PHYSICS 140 - General Physics 1, Fall 2007

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Ch 3 topics:

- relative motion
- circular motion
A physics lab to determine the acceleration of gravity involves measuring the time of flight of a small ball dropped down a vertical hollow tube.

Suppose this lab is performed inside a car of a TGV moving at a constant speed of 300 km/hr along a straight stretch of track. What will be the outcome of the experiment?

1) The ball will fall away from the vertical; it will hit the side of the tube and the experiment won’t work.
2) The ball will drop straight down with acceleration 9.8 m/s$^2$.
3) The ball will drop straight down with acceleration different from 9.8 m/s$^2$.
4) None of the above.
Measured values of displacements and velocities will depend on the frame of reference within which the measurements are made.

Observers moving at constant velocity relative to each other define a set of different, but equally valid, frames of reference called inertial reference frames.

When describing the motion of an object, different observers will generally see different displacements and velocities for that object. However, observers in all inertial frames will measure the same acceleration for that object.
Vector addition with \textit{careful use of subscripts} connects relative motions.

\[ \mathbf{v}_{B/S} = \mathbf{v}_{B/W} + \mathbf{v}_{W/S} \]

Note that \( \mathbf{v}_{B/S} = -\mathbf{v}_{S/B} \)
(The velocity of the boat as seen from shore is opposite the velocity of the shore as seen from the boat.)
You wish to cross a river to a point that is a distance D upstream from your start. The line labeled “Path of boat” corresponds to the direction of which velocity?

1. $v_{B/W}$
2. $v_{W/S}$
3. $v_{B/S}$
4. $v_{S/W}$
An object moving in a circular arc (or even just *a piece* of a circular arc) of radius $r$ at instantaneous speed $v$ will experience an instantaneous acceleration

$$a = \frac{v^2}{r}$$

directed *toward the center* of the circular arc.

This component of acceleration is known as **centripetal** (center seeking) acceleration.
Negotiating circular motion at tangential speed $v$ around a circular arc of radius $r$ requires a **radial component** of acceleration with magnitude

$$a_{\text{rad}} = \frac{v^2}{r}$$

directed towards the center of the circle. This component causes the velocity to change direction, keeping it tangent to the circle.

The **tangential component** of acceleration $a_{\text{tan}}$ acts tangent to the circle and affects the speed, by acting either in the direction of motion, causing $v$ to increase, or opposite the motion, causing $v$ to decrease.
Aaron the ant sits 1/2-way between the center and the edge of a playground merry-go-round, which can be treated as a simple disk of radius $R$. Suppose the disk is spun up by some local kids so that its period of rotation is $T$ seconds.

What is the magnitude of the centripetal acceleration experienced by Aaron the ant while spinning at this rate?

1. $4\pi R / T^2$
2. $\pi^2 R / 2T^2$
3. $2\pi^2 R / T^2$
4. $8\pi^2 R / T^2$
5. $4\pi^2 T / R^2$

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