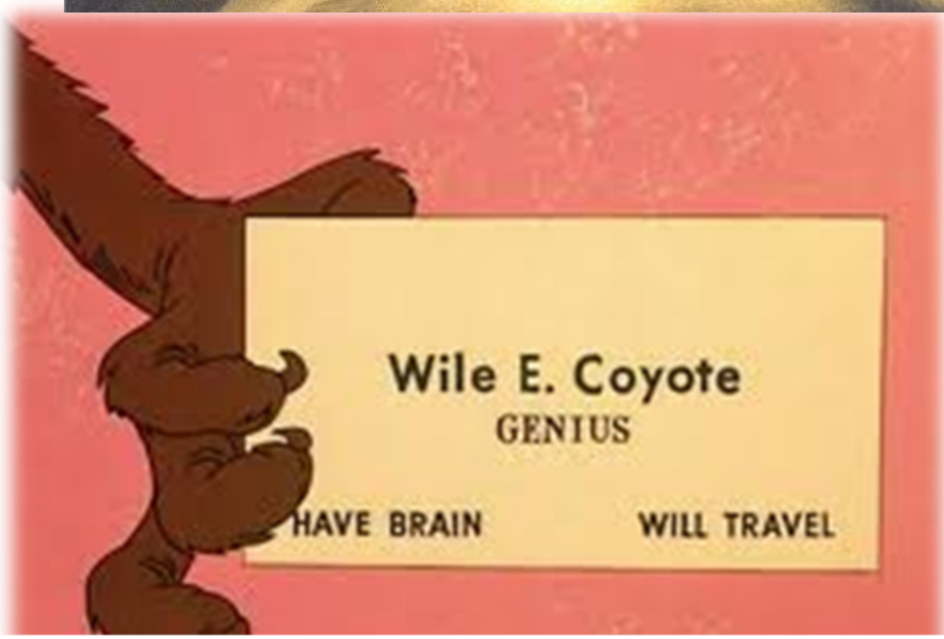
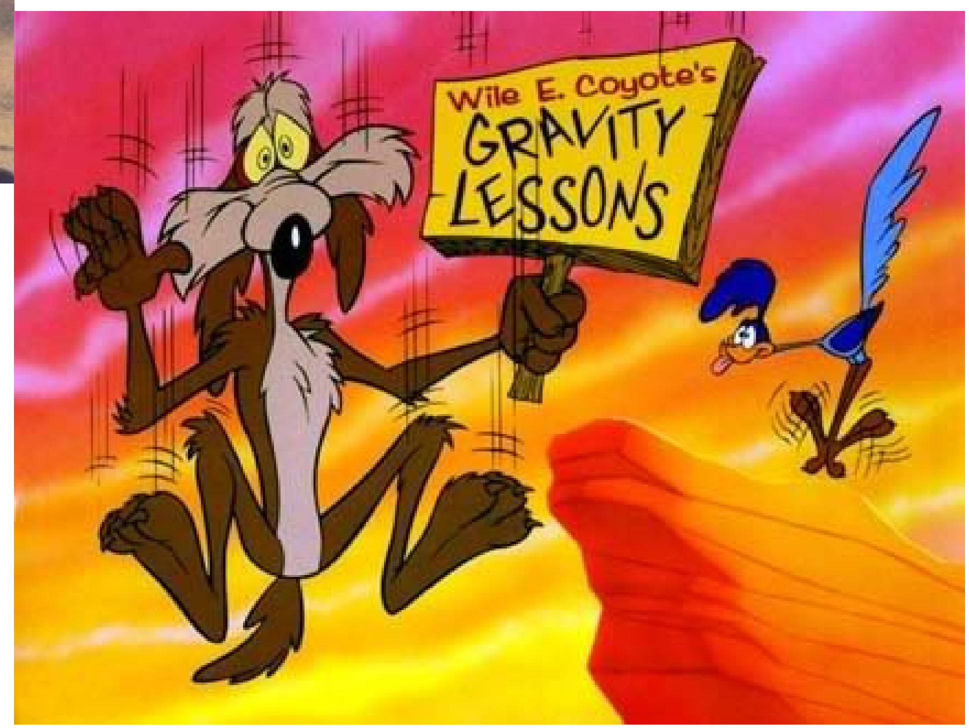
The Physics of Wile E. Coyote vs Roadrunner

