Announcements

- **Quiz tomorrow, covers math and Ch1, first problem set**
- **Movies are due tomorrow (at least one from each group)**
  Turn in your analyzed movies by posting movie and an image of the LP work to FB before class
- **Tutoring: www.gwu.edu/~sps**

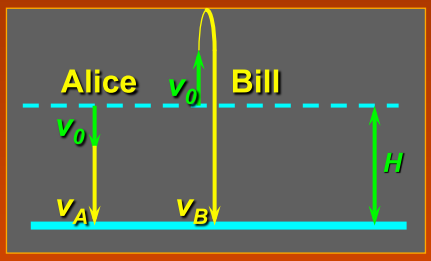
Physics 1021

Spring 2012 Ch 3,4a

ConcepTest 3.1a — Up in the air II

Alice and Bill are at the top of a cliff of height H. Both throw a ball with initial speed v_0, Alice straight down and Bill straight up. The speeds of the balls when they hit the ground are v_A and v_B. If there is no air resistance, which is true?

1) $v_A < v_B$
2) $v_A = v_B$
3) $v_A > v_B$
4) impossible to tell

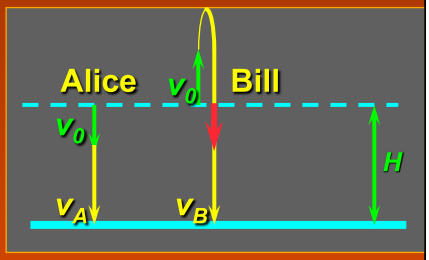


ConcepTest 3.1b — Up in the air II

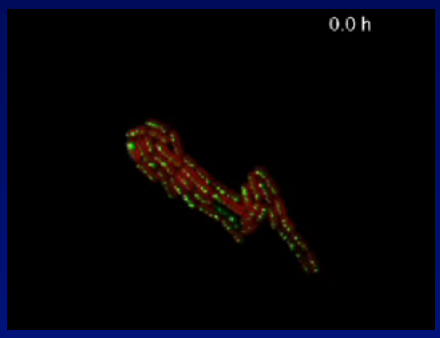
Alice and Bill are at the top of a cliff of height H. Both throw a ball with initial speed v_0, Alice straight down and Bill straight up. The speeds of the balls when they hit the ground are v_A and v_B. If there is no air resistance, which is true?

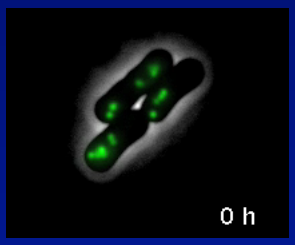
1) $v_A < v_B$
2) $v_A = v_B$
3) $v_A > v_B$
4) impossible to tell

Bill's ball goes up and comes back down to Bill's level. At that point, it is moving downward with v_0, the same as Alice's ball. Thus, it will hit the ground with the same speed as Alice's ball.



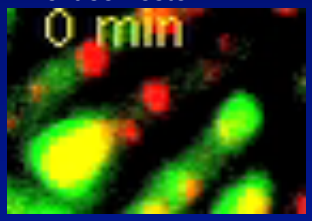
Kinematics in Cyanobacteria
sequestering CO_2 in carboxysomes



