Table of Contents Semester 1 Algebra-Based Physics
Loeblein's Course Sample- Kinematics, Energy, Fluids

The purpose of this contribution is to demonstrate how I use PhET in my course. The activities can also be found in the PhET Teaching Ideas in Microsoft office format if you would like to edit them- go to the PhET *Teaching Ideas* pages - search for the sim and my name. You are welcome to use or edit my activities for your course. All of my activities are posted under the Creative Commons - Attribution license, so please acknowledge that they were developed by Trish Loeblein and provide a link back to the main PhET website: http://phet.colorado.edu/

Plans for using PhET simulation activities in Loeblein's Honors Physics 2011-12

College Level Semester One Topics (schedule for high school is more than one semester)

IC In Class Activity; **CQ** clicker questions; **HW** homework ; **Demo**: teacher centered group discussion

Introduction to Motion:
- Moving Man IC/CQ
- Calculus Grapher HW/CQ

More on motion and Measurement
- Vector Addition IC/CQ
- Projectile motion IC/CQ

Forces and the Laws of Motion Publishing skills: curve fit, drawing, tables
- Forces and Motion: Two activities IC/CQ
- Ramp-Force and Motion: Two activities IC/CQ
- Maze Game: HW/CQ
- Curve Fitting: HW

Work, Energy, Momentum and Collisions
- Energy Skate Park: Four activities IC/CQ
- Masses and Springs: IC/CQ
- Collision Lab: HW

Semester Project and Circular Motion
- Pendulum: HW/CQ
- Gravity Force Lab: IC/CQ
- Pendulum: HW
- Ladybug 2D: HW/CQ
- Ladybug Revolution: HW/CQ
- Masses and Springs: HW
- Balancing Act: (simulation & activity coming soon)

Heat and Thermodynamics
- Friction: Demo
- States of matter and Gas Properties: IC/CQ

Fluids
- Density: IC
- Buoyancy: IC
- Balloons and Buoyancy: IC/CQ
- Under Pressure: IC/HW/CQ
- Estimation: HW

Unit 1 Motion in One Dimension
Loeblein Physics

Learning goals- **Students will be able to:**
From text book work:

- Begin describing problems in many different representations: Graphical, pictorial, mathematical.
- Develop their understanding of the kinematic variables position, velocity, and acceleration.
- Solve basic problems of motion in one dimension, including objects falling under the influence of gravity.

Moving Man PhET Activity

- Accurately interpret and draw position, velocity and acceleration graphs for common situations and explain their reasoning.

Calculus Grapher PhET Activity

- Use the language of calculus to discuss and interpret motion
- Given a function sketch the derivative, or integral curves

Lab skills:

- Use the Reflection process to design and modify
- Distinguish between accuracy and precision.
- Interpret data in tables and graphs, and use appropriate equations that summarize data.

Lab Report skills

- Header: Names, Title and Period
- Footer: Date, page
- Procedure: Materials and Methods: written steps, diagrams, samples calculations
- Results: tables of data, graphs, descriptive observations
- Write summary sentence: state the findings and include interpretation
- Discuss errors in terms of precision and accuracy

Unit 1: Introduction to Motion in One Dimension

Example Physics http://phet.colorado.edu (some days are 50 minutes and some 95 minutes)

1 Quiz 1
Lab 1: Determine the average speed of a Hot Wheels car
Turn in: data table, calculations, summary of results and error sources

2 Notes: Expectations, velocity, and experimental design, safety and honor code contracts, Paper header and footer*, Procedure writing, Accuracy and Precision, Reflection process,
Lab 2: Determine the average speed of a physics cart
Turn in: procedure, data table, calculations, summary of results and error sources

3 Quiz 2
Notes: Position, velocity, interpreting motion graphs, Scalar and vector quantities
Lab 3: Use the motion probe to graph position (x) and velocity (v) of some motion, also make motions to fit given graphs (nothing to turn-in, just need Loeblein to check your name in grade book)
Lab 4: *Moving man* activity **PhET**
Do: worksheet 1

4 Quiz 3: Be able to find position or velocity from position-time graphs and velocity time graphs, create a graph from data
Lab 4: Finish *Moving man* activity **PhET**
Do: read and do text problems; Try *Calculus Grapher* **PhET** simulation to check your ideas

5 Clicker questions for *Moving Man*
Notes: Uniform and Accelerated motion,
Do: read and do text problems;

6 Quiz 4: Be able to find position or velocity from position-time graphs and find position, velocity or acceleration from velocity time graphs
Notes: Calculator skills (graphing data, curve fitting with r^2, finding slope and area),
Do: Graph practice data to determine if the d vs t graph shows constant or accelerated motion, find velocity at some time. Also, find area under curve for a section.

1 Time	1 Position	2 Time	2 Position	3 Time	3 Position
1.08	31.63	.23	2.73	7.87	23.70
2.02	35.16	.40	4.10	11.59	31.09
2.23	38.80	1.21	20.00	13.83	35.06
2.44	42.55	3.25	130.00	16.81	41.72
2.65	46.40	5.04	309.00	21.25	50.58
2.87	50.37	7.22	631.09	25.00	58.02

7 Notes: Using equations for v and a to solve problems, Writing procedures
Lab 5: Figure out a way to make a cart move with constant (nonzero) velocity, use the motion probe to show that you have been successful and write a Procedure *(using the software and how to give evidence should be included)*. **Repeat** but make the cart move with constant acceleration (*so you will have 2 procedures to turn in)*
Do: read and do text problems

8 Clicker questions for *Calculus Grapher,* Class discussion **p61** #4, 5, 6
Do: read and do text problems;

9 Notes: Free fall , summary sentences
Lab 6: Use a falling balls to determine acceleration here in this room.
Turn in: Title, procedure, evidence, error analysis, summary sentence
Do: read and do text problems, questions

10 Notes: lab writing and physics topics review
Lab 6: finish free fall lab
Do: read and do text problems; standardized testing practice

11 Review study & test taking skills, complete equation sheet, Clicker Questions Moving Man

12 Unit 1 Test: **Also, this is the last day to turn in work from this unit**.

* Headers will need Names, Period, Title. Footers: date and page number

Lesson plan for Moving man v1r13
Approximately 100 minutes

Learning goals: Students will be able to accurately interpret and draw position, velocity and acceleration graphs for common situations and explain their reasoning.

Background: On the first day of class, students use the motion probe to investigate position graphs. That evening, they'll read in the text an introduction to motion. Position, velocity and acceleration are discussed and graphs are given for some life applications like running a race. On the next days of class, we will use the *Moving Man* simulation. There are pre/post lab questions written.

Moving Man Introduction:
Go to the PhET site, phet.colorado.edu launch *Moving Man* from the *Simulations* front page. Show how to use the sliders to make the man move. Also, demonstrate the playback features.

Lesson: Have the students use the lab sheet for guidance to learn the objective. The activity took my honors physics students about 100 minutes.

Student Directions for *Moving Man* Activity
Phet.colorado.edu

Learning goals: Students will be able to accurately interpret and draw position, velocity and acceleration graphs for common situations and explain their reasoning.

1. Investigate *Moving Man* by having the man move using the sliders. Use the playback features to look at the graphs. While you make observations talk about the reasons the graphs look the way they do.

2. Make a chart like the one below on your own paper. Without using *Moving Man*, sketch what you think the graphs would look like for the following scenario and explain your reasoning.

Scenario: The man starts at the tree and moves toward the house with constant velocity	
Position - time graph	Explain your reasoning for the graph's appearance
Velocity - time graph	Explain your reasoning for the graph's appearance
Acceleration - time graph	Explain your reasoning for the graph's appearance

3. Now, use the *Moving man* simulation to verify or correct your predicted graphs and reasoning with a different color pen.

4. Make new charts for each of the following scenarios. Predict what you think the graphs will look like, and then use *Moving man* to verify or correct your predicted graphs and reasoning with a different color pen.

a. The man starts three meters from the house and accelerates towards the tree.
b. The man stands still while he talks on his cell phone at the middle of the sidewalk, then walks toward the house at a constant rate trying to get better cell reception. He comes to a sudden stop when the coverage is good (about a meter before the house) and stands still to finish his conversation.

c.. The man starts close to the house, stands still for a little while, then walks toward the tree at a constant rate for a while, then the slows to a stop.

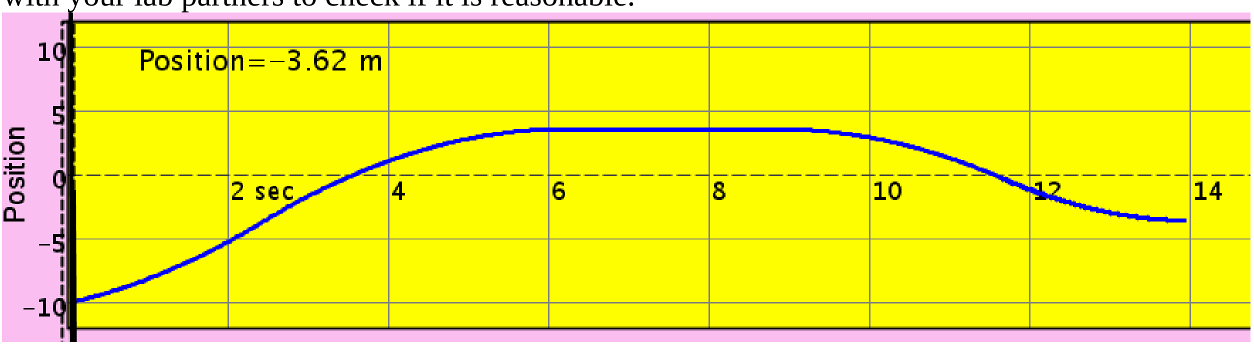
5. Look at your graphs, reasonings and the corrections from questions 2 and 3. Talk about why some of your predictions were wrong and how your ideas about motion have changed.

6. Sketch the position, velocity and acceleration graphs for the following scenario:

A man wakes up from his nap under the tree and speeds up toward the house. He stops because he is worried that he dropped his keys. He stands still as he searches his pockets for his keys. Once he finds them, he continues calmly to walk toward the house and then slows to a stop as he nears the door.

7. With your lab partners, write a motion scenario that you could test. Test it, and then write a description of how you used the program to generate the graphs. Sketch the graphs.

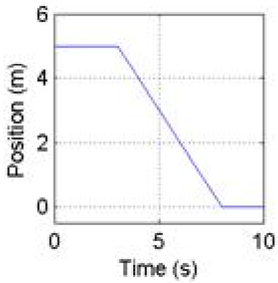
8. Individually write a possible scenario for the following graph. Then compare your scenario with your lab partners to check if it is reasonable.



time

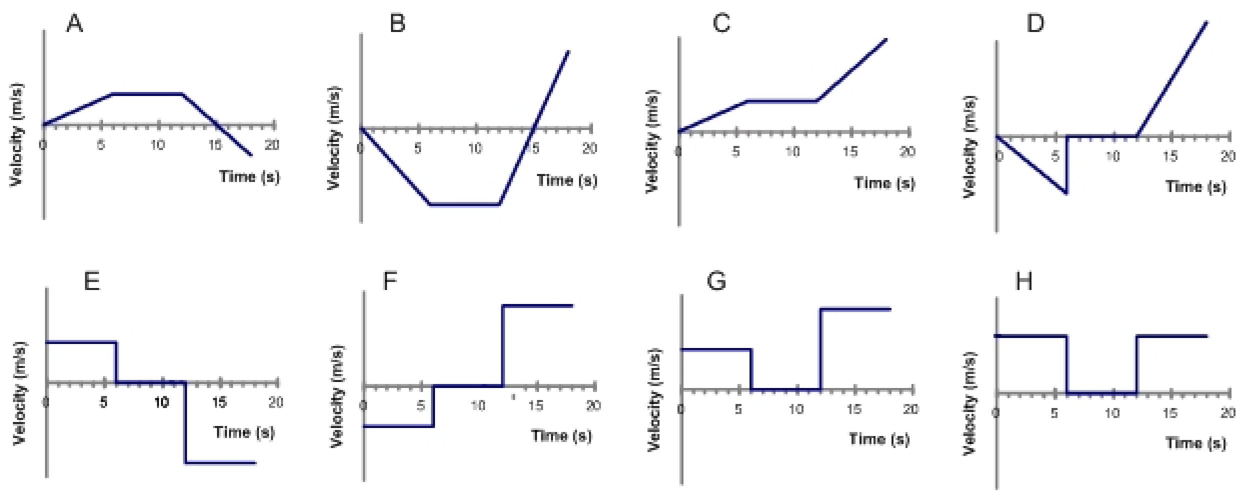
Prelab and Postlab questions for Moving Man

1. Below is a graph of a balls motion. Which of the following gives the best interpretation of the ball's motion?

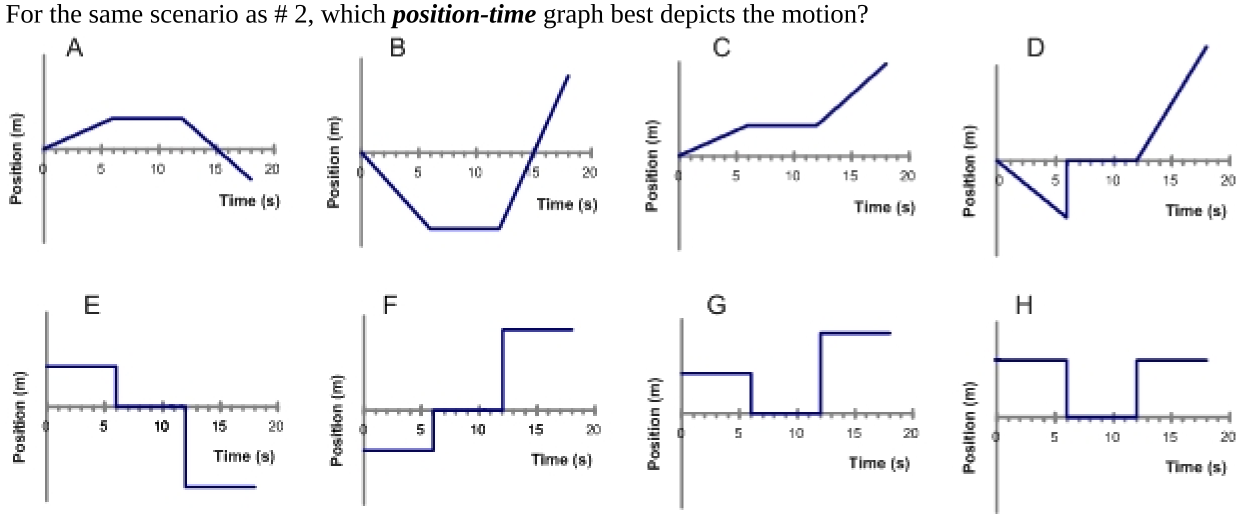


   a. The ball moves along a flat surface. Then it moves forward down a hill, and then finally stops.
   b. The ball doesn't move at first. Then it moves forward down a hill and finally stops.
   c. The ball is moving at constant velocity. Then it slows down and stops.
   d. The ball doesn't move at first. Then it moves backwards and then finally stops.
   e. The ball moves along a flat area, moves backwards down a hill and then it keeps moving.

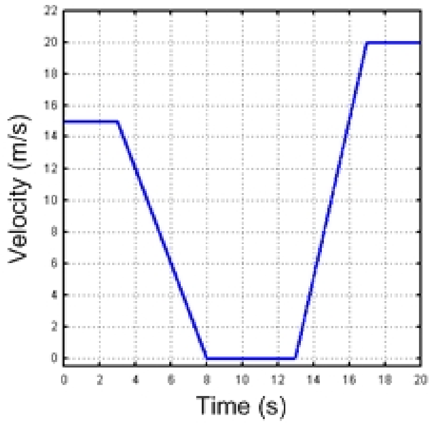
2. Which graph would best depict the following scenario? A man starts at the origin, walks back slowly and steadily for 6 seconds. Then he stands still for 6 seconds, then walks forward steadily about twice as fast for 6 seconds. Note that these are ***velocity-time*** graphs.



3. For the same scenario as # 2, which ***position-time*** graph best depicts the motion?



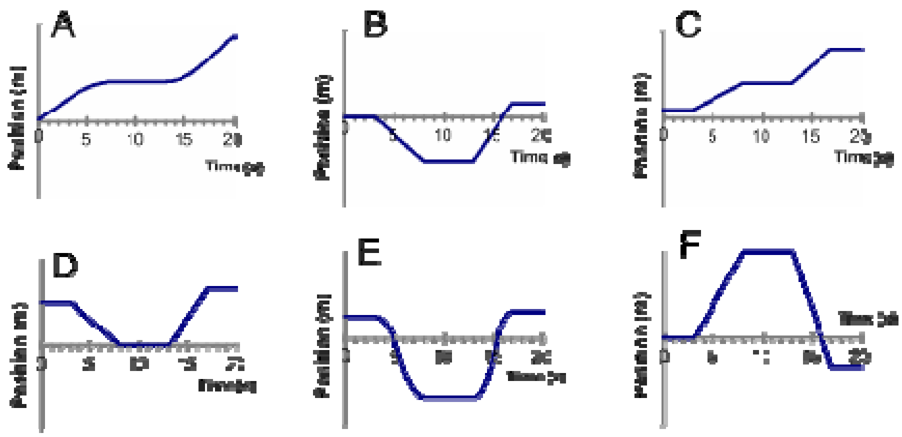
4. A car is traveling along a road. Its velocity is recorded as a function of time and is shown in the graph below.



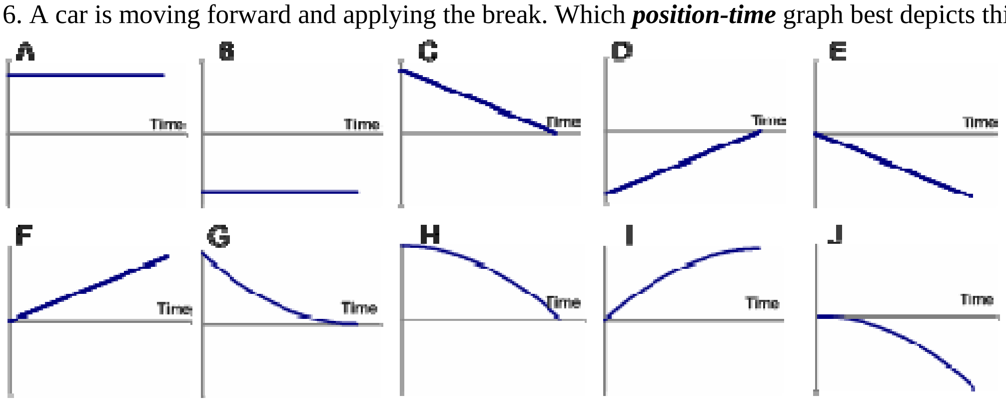
During which intervals is the car accelerating? Choose all the answers that apply.

a. between 0 and 3 seconds
b. for a brief instant at 3,8,13 and 17 seconds
c. between 3 and 8 seconds
d. between 8 and 13 seconds
e. between 13 and 17 seconds
f. between 17 and 20 seconds

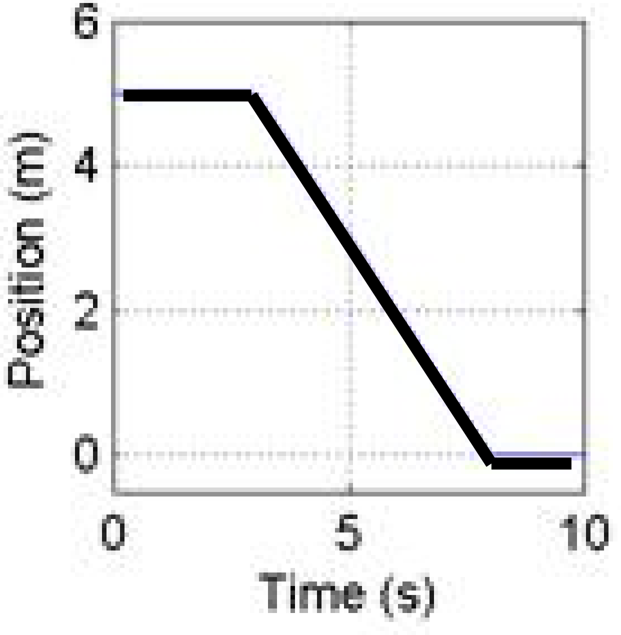
5. Which of the following ***position-time*** graphs would be consistent with the motion of the car in question #4?



6. A car is moving forward and applying the break. Which ***position-time*** graph best depicts this motion?



1.Below is a graph of a balls motion. Which of the following gives the best interpretation of the ball’s motion?



a. The ball moves along a flat surface. Then it moves forward down a hill, and then finally stops.

b. The ball doesn’t move at first. Then it moves forward down a hill and finally stops.

c. The ball is moving at constant velocity. Then it slows down and stops.

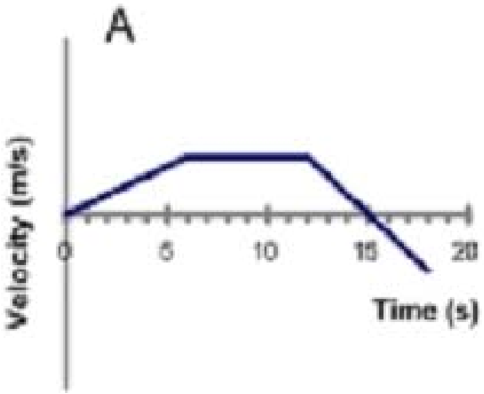
d. The ball doesn’t move at first. Then it moves backwards and then finally stops.