http://www.youtube.com/watch?v=_d8ROhH3_vs



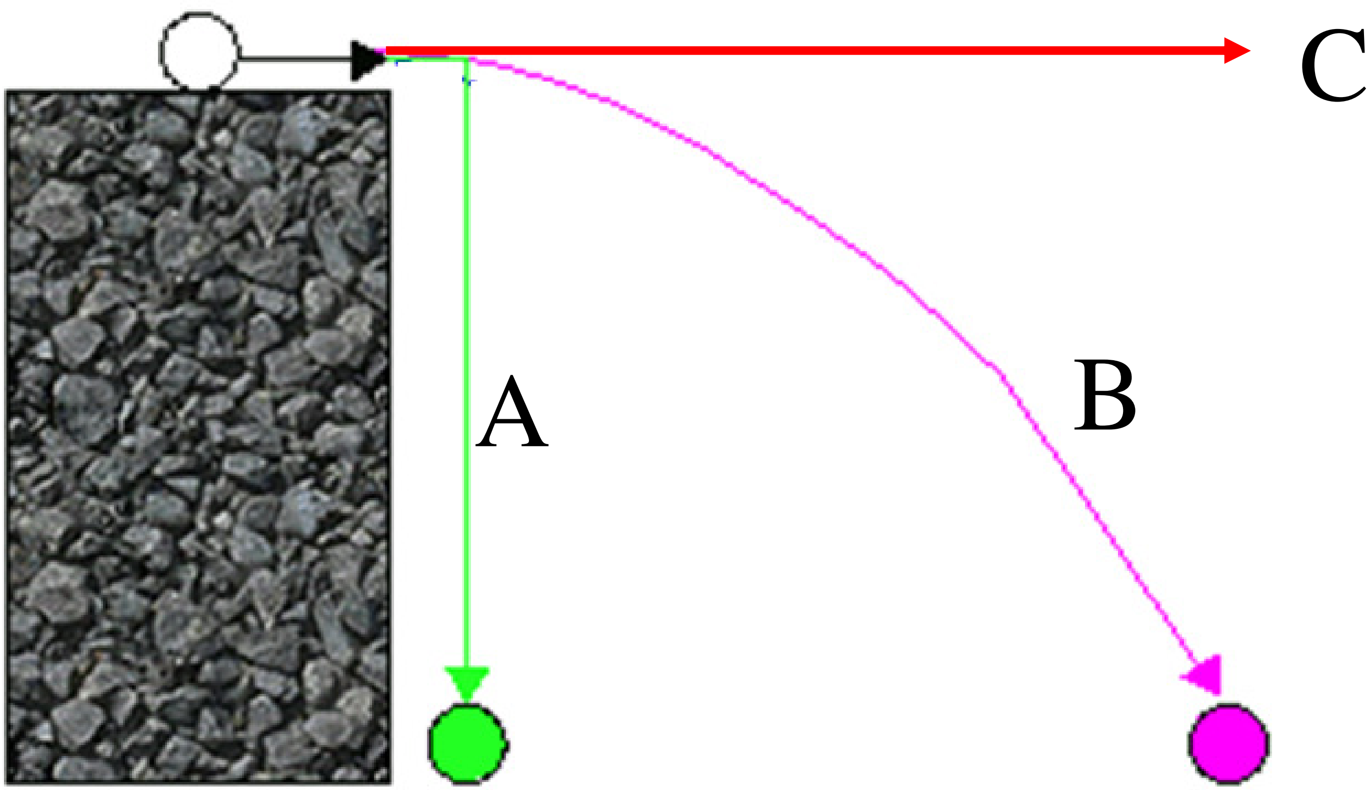


Main Ideas in Class Today

- Wile E. Coyote
- Projectile Motion
- Formulas/Graphs
- X Relative Velocity (not tested)

Practice: 3.7, 3.9, 3.11, 3.13, 3.17, 3.33, 3.37, 3.41, 3.43, 3.47, 3.53

Ignoring air resistance (very small effect), what would be the path of motion if someone **ran** off of a cliff?



