text{ rad/s}^2$

Q10 $\boxed{|\alpha_{BC}| = 18.54 \text{ rad/s}^2}$

Q13. ~~$F_C = m_C a_C = \frac{12}{32.2} \cdot (-23.6) \cdot \cos 45 = 6.21 \text{ lbs}$~~

FBD of C



x dir: $W_C \sin 45 + F_1 \cos 45 = m_C a_C$

$F = m_C a_C - W_C \sin 45$

$$F = \frac{\frac{12}{32.2} \cdot (-23.6) - 12 \sin 45}{\cos 45°}$$

$F = -24.43 \text{ lb}$

$\boxed{|F| = 24.43 \text{ lb}}$