Using kinematic equations

- 3 main kinematic equations for constantly accelerated motion:

$$v_2 = v_1 + a(\Delta t)$$

$$x_2 = x_1 + v_1(\Delta t) + \frac{1}{2}a(\Delta t)^2$$

$$(v_2)^2 = (v_1)^2 + 2a(x_2 - x_1)$$

- YOU need to know these for the test.

- Remember:
  - x is position (x_1 means position at time 1, etc) – change in position ($x_2 - x_1$) is displacement during time Δt ($t_2 - t_1$)
  - + sign means in the + direction; - sign means in the – direction
  - **** negative acceleration **does not have to mean** slowing down!!!
  - If in free fall, a = -9.8 m/s^2 the whole time, assuming up is positive.

Free fall

- A special case of kinematics is for objects moving under the influence of gravity only
- An object affected by only gravity is said to be in **free fall**
  - By the way, it doesn't actually have to be falling *down* to be in free fall – just free of any other influences
  - For now, we'll consider the effects of air resistance to be insignificant and therefore ignore it

- Question: if I drop a heavy object and a light object from the same height, which one will hit the ground first?

Test it!

Gravitational acceleration

- Gravity causes objects to accelerate
- If we're close to sea level, we consider the Earth's gravitational acceleration to be constant
- For our purposes, we will assume the magnitude of this acceleration is always $g = 9.80\ m/s^2$ and it always points towards the Earth's center (so $a_g = -9.8\ m/s^2$ if + is up)
- Next unit, we'll talk about why!

- Some notes:
  - Final velocity (at ground) is NOT zero!
  - Velocity at the <u>top</u> is…?

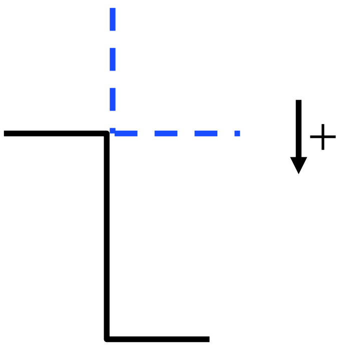
Free fall example #1

- Wile E. Coyote steps off a cliff after giving up pursuit of the Roadrunner (we'll assume his initial velocity is essentially 0 m/s). After 3.5 seconds, he hits the canyon floor below. How tall is the cliff, and how fast was he going when he hit the ground?

Free Fall Example #1 - solution

Where is the reference point and which direction is positive?

Origin is at the top of the cliff, and down is positive

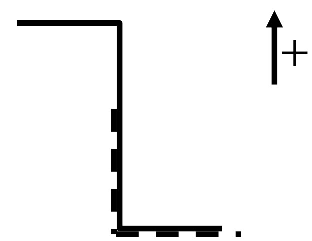


$$y_o = 0.00m$$
$$y = ?$$
$$v_o = 0.00m/s$$
$$v = ?$$
$$a = 9.80m/s^2$$
$$t = 3.5s$$

$$y = \frac{1}{2}(9.80)(3.5^2)$$
$$y = 60m$$
$$v = (9.80)(3.5)$$
$$v = 34m/s$$

Where is the reference point and which direction is positive?

Origin is at the bottom of the cliff, and up is positive



$$y_o = ?$$
$$y = 0.00m$$
$$v_o = 0.00m/s$$
$$v = ?$$
$$a = -9.80m/s^2$$
$$t = 3.5s$$

$$0.00 = y_o + \frac{1}{2}(-9.80)(3.5^2)$$
$$0.00 = y_o - 60.025$$
$$60m = y_o$$
$$v = (-9.80)(3.5)$$
$$v = -34m/s$$

Problem 2.51 (modified)

- A tennis player throws a ball straight up. It leaves the hand 2.0 m above the ground and takes 4.0 seconds to return to the starting height. (note: remember sign and units for all numeric answers!)

  a) What is the ball's acceleration on the way up?

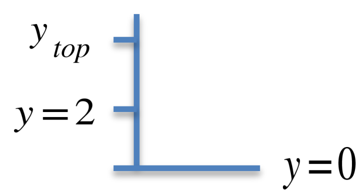
  b) What is the ball's acceleration at the top of its flight?

  c) What is the ball's acceleration on the way down?

  d) What is the velocity of the ball when it reaches its maximum height?

  e) What is the initial velocity of the ball?

  f) What is the ball's maximum height?



Problem 2.51 continued

- New set-up: The ball is again thrown upward. At a particular point in time, the velocity is registered at +12 m/s upward. If the stopwatch starts at that point:

g) How fast is it moving after 0.3 seconds?

h) How fast is it moving after it has traveled 0.2 meters?

i) How long will it take to get to the point where it is moving at -4 m/s?

j) Where will it be after the first 0.7 seconds?

Problem 2.51 solution

- See posted solution on class Website

the well problem

- Go to https://youtu.be/pey37CeaFVw?t=70. From what you find there, how deep is the well? (Kindly note that this video is from the last episode ever of the TV show "iZombie," and that the speed of sound is 330 m/s.)
  hint: the problem has two parts - how do you need to split it up and why?

the well Problem - solution

- See solution posted on class Website

- (Note that the "pebble in the well" problem on the Website is the same problem as this one with slight modification in the sense that it actually tells you it takes 8 seconds of total elapsed time for the sound of the splash to get back to you. The solution to the problem is essentially the same, though.)