http://www.youtube.com/watch?v=_d8ROhH3_vs

Q21

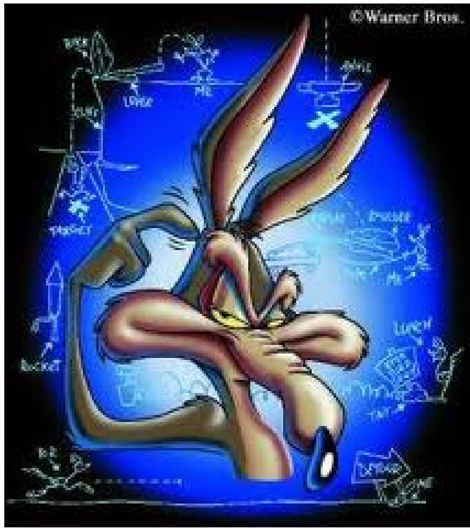
The Physics of Wile E. Coyote

- As Mr. Coyote runs off the cliff, he has horizontal velocity.
- A change in velocity is acceleration, in this case horizontal acceleration, which must come from a force in the horizontal direction. $v_{fx}=v_{ox}+a_x t$
- If we ignore air resistance (horizontal force = 0), then there is no horizontal force to slow him down horizontally.

$v_{fx}=v_{ox}$

- Thus, Mr. Coyote will travel ***horizontally at the same speed*** the whole time until he hits the ground!

The Physics of Wile E. Coyote



- Vertical motion is treated separately.
- As soon as the coyote leaves the cliff he will experience a vertical force due to gravity.
- This force will cause him to start to accelerate in the vertical direction. As he falls he will be going faster and faster in the vertical direction.
- The horizontal and vertical components of the motion of an object going off a cliff are separate from each other, and **can not affect each other**.

Watch: http://www.youtube.com/watch?v=bp0MuuR5Hqg

Amendment to Pro Tip 3: Break up what you know in terms of the horizontal and vertical

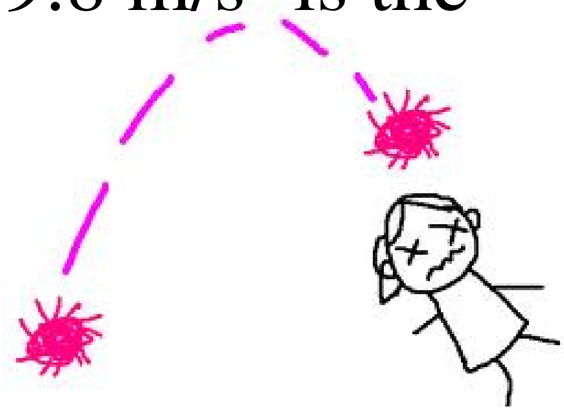
Prevents mistakes

X	Y

I can almost guarantee you will mess up if you don't do this.

Projectile Motion

- Freely falling objects near surface of earth
- Object can have an initial velocity component parallel to the ground
  - Object will move in two dimensions
- Assumptions:
  - Neglects air resistance because small effect normally
  - Means that acceleration of gravity $g = 9.8\ \mathrm{m/s^2}$ is the same for all objects (a_y)



Clicker Question

Ignoring air resistance, an object dropped from a plane continuing to fly at constant speed in a straight line will

