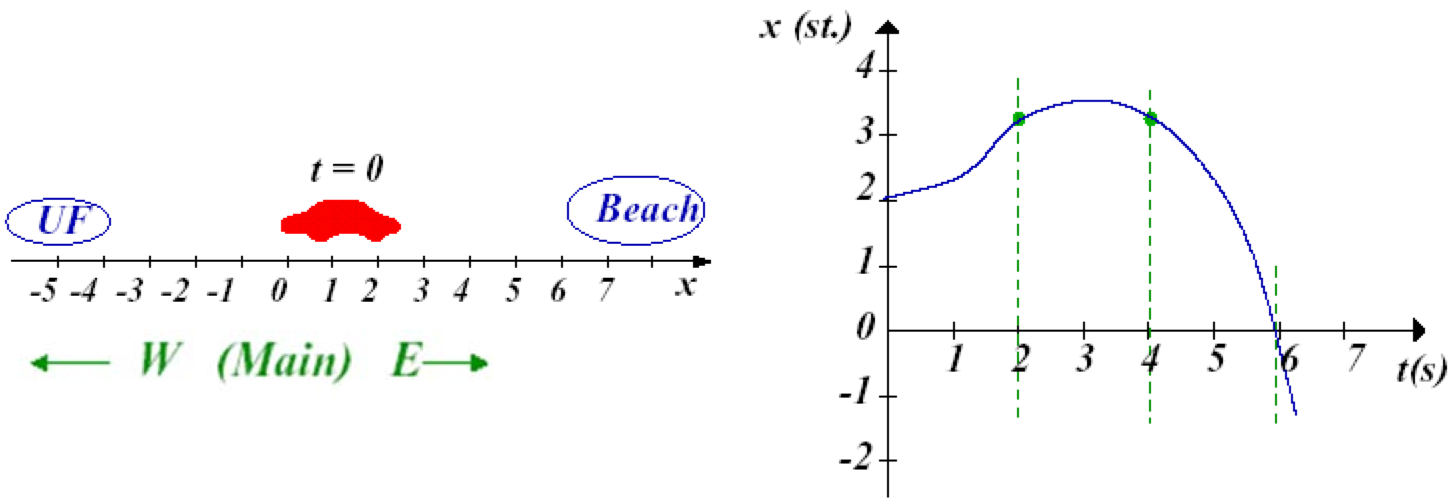
PHY1033C
DISCOVERING PHYSICS

Position of an object

Define the *position* of an object as where it is at some time t relative to some coordinate system.



the position of a car on University Avenue

We sometimes use the word *displacement* to mean the same thing as position.

