Velocity & speed:

Speed is the magnitude of ***velocity***

$$\vec{v}_{avg} = \frac{\Delta \vec{r}}{\Delta t}, \text{ average velocity}$$

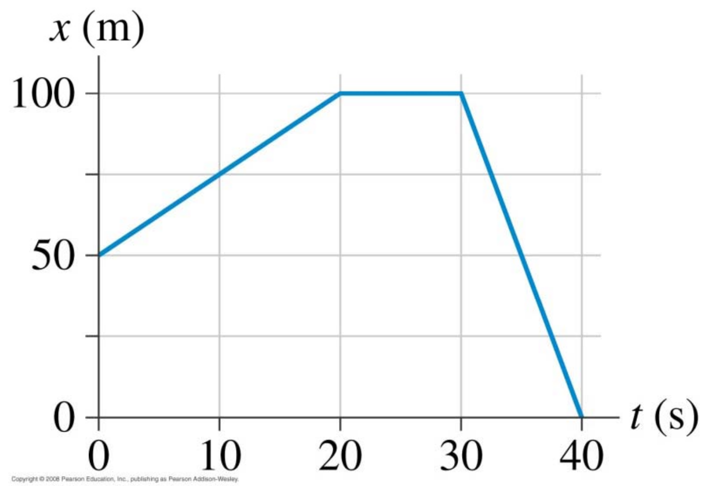
$$\vec{v}_{inst} = \lim_{\Delta t \to 0} \frac{\Delta \vec{r}}{\Delta t} = \frac{d\vec{r}}{dt}, \text{ instantaneous velocity}$$

Ex. 2.5: A bicyclist has the position-versus-time graph shown .

a. What is the bicyclist's velocity at t = 10s?

b. What is the bicyclist's velocity at t = 25s?

c. What is the bicyclist's velocity at t = 35s?



Ex. 2.2: Larry leaves home at 9:04 and runs at constant speed to the lamppost. He reaches the lamppost at 9:09, immediately turns, and runs to the tree. Larry arrives at the tree at 9:11. He then turns immediately and runs home, arriving at 9:15.

a. What is Larry's average velocity, in yards / min, during each of these three intervals?

b. What is Larry's average velocity for the entire run?

Acceleration, etc:

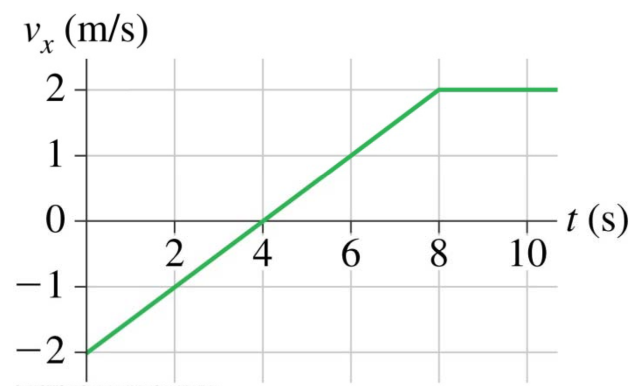
$$\vec{a}_{avg} = \frac{\Delta \vec{v}}{\Delta t}, \text{ average acceleration}$$

$$\vec{a}_{inst} = \lim_{\Delta t \to 0} \frac{\Delta \vec{v}}{\Delta t} = \frac{d\vec{v}}{dt}, \text{ instantaneous acceleration}$$

Prob. 2.21. A particle moving along the *x*-axis has its position described by the function $x = (5.00t^3 - 5.00t + 2.00)\ m$, where t is in s. At *t*= 4.00s, what are the particle's (a) position, (b) velocity, and (c) acceleration?

Prob. 2.9. The figure shows the velocity graph of a train that starts from the origin at *t* = 0s.

a. Find the speed of the train at *t* = 6.0s.
b. Find the acceleration of the train at *t* = 3.0s.
c. Find the position of the train at *t* = 8.0s.