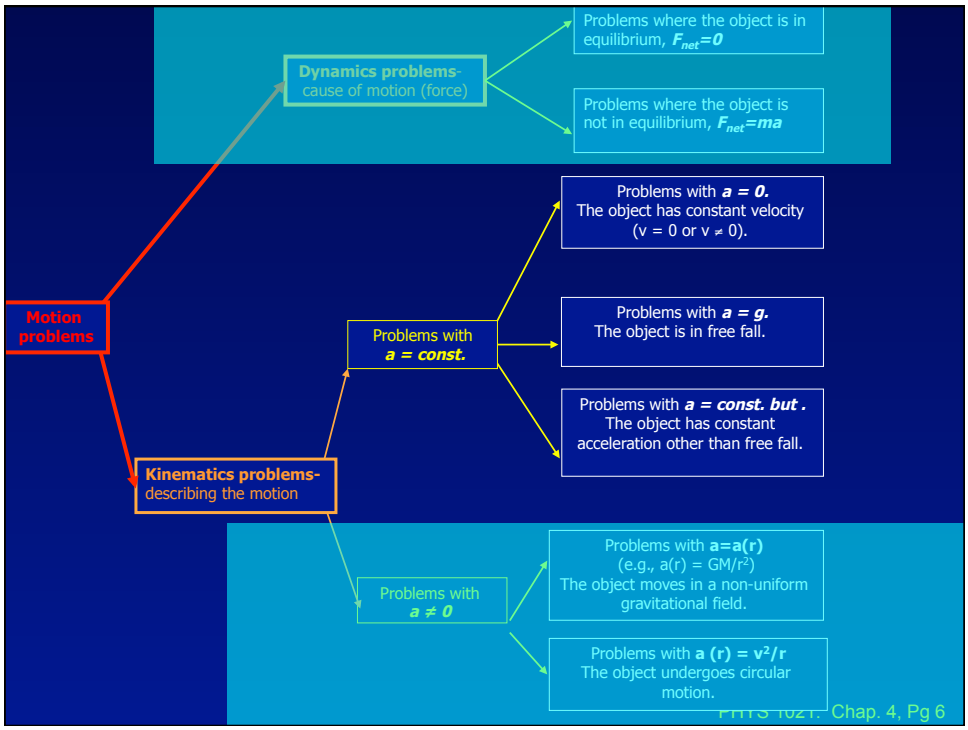


What do you need to understand these movies?

- 2-d kinematics … this lecture
- Forces – acceleration – change in velocity. Last week and this week
- Statistical approach to physics, diffusion – later this semester
- Atomic states and fluorescence – next semester



Dave Savage Wyss Institute, Harvard



ConcepTest 3.2a Two balls in the air

A ball is thrown straight upward with some initial speed. When it reaches the top of its flight (at a height *h*), a second ball is thrown straight upward with the same initial speed. Where will the balls cross paths?

1) at height h
2) above height h/2
3) at height h/2
4) below height h/2 but above 0
5) at height 0

ConcepTest 3.2b Two balls in the air

A ball is thrown straight upward with some initial speed. When it reaches the top of its flight (at a height *h*), a second ball is thrown straight upward with the same initial speed. Where will the balls cross paths?

1) at height h
2) above height h/2
3) at height h/2
4) below height h/2 but above 0
5) at height 0

The first ball starts at the top with no initial speed. The second ball starts at the bottom with a large initial speed. Since the balls travel the same time until they meet, the second ball will cover more distance in that time, which will carry it over the halfway point before the first ball can reach it.

ConcepTest3.3a Throwing rocks I

You drop a rock off a bridge. When the rock has fallen 4 m, you drop a second rock. As the two rocks continue to fall, what happens to their separation?

1) the separation increases as they fall
2) the separation stays constant at 4 m
3) the separation decreases as they fall
4) it is impossible to answer without more information

ConcepTest 3.3b Throwing rocks I

You drop a rock off a bridge. When the rock has fallen 4 m, you drop a second rock. As the two rocks continue to fall, what happens to their separation?

1) the separation increases as they fall
2) the separation stays constant at 4 m
3) the separation decreases as they fall
4) it is impossible to answer without more information

At any given time, the first rock always has a greater velocity than the second rock, therefore it will always be increasing its lead as it falls. Thus, the separation will increase.

Follow-up: What happens to their velocities?

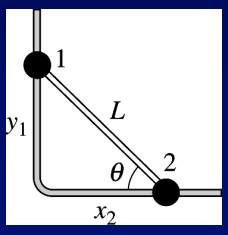
Problem-solving according to the *GOAL Strategy*

1. **Gather:** What's going on here, draw a picture, What physics concepts do you need? Make an estimate
2. **Organize:** Translate words into physics terms, write down some equations you think you'll need. Decide what is known and unknown in the problem
3. **Analyze:** Use equations to solve for unknown variable
4. **Learn:** Insert numbers into solved equations. Does the answer make sense? Why was this problem assigned?

Example

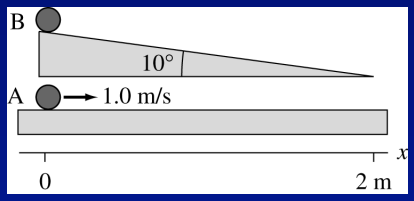
- The two masses in the figure slide on frictionless wires. They are connected by a pivoting rigid rod of length L. Prove that

$v_{2x} = - v_{1y} \tan\theta$



Ponderable

- Ball A rolls along a frictionless, horizontal surface at a speed of 1.0 m/s. Ball B is released from rest at the top of a 2.0-m-long, 10° ramp at the exact instant ball A passes by. Will B overtake A before reaching the bottom of the ramp? If so, at what position? (Before doing the mathematics, it's worth sketching position graphs and showing that you're trying to find where the two graphs intersect.)



