

## 21-R-KM-SS-32

A pinion gear is attached to a ring gear with an arm. The arm and the ring gear share a pivot as shown in the diagram. The arm of length,  $l$  is 10cm and it rotates clockwise at 2rad/s. The ring gear has a diameter,  $d$  of 30cm and it rotates clockwise at 1 rad/s. Find the angular velocity of the pinion gear.

Enter a positive value if it rotates counter-clockwise, and negative if it rotates clockwise.

### Soluton

The diameter of the pinion gear can be found by subtracting radius of the arm from the radius of the ring gear. In a gear system, there is no slippage at the point of contacts between gears. We shall find two equations for the velocity of this point of contact and equate them.

$$\begin{aligned}\vec{v}_P &= \vec{\omega}_C \times \vec{r}_C \\ &= -1\hat{k} \times 0.15\hat{j} \\ &= 0.15\hat{i} \quad [ \text{ m/s } ]\end{aligned}$$

$$\begin{aligned}\vec{v}_P &= \vec{v}_B + \vec{\omega}_B \times \vec{r}_B \\ &= \vec{\omega}_A \times \vec{r}_A + \vec{\omega}_B \times \vec{r}_B \\ &= -2\hat{k} \times 0.1\hat{j} + \omega_B\hat{k} \times (0.15 - 0.1)\hat{j} \\ &= 0.2\hat{i} - 0.05\omega_B\hat{i} \quad [ \text{ m/s } ]\end{aligned}$$

$$\begin{aligned}0.15\hat{i} &= 0.2\hat{i} - 0.05\omega_B\hat{i} \\ \Rightarrow \omega_B &= 1 \quad [ \text{ rad/s } ]\end{aligned}$$

So the pinion gear is rotating counter-clockwise at 1 rad/s.

The question asked counter-clockwise rotations to be entered as a positive value.