A. quickly lag behind the plane.

B. remain vertically under the plane.

C. move ahead of the plane.

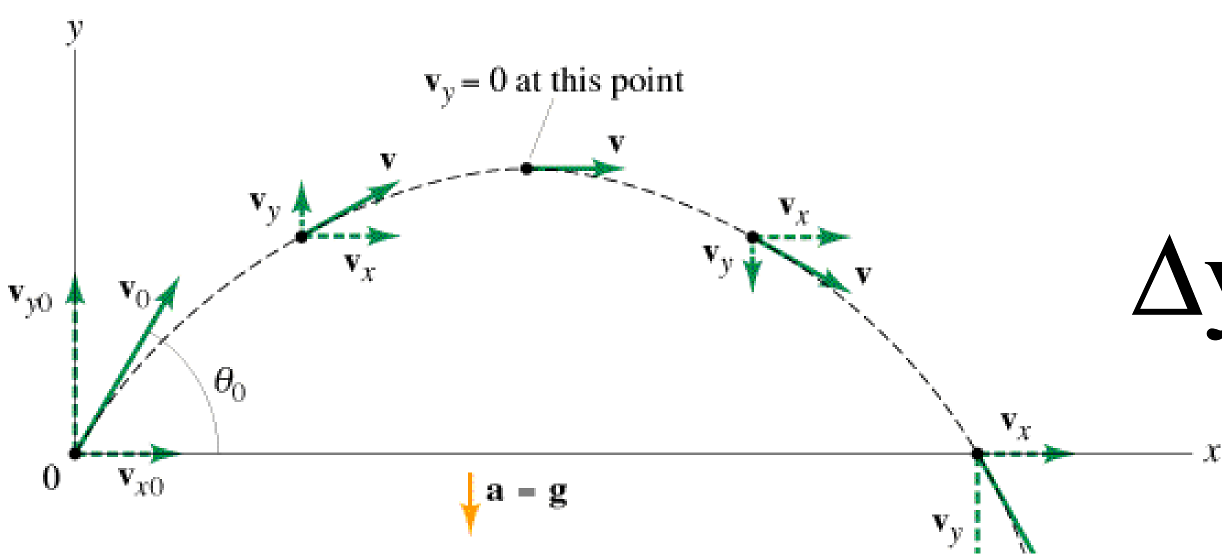
D. not enough information to determine

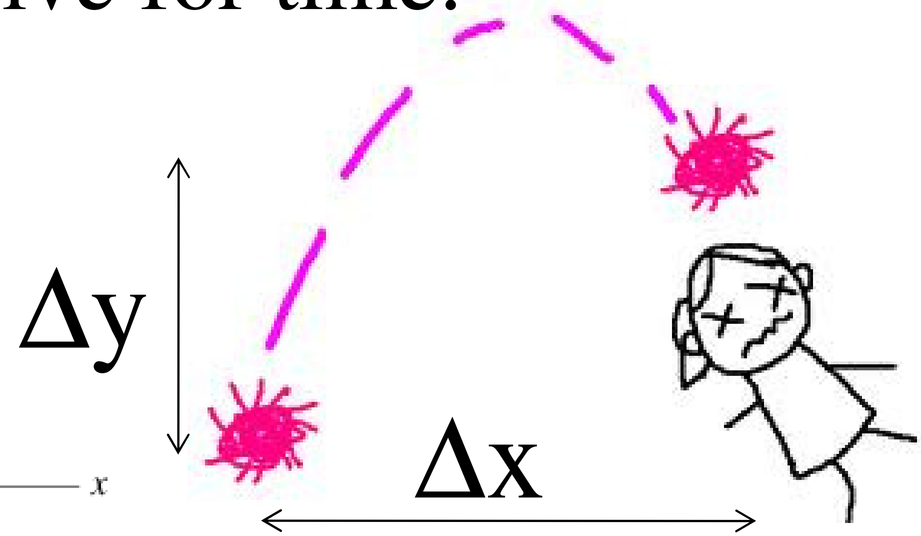
Q22

Common Strategy for Projectile Motion Problems

The time will be the same for x and y parts of the question.

If you don't have enough information for x or y components, solve for time.





Throwing something off of a cliff (5 examples of possible questions with ~ increasing difficulty)

I throw a ball off the edge of a 15.0m tall cliff. I threw it at 16 m/s at an angle of 60 degrees from the horizontal.

A. Determine how much time it takes to fall.

B. Determine how far from the base of the cliff it hits the ground. (Need the time first)

C. Determine how fast it is moving vertically when it hits the ground. (y component of final velocity)

D. Determine what its magnitude of velocity is when it hits the ground.

E. Determine the angle that it hits the ground from the horizontal.

Part A: Time to Fall (more than one way to approach)

Use either vertical or horizontal depending on which has more info. Here, we will only use vertical numbers.

