

ME 2580 Example #32: (Rigid Body Kinematics – Relative Velocity)

Given: $R = 3$ (in), $L = 6$ (in), $\theta = 30$ (deg)

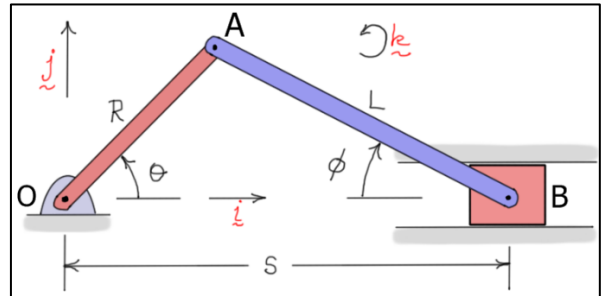
$$\omega_{OA} = \dot{\theta} = 100 \text{ (rpm) (CCW)}$$

Find: ω_{AB} , $v_B = \dot{s}$

Solution:

From the triangle formed by the mechanism,

$$\boxed{R \sin(\theta) = L \sin(\phi)} \Rightarrow \phi = \sin^{-1}\left(\frac{R \sin(\theta)}{L}\right)_{\theta=30 \text{ (deg)}} = 14.4775 \text{ (deg)}$$



Using the relative velocity equations, write

$$\boxed{\underline{v}_B = \underline{v}_A + \underline{v}_{B/A}}^*$$

where

$$\boxed{\underline{v}_B = v_B \underline{i}}$$

$$\underline{v}_A = \underbrace{\underline{v}_O}_{\text{zero}} + \underline{v}_{A/O} = \omega_{OA} \underline{k} \times R(\cos(\theta) \underline{i} + \sin(\theta) \underline{j}) = R\omega_{OA}(-\sin(\theta) \underline{i} + \cos(\theta) \underline{j})$$

$$= 3(100)\left(\frac{2\pi}{60}\right)(-\sin(30) \underline{i} + \cos(30) \underline{j})$$

$$\Rightarrow \boxed{\underline{v}_A = -15.708 \underline{i} + 27.207 \underline{j} \text{ (in/s)}}$$

$$\boxed{\underline{v}_{B/A} = \omega_{AB} \underline{k} \times L(\cos(\phi) \underline{i} - \sin(\phi) \underline{j}) = 6\omega_{AB}(\sin(\phi) \underline{i} + \cos(\phi) \underline{j})}$$

Substituting into the relative velocity equation (*) give the following scalar equations:

$$\boxed{\begin{aligned} v_B &= -15.708 + 6\omega_{AB} \sin(\phi) \\ 0 &= 27.207 + 6\omega_{AB} \cos(\phi) \end{aligned}}$$

Solving for ω_{AB} and v_B gives

$$\omega_{AB} = -27.207 / (6 \cos(\phi)) = -4.68321 \Rightarrow \boxed{\omega_{AB} \approx -4.68 \underline{k} \text{ (rad/s)}}$$

$$v_B = -15.708 + 6\omega_{AB} \sin(\phi) = -22.7328 \Rightarrow \boxed{v_B \approx -22.7 \underline{i} \text{ (in/s)} \approx -1.89 \underline{i} \text{ (ft/s)}}$$

So, in the current position, link AB is **rotating clockwise** at 4.68 (rad/s) and B is moving to the **left** at 1.89 (ft/s).

Note: The signs of the variables ω_{AB} and v_B are found by solving the simultaneous scalar equations. They need not be known prior to solving the equations.