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University of Michigan

Physics 140 – Fa 2007
Lecture 4 : 13 Sep

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.

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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.

relative motion: inertial reference frames

Measured values of displacements and velocities will depend on the frame of reference within which the measurements are made.

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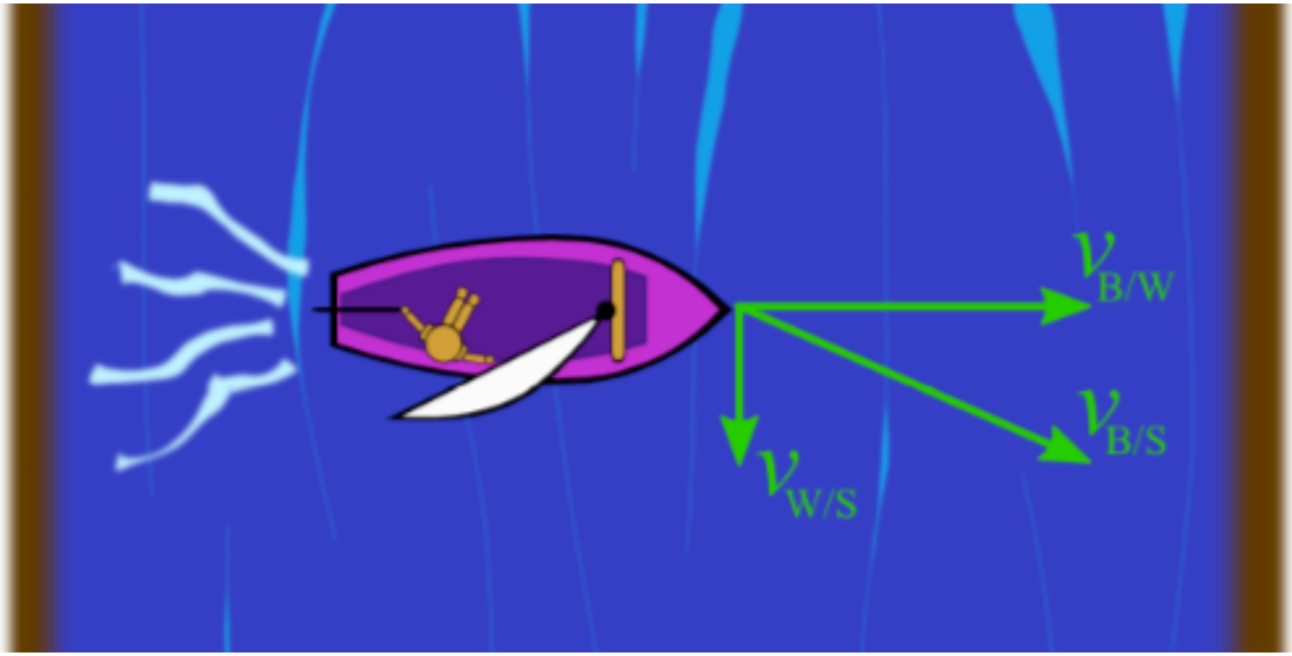
Observers moving at *constant velocity* relative to each other define a set of different, **but equally valid**, frames of reference called *inertial reference frames*.

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.

relative motion: connecting frames of reference



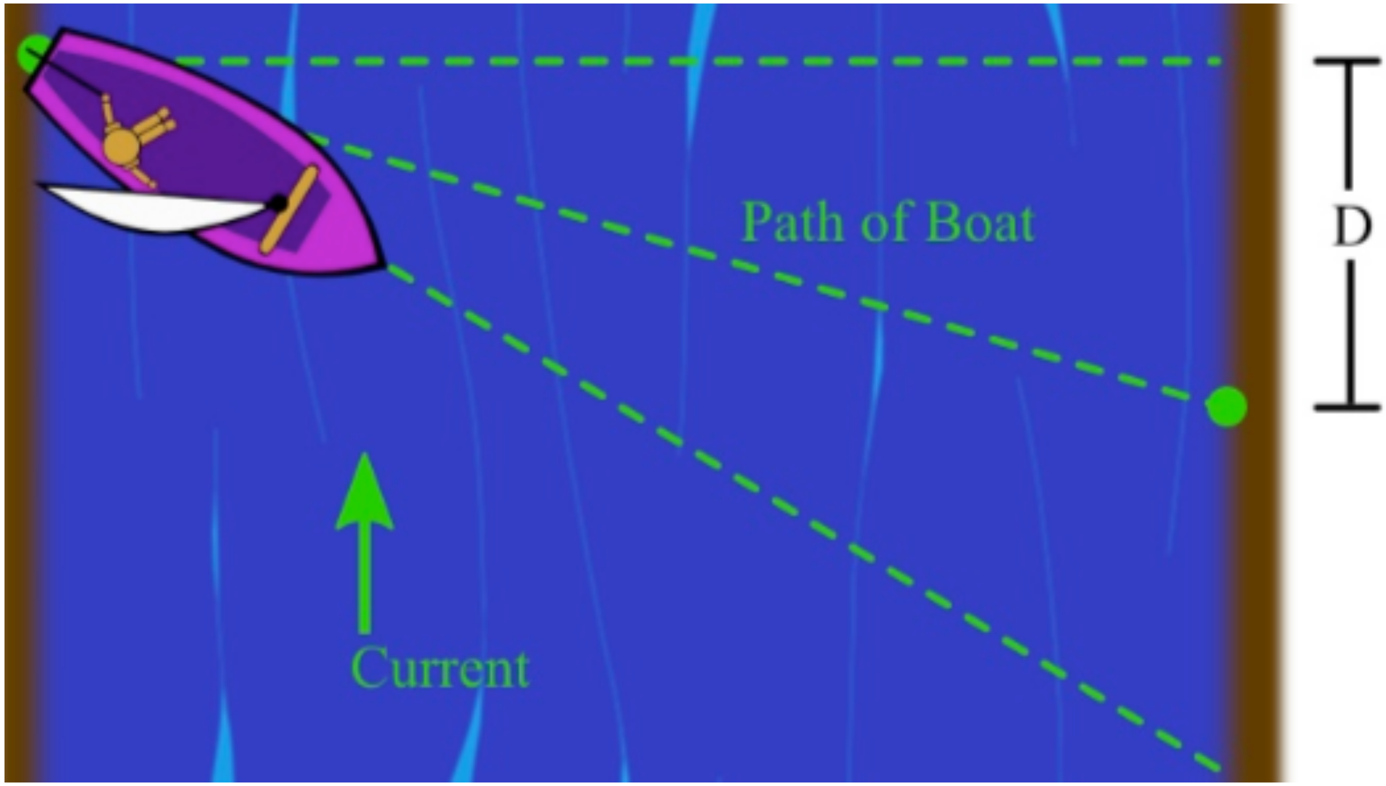
Vector addition with *careful use of subscripts* connects relative motions.