Some relationships

Constant speed: $r = r_o + vt$

Constant acceleration: $v = v_o + at$

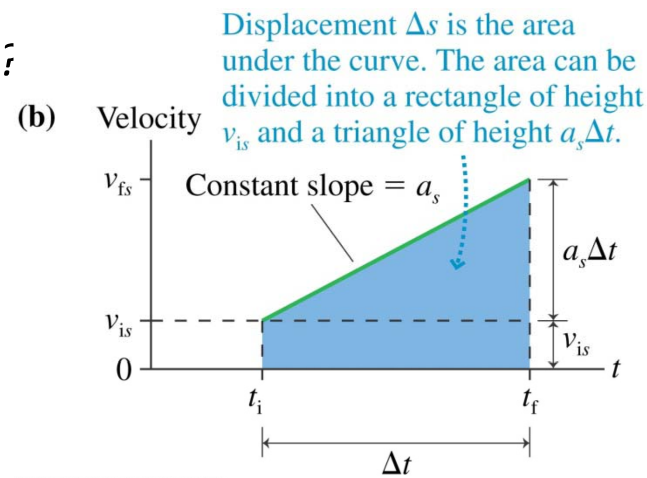
So, what is the time dependence of *r* during constant acceleration?

Under constant acceleration,

$v_{avg} = \frac{1}{2}(v_o + v_f)$ *& how do we know???*

$r = r_o + v_o t + \frac{1}{2}at^2$ *& how do we know???*

$v_f^2 = v_o^2 + 2ar$ *& how do we know this???*



How we know that $r = r_o + v_0 t + ½at^2$:

Begin with

$$v = \frac{dr}{dt} = v_0 + at \Rightarrow dr = (v_0 + at)dt$$

integrate both sides of the equation (the limits must be correlated: $r = r_0$ @ $t = 0$ *and* $r = r$ *at* t):

$$\int_{r=r_0}^{r} dr = \int_{t=0}^{t} (v_0 + at)dt \quad \Rightarrow \quad (r - r_0) = \left(v_0 t + \tfrac{1}{2}at^2\right) \Rightarrow r = r_0 + v_0 t + \tfrac{1}{2}at^2$$

How we know that $v_f^2 = v_0^2 + 2ad$:

Use

$$v_f = v_0 + at \Rightarrow t = \frac{v_f - v_0}{a}$$

Substitute this expression for t into

$$r = r_0 + v_0 t + \tfrac{1}{2}at^2$$

$$d = (r - r_0) = v_0\left(\frac{v_f - v_0}{a}\right) + \tfrac{1}{2}a\left(\frac{v_f - v_0}{a}\right)^2 \Rightarrow 2ad$$

$$= 2\left(v_0 v_f - v_0^2\right) + \left(v_f^2 - 2v_0 v_f + v_0^2\right)$$

After collecting terms, the result is:

$$2ad = v_f^2 - v_0^2 \Rightarrow v_f^2 = v_0^2 + 2ad$$

Prob. 2.46: You are driving to the grocery store at 20 m/s. When you are 110m from an intersection, the traffic light turns red. If your reaction time is 0.50s and your car comes to a stop with constant acceleration:

a. How far are you from the intersection when you begin to apply the brakes?
b. What acceleration will bring you to rest right at the intersection?
c. How long does it take you to stop after the light turns red?

Prob. 2.48: The minimum stopping distance for a car traveling at a speed of 30 m/s is 60m, including the distance traveled during the driver's reaction time of 0.50 s..

- What is the minimum stopping distance for the same car traveling at a speed of 33 m/s ?

Acceleration due to gravity, projectiles, free fall, and "going ballistic":

Until Ch.'s 5 & 6, our summary description of gravity is that it causes all objects to accelerate ***downwards*** at the rate:

$$\mathbf{g = 9.8\ m/s^2}$$

Example: An object is dropped (***with initial speed = 0m/s***) from ***5m*** above the ground.

a. How long does it take to reach the ground?

b. How fast is it traveling just before impact?