Announcements

1. **Exam 1 coming up!**
   a. Next lecture (Tues Sep 16) will be review
   b. You have 6 days to take it: Tues 10:15 am – next Mon, testing center closing
   c. Covers chapters 1-3
   d. Covers HW 1-3

2. No reading assignment or warmup quiz for next lecture

Review 1-D Motion - Gravity

Video: Penny & Feather

Worked Problem: A rock is thrown upward off a cliff 30 m high, with an initial velocity of 20 m/s.

a) How long does it take to reach the top of its path?
b) What is the velocity just before it hits the ground (30 m below the cliff)?
c) How long does it take to hit the ground?

- Use up = positive direction
- Use $a_y = -g$
- Choose origin ($y = 0$ point)

Review Vector Problem

A spaceship has two rockets: one operating correctly but one malfunctioning. The correct rocket supplies a force which would produce an acceleration of 100 m/s^2 along the x-axis if it were by itself. The other rocket supplies what would be an acceleration of 90 m/s^2 at an angle of 10°, if it were by itself.

What is the overall acceleration the spaceship experiences? (magnitude and direction)

Today's Basic Concept

Motions in perpendicular directions can be **decoupled** from each other.

Think **shadows** again**…**

x-direction

$$v_x = v_{0x} + a_x t$$
$$x = x_0 + v_{0x} t + \tfrac{1}{2} a_x t^2$$
$$v_{fx}^{\ 2} = v_{0x}^{\ 2} + 2 a_x \Delta x$$

y-direction

$$v_y = v_{0y} + a_y t$$
$$y = y_0 + v_{0y} t + \tfrac{1}{2} a_y t^2$$
$$v_{fy}^{\ 2} = v_{0y}^{\ 2} + 2 a_y \Delta y$$

} Same equations, essentially

2-D Projectile motion: $\boxed{a_x = 0}$ $\boxed{a_y = -g}$ (= –9.8 m/s^2)

projectile: an object in free fall

x-direction motion is independent from y-direction motion

Video: "Shooter & dropper" (2 balls, one shot & one dropped)

Flash animation: baseball velocity components
http://stokes.byu.edu/baseball_flash.html

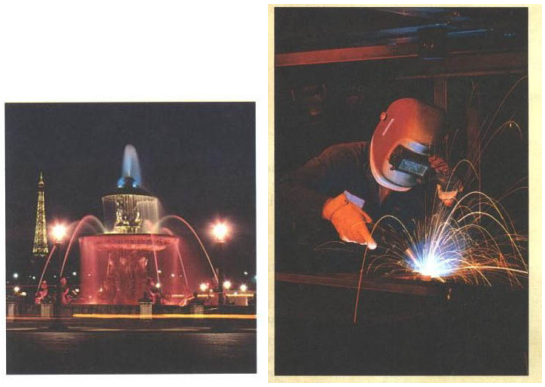
Demo: Cart & ball

Clicker quiz: what will happen?
A. Ball will land in front of cart
B. Ball will land in back of cart
C. Ball will land in cart

Parabolic Trajectories

$y \sim t^2$ (parabola) $x \sim t$

Therefore $y \sim x^2$ → **parabola** (assuming no air resistance)



Video: Motorcycle jumping over airplane
http://www.youtube.com/watch?v=0p8xRNAga80

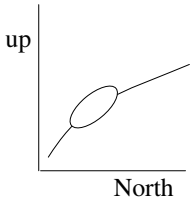
Video: Matrix ping-pong
http://www.youtube.com/watch?v=PgM11RtGjeI

Demo: monkey gun

Clicker quiz: What will happen?
A. Bullet will pass over monkey
B. Bullet will pass under monkey
C. Bullet will hit monkey

Clicker quiz: A football is thrown and it travels up and north through the air. Just after it is thrown the acceleration points: (assume no air friction)

a. up
b. down
c. north
d. south
e. south and down



Range problems

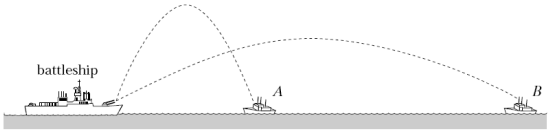
Usually use the **y-equations** to figure out the **time** it takes
→ Then use the **x-equations** to figure out **how far** it has traveled in that time

Exception: Sometimes the nature of the problem means the x-equations determine the time it takes (e.g. if the projectile runs into something)

Nearly always: use one equation to find time, plug into the other equation.

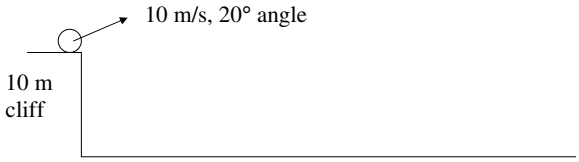
_____

Clicker quiz: A battleship simultaneously fires two shells at enemy ships. If the shells follow the parabolic trajectories shown, which ship gets hit first? (similar to warmup problem)



a. *A*
b. *B*
c. both at the same time

Worked Problem



Where does it hit?

Worked Problem

For the previous problem, how fast is the ball going when it hits?

Warmup: I throw a ball at an upward angle across a flat field. Neglecting air resistance, at what part of its path does the ball have its maximum speed?

a. right before it hits the ground
b. halfway to the top
c. at the top of its path
d. right after it leaves my hand
e. There's not enough information to say

Worked Problem

A rifle at the same height as a target tries to hit the center of a large target 200 m away. The rifle is shot at 1° above the horizontal. The initial velocity of the bullet is 500 m/s. How far above/below the target does the bullet strike the target?

Sally and Bob each throw a rock horizontally from a cliff. Sally throws her rock hard. Bob throws his more easily.

Clicker quiz: Which spends the longest time falling?

a. Sally's
b. Bob's
c. same

Clicker quiz: Which rock is going fastest (vector magnitude) just before it hits the ground?

a. Sally's
b. Bob's
c. same

Sally throws a rock horizontally from a cliff. Bob throws his at an angle above horizontal. They throw the same speed.

Clicker quiz: Which hits first?

a. Sally's
b. Bob's
c. same

Maximum range

Warmup: Neglecting air resistance, at what angle should you throw a ball on a flat field in order to get the maximum range?

a. 30°
b. 45°
c. 60°
d. It depends on the initial speed

(Also neglecting height of person…could have a slight effect)

What if you worry about **air resistance**?

Simulation:
http://phet.colorado.edu/new/simulations/sims.php?sim=Projectile_Motion