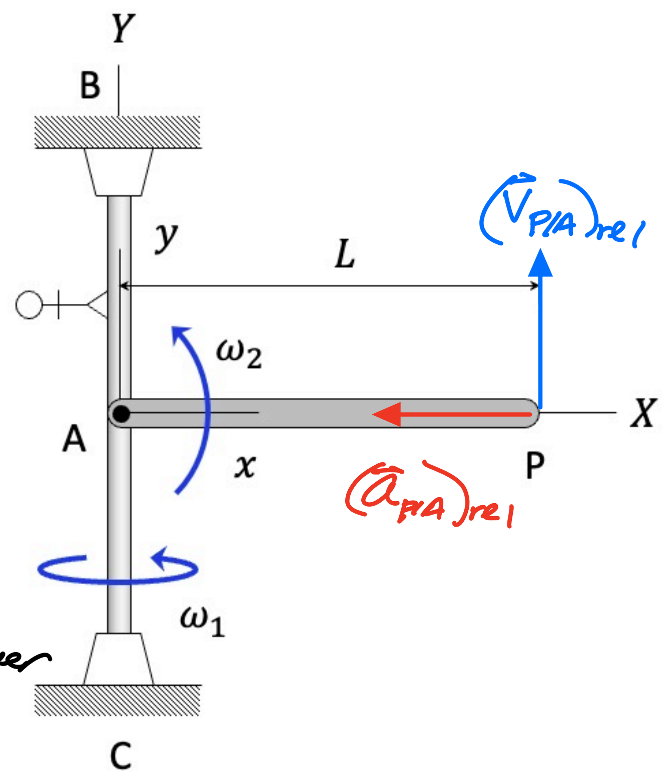
ME 274 – Fall 2024 – Quiz 4A **Name** SOLUTION

Shaft BC rotates at a constant rate ω_1 about a fixed vertical axis. Arm AP rotates at a constant rate of ω_2 relative to shaft BC. The *XYZ*-axes are fixed in space. It is desired to know the acceleration of end P of arm AP at the instant when AP is horizontal using the moving reference frame kinematics equation:

$$\vec{a}_P = \vec{a}_A + \left(\vec{a}_{P/A}\right)_{rel} + \vec{\alpha} \times \vec{r}_{P/A} + 2\,\vec{\omega} \times \left(\vec{v}_{P/A}\right)_{rel} + \vec{\omega} \times \left(\vec{\omega} \times \vec{r}_{P/A}\right)$$

You are asked to use an *observer that is attached to shaft BC* with the moving *xyz*-axes also attached to BC. At the instant shown, the *xyz*-axes and *XYZ*-axes are aligned.

Write down expressions for the following terms of the above equation in terms of their *xyz*-components. You do NOT need to find $\vec{a}_P$.



$\vec{\omega}$ = ang. vel. of observer
$= \omega_1 \hat{J} = \omega_1 \hat{j}$

$\vec{\alpha} = \frac{d\vec{\omega}}{dt} = \cancel{\dot{\omega}_1}^{0}\hat{J} + \omega_1 \cancel{\dot{\hat{J}}}^{0} = \vec{0}$

$\left(\vec{v}_{P/A}\right)_{rel}$ = vel. of P as seen by observer
$= L\omega_2 \hat{j}$

$\left(\vec{a}_{P/A}\right)_{rel}$ = acc. of P as seen by observer
$= -L\omega_2^2\, \hat{i}$

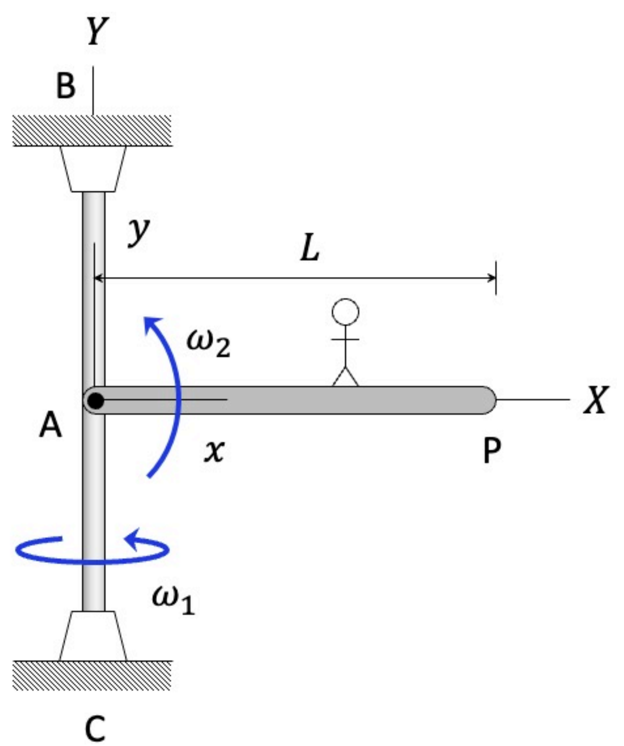
ME 274 – Fall 2024 – Quiz 4B **Name** SOLUTION

Shaft BC rotates at a constant rate ω_1 about a fixed vertical axis. Arm AP rotates at a constant rate of ω_2 relative to shaft BC. The *XYZ*-axes are fixed in space. It is desired to know the acceleration of end P of arm AP at the instant when AP is horizontal using the moving reference frame kinematics equation:

$$\vec{a}_P = \vec{a}_A + \left(\vec{a}_{P/A}\right)_{rel} + \vec{\alpha} \times \vec{r}_{P/A} + 2\,\vec{\omega} \times \left(\vec{v}_{P/A}\right)_{rel} + \vec{\omega} \times \left(\vec{\omega} \times \vec{r}_{P/A}\right)$$

You are asked to use an *observer that is attached to arm AP* with the moving *xyz*-axes also attached to AP. At the instant shown, the *xyz*-axes and *XYZ*-axes are aligned.

Write down expressions for the following terms of the above equation in terms of their *xyz*-components. You do NOT need to find $\vec{a}_P$.



$\vec{\omega}$ = ang. vel. of observer

$= \omega_1 \hat{J} + \omega_2 \hat{K} = \omega_1 \hat{j} + \omega_2 \hat{k}$

$\vec{\alpha} = \frac{d\vec{\omega}}{dt} = \overset{0}{\cancel{\dot{\omega}_1}} \hat{J} + \omega_1 \overset{0}{\cancel{\dot{\hat{J}}}} + \overset{0}{\cancel{\dot{\omega}_2}} \hat{k} + \omega_2 \dot{\hat{k}}$

$= \omega_2(\vec{\omega} \times \hat{k}) = \omega_2[\omega_1 \hat{j} + \omega_2 \underbrace{\hat{k}] \times \hat{k}}_{0}$

$= \omega_1 \omega_2 \hat{i}$

$\left(\vec{v}_{P/A}\right)_{rel} = \vec{0}$

Observer is on same rigid body as P

$\left(\vec{a}_{P/A}\right)_{rel} = \vec{0}$