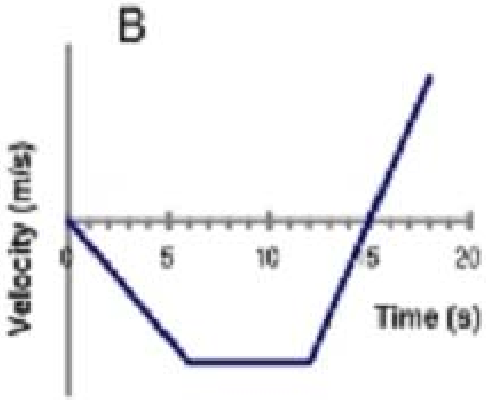
e. The ball moves along a flat area, moves backwards down a hill and then it keeps moving.

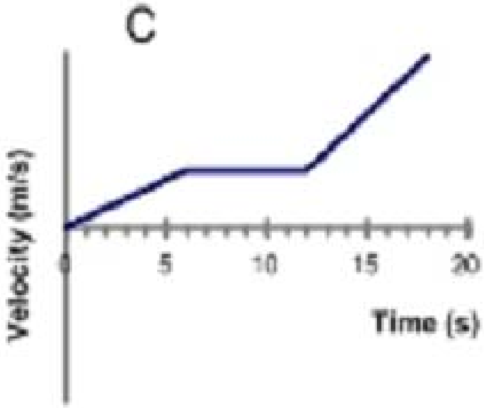
2. Draw a ***velocity-time*** graph would best depict the following scenario?

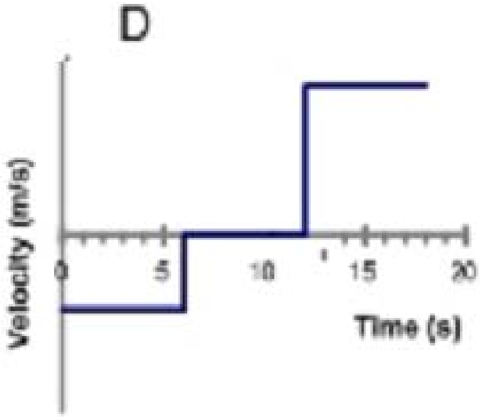
A man starts at the origin, walks back slowly and steadily for 6 seconds. Then he stands still for 6 seconds, then walks forward steadily about twice as fast for 6 seconds.

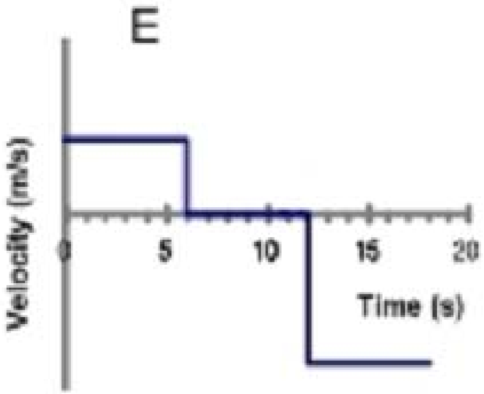
2 Which velocity time graph best depicts the scenario?





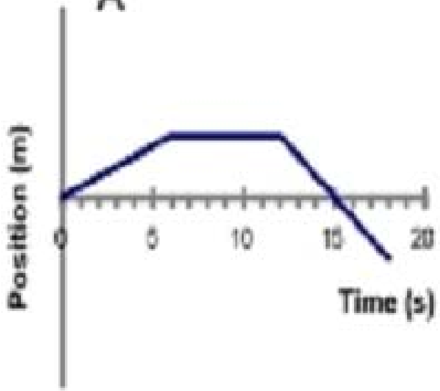




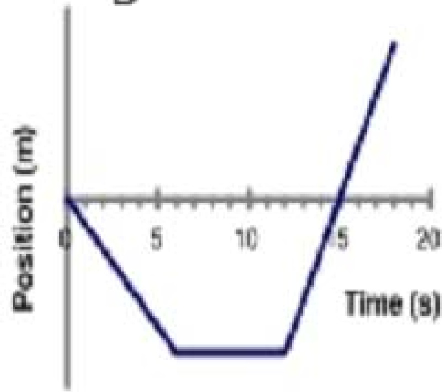


3. For the same scenario as # 2, which ***position-time*** graph best depicts the motion?

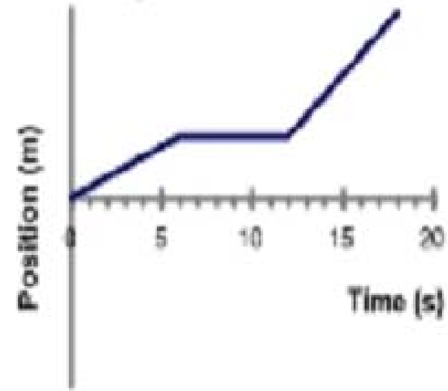
A



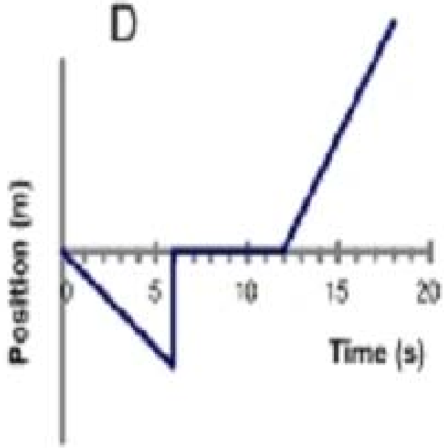
B



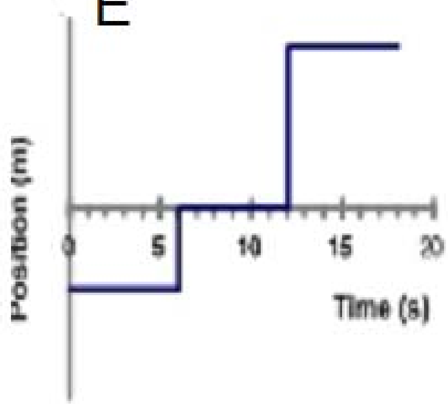
C



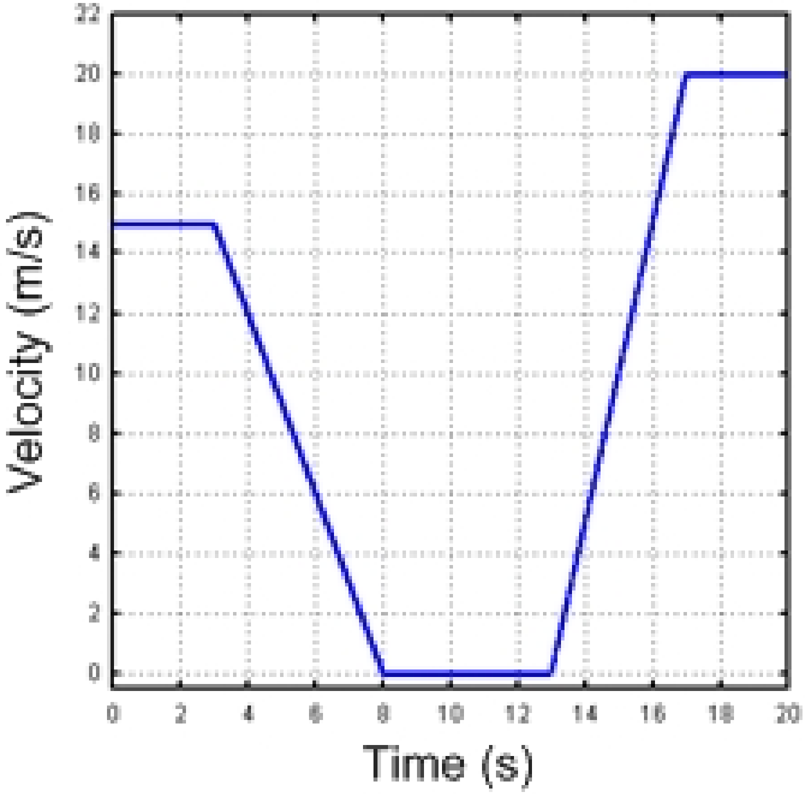
D



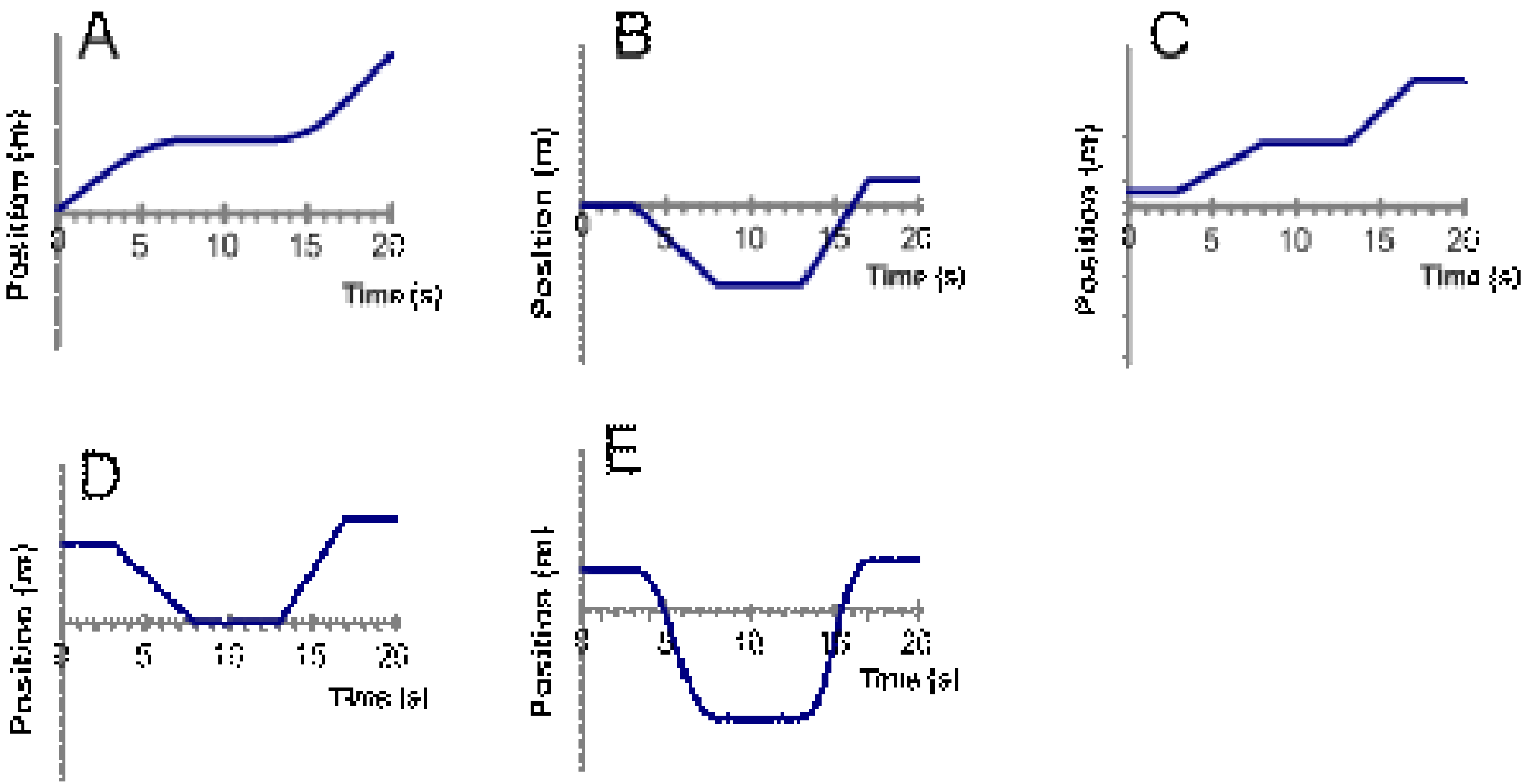
E



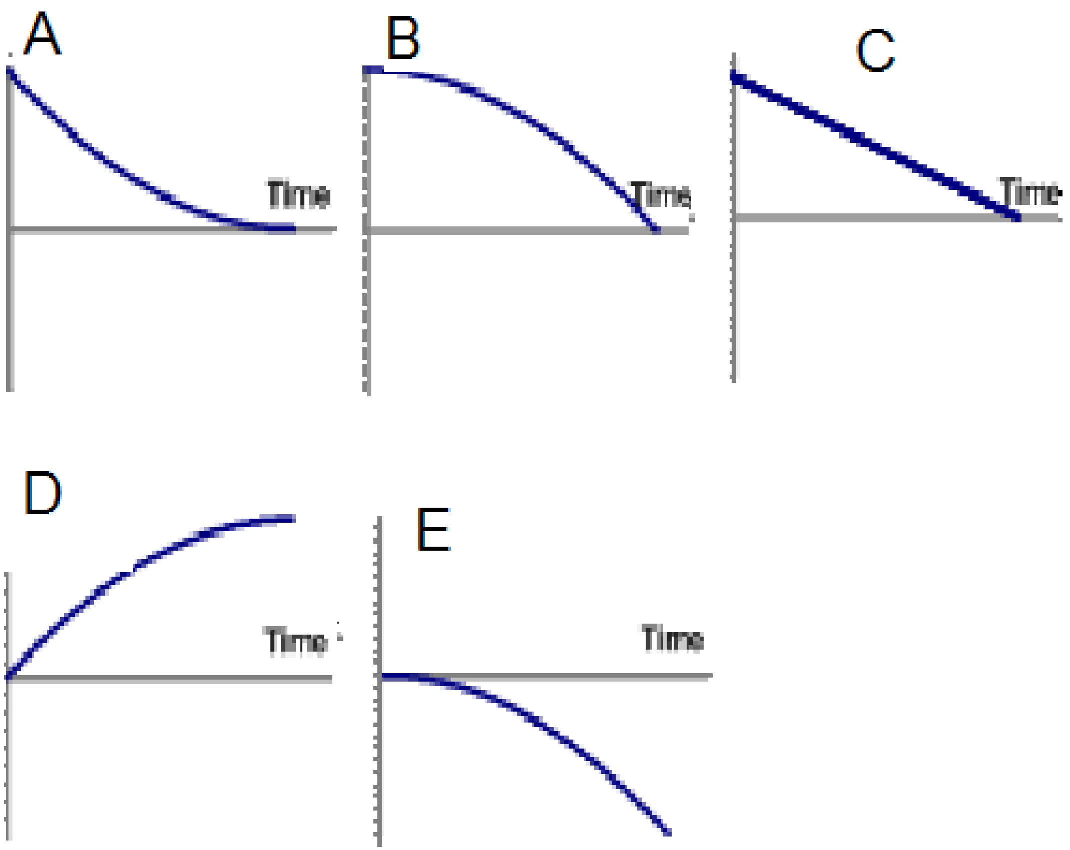
4 A car is traveling along a road. Its velocity is recorded as a function of time and is shown in the graph below.



5. Which of the following ***position-time*** graphs would be consistent with the motion of



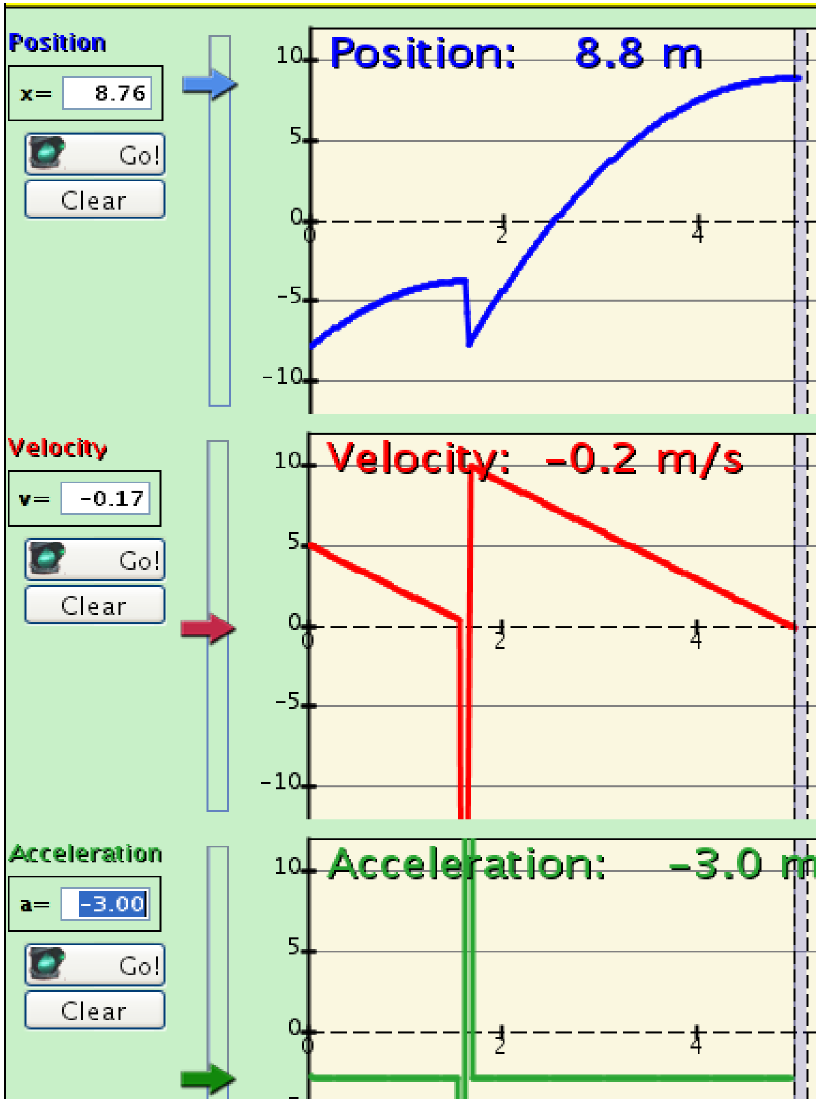
6. A car is moving forward and applying the break. Which ***position-time*** graph best depicts this motion?



Stopping Distance. Consider two cars, a 700kg Porsche and a 600kg Honda Civic. The Porsche is speeding along at 40 m/s (mph) and the Civic is going half the speed at 20 m/s. If the two cars brake to a stop with the same constant acceleration, lets look at whether the amount of time required to come to a stop or the distance traveled prior to stopping is influenced by their initial velocity.

Using Moving man

Select the accelerate option and set the initial velocity, initial position, and an acceleration rate so that the walking man's motion will emulate that of the car stopping with constant acceleration.



7. If you double the initial walking speed, the amount of time it takes to stop

A. is six times longer
B. is four times longer
C. is two times longer
D. does not change
E. is half as long

8. If you double the initial walking speed, the man walks … before coming to a stop.

- Half the distance
- four times farther
- three times farther
- two times farther
- The same distance

9. If you triple the initial walking speed, the walking man goes … before stopping.

A. one third as far
B. One ninth as far
C. three times farther
D. six times farther
E. nine times farther

Notes from Perkins' homework

While moving man is useful to answer this question, equations give us the same result.

Use Velocity = Initial velocity + acceleration x time or acceleration = (change in velocity)/(time elapsed) which is the same as (time elapsed) = (change in velocity)/acceleration.

So it will take 2 times as long to stop if the initial velocity is 2 times larger and the acceleration is the same.

distance traveled = (initial velocity) x time + (1/2 x acceleration x time x time)

10. If the acceleration is zero, the man must be standing still.

A. True

B. False

11. Velocity and acceleration are always the same sign (both positive or both negative).

A. True
B. False

12. If the speed is increasing, the acceleration must be positive.

A. True
B. False

Notes from Perkins' homework

A negative acceleration indicates that the acceleration points in the negative direction. Under these conditions, if the man is moving in the positive direction, the negative acceleration will be acting to slow him down (velocity and acceleration point in opposite directions). If the man is moving in the negative direction, the negative acceleration will be acting to speed him up (velocity and acceleration point in the same direction).

