1 Still Hockey Puck on a Rotating Ice Rink

A hockey puck, with mass m, slides without friction on a flat level ice surface. The flat surface is rotating at an angular speed Ω counter-clock-wise about a fixed axis that is perpendicular to the flat surface. The puck is not moving in the fixed frame of reference and has a position that is a distance D from the axis of rotation.

1.1 Motion in the Rotating Frame

Describe the motion of the puck in the frame of reference that is rotating with the flat surface. Include the sense of direction of the motion.

1.1 solution

The puck moves in a circle about the axis of rotation with an radius D with a angular speed Ω in a clock-wise direction.

1.2 Effective Forces on the Puck

In terms of m, Ω, D and $\hat{r}$, the unit radial vector in the rotating frame (measured from the axis of rotation), find the net effective force, $\vec{F}_{\text{eff}}$, the Coriolis force, $-2m\vec{\omega} \times \vec{v}_r$, and the centrifugal force, $-m\vec{\omega} \times (\vec{\omega} \times \vec{r})$, that act on the puck in the frame of reference that is rotating with the flat surface.

1.2 solution

In the rotating frame the net force must be causing the puck to go in uniform circular motion, so

$$\boxed{\vec{F}_{\text{eff}} = -m\Omega^2 D\hat{r}}. \tag{1.1}$$

Using the right-hand rule with the cross products we get:

$$\boxed{-2m\vec{\omega} \times \vec{v}_r = -2m\Omega^2 D\hat{r} \qquad -m\vec{\omega} \times (\vec{\omega} \times \vec{r}) = m\Omega^2 D\hat{r}}. \tag{1.2}$$

So

$$\vec{F}_{\text{eff}} = -2m\vec{\omega} \times \vec{v}_r - m\vec{\omega} \times (\vec{\omega} \times \vec{r}) = -2m\Omega^2 D\hat{r} + m\Omega^2 D\hat{r} = -m\Omega^2 D\hat{r} \tag{1.3}$$