46.1: Introduction to the Coriolis Force

Imagine you're on a rotating merry-go-round, and you throw a ball to another person who's on the opposite side of the merry-go-round. If you aim directly at the other person, you'll miss them - the ball will travel in a straight line relative to the ground, but the merry-go-round will have rotated during the time the ball is in the air. Relative to the merry-go-round, the ball will appear to move along a curved path. You can attribute this curvature to a "fictitious force" called the Coriolis force. The Coriolis force is not a real force-it's just an artifact of viewing the ball's motion in a rotating reference frame. The ball really moves in a straight line relative to the ground.

So in the rotating reference frame of the merry-go-round, you'll see the ball move in a curved path, which can't happen unless there is a "force" present. We can compute the magnitude of this Coriolis force by considering the following situation. Suppose you're at the center of the merry-go-round, and throw a ball outward with velocity v while the merry-go-round is rotating with an angular velocity Ω. After a time t, the ball will have moved a radial distance $r = vt$. At time t, a point on the merry-go-round a distance r from the center will have moved through an arc length

$$s = r\theta \tag{46.1.1}$$

$$= r(\Omega t) \tag{46.1.2}$$

$$= (vt)\Omega t \tag{46.1.3}$$

$$= \Omega v t^2. \tag{46.1.4}$$

But under a constant acceleration a_c, we know

$$s = \frac{1}{2} a_c t^2. \tag{46.1.5}$$

Comparing Eq. $46.1.4$ with Eq. $46.1.5$, we deduce that the Coriolis acceleration a_c is given by

$$a_c = 2\Omega v. \tag{46.1.6}$$

More generally, in terms of vectors, the Coriolis acceleration vector $\mathbf{a}_c$ is given by

$$\mathbf{a}_c = -2(\boldsymbol{\Omega} \times \mathbf{v}) \tag{46.1.7}$$

From Newton's second law, the corresponding Coriolis force $\mathbf{F}_c$ on a body of mass m is then

$$\mathbf{F}_c = -2m(\boldsymbol{\Omega} \times \mathbf{v}) \tag{46.1.8}$$