Lesson plan for *Calculus Grapher* Homework and Demonstrations for Physics

Time for activity

Learning Goals: Students will be able to:

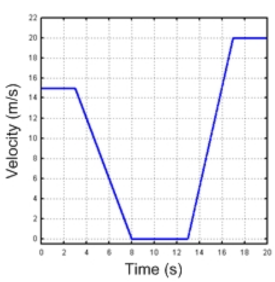
- Use the language of calculus to discuss and interpret motion
- Given a function sketch the derivative, or integral curves

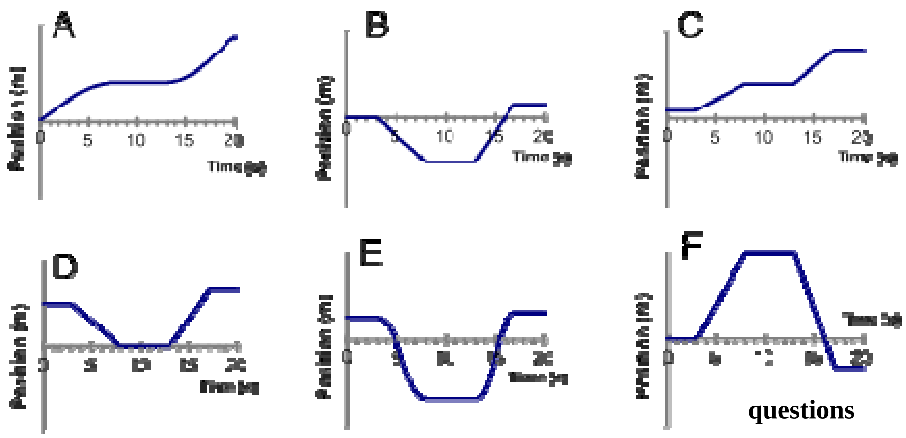
Background: I teach algebra based College Physics at my high school to juniors. To see how this activity fits into my curriculum, check my website at http://jeffcoweb.jeffco.k12.co.us/high/evergreen/science/loeblein/phys_syl/syllabus_p.html My syllabus reflects plans, but adjustments are often made based on the students' skills. I will use this as a homework assignment to reinforce ideas from *Moving Man* and the course text. (College Physics: A Strategic Approach, Knight – Jones – Field. Pearson 2007). We will have done labs with cars, carts, motion probe, and *Moving Man* by PhET.

***Calculus Grapher* Introduction:** I don't plan to do any introduction to the simulation, but I have plans to follow up with clicker questions.

Lesson:

I will be assigning some questions from Chapter 2 and I have put in the assignment **"Try *Calculus Grapher* PhET simulation to check your ideas"**. The questions require skills similar to my activity using *Moving Man*. For example, the students are given a velocity graph and asked: Which of the following ***position-time*** graphs would be consistent with the motion? Students are also asked to describe possible motion, construct graphs, or make interpretations based on slope or area. This is an example from my pre/post test used with *Moving Man*.





Post lesson: Clicker questions

Calculus Grapher for Physics

Learning Goals: Students will be able to:

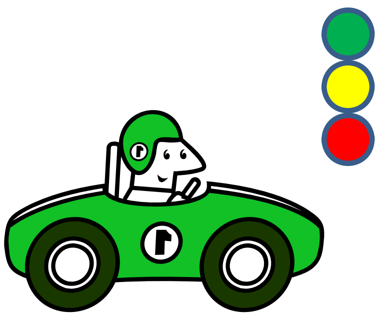
•Use the language of calculus to discuss motion

•Given a function sketch the derivative, or integral curves

Open ***Calculus Grapher and Moving Man before starting presentation***

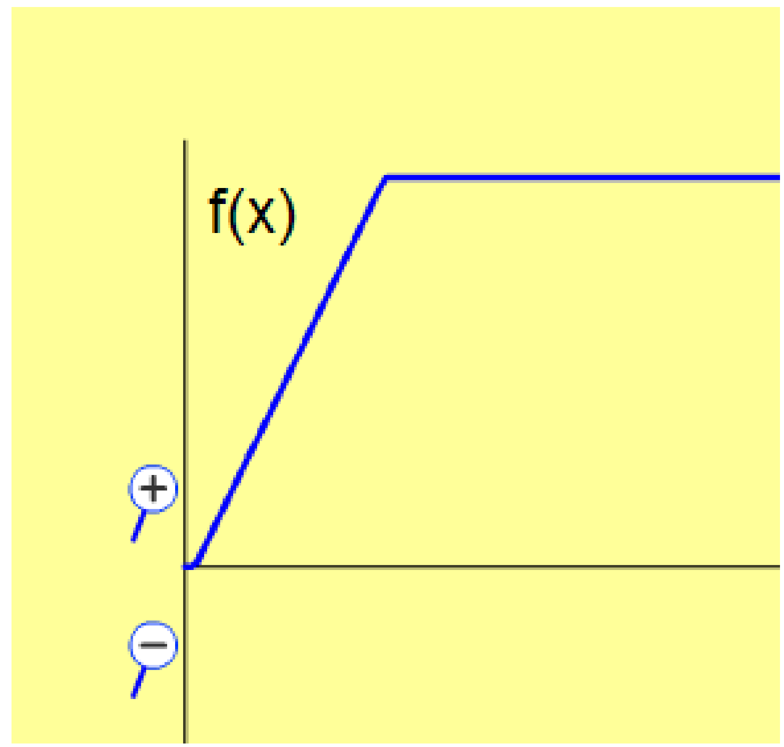
Trish Loeblein July 2009 to see course syllabi :

http://jeffcoweb.jeffco.k12.co.us/high/evergreen/science/loeblein/phys_syl/syllabus_p.html

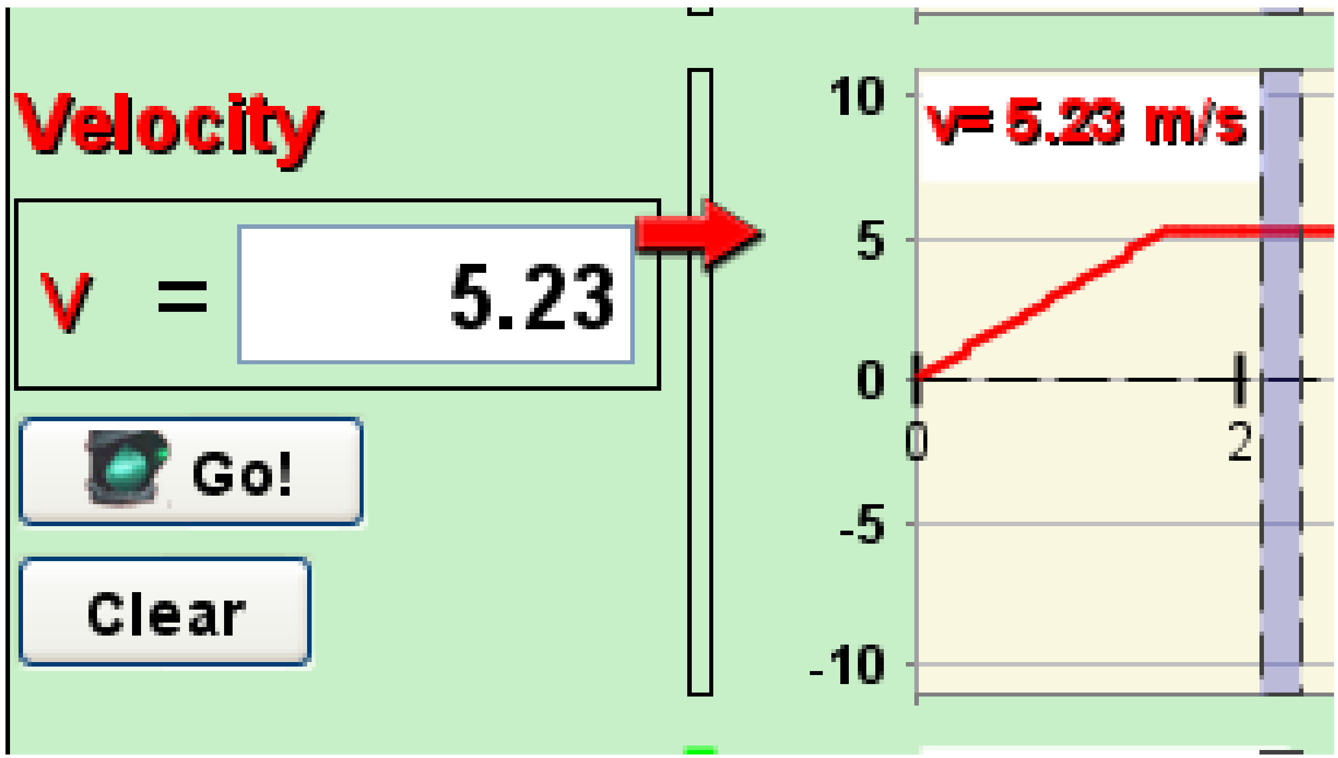


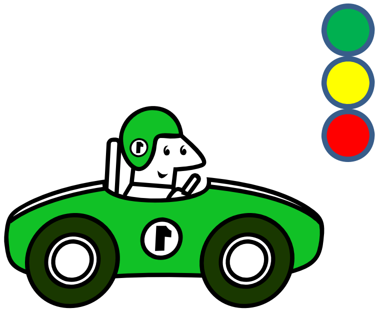
1. A car started from a stoplight, then sped up to a constant speed. This function graph describes his..

A. Position
B. Velocity
C. Acceleration



Use Moving man to show this: I set the acceleration at about 3 then paused the sim by the time the man got to the 4 spot, then I changed the acceleration to 0. If you have Moving man open with this type of scenario, you can use the grey bar to show that the speed was zero increasing and then constant.



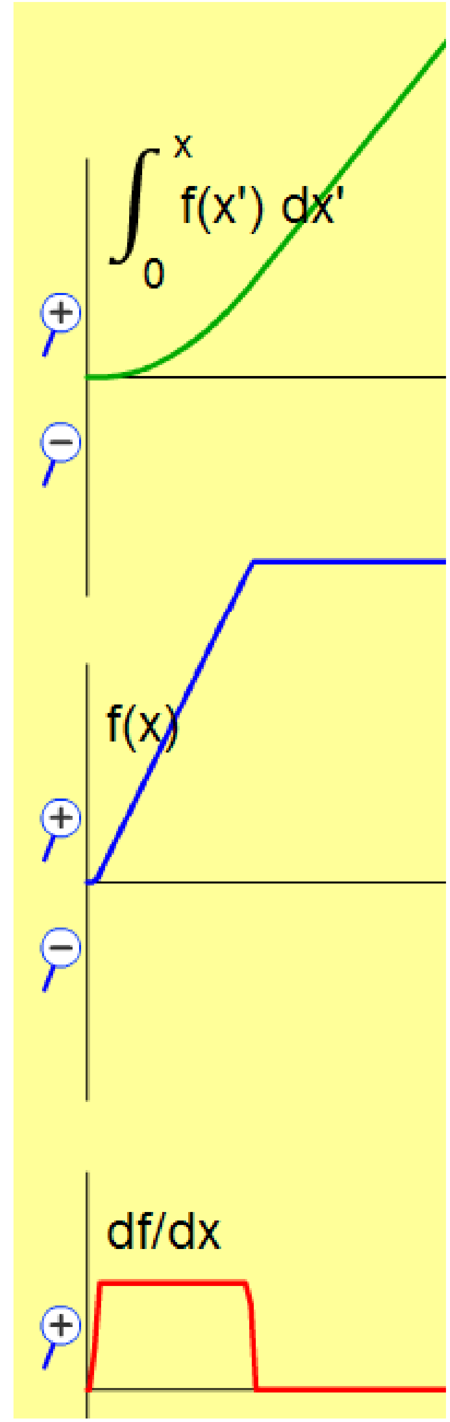


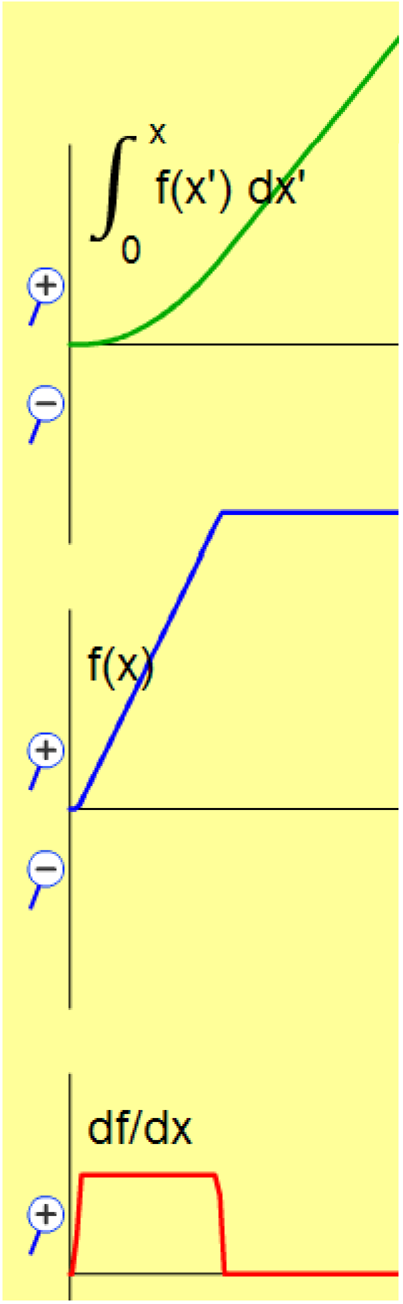
2. To find out how far he traveled, you would use

A. Integral

B. Function

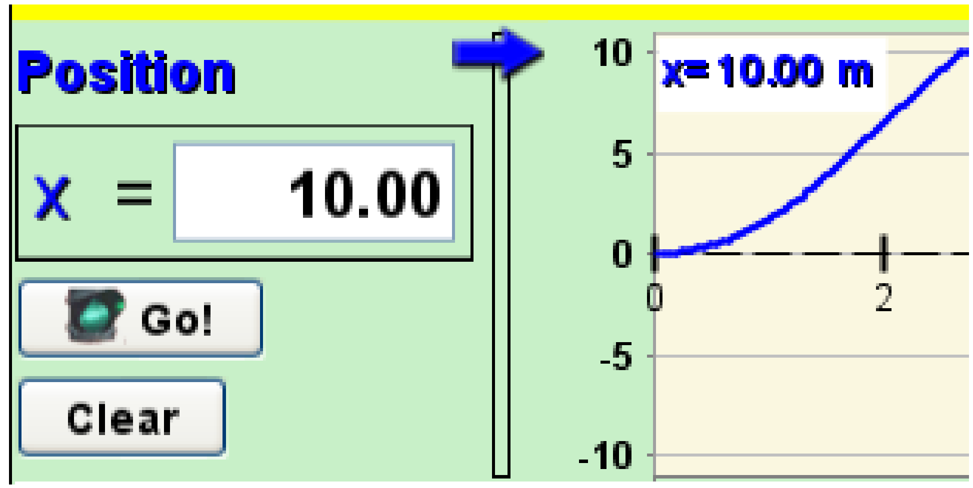
C. Derivative



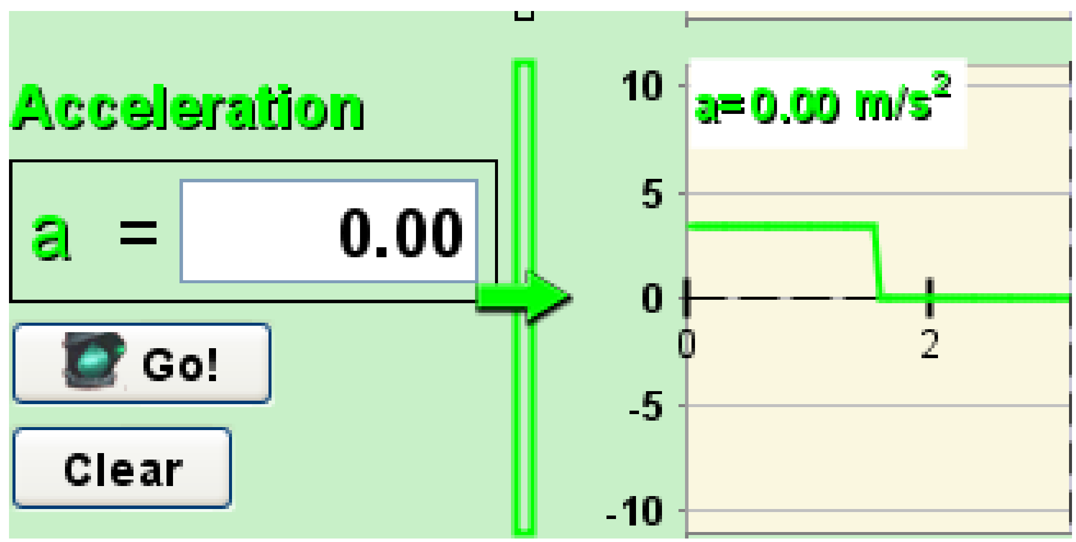


Use Moving Man **Replay** to show

Position is found by the integral curve

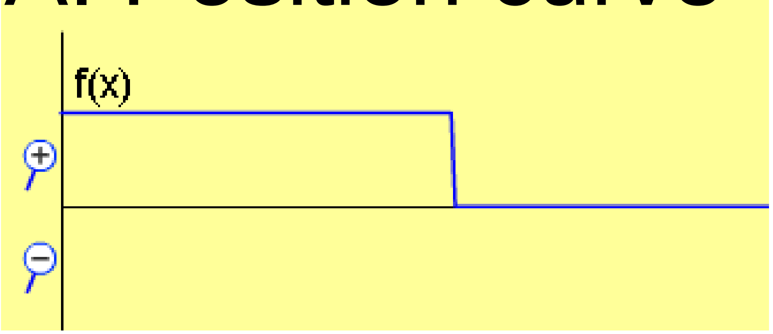


Derivative curve shows acceleration

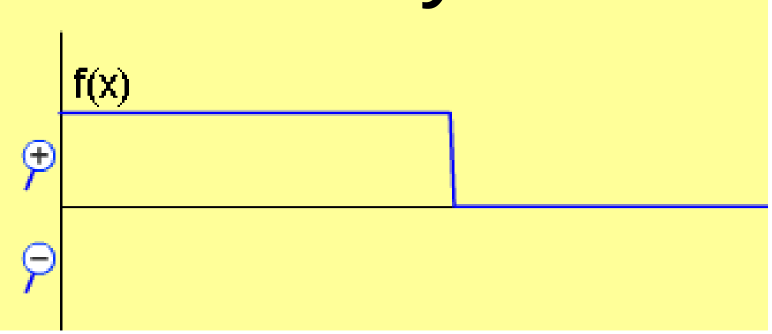


3. Your friend walks forward at a constant speed and then stops. Which graph matches her motion?

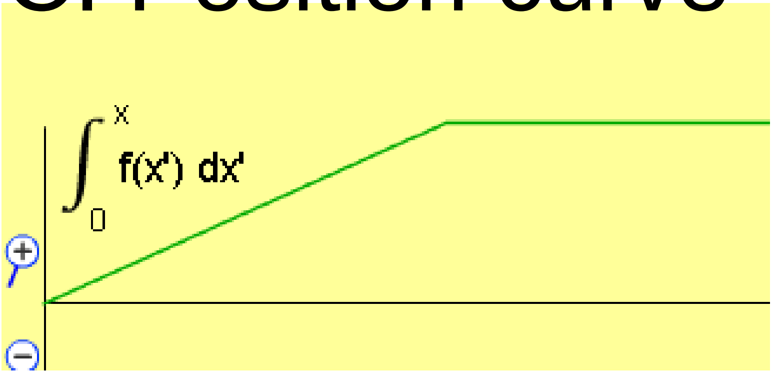
A. Position curve



B. Velocity curve



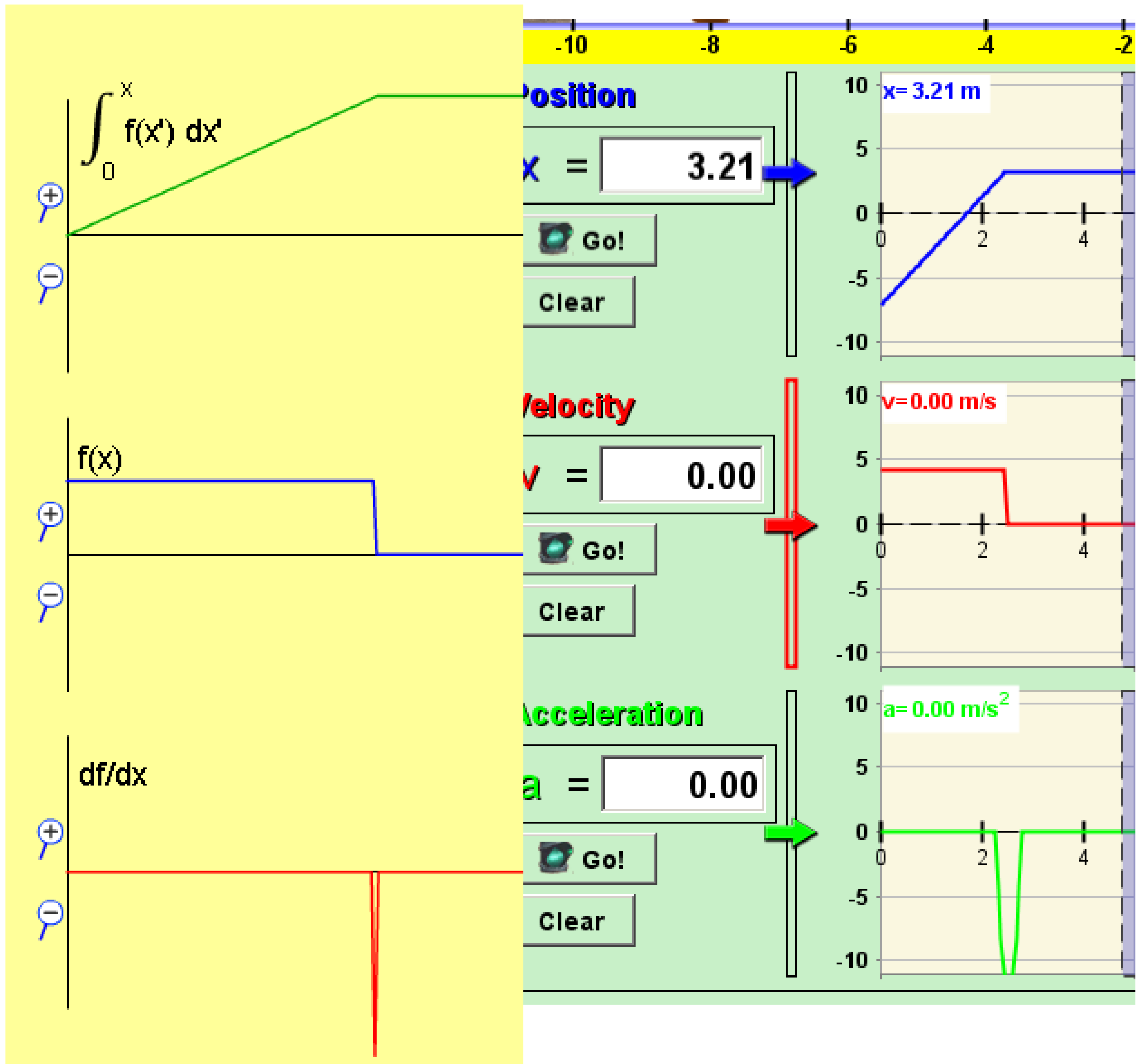
C. Position curve



D. Acceleration curve

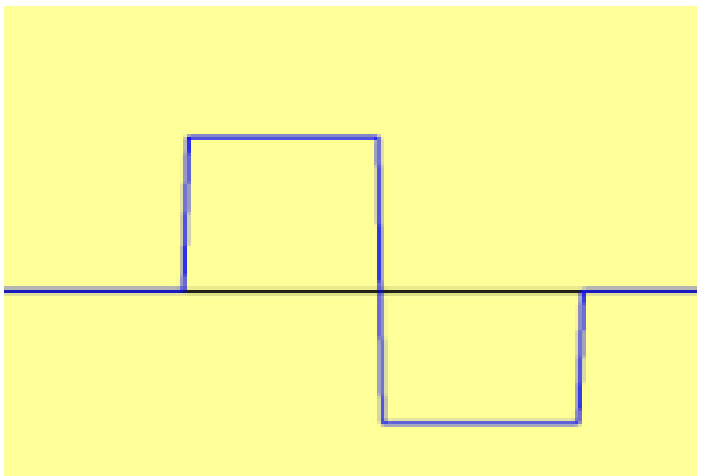
E. More than one of these

Use Moving man to show this: I set the Man at about -6 position, made the velocity about 4, then paused the sim by the time the man got to the 4 spot, then I changed the velocity to 0. If you have Moving man open with this type of scenario, you can use the grey bar to help.