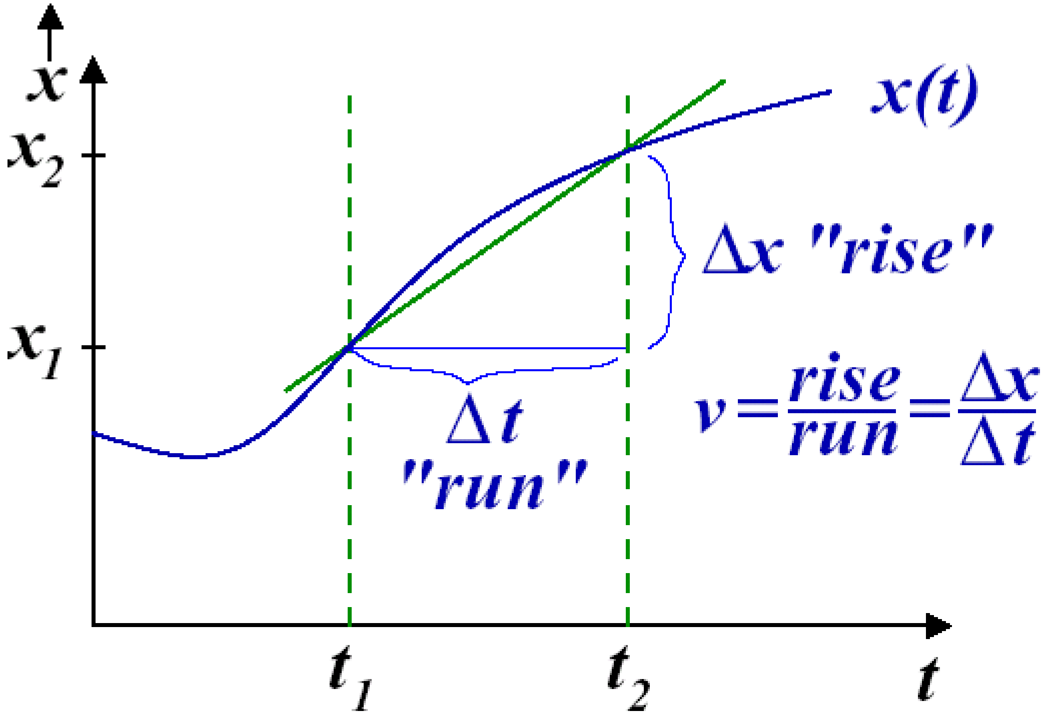
Speed & velocity

Def: Speed–rate of change of object's position. Defined always as *positive* number.

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

Def: Velocity – rate of change of position in a particular direction. Can be +/-.

Def: *average* velocity



$$\text{average } v = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i},$$

(*f* means final and *i* means initial)

Exercise: you drive a pickup truck down a straight road for 5.2 mi at 43 mi/hr, at which point you run out of fuel. You walk 1.2 mi farther, to the nearest gas station, in 27 min (=0.450 h). What is your average velocity?

Displacement start to finish Δx = 5.2 mi + 1.2 mi = 6.4 mi

Total time $\Delta t = \Delta t_{drive} + \Delta t_{walk}$=[5.2mi/(43 mi/h)]+0.450h
= 0.121h + 0.450h = 0.57h

Avg. velocity = $\Delta x / \Delta t$ = 6.4mi/0.57h = +11mi/h

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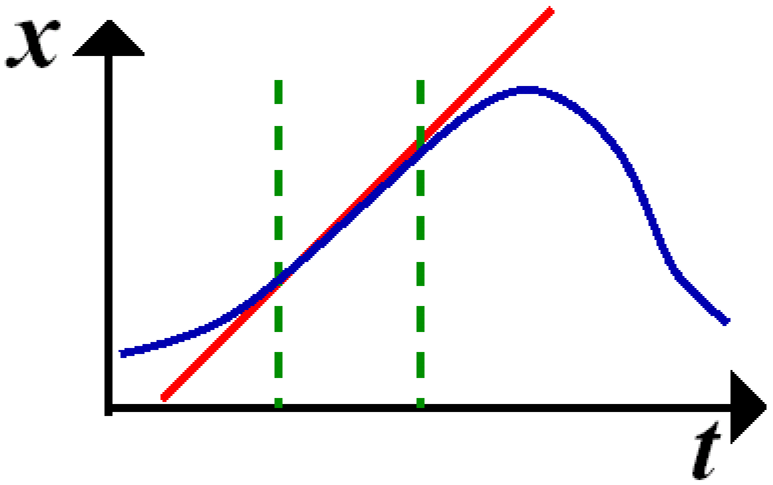
If velocity is constant, average $v = v(t)$



Quickie

Here's a quick (trick) question to see if you're getting some of the physicists' definitions before we go on:

Q: If you travel from Gainesville to Miami at 20 mph and return to Gainesville at 40 mph, what is your average velocity?

A: Zero
B: 30 mph
C: Impossible to say since distances aren’t given.
D: 30 mph south

A: Zero, because

$$\text{average } v = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i},$$

and the total displacement Δx =0 (you came back to where you started!).

Acceleration

Velocity was the rate of change of the *position* of an object. What's the rate of change of the velocity called?

Def: *acceleration*-- rate of change of the velocity of an object.

Q: Can you have *a*=0 and *v*$\neq$ 0?

A: Yes, when object has constant velocity!

Q: Can you have *a*$\neq$ 0 and *v* = 0 ?

A: Yes, e.g. when you throw a ball up and it is at the very top of its trajectory before starting back down: a=-9.8m/s^2, v=0.