$\Delta y = v_{oy}t + 1/2\ at^2$

$\Delta y = (16 \sin 60)\ t + 1/2\ (-9.8)\ t^2$

Quadratic eq. ($at^2+bt+c=0$): a=-4.9, b=13.85, c=- Δy =15 m

$t=[-b \pm (b^2-4(a)(c))^{\wedge}\ ½]\ /(2a)$

$=-13.85 \pm (191.8-4(-4.9)(15))^{\wedge}\ ½\ ]/(-9.8)$

t= 1.41 ± 2.25= -0.84 s or 3.66 s

Part B: How far from cliff base (Think Horizontal)

Well, we know it was in the air for 3.66s (from the previous question), and it was moving at a constant speed in the x-direction the whole time (a_x=0), so…

$v = \Delta x/t$ or $\Delta x = v_{ox}t + \frac{1}{2} a_x t^2$ where ax=0

$\Delta x = v_x t = (16 \cos 60^\circ)(3.66\text{s})$

$\Delta x = 29\text{m}$ It will move 29m horizontally, so it hits the ground 29m away from the base of the cliff.

Part C: Vertical speed at the bottom (Think Vertical)

It has been accelerating down the whole time. We know that gravity is causing this acceleration, so we can figure out how fast it is going (vertically) when it hits the ground.

(This is one other equation you could use. This one is easier.)

$v_{fy} = v_{iy} + a\ t$

$v_{fy} = 16 \sin 60^\circ - 9.8 \times 3.66$

$v_{fy} = -22$ m/s

Should be negative since moving opposite from positive y direction

Part D/E: Velocity when hits (Combination of x and y directions)

It's total velocity is found by adding the horizontal and final vertical components of the velocity to find the resultant.

$c^2 = a^2 + b^2$

$= (8.0\text{m/s})^2 + (-22\text{m/s})^2$

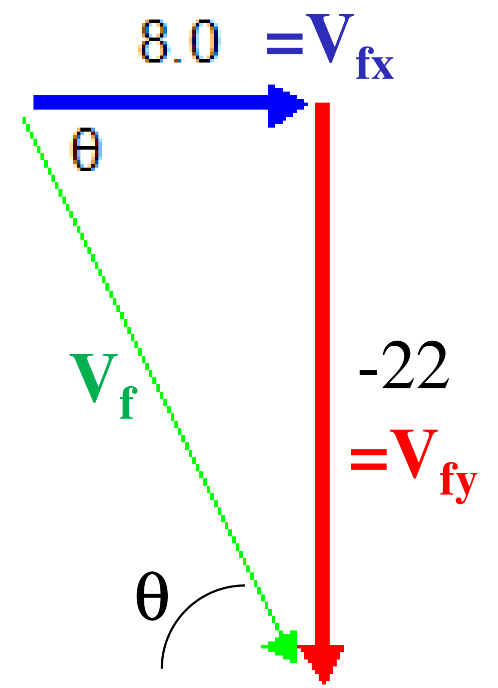
$c = 23.4$ m/s

$\tan\Theta = \text{opp/adj}$

$= (-22 \text{ m/s}) / (8\text{m/s})$

$\Theta = \tan^{-1}(-22/8) = -70°$

The object is moving at 23m/s at an angle of 70° with respect to the horizontal.



Probably some of these problems will be on the problem solving day unless other questions are asked

The Long Jump

A long jumper leaves the ground at an angle of 20 degrees to the horizontal at a speed of 11 m/s.

(a) How long does it take for him to reach maximum height?

(b) What is the maximum height?

(c) How far does he jump?

At an altitude of 1000 m, you drop something from a plane traveling at 60 m/s.

- How long does it take to reach the ground?
- Horizontally, how far is the object displaced from the position the plane was above when the object was dropped?

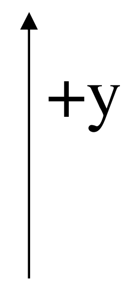
Motion in Two Dimensions With Constant Acceleration

- Separation of vectors into components allows separation of equations into components:

