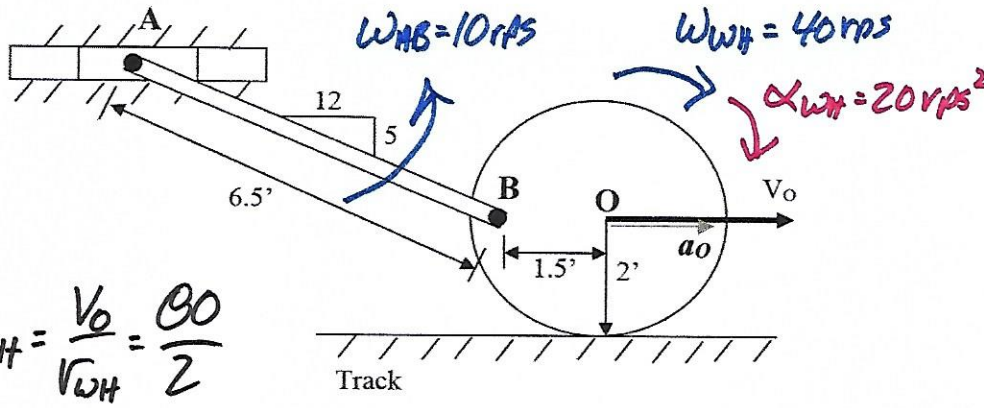
Rigid Body Kinematics III – Problem 3

For the train wheel shown, find the acceleration of the piston at A relative to the track and the angular acceleration of the push arm AB when the velocity and acceleration of the train is $v_O = 80$ fps and $a_O = 40$ fps^2 and the angular velocity of the push arm AB is $\omega_{AB} = 10$ rps (CCW). Assume no slip.

CLASSIFY MOTION

PISTON A TRANS
ARM AB GPM
WHEEL GPM



NO SLIP WHEEL

$V_O = \omega_{WH} r_{WH}$, $\omega_{WH} = \frac{V_O}{r_{WH}} = \frac{80}{2}$

$\omega_{WH} = 40$ rps ↻

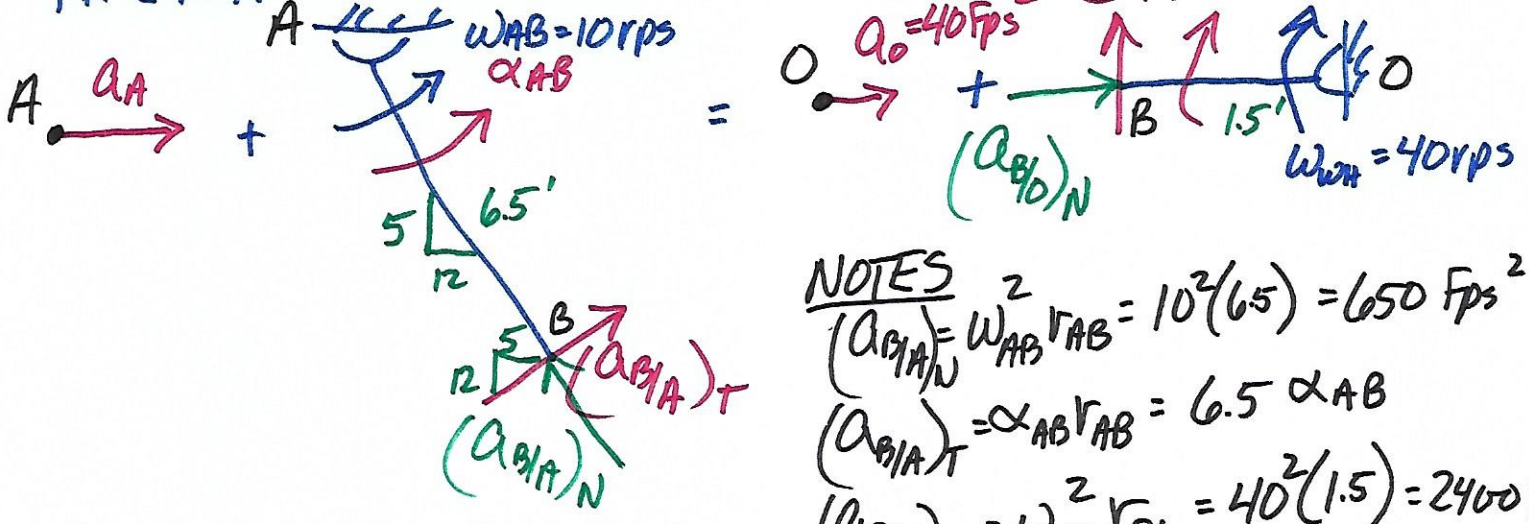
$a_O = \alpha_{WH} r_{WH}$, $\alpha_{WH} = \frac{a_O}{r_{WH}} = \frac{40}{2} = 20$ rps^2 ↻

ALL ωs KNOWN, NO NEED TO SOLVE VELOCITY PROBLEM

RELATIVE ACCELERATION EQN

$\vec{a}_B = \vec{a}_A + \vec{a}_{B/A} = \vec{a}_O + \vec{a}_{B/O}$

KINEMATIC DIAGRAMS



NOTES

$(a_{B/A})_N = \omega_{AB}^2 r_{AB} = 10^2(6.5) = 650$ fps^2

$(a_{B/A})_T = \alpha_{AB} r_{AB} = 6.5\,\alpha_{AB}$

$(a_{B/O})_N = \omega_{WH}^2 r_{B/O} = 40^2(1.5) = 2400$ fps^2

$(a_{B/O})_T = \alpha_{WH}^2 r_{B/O} = 20(1.5) = 30$ fps^2

Rigid Body Kinematics III – Problem 3 (Continued)

SCALAR EQUATIONS

$$\rightarrow x \quad a_A + \frac{5}{13}(6.5\alpha_{AB}) - \frac{12}{13}(650) = 40 + 2400$$

$$\uparrow y \quad 0 + \frac{12}{13}(6.5\alpha_{AB}) + \frac{5}{13}(650) = 30$$

$$\alpha_{AB} = -36.7 = 36.7 \text{ rps}^2 \curvearrowright$$

$$a_A = 2948 \text{ Fps}^2 \rightarrow$$