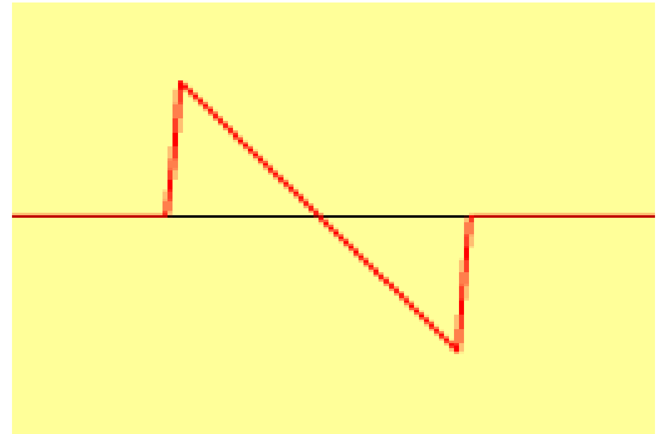


4. Which could be the derivative curve?

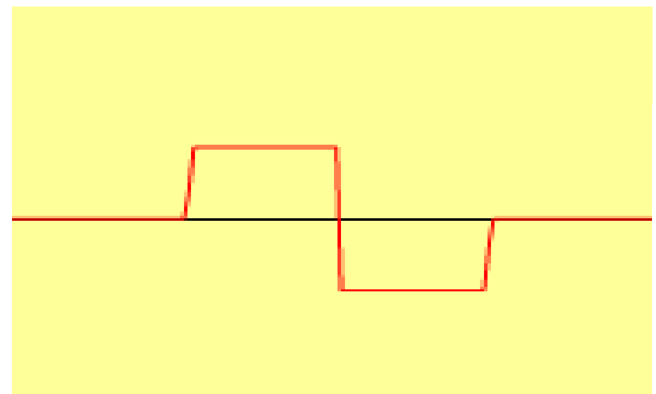
F(x)



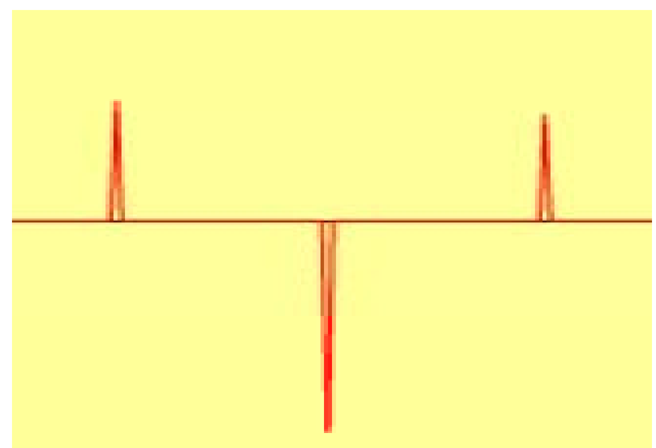
A



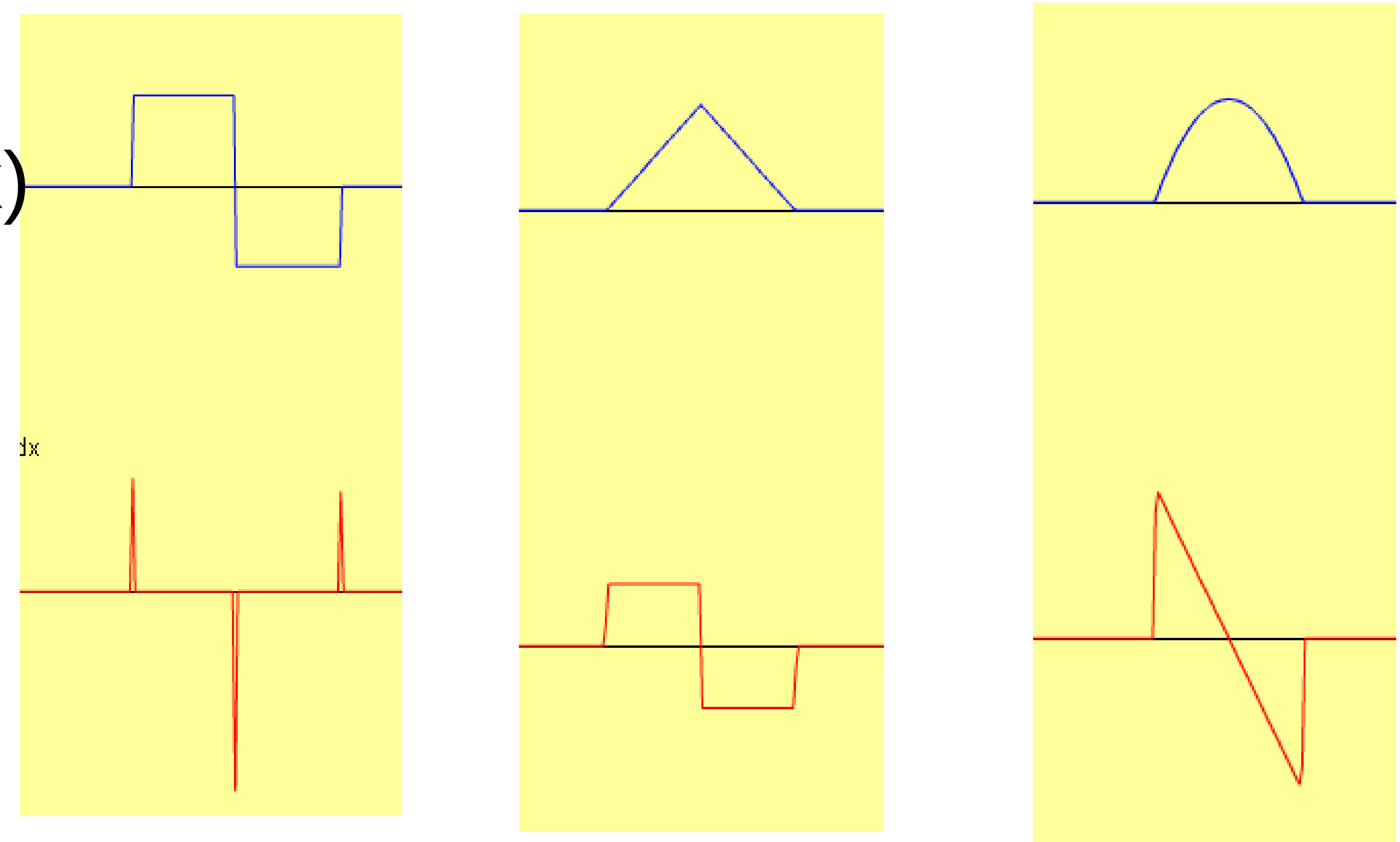
B



C



Pedestal Linear Parabola

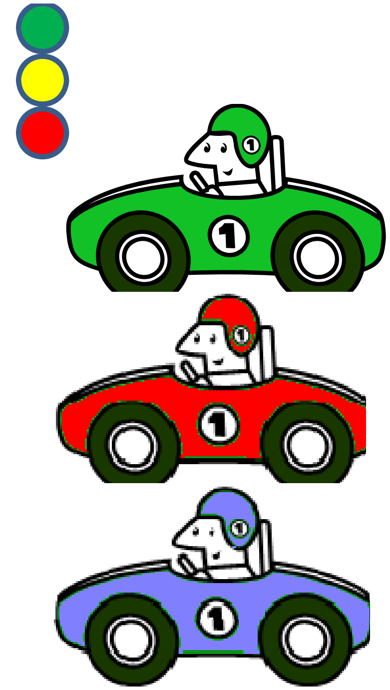


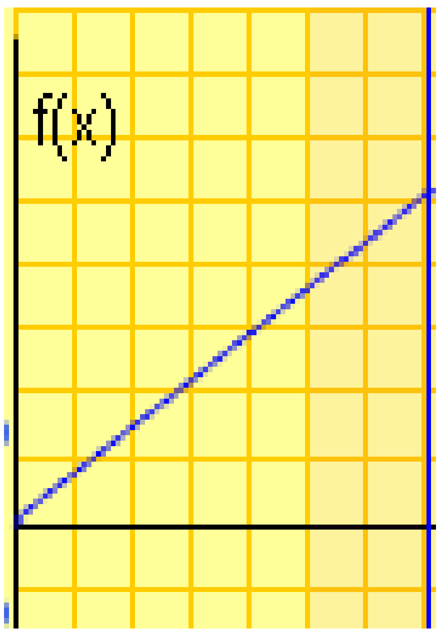
F(x)

$$\frac{df}{dx}$$

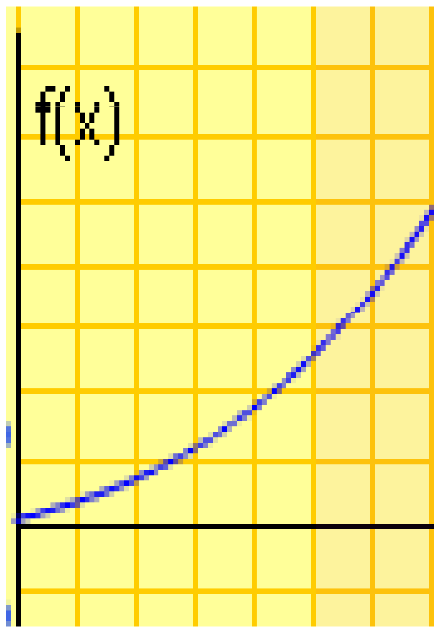
For each case, if the function, F(x) is velocity, what could a possible story for the motion of a person walking?

5. Three race cars have these velocity graphs. Which one probably wins?

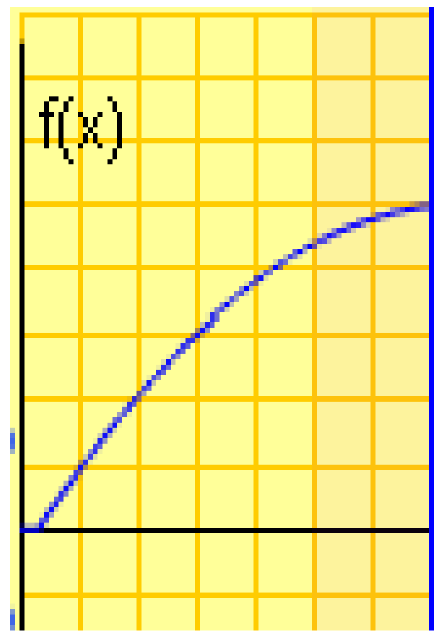




A



B



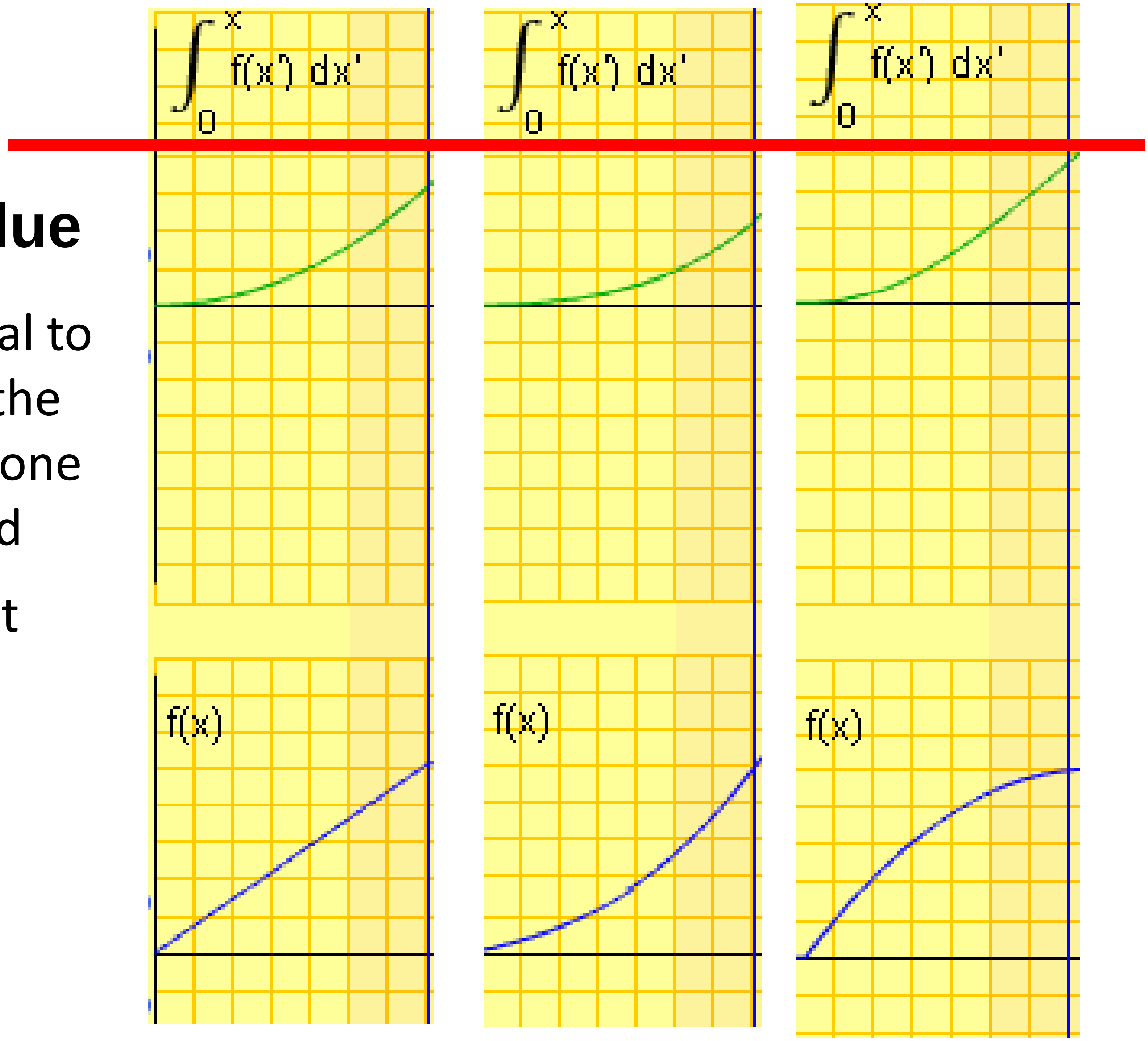
C

D No way to tell

Max value

Use integral to tell that the parabolic one traveled

farthest



Semester 1 Unit 2 More on motion: Two-Dimensional Motion and Vectors

Learning goals-Students will be able to :

<u>Introduction to Vectors</u>

- Distinguish between a scalar and a vector
- Add and subtract vectors using the graphical method
- Multiply and divide vectors by scalars

<u>Vector Operations</u>

- Identify appropriate coordinate systems for solving problems with vectors
- Apply the Pythagorean Theorem and tangent function to calculate the magnitude and direction of a resultant vector
- Resolve vectors into components using sine and cosine functions
- Add vectors that are not perpendicular

<u>Projectile Motion</u>

- Recognize examples of projectile motion
- Describe the path of a projectile as a parabola
- Resolve vectors into their components and apply the kinematic equations to solve problems involving projectile motion

Relative Motion

- Describe situations in terms of frame of reference
- Solve problems involving relative velocity

PhET activities

Vector Addition activity 1: Introduction to Vector math

- Explain vector representations in their own words
- Convert between the of angular form of vectors and the component form
- Add vectors

Vector Addition activity 2: Understanding Force equilibrium

- Explain vector representations in their own words
- Convert between the of angular form of vectors and the component form
- Add vectors
- Calculate % error using the best measurement for the expected value

Projectile Motion Activity: Introduction to Projectile Motion

- Predict how varying initial conditions effect a projectile path
- Use reasoning to explain the predictions.
- Explain projectile motion terms in their own words.
- Describe why using the simulation is a good method for studying projectiles.

Unit 2 Semester 1 More on Motion and Measurement

1 Lab: Vector addition PhET activity
Do: read and do text problems, questions

2 Notes: Review ideas from the vector activity, %error ,Vector addition clicker questions,
Lab: Comparing forces (Turn in: work to show that the sum of 2 forces doesn't exactly equal an opposing force and calculate the %error; do 2 different trials, and write a summary with results and error analysis)
Do: read and do text problems, questions

3 Notes: Reflect on the test, Motion on Ramp, lab practice problem
Do: read and do text problems, questions

4 Notes: Significant Figures (p13-15)
Do: read and do text problems, questions; **Physics Skills worksheet**

5 **Vector and sig fig quiz**
Notes: Relative Motion
Lab: Projectile Motion PhET activity
Do: read and do text problems, questions

6 Notes: Introduction to Projectiles
Lab: Predict the landing site of a ball launched horizontally
Do: read and do text problems, questions

7 Lab: Predict landing site of a car launched at an angle
Do: Type equation sheet

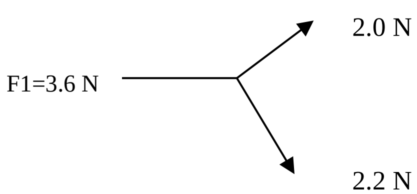
8 Notes: Projectile motion launched at an angle
Do: **Projectile worksheet**

9 Notes: Clicker questions projectiles,
Do: read and do text problems, questions

10 Review study & test taking skills
Do: read and do text problems, questions and standardized testing practice

11 Do:

1. How does $\mathbf{F_1}$ compare to $\mathbf{F_2} + \mathbf{F_3}$?



2. A student does the ball launch lab. Initially, the student puts the ramp on a shelf and the ball lands 0.85m horizontally in .35 seconds. Then, the student places the ramp on a table. The drop distance is measured at 1.0 meter. How far out should a cup be placed to catch the ball?

3. Resolve 780 n at angle of 35 from the vertical.
4. Resolve 780 n at angle of 35 from the horizontal

12 **TEST** with typed equation sheet

7/7/13 Need information about measurement topics like vector vs scalor, significant figures? Use text or web

Lesson plan for *Vector Addition*1: Introduction to Vector math
phet.colorado.edu
Time for activity 80 minutes

Learning Goals: Students will be able to

- Explain vector representations in their own words
- Convert between the of angular form of vectors and the component form
- Add vectors.

