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/s² along the x-axis if it were by itself. The other rocket supplies what would be an acceleration of 90 m/s² 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
\[ v_x = v_{0x} + a_x t \]
\[ x = x_0 + v_{0x} t + \frac{1}{2} a_x t^2 \]
\[ v_{fx}^2 = v_{0x}^2 + 2a_x \Delta x \]

y-direction
\[ v_y = v_{0y} + a_y t \]
\[ y = y_0 + v_{0y} t + \frac{1}{2} a_y t^2 \]
\[ v_{fy}^2 = v_{0y}^2 + 2a_y \Delta y \]

Same equations, essentially

2-D Projectile motion:
\[ a_x = 0 \]
\[ a_y = -g \]
\[ (= -9.8 \text{ m/s}^2) \]

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 \( y \propto x^2 \) \( \rightarrow \) \textbf{parabola} (assuming no air resistance)

\[ \text{Video: Motorcycle jumping over airplane} \]
\[ \text{http://www.youtube.com/watch?v=0p8xRNAga80} \]

\[ \text{Video: Matrix ping-pong} \]
\[ \text{http://www.youtube.com/watch?v=PgM11RtGjeI} \]

Range problems

[Usually] use the \textbf{y-equations} to figure out the \textit{time} it takes \( \rightarrow \) Then use the \textbf{x-equations} to figure out \textit{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

\[ \text{Exception: if the nature of the problem means the x-equations determine the time it takes (e.g. projectile runs into something, etc.)} \]

Worked Problem

\[ 10 \text{ m/s, } 20^\circ \text{ angle} \]

\[ 10 \text{ m cliff} \]

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?