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

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

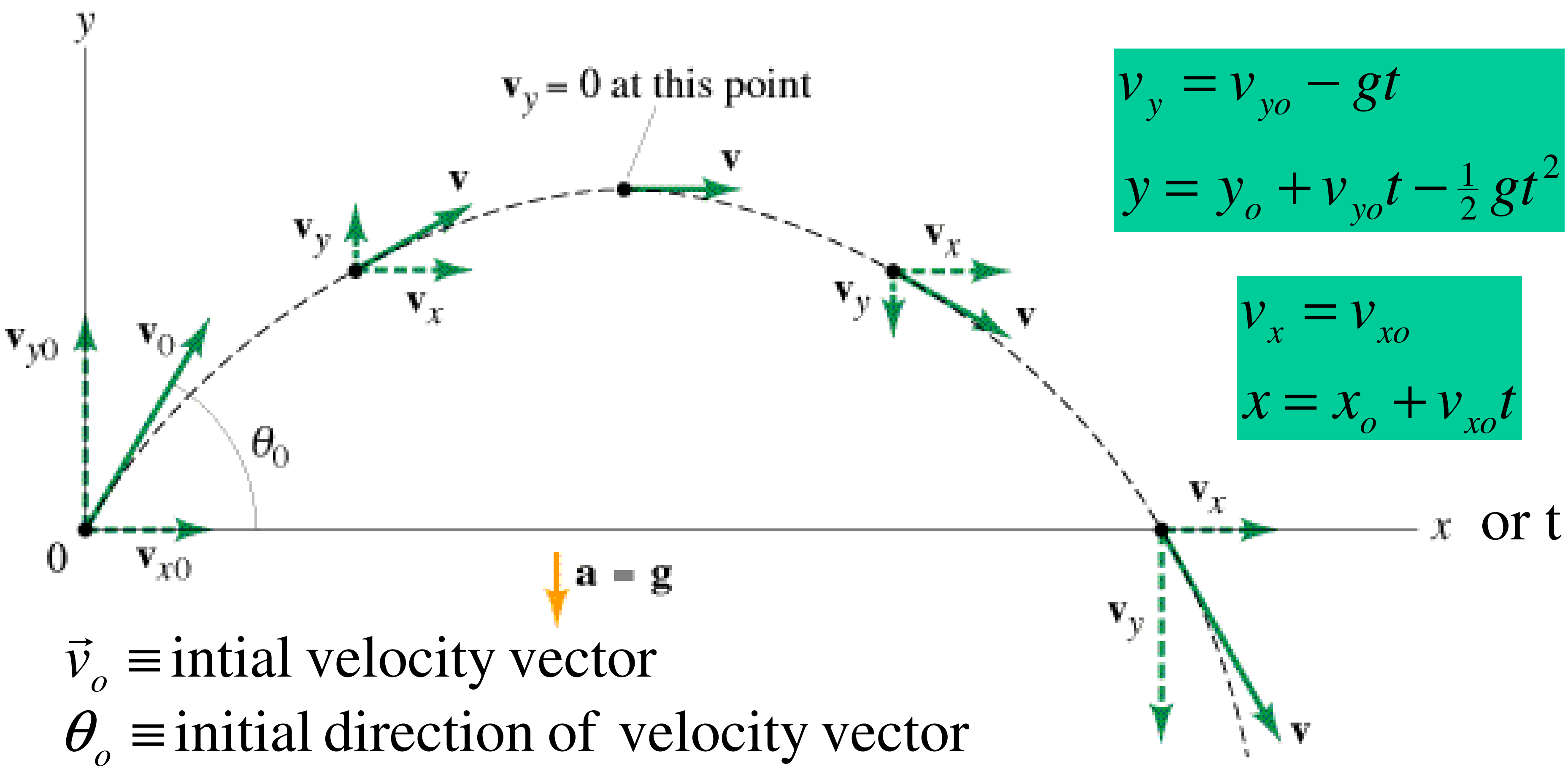
- For projectile motion: $a_x = 0$ $\quad a_y = -g = -9.8\ \text{m/s}^2$



$$v_x = v_{xo}$$
$$\Delta x = v_{xo} t$$

$$v_y = v_{yo} - gt$$
$$\Delta y = v_{yo} t - \tfrac{1}{2} g t^2$$

Projectile motion means right after it leaves your hand, and right before it hits the ground (when only gravity acts on the object!)



