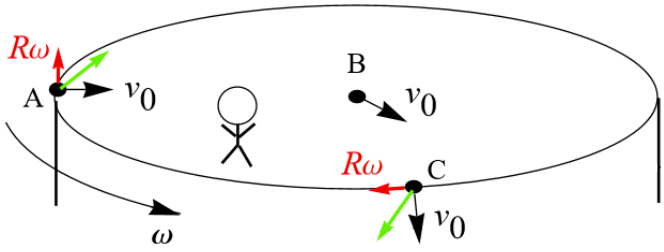
Problem 1.27

The hallmark of an inertial reference frame is that any object which is subject to zero net force will travel in a straight line at constant speed. To illustrate this, consider the following experiment: I am standing on the ground (which we shall take to be an inertial frame) beside a perfectly flat horizontal turntable, rotating with constant angular velocity ω. I lean over and shove a frictionless puck so that it slides across the turntable, straight through the center. The puck is subject to zero net force and, as seen from my inertial frame, travels in a straight line. Describe the puck's path as observed by someone sitting at rest on the turntable. This requires careful thought, but you should be able to get a qualitative picture. For a quantitative picture, it helps to use polar coordinates; see Problem 1.46.

Solution

The figure below shows the velocity of the puck at the start (A), center (B), and end (C) of its motion according to an observer standing on the turntable. The vectors in green at A and C are the total velocity vectors at these points.



Since the puck is frictionless, the rotation of the turntable exerts no force on the puck, and the black vector's magnitude never changes. However, due to the turntable's counterclockwise rotation, the black vector's direction turns more and more clockwise (the turntable points it in a different direction just by rotating). At point A the turntable has tangential speed $R\omega$ downward, which makes the puck move upward at this speed to an observer standing on the turntable. Similarly, at point C the turntable has tangential speed $R\omega$ to the right, which makes the puck move to the left at this speed to an observer standing on the turntable. The puck moves fastest at the edges (with speed $\sqrt{v_0^2 + R^2\omega^2}$) and slowest at the center (with speed v_0). Below is a sketch of the frictionless puck's path on the turntable.