$\mathbf{v}_{B/W}$ = velocity of the	Boat	relative to the	Water
$\mathbf{v}_{W/S}$ = velocity of the	Water	relative to the	Shore
$\mathbf{v}_{B/S}$ = velocity of the	Boat	relative to the	Shore

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

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.)

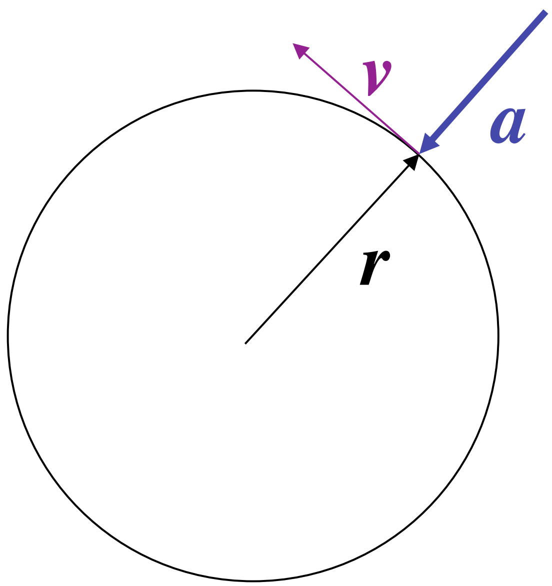


You wish to cross a river to a point that is a distance D upstream from your start. The line labeled "Path of boat" corresponds to the direction of which velocity?

1. $v_{B/W}$
2. $v_{W/S}$
3. $v_{B/S}$
4. $v_{S/W}$

uniform circular motion

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



$$a = v^2 / r$$

directed *toward the center* of the circular arc.

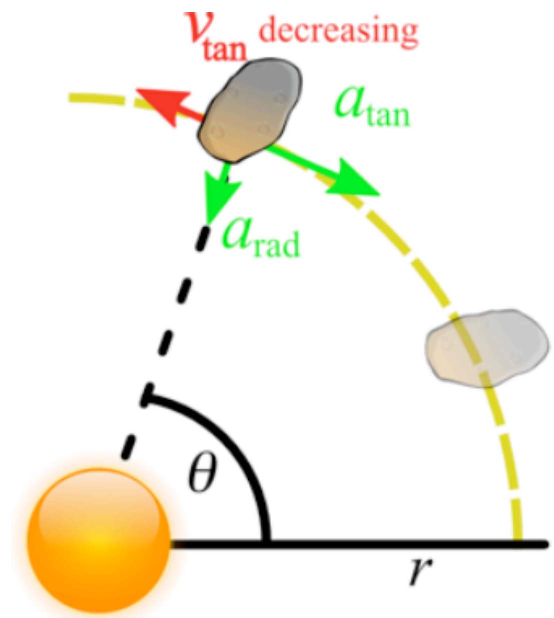
This component of acceleration is known as **centripetal** (center seeking) **acceleration**.

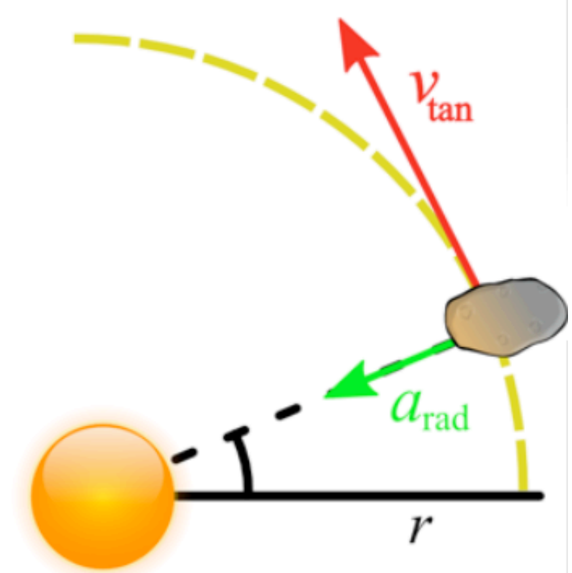
Negotiating circular motion at tangential speed v around a circular arc of radius r requires a ***radial component*** of acceleration with magnitude

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

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_{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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