2-dimensional motion (Projectile motion)

New Topic

2-D Kinematics

- **Projectile Motion**: 2-D problem with *constant acceleration*
  - Choose *y* axis vertical (direction of acceleration)
  - Choose *x* axis horizontal ("other" direction of motion)

→ Horizontal and vertical motions are ***independent***
Analyze **separately** !!

- Example: Throwing a baseball (neglecting air resistance)
  - Acceleration in *y* direction is constant (gravity)
    - with +*y* axis up, we know that $a_y = -g$
  - Acceleration in *x* direction is zero !!
    - projectile maintains constant velocity in *x direction*

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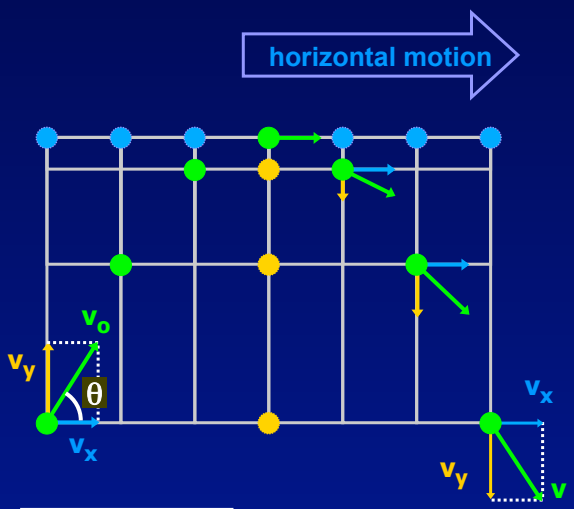
2-D Kinematics Problems



Constant Velocity
$x = x_o + v_{ox}t$
$v_x = v_{ox}$
$a_x = 0$

Initial velocity
$v_{ox} = v_o \cos\theta$
$v_{oy} = v_o \sin\theta$

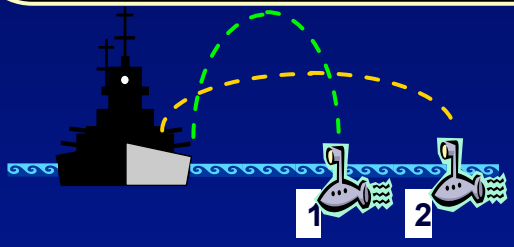
Free Fall
$y = y_o + v_{oy}t + \frac{1}{2}a_y t^2$
$v_y = v_{oy} + a_y t$
$a_y = -g$

PHYS 1021: Chap. 4, Pg 16

ConcepTest 4.1a Shells

A battleship simultaneously fires two shells at two enemy submarines. The shells are launched with the same initial velocity. If the shells follow the trajectories shown, which submarine gets hit first ?

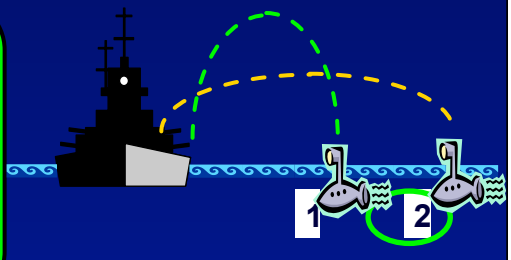
1) 1
2) 2
3) Both same time



ConcepTest 4.1b Shells

A battleship simultaneously fires two shells at two enemy submarines. The shells are launched with the same initial velocity. If the shells follow the trajectories shown, which submarine gets hit first ?

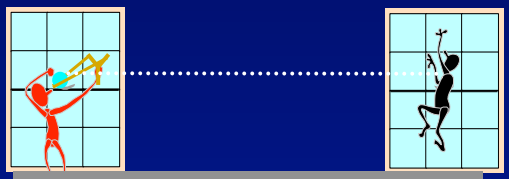
The flight time is fixed by the motion in the y-direction. The *higher* an object goes, the *longer* it stays in flight. The shell hitting ship #2 goes *less high*, therefore it stays in flight for *less time* than the other shell. Thus, ship #2 is hit first.