Q: Can you have a$\neq$ 0, v = constant?

A: Yes, when something is going in a circle at constant *speed*, it is continuously changing the *direction* of its velocity, so a $\neq$ 0.

Equations of motion

Already know one special equation for something moving at constant *velocity*,

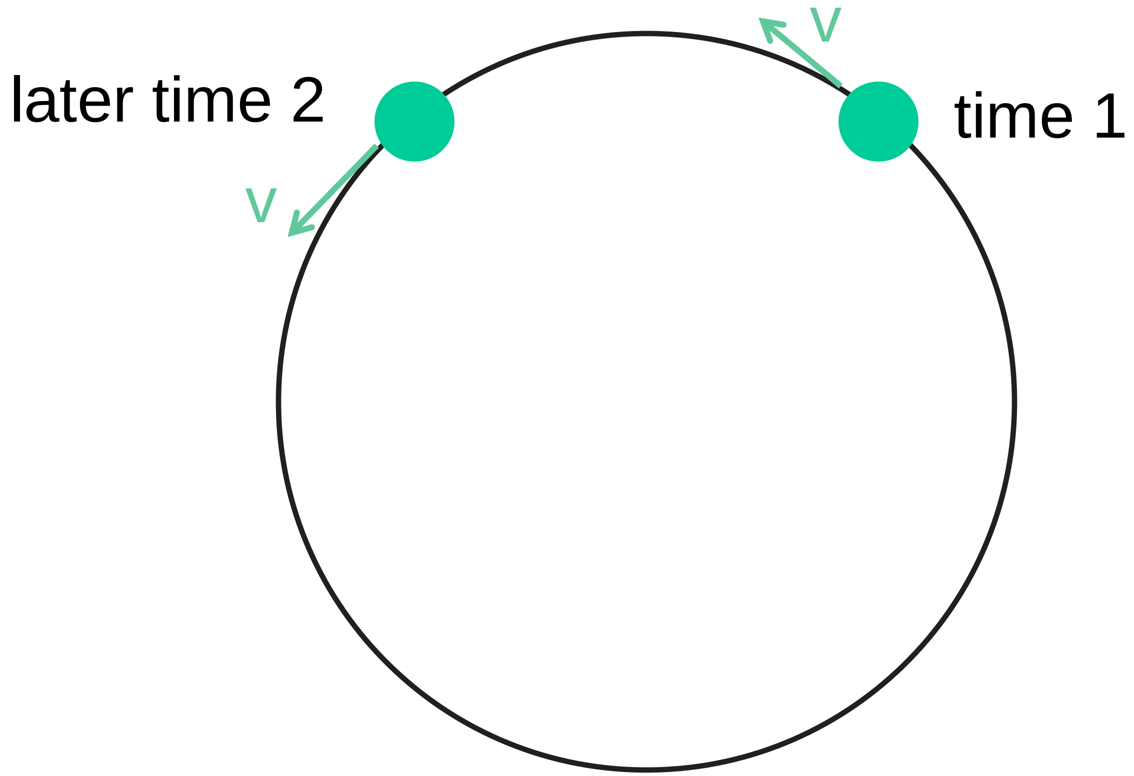
$$\Delta x = v\,\Delta t.$$

If we measure with respect to the origin of the coordinate system at t=0 (choose $x_i=0$ and $t_i=0$), then we just write

$$x = v\,t.$$

What about if *acceleration* is constant? This would occur if you are keeping the gas pedal depressed at a fixed angle for a few seconds, or when an object is in free fall near the Earth's surface.

In this course, we have referred to “uniform circular motion” where a planet moves at constant *speed*



From modern perspective, since it’s velocity direction is changing, it is accelerating. Greeks & medievals would not have called this acceleration.

Constant *acceleration a*

The same kind of reasoning as above leads to

$$v = a\, t,$$

The velocity increases at a constant rate! You might be tempted to substitute this into our x-equation, but this is wrong, because $x = v\, t$ is only good for constant velocity, not changing velocity. It turns out for the special case of constant a, we get

$$v = a\, t$$
$$x = \tfrac{1}{2}\, a\, t^2$$

constant acceleration only!