$$v_y = v_{yo} - gt$$

$$y = y_o + v_{yo}t - \tfrac{1}{2}gt^2$$

$$v_x = v_{xo}$$

$$x = x_o + v_{xo}t$$

$\vec{v}_o \equiv$ intial velocity vector

$\theta_o \equiv$ initial direction of velocity vector

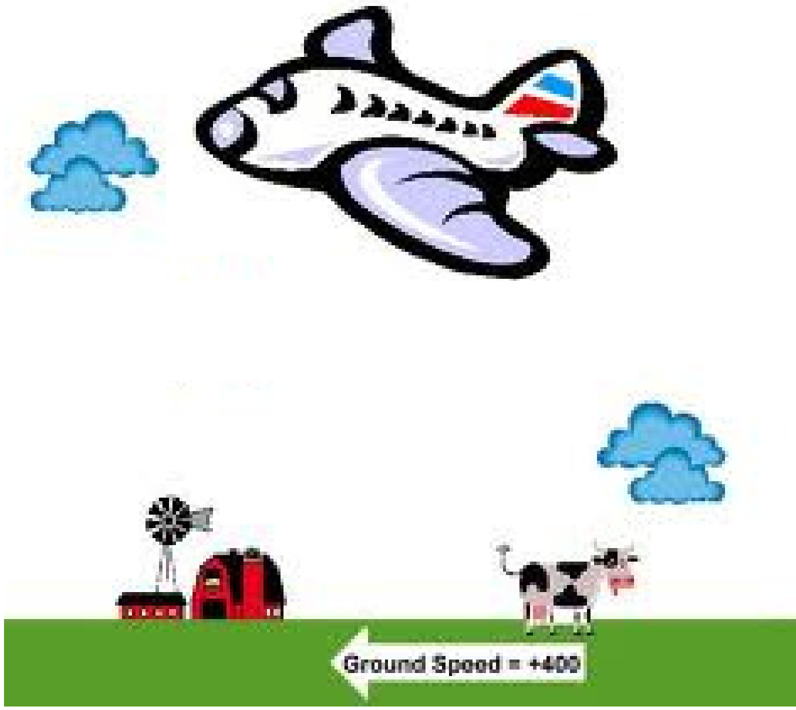
- $v_y = 0$ at top of trajectory
- $v_x = v_{xo}$ remains the same throughout trajectory because there is no acceleration along the *x*-direction

Physics for Pilots

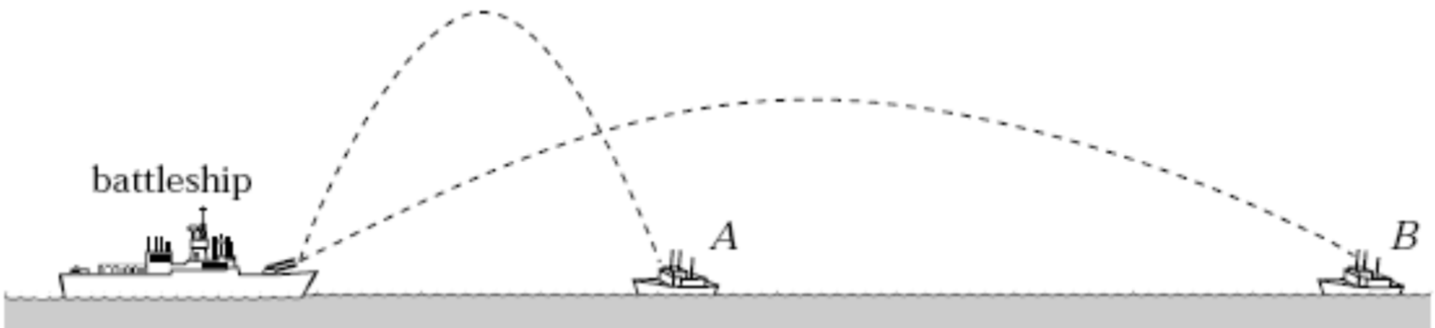
Similar formulas even if not in freefall!

An airplane is approaching a runway. The pilot measures her horizontal speed to be 400 mph. The altimeter indicates that the plane is dropping at a constant speed of 10 feet/s. If the plane is at a height of 3000 feet and the start of the runway is 28 miles away (horizontally), does the pilot need to make any adjustments to her descent?

Similar strategy, but not projectile motion
(this case a_y=0 because plane not accelerating)



(Harder) 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. *B*

C. Both at the same time

D. need more information

Q24

“Money Hunter” Demo

https://www.youtube.com/watch?v=TbWiMsfr_DQ

Follow ups:

https://www.youtube.com/watch?v=0jGZnMf3rPo

https://www.youtube.com/watch?v=3ECZRejB5d4

Show pForce (first) video.

Clicker Answers

Chapter/Section: Clicker #=Answer

21=B, 22=B, 23=A, 24=B