Background:
I used this as part of an introduction to vectors. The students had been working with vector and scalar quantities for about a month. My students had no experience with vector math. Almost all the book problems give vectors in angular style. My text uses all acute angles in map coordinates. In our book, 30NW means 30 north of west. After this activity, I'll have to help the students think about vectors with this system since the simulation a different system. The angles in the sim have a max of 180. They are measured from due east. Counter-clockwise is positive. So 60 NW is 150. Clockwise is negative. So 60 SE is -60 and 60 SW is -150.
Also, I reviewed some geometry including the definitions of sine, cosine and tangent. My students are not very familiar with the unit circle and few have had trigonometry. I drew a right triangle with a,b,c notation like they used in geometry and then with x,y,R notation that is used in physics. I also drew a unit circle and helped make sense of the angle measure. One thing I found, during the activity, was that some of them wanted to use sine, etc on any triangle and that they needed to be reminded that the triangle must be a right triangle.

Vector Addition Introduction: I did not demonstrate how to use the sim, I just gave them the path from the home page. If they use Firefox, they need to hit the refresh button to get the latest version of the sim.

Lesson:
Remind the students to change their calculator mode to **Degrees**.
Have the students use the lab sheet for guidance after the class discussion. My students worked in pairs. I frequently checked understanding by stopping at each group. After they finished question 3, I asked them about their understanding of linear verses 2D math using their answer for example: "If you are driving 11 mph east and 8 mph north, are you going 19 mph?" Many of my students did not use the SUM button as I expected in step 5. I had to give hints as I checked their answers. I was expecting them to write their designs in paragraph form, but many made their plans with pictures. I decided to ask them to write a paragraph for 5 and 6.
The activity took my honors physics students about 80 minutes. There are some clicker questions that I adapted from the algebra based physics class at Colorado University.
After this activity, we did a lab using spring scales and used the sim to help the students understand the vector math. There is a lesson plan included called *Vector Addition*2: Understanding Force equilibrium

Post lesson: There are 7 clicker questions. Answers are
1. 200/3 =67
2. 141/3= 47
3. 0
4. 100 + 200cos60 = 200
5. 200 sin 60 = 170 6. 40 degrees NE

Student directions *Vector Addition* activity: Introduction to Vector math
phet.colorado.edu

Learning Goals: Students will be able to
- Explain vector representations in their own words
- Convert between the of angular form of vectors and the component form
- Add vectors

1. You take a walk in the park for 15 steps using a compass that points 25º North of East.
   - How would you use the simulation to represent your path?
   - Explain why the same representation works for illustrating this different scenario: You drive at 15 miles/hour using a compass that points 25º North of East.
   - Write another scenario using different units that could also be represented the same.

2. In the simulation, a vector is described by four measurements: |R|, Θ, R_x, and R_y. Put a vector in the work area, and then investigate to make sense of what these four things represent. In your investigation, use a wide variety of vector measurements and all three styles of **Component Displays**. Then, describe in your own words what the measurements represent and what "component" means.

3. Suppose you are driving 14 miles/hour with a compass reading of 35°north of east.
   - Represent the vector using the simulation. How fast is your car traveling in the north direction? How fast in the east direction?
   - Figure out how the components could be calculated using geometry if you couldn't use the simulation.
   - Check your ideas by testing with other vectors and then write a plan for finding the components of any vector.

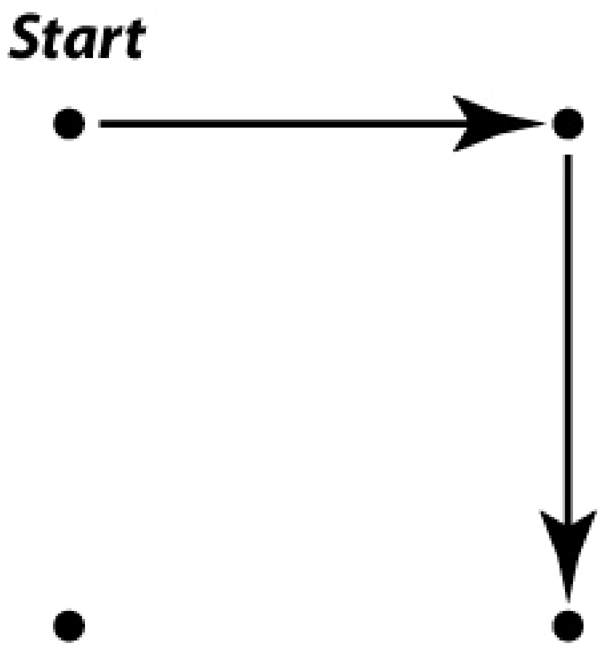
4. To get to the sandwich shop, you left home and drove 6 miles south and then 10 miles west.
   - If a bird flew from your house to the sandwich shop in a straight line, how far do you think the bird would fly? Use the simulation to check your reasoning.
   - What direction should it fly from your house to get to the shop?
   - Explain how you could use the simulation to answer these questions.
   - Explain how you could use geometry equations to answer these questions.

5. Suppose you and a friend are test driving a new car. You drive out of the car dealership and go 10 miles east, and then 8 miles south. Then, your friend drives 8 miles west, and 6 miles north.
   - If you had the dealer's homing pigeon in the car, how far do you think it would have to fly to get back to the dealership? Use the simulation to test ideas.
   - The distance that the bird has to fly represents the sum of the 4 displacement vectors. Use the simulation to test ideas you have about vector addition. After your tests, describe how you can use the simulation to add vectors.

6. A paper airplane is given a push so that it could fly 7m/s 35° North of East, but there is wind that also pushes it 8 m/s 15° North of East.
- Use the simulation to solve the problem. How fast could it go and in what direction would it travel?
- Think about your math tools and design a way to add vectors without the simulation.
- Check your design by adding several vectors mathematically and then checking your answers using the simulation.

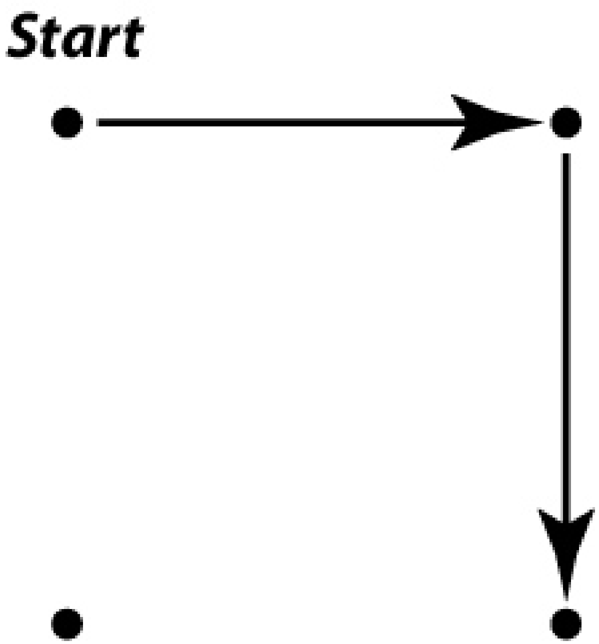
*Sinθ = opposite leg/ hypotenuse Cosθ = adjacent leg/ hypotenuse Tanθ = opposite leg/ adjacent leg

1. For one hour, you travel east in your car covering 100 km .Then travel south 100 km in 2 hours. You would tell your friends that your average speed was



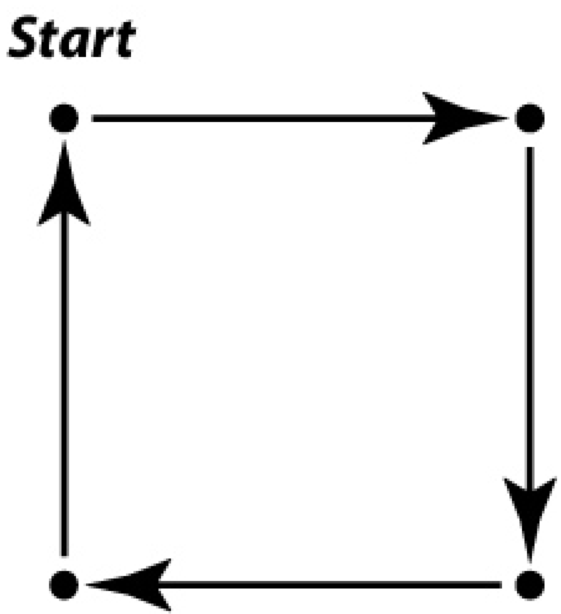
A. 47 km/hr
B. 67 km/hr
C. 75 km/hr
D. 141 km/hr
E. 200 km/hr

2. For one hour, you travel east in your car covering 100 km .Then travel south 100 km in 2 hours. You would tell your friends that your average velocity was



A. 47 km/hr
B. 67 km/hr
C. 75 km/hr
D. 141 km/hr
E. 200 km/hr

3. You have already traveled east in your car 100 km in 1 hr and then south 100 km in 2 hrs. To get back home, you then drive west 100 km for 3 hours and then go north 100 km in 4 hours. You would say your average velocity for the total trip was



A. 20 km/hr

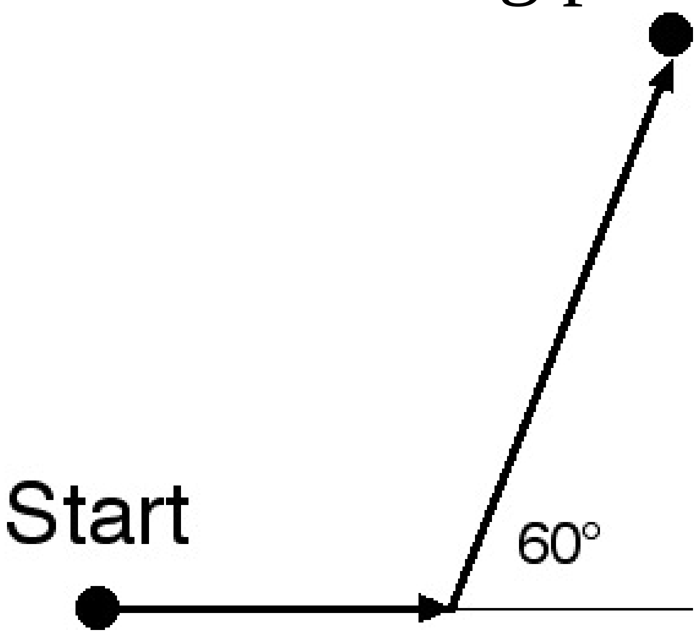
B. 40 km/hr

C. 60 km/hr

D. 100 km/hr

E. None of the above

4. You fly east in an airplane for 100 km. You then turn left 60 degrees and travel 200 km. How far east of the starting point are you? (approximately)



A. 100 km

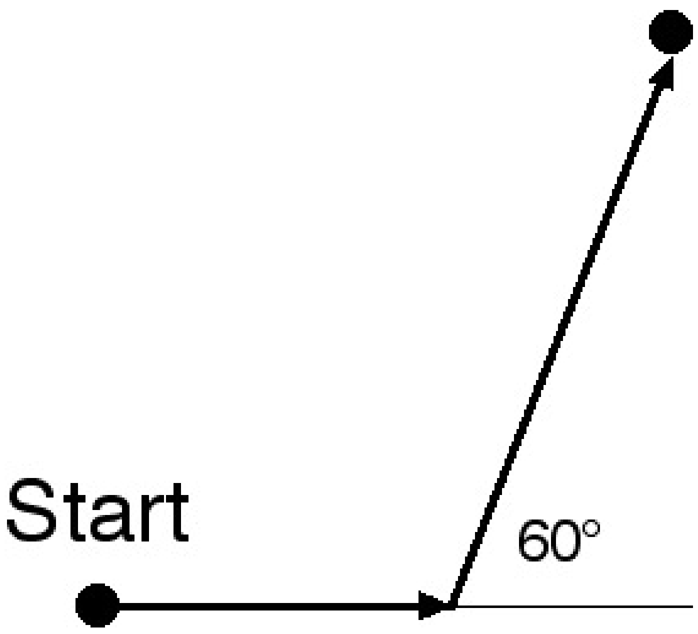
B. 150 km

C. 200 km

D. 300 km

E. none of the above

5. You fly east in an airplane for 100 km. You then turn left 60 degrees and fly 200 km. How far north of the starting point are you? (approximately)



A. 100 km

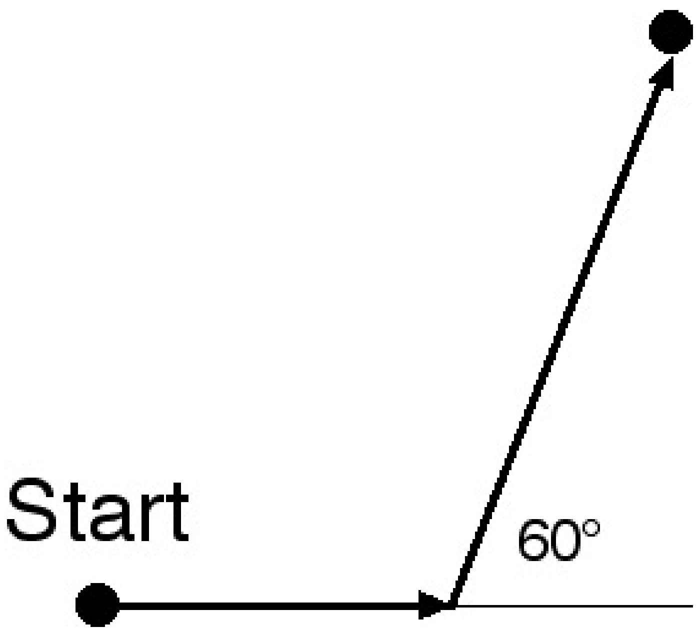
B. 130 km

C. 170 km

D. 200 km

E. none of the above

6. You fly east in an airplane for 100 km. You then turn left 60 degrees and fly 200 km. How far from the starting point are you? (approximately)



A. 170 km

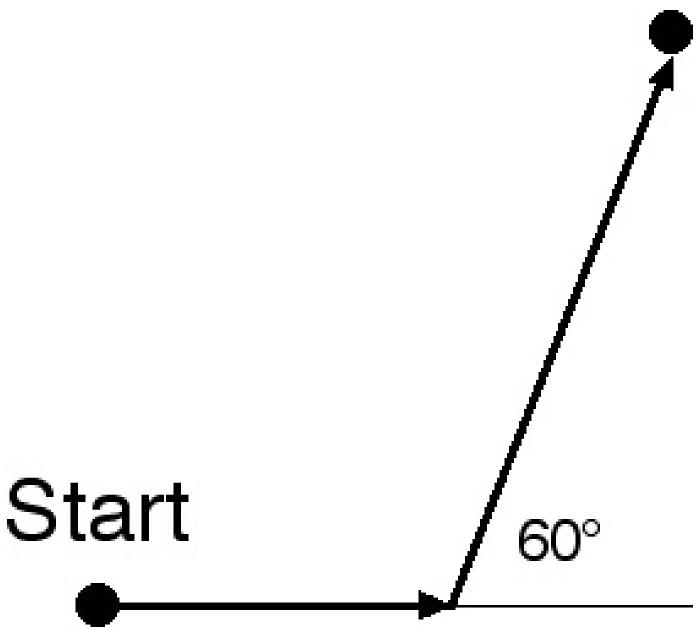
B. 200 km

C. 260 km

D. 300 km

E. 370 km

7. You fly east in an airplane for 100 km. You then turn left 60 degrees and fly 200 km. In what direction are you from the starting point?



A. South of west
B. Directly southwest
C. Directly northeast
D. North of east
E. None of the above

Lesson plan for *Vector Addition*2: Understanding Force equilibrium
http://www.colorado.edu/physics/phet
Time for activity 80 minutes day 1 and 30 minutes day 2

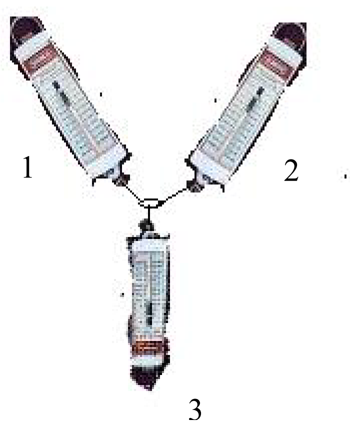
Learning Goals: Students will be able to

- Explain vector representations in their own words
- Convert between the of angular form of vectors and the component form
- Add vectors
- Calculate % error using the best measurement for the expected value

Background:
My students did my first *Vector Addition* activity: Introduction to Vector math, then we did this lab. I have done this lab for many years and students struggle with making sense of how two forces like 1.2n and 1.3n can add to 1.4n. This year, using the simulation, went much better. My vector addition quiz had very high scores.
As I mentioned in the other lesson plan, my students do not have much exposure to vector math from math classes even if they have had calculus. I do not have a student handout, but I explain how to do the lab.

Materials: Three spring scales, protractors, rulers and a computer with *Vector Math* for each group. If you have force tables, they would work very well.

Class discussion: I connect three scales and then duct-tape them to a piece of cardboard as shown in the figure to the left. We talk about the fact that the forces should add to zero. In my class, we use % error to make sense out of how well experiments match ideal physics relationships:

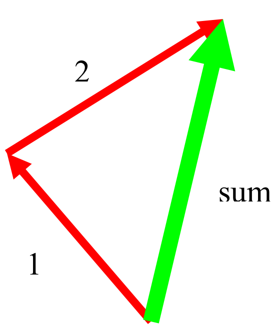


$$\%error = \frac{|experimental - theoretical|}{theoretical} * 100$$

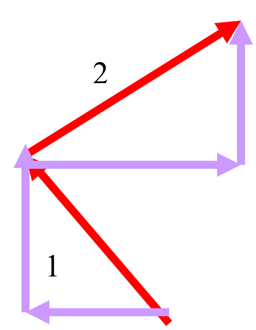
We discuss that using the fact that the sum of the three should be zero would lead to an undefined answer. So we use the idea that the sum of two of the vectors should equal the third. ie:

$$\%error = \frac{|(1+2)-3|}{3} * 100$$

I draw this on the board making sure that I use the same colors as the simulation. We discuss that the sum should have the same magnitude as the third force (We ignore the angle for this experiment because it is only the second day of vector math).



Then we discuss how the students might add the two vectors by breaking the vectors into components. (I do not have them add vectors by construction because I have found that their drawing skills interfere with understanding the basic idea of vector addition). I project the simulation and ask the students how they could use the sim to help them make sense of the addition (turning off the Show sum). I start with Style 2 as shown on the right , but go through all three styles emphasizing that students can chose any style that helps them



make sense of vector addition. We discuss the math that we will do and the fact that we can check each step using the display $|R|$, θ, R_x, R_y.
For example: R_{x1}= Force reading on scale 1* cosθ (θ measured acutely from –y axis).

From there I let them work in groups, taping down a set of scales to their tabletops. I require that each person record the data and show the work required to find the % error. They are to use the simulation to check their reasoning. I move around the room asking probing questions and helping students with measuring angles.

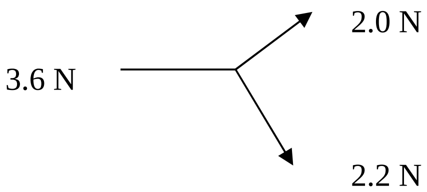
The groups are instructed to have me check their work after they finish a trial. Then they do another trial. In addition, they are asked to write a summary paragraph of their results including a description of why the error is not zero.

The next day: I handed out the problems worksheet. They worked on 1 and 2 while I went around the room checking for learning. After that, they put up the sheet to finish at home.

Worksheet *Vector Addition* 2: Understanding Force equilibrium

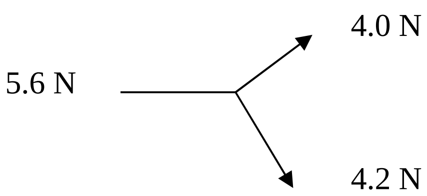
Practice problems

1. How does $\mathbf{F_1}$ compare to $\mathbf{F_2} + \mathbf{F_3}$ **?**



2. Resolve 780 n at angle of 35 from the vertical.

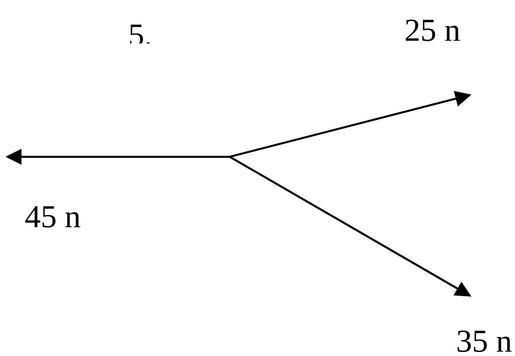
3. How does $\mathbf{F_1}$ compare to $\mathbf{F_2} + \mathbf{F_3}$ **?**



4. Resolve 780 n at angle of 35 from the horizontal vertical.

For 5 and 6, find the percent error for the lab data using the west vector for the best measurement.

5.



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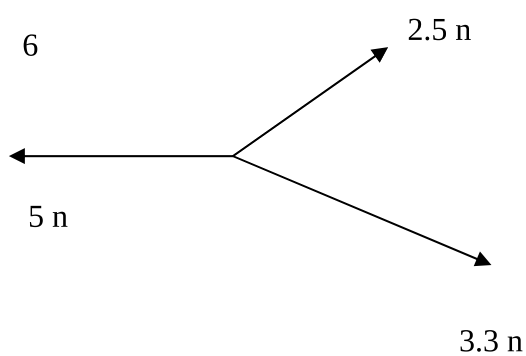


Lesson plan for *Projectile Motion:* Introduction to Projectile Motion

Approximately 50 minutes

Learning Goals: Students will be able to

- Predict how varying initial conditions effect a projectile path*(various objects, angles ,initial speed, mass, diameter, initial height, with and without air resistance)*
- Use reasoning to explain the predictions.
- Explain common projectile motion terms in their own words. (*launch angle, initial speed, initial height, range, final height, time)*
- Describe why using the simulation is a good method for studying projectiles.

