Tangential Speed and Acceleration

The chapter on circular motion introduced the concepts of tangential speed and acceleration. This feature explores these concepts in greater detail. Before reading further, be sure you have read the appendix feature "Angular Kinematics."

Tangential speed

Imagine an amusement-park carousel rotating about its center. Because a carousel is a rigid object, any two horses attached to the carousel have the same angular speed and angular acceleration. However, if the two horses are different distances from the axis of rotation, they have different **tangential speeds.** The tangential speed of a horse on the carousel is its speed along a line drawn tangent to its circular path.

The tangential speeds of two horses at different distances from the center of a carousel are represented in **Figure 1.** Note that the two horses travel the same angular displacement during the same time interval. To achieve this, the horse on the outside must travel a greater distance (Δs) than the horse on the inside. Thus, the outside horse at point B has a greater tangential speed than the inside horse at point A. In general, an object that is farther from the axis of a rigid rotating body must travel at a higher tangential speed to cover the same angular displacement as would an object closer to the axis.

If the carousel rotates through an angle θ, a horse rotates through an arc length Δs in the interval Δt. To find the tangential speed, start with the equation for angular displacement:

$$\Delta\theta = \frac{\Delta s}{r}$$

Next, divide both sides of the equation by the time it takes to travel Δs:

$$\frac{\Delta\theta}{\Delta t} = \frac{\Delta s}{r\Delta t}$$

As discussed in the appendix feature "Angular Kinematics," the left side of the equation equals ω_{avg}. Also, Δs is a linear distance, so Δs divided by Δt is a linear speed along an arc length. If Δt is very short, then Δs is so small that it is nearly tangent to the circle; therefore, $\Delta s/\Delta t$ is the tangential speed, v_t.

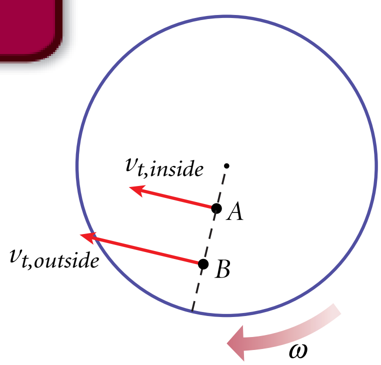

Figure 1
Horses on a carousel move at the same angular speed but different tangential speeds.

TANGENTIAL SPEED

$$v_t = r\omega$$

tangential speed = distance from axis × angular speed

In the tangential speed equation, ω is the instantaneous angular speed, rather than the average angular speed, because the time interval is so short.