ConcepTest 4.2a-post water balloons I

You are trying to hit a friend with a water balloon. She is sitting in the window of her dorm room directly across the street. You aim straight at her and shoot. Just when you shoot, she falls out of the window! Does the water balloon hit her??

1) yes, it hits
2) maybe -- it depends on the speed of the shot
3) no, it misses
4) the shot is impossible
5) not really sure



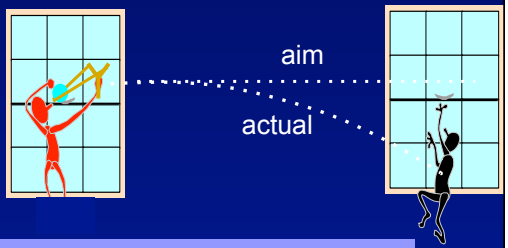
Assume that the shot does have enough speed to reach the dorm across the street.

ConcepTest 4.2b water balloons I

You are trying to hit a friend with a water balloon. She is sitting in the window of her dorm room directly across the street. You aim straight at her and shoot. Just when you shoot, she falls out of the window! Does the water balloon hit her??

1) yes, it hits
2) maybe -- it depends on the speed of the shot
3) no, it misses
4) the shot is impossible
5) not really sure

Your friend falls under the influence of gravity, just like the water balloon. **Thus, they are both undergoing free fall in the y-direction.** Since the sling shot was accurately aimed at the right height, the water balloon will fall exactly as your friend does, and it will hit her!

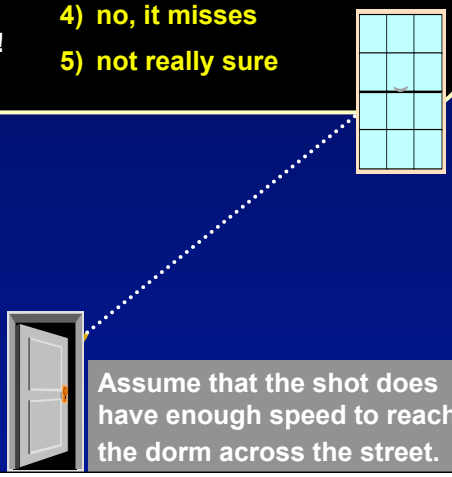


Follow-up: If your friend does not fall out of the window?

ConcepTest 4.3a water balloons II

You're on the street, trying to hit a friend with a water balloon. He sits in his dorm room window above your position. You aim straight at him and shoot. Just when you shoot, he falls out of the window! Does the water balloon hit him??

1) yes, it hits
2) maybe -- it depends on the speed of the shot
3) the shot is impossible
4) no, it misses
5) not really sure



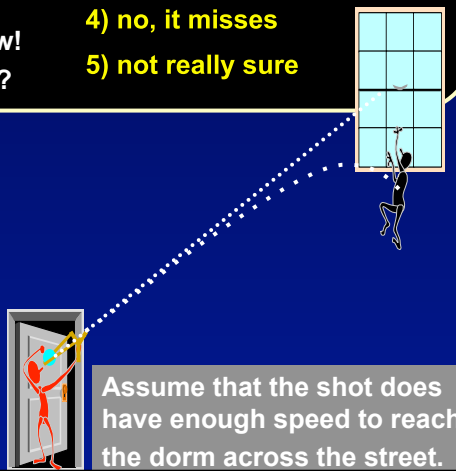
Assume that the shot does have enough speed to reach the dorm across the street.

ConcepTest 4.3b water balloons II

You're on the street, trying to hit a friend with a water balloon. He sits in his dorm room window above your position. You aim straight at him and shoot. Just when you shoot, he falls out of the window! Does the water balloon hit him??

1) yes, it hits
2) maybe -- it depends on the speed of the shot
3) the shot is impossible
4) no, it misses
5) not really sure

This is really the same situation as before!! The only change is that the initial velocity of the water balloon now has a y-component as well. But both your friend and the water balloon still fall with the same acceleration -- *g* !!



Assume that the shot does have enough speed to reach the dorm across the street.

Example

78. A seagull is flying horizontally 8.00 m above the ground at 6.00 m/s. The bird is carrying a clam in its beak and plans to crack the clamshell by dropping it on some rocks below. Ignoring air resistance, (a) what is the horizontal distance to the rocks at the moment that the seagull should let go of the clam? (b) With what speed relative to the rocks does the clam smash into the rocks? (c) With what speed relative to the seagull does the clam smash into the rocks?