Background: The students will have studied one dimensional motion in general and free fall, but our text doesn't introduce Newton's laws until the next chapter. I want to use the same sequence as the book because I am teaching them to use the book for learning. Therefore the emphasis of this activity is to give the students a wide variety of projectile data for them to make their own generalizations for predicting projectile behavior without Newton's Laws. In my course, the students design their own labs and there is a strong focus on identifying and minimizing error sources.

The day before the activity, I demonstrated projectile motion by dropping a ball and throwing it different ways. We had a class discussion to devise a definition of projectile. I also used some things that are more affected by air resistance like paper, balloon, and cotton ball. We will have done a free fall lab using a motion detector, so we will have a reflection about error sources. Our text objectives for projectiles include identifying whether or not an object will fit the given equations, so we worked in groups on text questions addressing this learning goal. The day of the activity, the students received the activity handout and they went directly to work. We have 50 minute periods; some students needed a little more time, so they finished the activity outside of class.

***Projectile Motion* Introduction**:

I did not demonstrate anything about the sim. I observed that the groups were able to find all the features without my help.

Notes to myself: The cannon fires the object from a height of 1.2m when it is on the ground. If you move the cannon higher, you can use the tape to measure the initial height of the object by putting the tape from the cross hairs to the bottom of the lifting cylinder. This does not exactly coordinate to the relative landing height of the object as displayed in the sim. For example, I had the cannon at 14.21 m, object landed at -14.0 m. At 21.5, landing was -21.3.

Lesson: Have the students use the lab sheet for guidance to learn the objective. The activity took my honors physics students about 50 minutes.

Post lesson: Use clicker questions

Student Directions for *Projectile Motion* Activity: Introduction to Projectile Motion
phet.colorado.edu

Learning Goal: Students will be able to
- Predict how varying initial conditions effect a projectile path
- Use reasoning to explain the predictions.
- Explain projectile motion terms in their own words.
- Describe why using the simulation is a good method for studying projectiles.

1. One day after school, you are enjoying a soda in the back yard. When the can is empty, you decide to throw it in the trashcan. What effects whether or not it gets in the can?

2. Use *Projectile Motion* to test your ideas about the things that affect the landing location of a projectile.
   - Make a complete list of things that affect the landing site of a projectile including your ideas from question #1 and any discoveries you made using the simulation.
   - Next to each item, briefly explain why you think the landing location changes.
   - Compare your list with another group, discuss your explanations and make modifications

3. What is meant by the expression "flight path of a projectile"? Draw the flight path of your soda can and describe the shape. Use the simulation to investigate how the items you listed in #2 affect the shape of the flight path. Summarize your discoveries including explanations for the different flight paths.

4. Suppose your friend asks you to tell them about projectiles. You start to explain, but she interrupts. "Wait," she says, "You're using a lot of words I don't understand. Can you explain in English?" Knowing that a picture is worth a thousand words, you draw a picture of a projectile path and label all the terms that are on the simulation page. Draw a picture like you would for your friend and write what you would tell her about the terms.

5. Describe why using the simulation is a good method for studying projectiles. Clearly identify the error sources the simulation eliminates or minimizes. Also, run tests to determine how well the simulation represents projectile motion and identify limitations.

Clicker questions for Projectile Motion

Trish Loeblein

June 08

Download the lesson plan and student directions for the lab HERE

There are some screen shots included to illustrate answers, but it would be better to use the simulation during discussion.

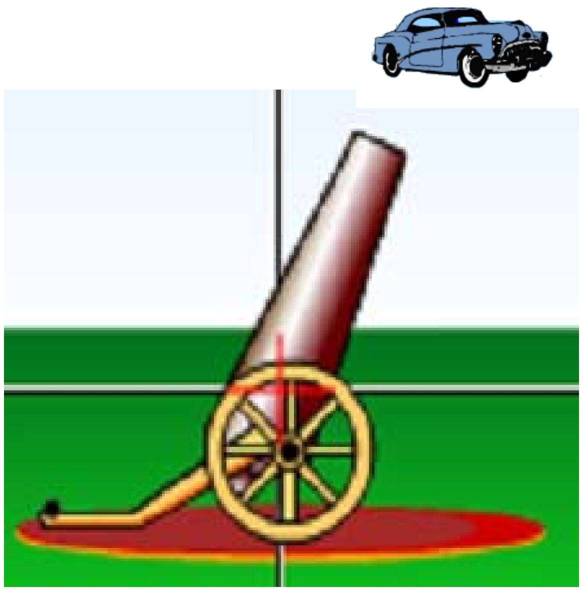
Learning Goals

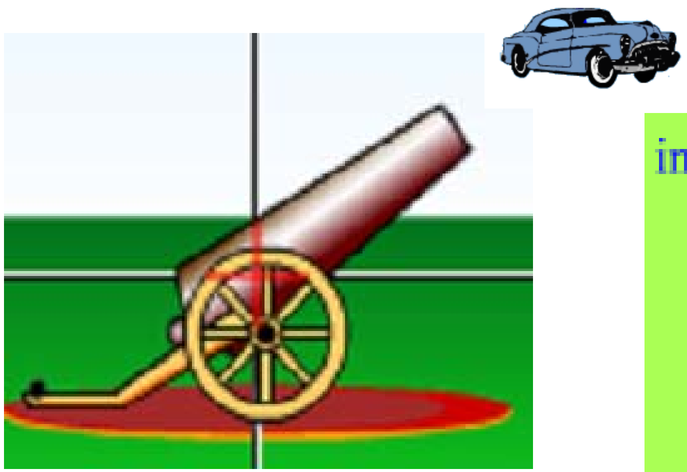
- Predict how varying initial conditions effect a projectile path

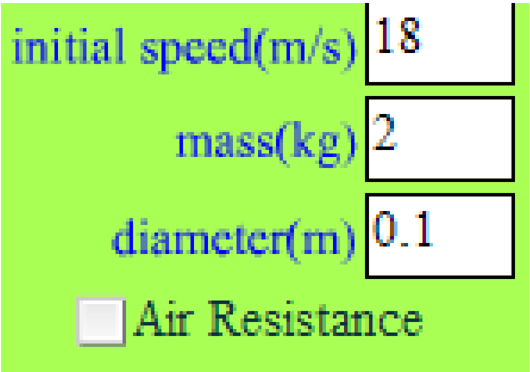
These are part of the lesson, but not addressed in the clicker questions:

- Use reasoning to explain the predictions.
- Explain projectile motion terms in their own words.
- Describe why using the simulation is a good method for studying projectiles.

1. Which car will go farther?





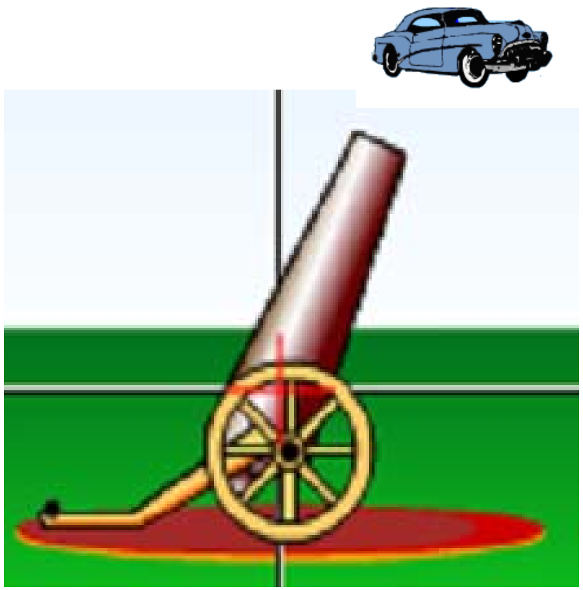


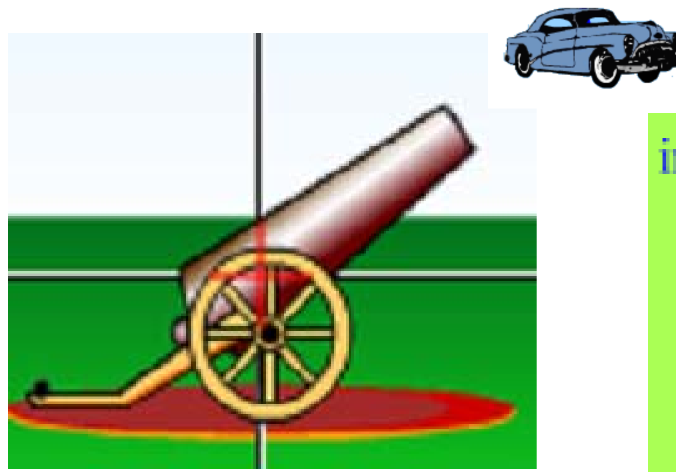
A

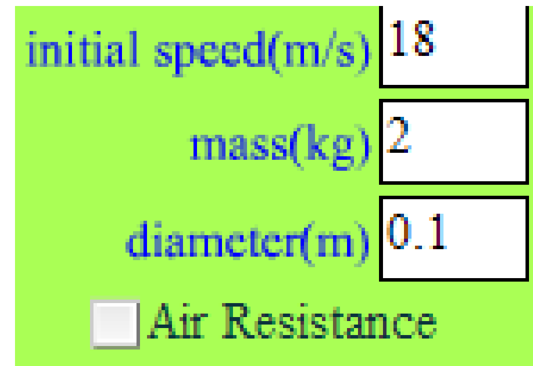
B

C They will go the same distance

2. Which will be in the air longer?





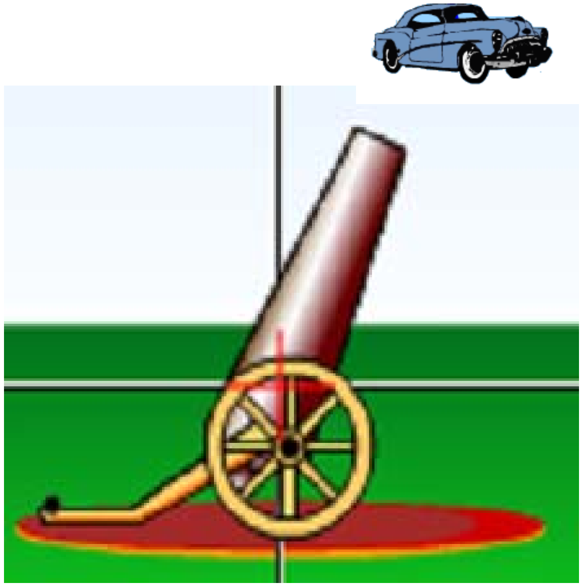


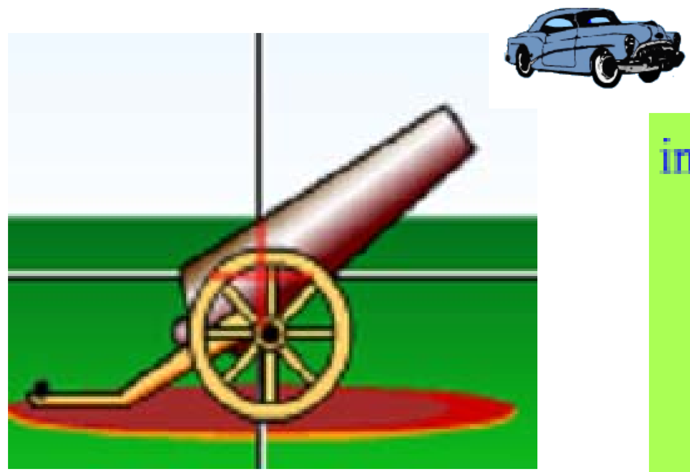
A

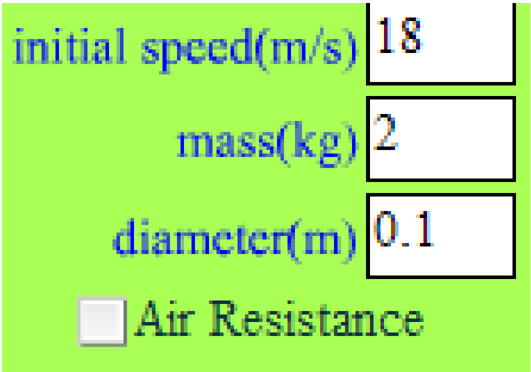
B

C same time in air

3. Which car will go higher?



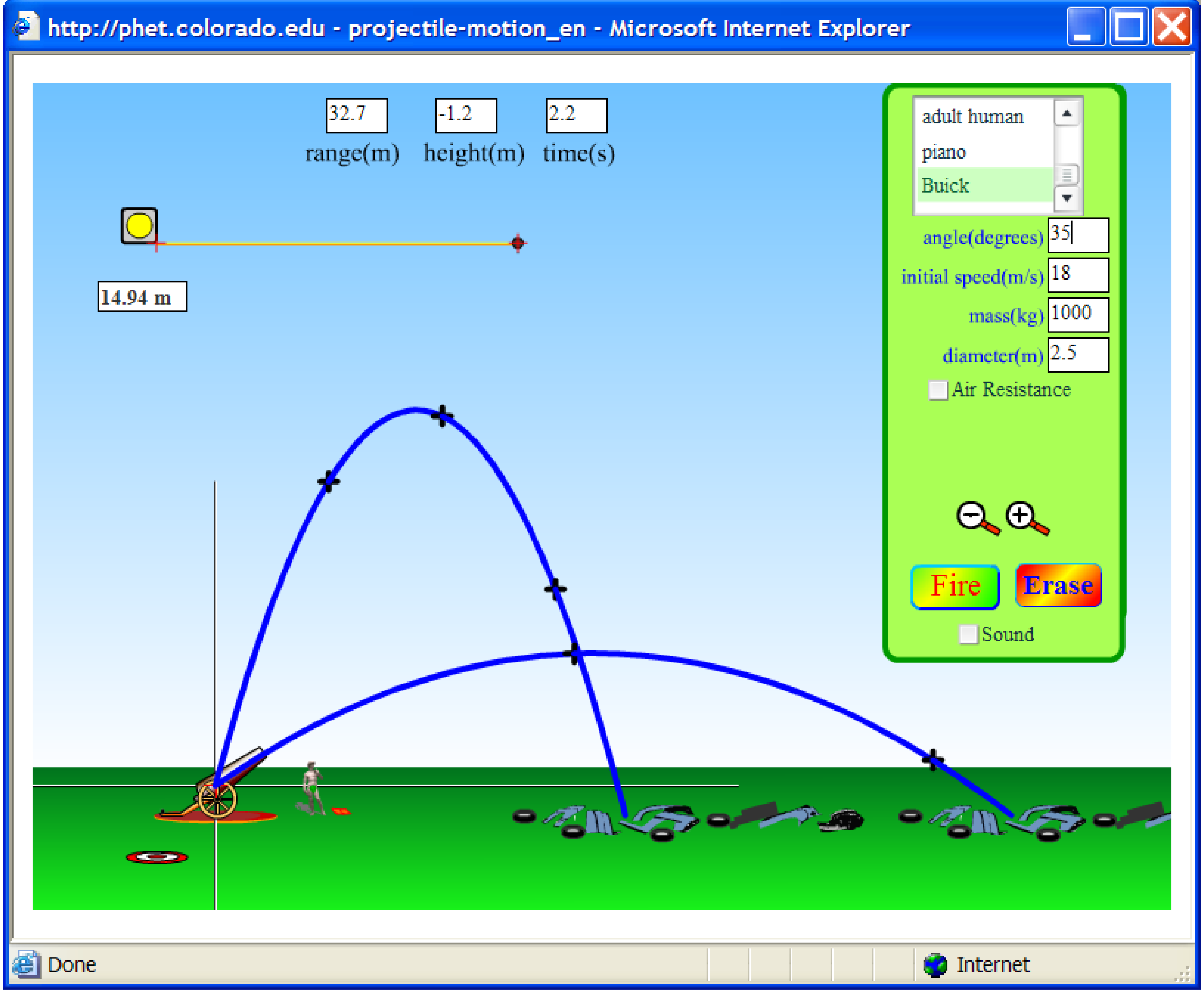




A

B

C They will go the same height



Time for 75 degrees 3.6 s, 35 degrees 2.2

4. Which will go farther?

Buick

angle(degrees) 75

initial speed(m/s) 18

mass(kg) 1000

diameter(m) 2.5

Air Resistance

A

tankshell

angle(degrees) 75

initial speed(m/s) 18

mass(kg) 150

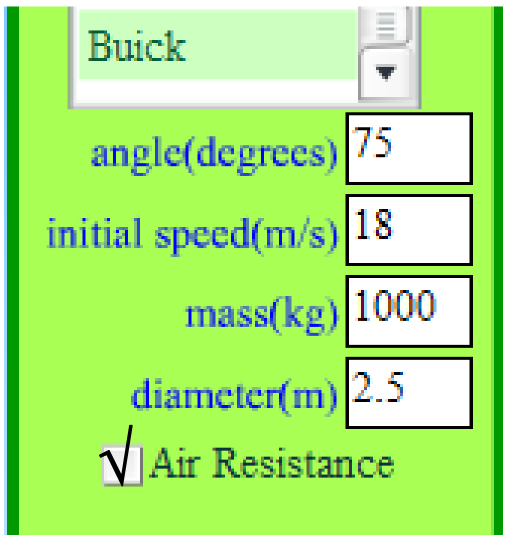
diameter(m) 0.15

Air Resistance

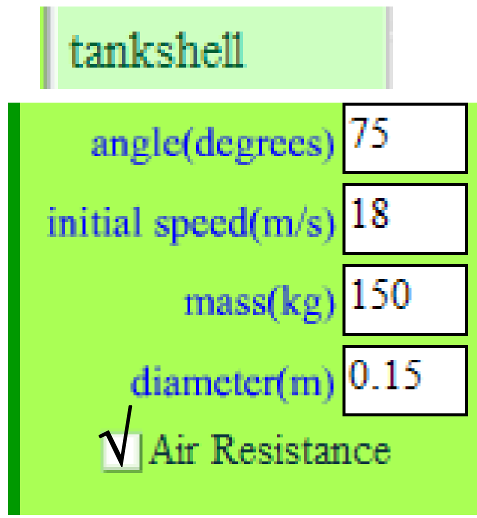
B

C They will go same distance

5. Which will go farther?



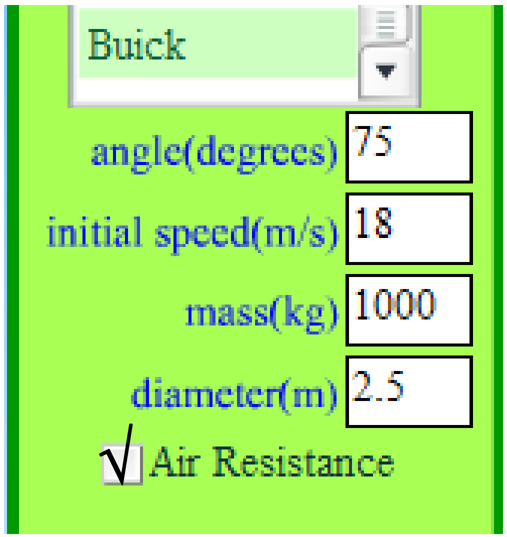
A



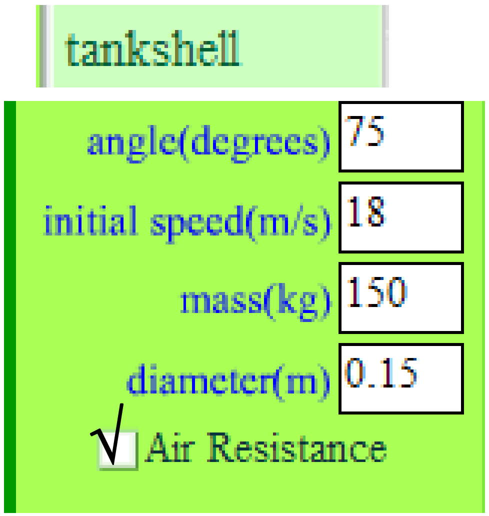
B

C They will go same distance

6. Which will go higher?



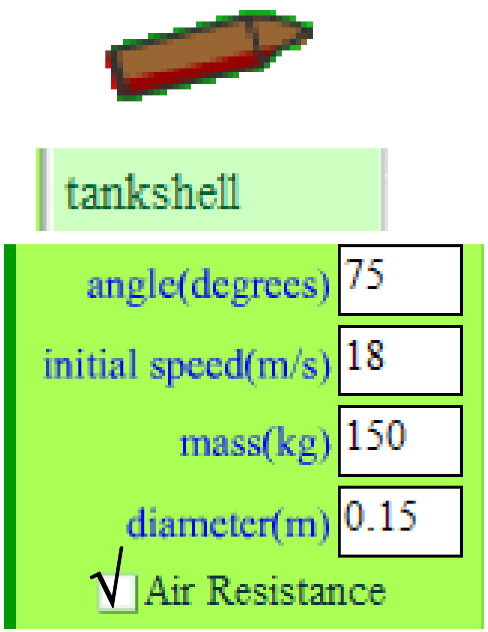
A

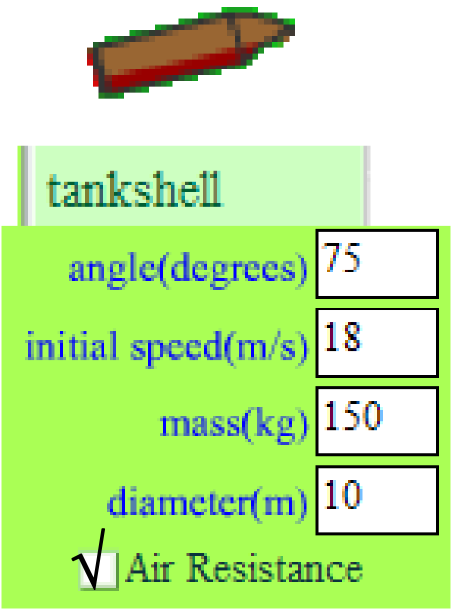


B

C They will go same height

7. Which will go farther?





A

B

C They will go same distance

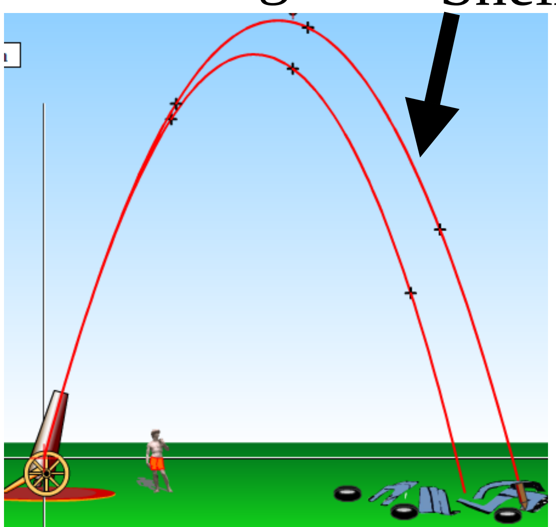
Results 4-7 Small vs large object
Red paths have air resistance

