## *Announcements*

1. No one in the "not receiving emails" category talked to me after class on Tuesday.
   → If you're still not receiving emails, something's wrong!



## 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 rocket experiences? (magnitude and direction)



## Today's Basic Concept

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

**Two-dimensional motion:**

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$^2$)



**Demo**: Cart catching its own ball

**Video 1**: "Shooter-dropper" (2 balls, one shot & one dropped)

**Video 2**: "Airplane flare"

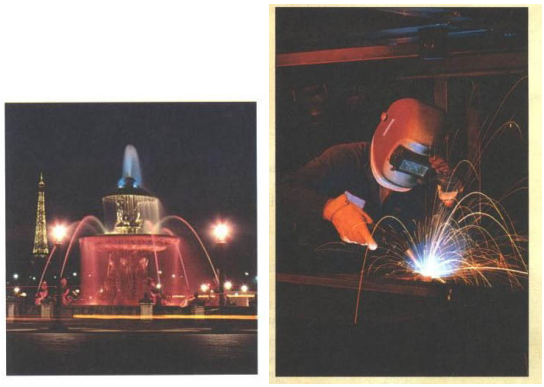
**Flash animation: baseball velocity components**
http://stokes.byu.edu/baseball_flash.html

# Parabolic Trajectories

$y \propto t^2$

$x \propto t$

Therefore $y \propto x^2$ → **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



**y-components**—velocity always decreases with $a_y = -g$

**Demo**: monkey gun

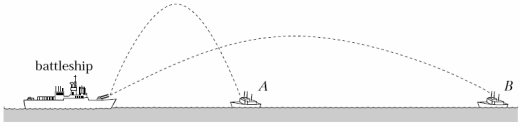
**Flash animation**: Two cannons firing at each other
http://www.phy.ntnu.edu.tw/ntnujava/index.php?topic=144



# 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

Q4. A battleship simultaneously fires two shells at enemy ships. If the shells follow the parabolic trajectories shown, which ship gets hit first?

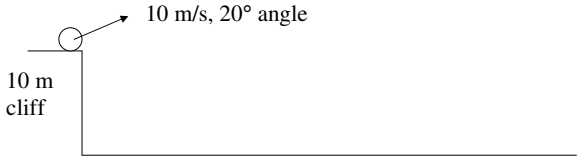



a. *A*
b. both at the same time
c. *B*
d. need more information

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



# Worked Problem




Where does it hit?

# 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.

Q5. Which spends the longest time falling?
- a. Sally's
- b. Bob's
- c. same

Q6. 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.

Q7. Which hits first?
- a. Sally's
- b. Bob's
- c. same



# Maximum range

On a flat surface, best angle for farthest range:
- 45° (if no air resistance)
- Less than that (if air resistance is a factor)

**Longest motorcycle jump in the world:**
**Trigger Gumm, 94.5 m**
http://www.youtube.com/watch?v=aZezH5fnMrk
(starting about 2:09)

Neglect air-resistance…

Problem: How fast was he going on take-off?