Without air resistance no difference

Shell drag .05

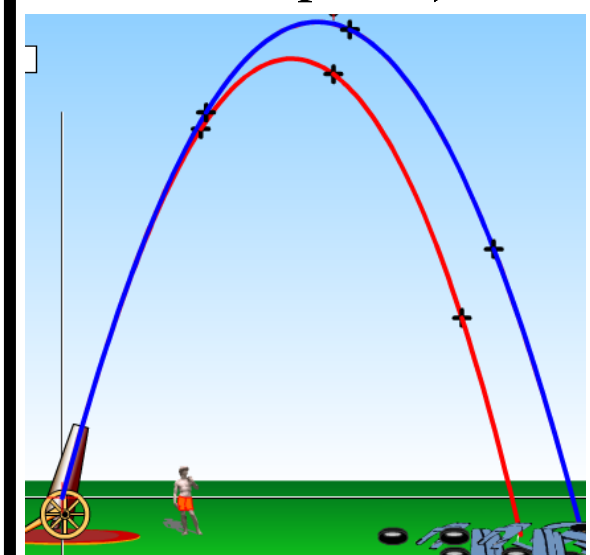
Buick drag 1.3

Shell

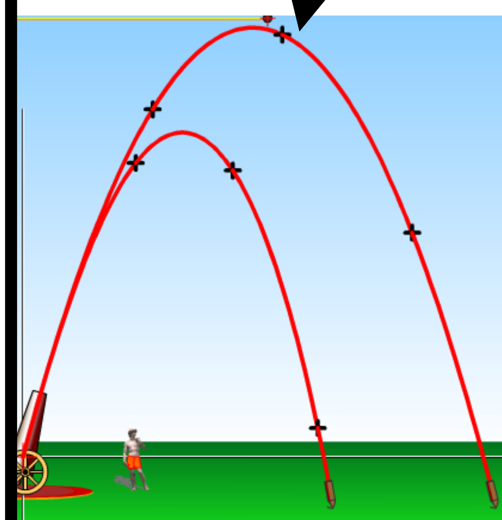


Buick shown

(Shell has identical paths)



Small Shell



Unit 3: Forces and the Laws of Motion

Learning goals-Students will be able to :

Changes in motion

- Explain how force affects the motion of an object.
- Distinguish between contact forces and field forces.
- Interpret and construct free body diagrams.

Newton's First Law

- Explain the relationship between the motion of an object and the net external force acting on it.
- Determine the net external force on an object.
- Calculate the force required to bring an object into equilibrium.

Newton's Second and Third Laws

- Describe the acceleration of an object in terms of its mass and the net external force acting on it.
- Predict the direction and magnitude of the acceleration caused by a known net external force.
- Identify action-reaction pairs.
- Explain why action-reaction pairs do not result in equilibrium.

Everyday Forces

- Explain the difference between mass and weight.
- Find the direction and magnitude of the normal force.
- Describe air resistance as a form of friction.
- Use coefficients of friction to calculate frictional force.

PhET Activity Learning Goals:

Forces and Motion: activity #1:

- Predict, qualitatively, how an external force will affect the speed and direction of an object's motion
- Explain the effects with the help of a free body diagram

Forces and Motion: activity #2:

- Use free body diagrams to draw position, velocity, acceleration and force graphs and vice versa
- Explain how the graphs relate to one another
- Given a scenario or a graph, sketch all four graphs

Ramp-Force and Motion activity #1:

- Explain the motion of an object on an incline plane by drawing free body diagrams

Ramp-Force and Motion activity #2:

- Calculate the net force of an object on an incline

Maze Game:

- Maneuver through the maze controlling position, velocity, or acceleration.
- Explain game strategies using physics principles.

Curve Fitting:

- Explain how the range, uncertainty and number of data points affect correlation coefficient and Chi squared.
- Describe how correlation coefficient and chi squared can be used to indicate how well a curve describes the data relationship.
- Apply understanding of *Curve Fitting* to designing experiments

Unit 3 Forces and the Laws of Motion
Publishing skills: drawing, tables, discussion, curve fitting

1 Notes: Check Your Understanding Forces 1D PhET worksheet
Lab: Forces and Motion activity **1** PhET

2 Labs: Quick lab p 126 (available online only), Finish Forces and Motion
Notes: Forces and Motion clicker questions, Static vs Kinetic Friction
Do: read and do text problems, questions

3 Lab: How does force effect acceleration and mass effect acceleration?
Turn in: header/footer, procedure, diagram of equipment, summary data tables with 7 trials per question, 2 final graphs with equation and correlation, discussion (purpose, results, how the results relate to known physics, and error analysis)
Do: Quick lab, Curve fitting PhET, Also: read and do text problems, questions

4 Notes: Publication skills: drawing and tables, lab discussion, power regression in Excel
Lab: finish acceleration lab
Do: Homework Maze Game 1 PhET, Also: read and do text problems, questions

5 Notes: Newton's laws, Weight, Normal force, review test
Lab: Forces and Motion Activity **2** PhET
Do: read and do text problems, questions)

6 Notes: Clicker questions Forces and Motion act 2, Friction ex p153 and added a=2 m/s^2
Do: read and do text problems, questions

7 Notes: Example Problems for net force with angled forces or surfaces
Lab: Ramp Activity **1** PhET
Do: read and do text problems, questions

8 Lab: Ramp Activity **2** PhET
Do: read and do text problems, questions and standardized testing practice

9 Clicker questions for Ramp and Maze
Do: Objective Test Taking Worksheet for Forces and Motion
Need more practice? Check concept questions in reading

10/ TEST

Lesson Plan *Forces and Motion* Activity #1 How does an external force affect speed and direction?
2 50 minute periods including prelesson, lesson, and post-lesson with clicker questions and demos (http://phet.colorado.edu)

Learning Goals: Students will be able to

- Predict, qualitatively, how an external force will affect the speed and direction of an object's motion
- Explain the effects with the help of a free body diagram
- Explain the difference between static friction, kinetic friction and friction force. *This goal is not addressed in the student directions, but is part of the post-lesson.*

Background:
We will have studied one-dimensional motion and projectile motion only in terms of observable measurements, graphical representations, and the kinematics' equations. I plan to use 2 class periods to complete the entire lesson.

Forces and Motion Introduction:
Show the students:

1. The little guy is just an agent of change; he's supposed to help the students' see that an applied force comes from some action like a person pushing. He is not a clickable object.
~~1.~~2. There are three ways to apply a force: the slider on the left, click & drag the object, or use the free body diagram box. It doesn't work very well to push on the object because when you let go, the force disappears. This makes analysis difficult.
~~2.~~3. *Playback* is useful like in *Moving Man* for closer analysis.
~~3.~~4. Having the velocity graph on may be helpful.

Lesson:

1. They will do the Check Your Understanding page before the simulation activity. I will not have a class discussion about their thinking, but we will discuss that they will be checking to see if there present knowledge will be confirmed or needs to be confronted.
2. Hand out the Student directions and have the students read the learning goals and have a class discussion about what "qualitatively" means.
3. Have them get out a different colored pen or pencil to make corrections while doing the activity.
4. Then, the students will use the lab sheet to complete the activity. I had to remind the students that I am expecting data tables that demonstrate serious experimentation for 4 & 6. After the first day, I looked at some of the students' papers and saw that they were not thoroughly exploring and that their record keeping was not sufficient. I decided that they needed more guidance, so we had a class discussion about experimental design and recording and I put these table headings on the board. I will still use the same directions and strategy next year. The opportunity to discuss and support their design and reporting was very valuable.

What is the cabinet doing? Is it: not moving moving right moving left	Which direction is it being pushed? Relatively, by how much?	Draw the Free Body Diagram	What happens to the speed?	What direction does it go? At first and after a while

Lesson Plan *Forces and Motion* Activity #1 How does an external force affect speed and direction?
2 50 minute periods including prelesson, lesson, and post-lesson with clicker questions and demos (http://phet.colorado.edu)

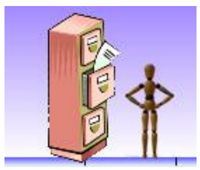
Post-lesson:

1. I'll use the clicker questions.
2. There is also a handout for Objective Test Taking Practice that I will give as homework.
3. Using the textbook as support, we will discuss the first law and I'll do a few demonstrations. I will have the simulation open and we will have a discussion to address the final learning goal: Explain the difference between static friction, kinetic friction and friction force.
4. In out text, there is an introduction to free body diagrams and a fun activity using a cart running into a book (represents a wall). The students roll the cart and make observations, and then they have to try to explain what forces are acting using diagrams. There's another where you put a ball on the cart.
5. Then they will do the practice problems in our text

Check Your Understanding: How does an external force affect speed and direction?
***Forces and Motion* activity #1**

1. *Joe has just been promoted and is pushing a file cabinet down the hall to his new office. He begins by looking at the file cabinet and considering how to best go about his task (scene 1). He then begins pushing on the file cabinet, which, at first, does not move at all (scene 2). Eventually the file cabinet begins to slide across the floor, slowly moving towards Joe's new office.*

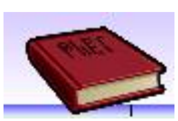
a. Draw all the forces you think are acting on the file cabinet in each scene.

Scene 1: Man not pushing	Scene 2: Man pushing but file cabinet not moving	Scene 3: Man pushing and file cabinet moving to right
		

b. Why do you think the file cabinet moves in scene 3 but not in scene 1 or 2?

2. *When Annette finishes her physics homework, she closes her book and shoves it (scene 1) to the other end of the table. The book slows down as it crosses the table (scene 2) until it eventually stops (scene 3).*

a. Draw all the forces you think are acting on the book in each scene.

Scene 1: Annette pushing book and book moving (to the right)	Scene 2: Book moving (to right) across table	Scene 3: Book stopped at end of table
		

b. Why do you think the book moves when Annette pushes it (scene 1)?

c. Why do you think the book continues to move when she takes her hand away from the book (scene 2)?

d. Why do you think the book eventually stops moving (scene 3)

3. *At the park, Emily is sliding into home plate. Inside the ice rink, Fran fell and is sliding across the ice.*
a. On the back of your paper, draw a picture of both Emily and Fran sliding.
b. Draw the forces you think are acting on Emily and Fran.
c. Describe what will happen to each one's speed and direction and explain why sliding on dirt different from sliding on frictionless ice.

Student directions *Forces and Motion* activity 1: How does an external force affect speed and direction?
http://phet.colorado.edu

Learning Goals: Students will be able to

- Predict, qualitatively, how an external force will affect the speed and direction of an object's motion
- Explain the effects with the help of a free body diagram

1. Use ***Forces and Motion*** simulation to create Joe's situation from the ***Check Your Understanding*** page.
   a. Talk about how your force drawings compare to the free body diagram window for each scene and adjust your sketches with a new color if necessary.
   b. Look at your reasoning **1b**. Have your thoughts changed now that you run the experiment? Explain your answer.

2. Use the simulation to verify or correct your drawings and reasonings for Annette's book. Make changes in a new color.

3. Explain how you could use the simulation to study Emily and Fran's situations even though there are no people in the simulation. Test your ideas and make corrections to your page in a new color.

You have thought about how a force can make something move or stop. Now you'll want develop a more complex understanding. Remember, the goal is to predict how applying force effects an object's speed and direction.

4. Start with a short investigation using the file cabinet. In an organized fashion, **record observations** about how pushing on the cabinet changes it's speed and direction of motion. **Include the free body diagrams.**
   For example, you might test the following: Does a push from the right always make the file cabinet go right? What roll does friction play? How can you use the free body diagram to help you make predictions?

5. Using your observations, summarize how you could predict what happens to the speed and direction of a file cabinet when a force is applied.

6. Test how well your understanding applies in specific situations. For each, make a prediction, and then test your ideas using the simulation. Make a table to record your prediction, observations, and draw the free body diagram. Include comments about whether the test supports or refutes your summary in question 5.

   a. How much force does it take to make the cabinet move from rest with friction on?
   b. What's different with the friction off?
   c. What happens if you change the cabinet to a book and also to a refrigerator?
   d. If the cabinet is moving when the force is applied, what do you need to consider? Are there different things to consider if you switch the cabinet to a dog or crate?
   e. Think of other experiments that would help you verify your ideas. Describe your experiments and continue to fill in your table.

7. Write a final summary of how you can predict, with the help of free body diagrams, what effects an external force will have on the speed and direction of an object's motion.

Clicker questions for Forces and Motion Activity 1

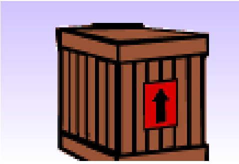
Trish Loeblein phet.colorado.edu

Learning Goals: Students will be able to

•Predict, qualitatively, how an external force will affect the speed and direction of an object's motion

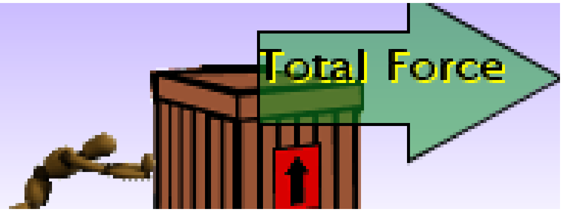
•Explain the effects with the help of a free body diagram

•Explain the difference between static friction, kinetic friction and friction force. *This goal is not addressed in the student directions, but is part of the post-lesson.*



Crate was moving to the right

Then, the guy pushed the crate



1. If the total force acts in the same direction as the crate is sliding, the crate

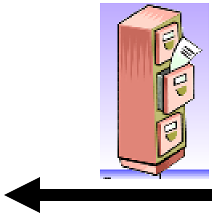
A. slows down

B. speeds up

C. remains at same speed

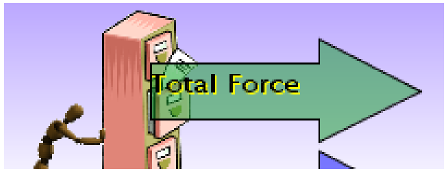
D. slows down, changes direction and then speeds up going the other way

E. remains at same speed, but changes direction



Cabinet was moving to the left

Then, the guy pushed the cabinet

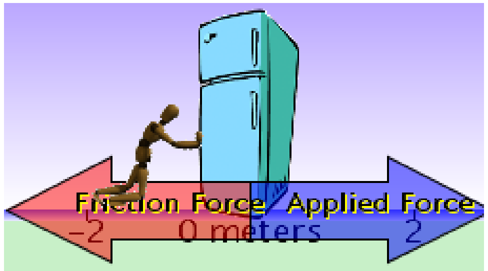


2. If the total force acts in the opposite direction as the cabinet is sliding, the cabinet would

A. slow down
B. speed up
C. remain at same speed
D. slow down, change direction and then speed up going the other way
E. remain at same speed, but change direction

Refrigerator was moving to the right

Then, the guy pushed the refrigerator



3. If there is zero total force acting on on the refrigerator, the refrigerator would

A. slow down
B. speed up
C. remain at same speed
D. slow down, change direction and then speed up going the other way
E. remain at same speed, but change direction

Lesson plan *Forces and Motion* activity 2: Graphing position, velocity, acceleration and force http://phet.colorado.edu 90 minutes (uses *Moving Man* too)

Learning Goals:
Students will be able to:
- Use free body diagrams to draw position, velocity, acceleration and force graphs and vice versa
- Explain how the graphs relate to one another.
- Given a scenario or a graph, sketch all four graphs

Background:
We will have done the *Forces and Motion* activity "How do external forces effect speed and direction?" and the *Moving man* activity. So the students are familiar with *Forces and Motion, free body diagrams* and relating position, velocity and acceleration graphs. Also, we will have done the *Moving Man* activity.

Forces and Motion Introduction:
I'll remind them that when using *Moving Man*: Using the sliders makes for more smooth graphs; it is handy to *Pause* before changing conditions; *Playback* is a great analysis tool.

I'll open *Forces and Motion* and point to the same tools, plus I think it's easier to look at the vectors that appear right on the object because they are larger. Matching motion graphs is more difficult than with *Moving Man* because the students have to use force to change the motion.

I want to remember: The little guy is just an agent of change; he's supposed to help the students' see that an applied force comes from some action like a person pushing. He is not a clickable object. There are three ways to apply a force: the slider on the left, click & drag the object, or use the free body diagram box. *I think it might be easier to have just the position and force graphs open as you are trying to match a story.*

Lesson:
For my class, it seems easier to have them copy and paste the graphs because then they can control the size. Have the students use the lab sheet for guidance. The activity is expected to take my honors physics students about 50minutes.

Post lesson: I will use the clicker questions that are on the document called *Forces and Motion* activity clicker questions

Student directions *Forces and Motion* activity 2: Graphing position, velocity, acceleration and force
http://phet.colorado.edu (uses *Moving Man* too)

Learning Goals: Students will be able to

- Use free body diagrams to draw position, velocity, acceleration and force graphs and vice versa
- Explain how the graphs relate to one another.
- Given a scenario or a graph, sketch all four graphs.

1. Consider this story: *A man wakes up from his nap under the tree and goes toward the house. He stops because he is worried that he dropped his keys. He stands still as he searches his pockets for his keys. He realizes he has them, but he left his jacket under the tree and heads back to get it.*

   a. Open *Moving Man.* Make the *Man* model the story with the following stages.
   1) The man starts by the tree and moves toward the house 2) Walks with constant velocity.
   3) Slows to a stop 4) Stands still for a while 5) Changes direction moving towards the tree.

   b. When you get a good set of graphs, print them and label the 5 stages of his trip. Don't clear your graphs because you may want to replay them.

   c. Below your graphs, draw free body diagrams to explain what forces you think are acting during each stage. Then, explain your reasoning for each diagram.

   d. Sketch what you think the force graph would look like. (*Just try to get the general shape don't include a scale)*

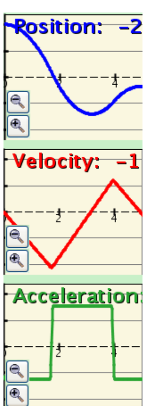
2. Open *Forces and Motion.* Make similar graphs using the *Dog* to mimic the *Man*'s motion.

   a. When you get a good set of graphs, print them and label the stages of his trip. Don't clear your graphs because you will want to replay them.

   b. Below your graphs, draw the actual free body diagrams for each stage by using *Playback*.

   c. Compare the diagrams and force graph to the ones you predicted. Explain the differences and rewrite your reasonings where your predictions didn't work.

3. This is a set of graphs from *Moving Man.*



   a. Make up a story that could describe what the man was doing.

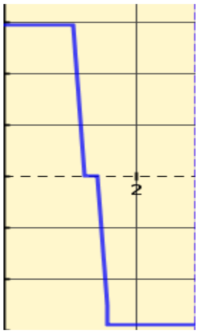
   b. Make free body diagrams for each part of your story, draw what the force graph would look like and include your reasoning *(Just the general shape)*

   c. Use *Forces and Motion* to test your predictions and use a different color to modify your diagrams, force graph and thinking.

4. If you were given just a position graph, explain what you could use to make a force graph. Test your theory by having one person draw a graph, have the other predict the force graph. Then use the sim to verify or modify your ideas.

5. Use a similar testing model to produce a plan to use a velocity graph to make a force graph and then how to use an acceleration graph.

6. Below is a total force graph from *Forces and Motion*.



a. Make up a story that could describe how the dog was pushed. *(I had friction off, so the total force is the push)*

b. Draw what the position, velocity and time graphs might look like. Explain how you used the force graph to develop the other three.

c. Use *Forces and Motion* to test your predictions and use a different color to modify your story, force graph and plan to use the force graph.

Clicker Questions for Forces and Motion Activity 2

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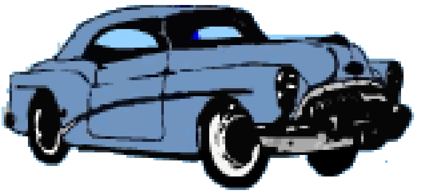
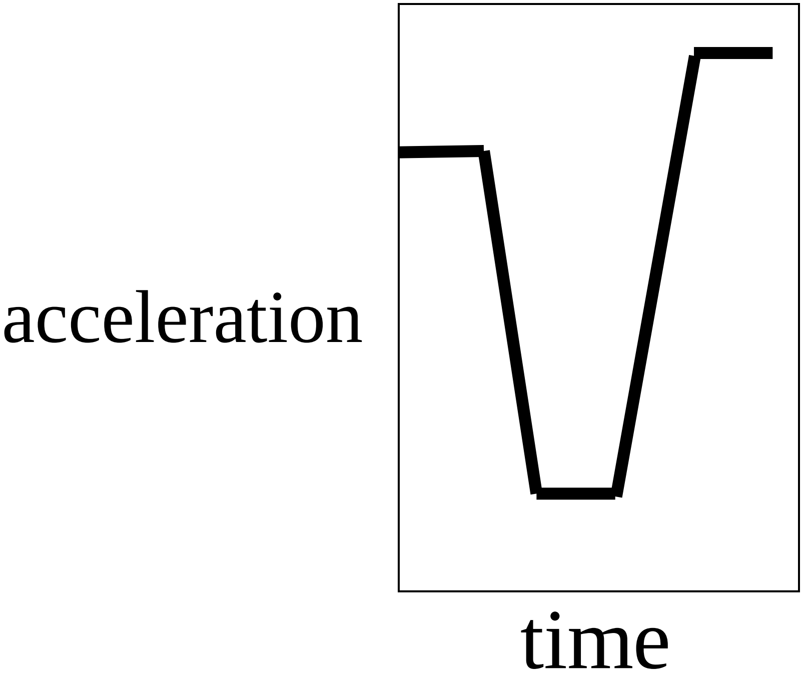
Learning Goals:

Students will be able to:

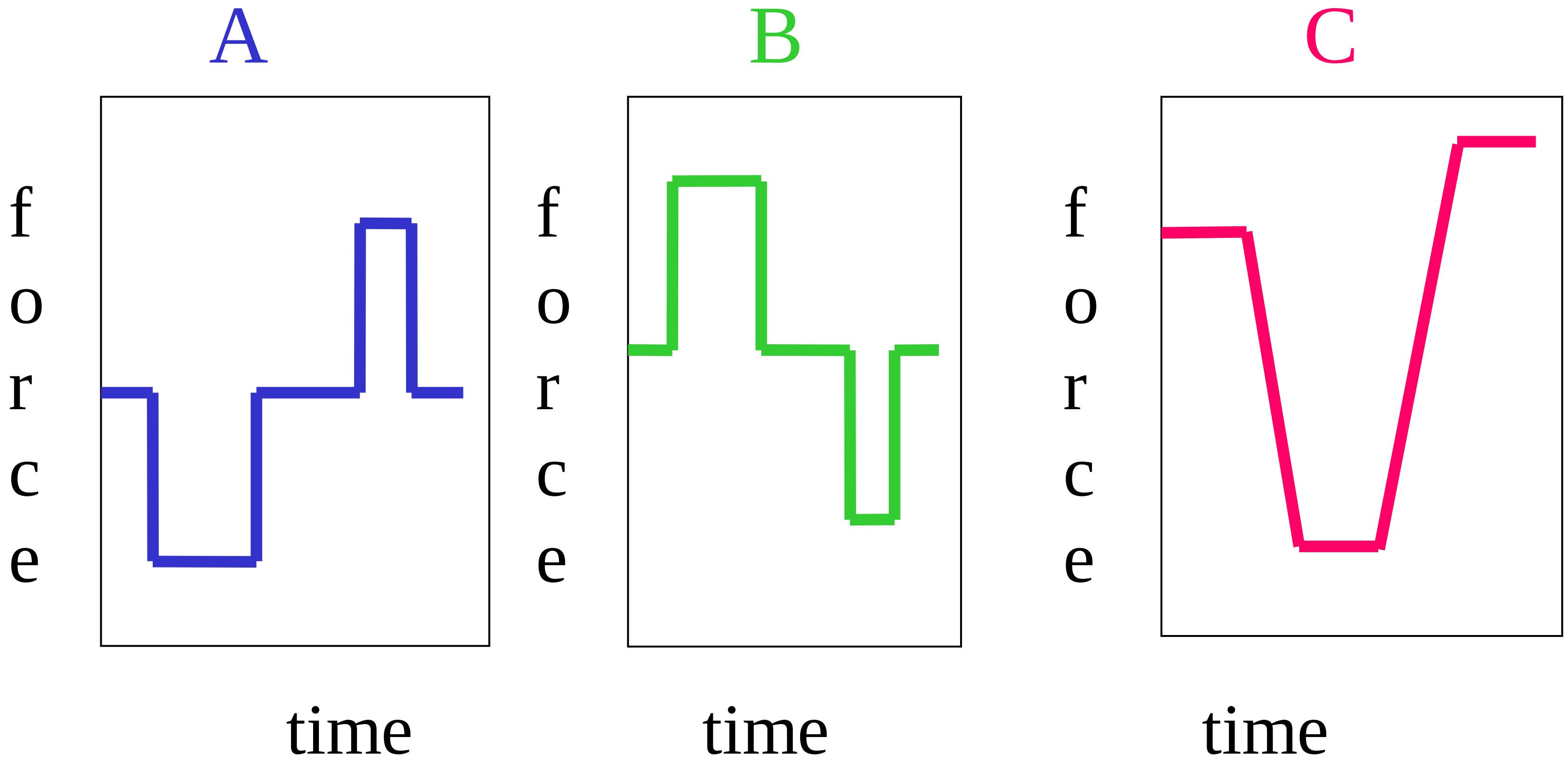
- **Use free body diagrams to draw position, velocity, acceleration and force graphs and vice versa**
- **Explain how the graphs relate to one another.**
- **Given a scenario or a graph, sketch all four graphs**

1. A car is traveling along a road. Its acceleration is recorded as a function of time.

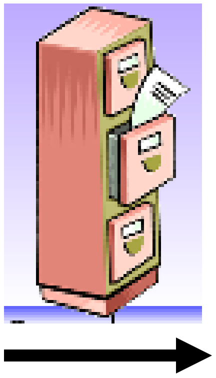




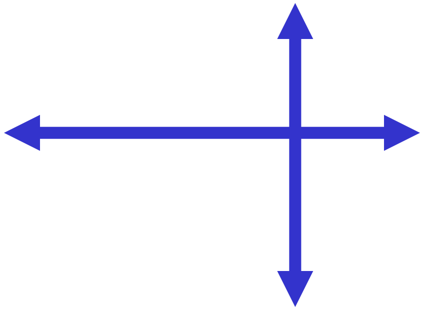
1. Which **<u>Total</u> force-time** graph would best match the scenario?



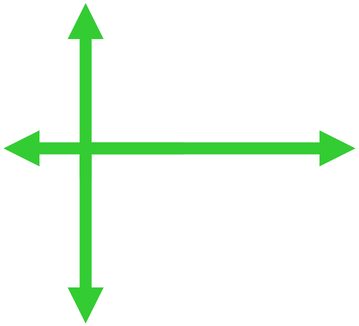
2. A cabinet is speeding up as it slides right across the room. Which of the following is a possible free body diagram?



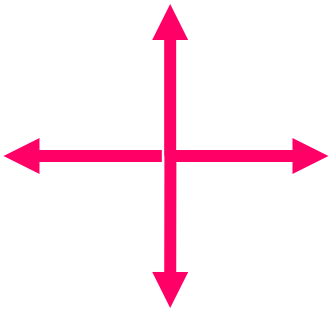
A



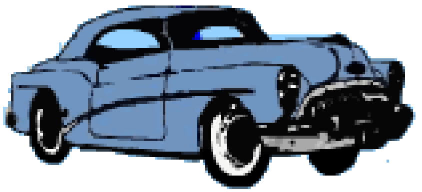
B

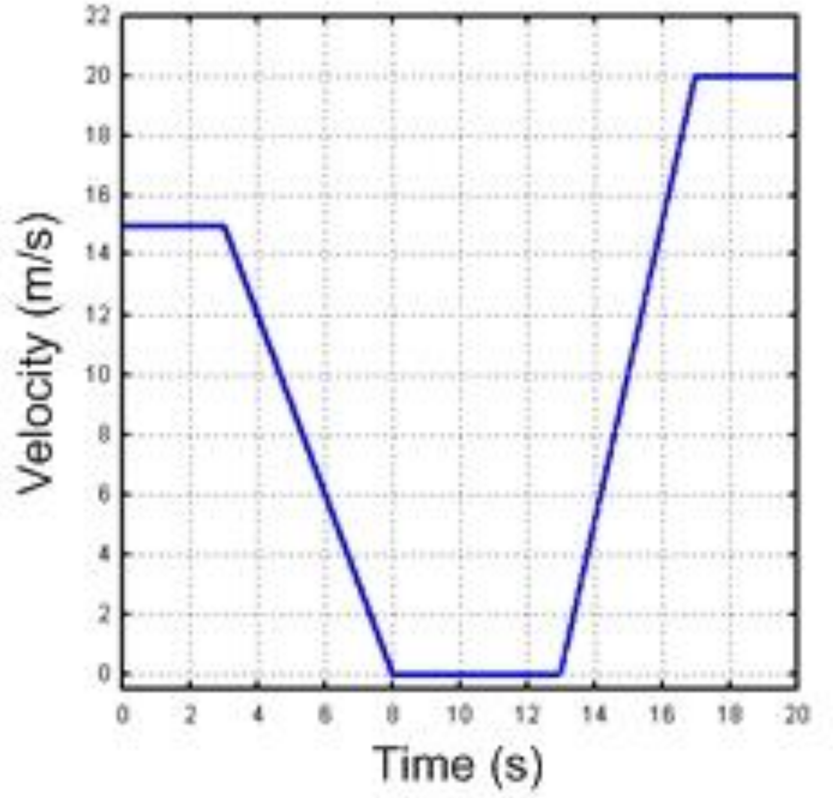


C

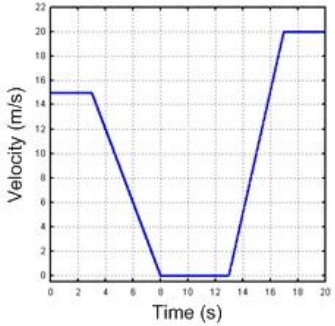


3. A car is traveling along a road. Its velocity is recorded as a function of time.

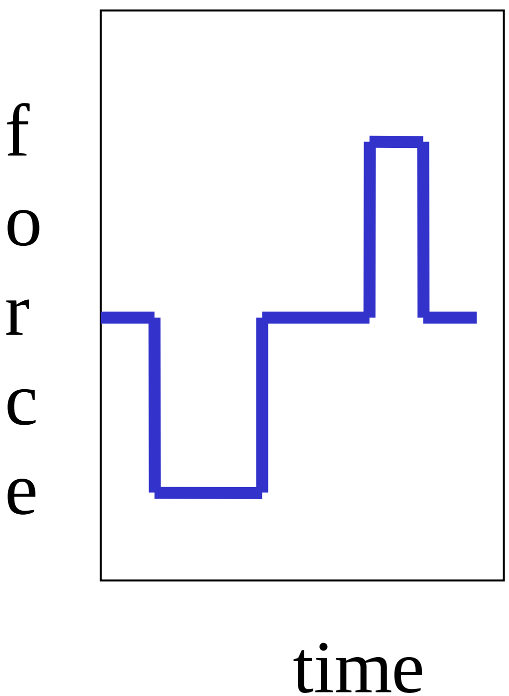




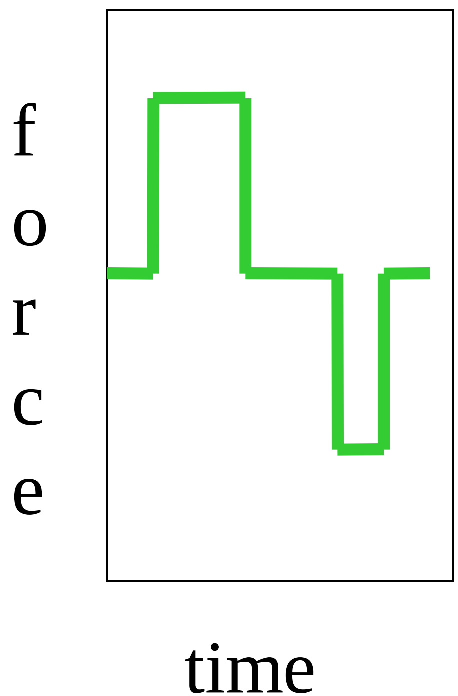
3. Which would be the **Total force-time** graph?



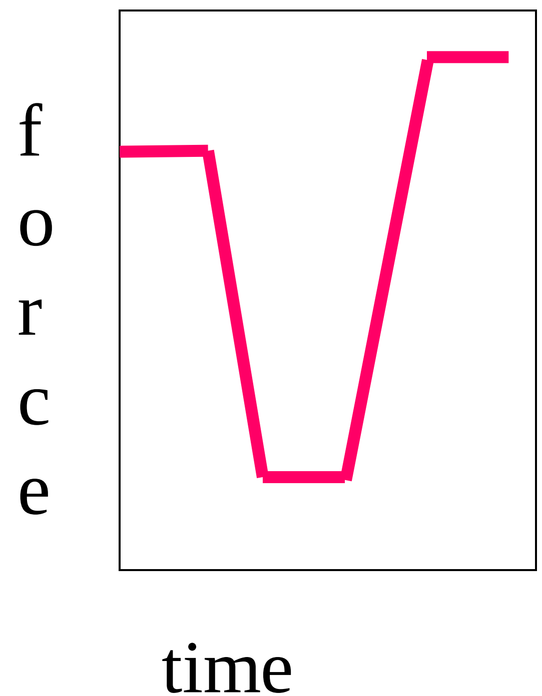
A



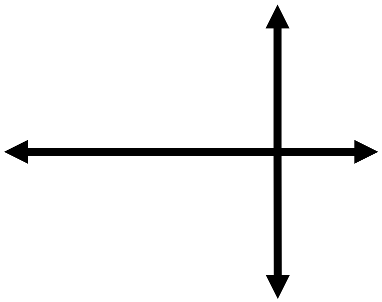
B



C



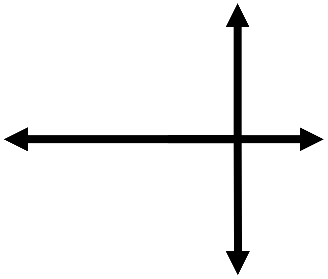
4. A car is moving towards the right. Then a force is applied and the free body diagram looks like this

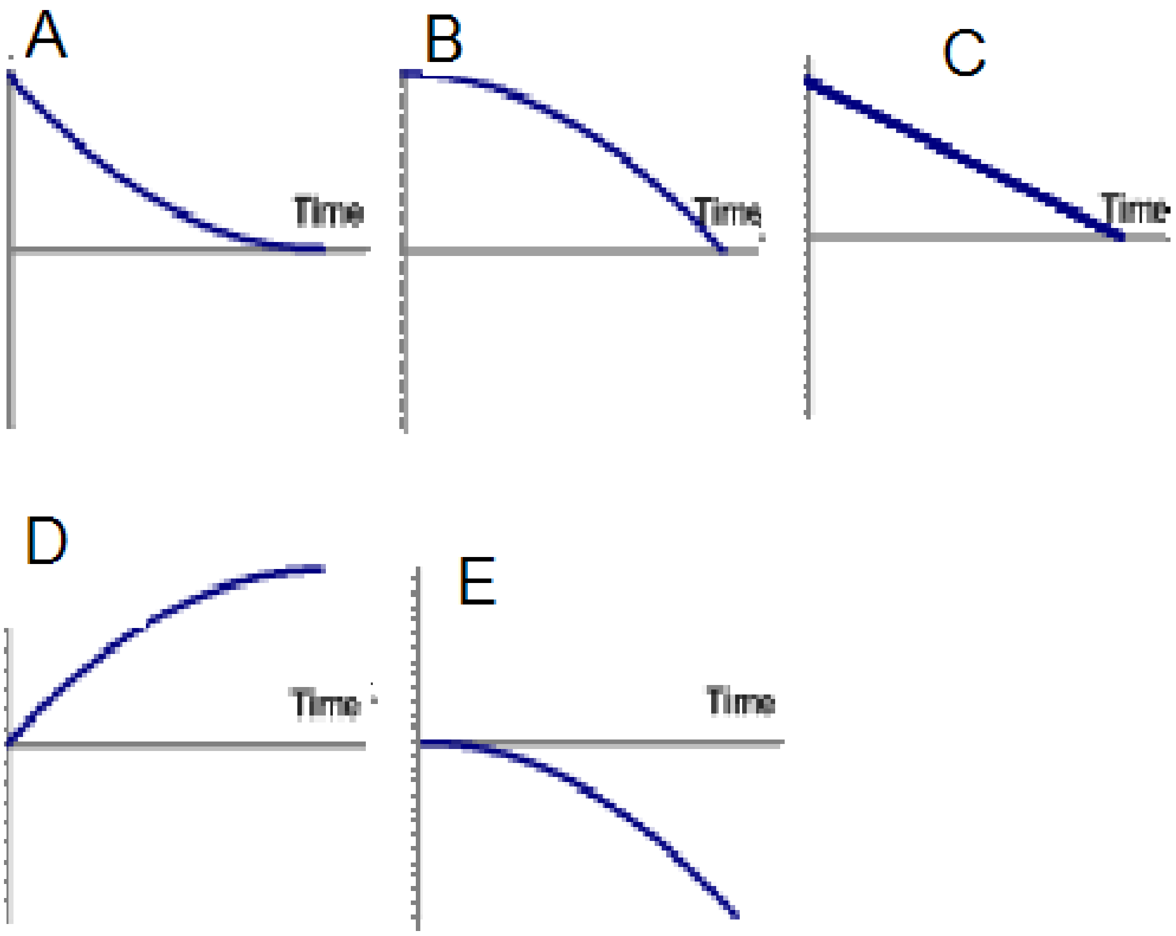


Force diagram

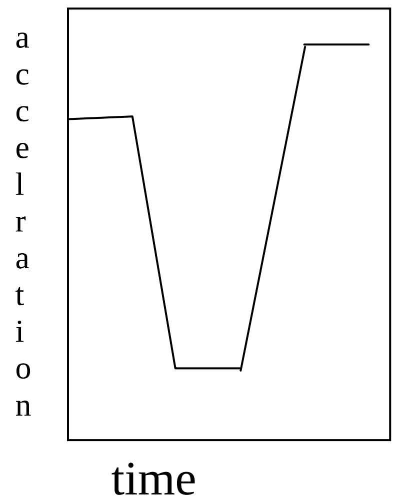
Draw what you think the ***position-time*** graph would look like.

4. Which ***position-time*** graph best matches your idea?



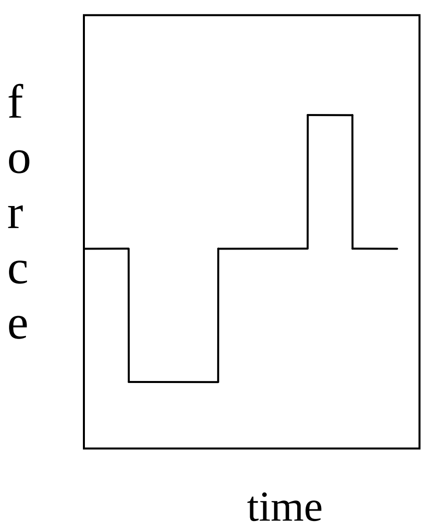


1. A car is traveling along a road. Its acceleration is recorded as a function of time and is shown in the graph below.

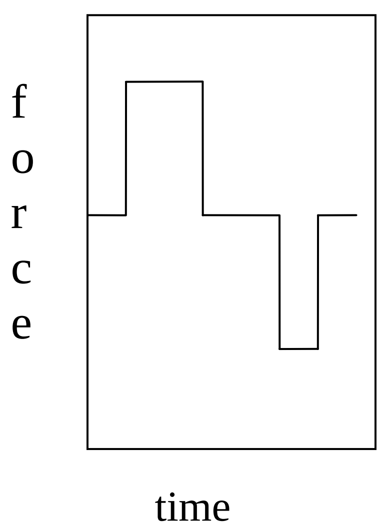


Which would be the **force-time** graph?

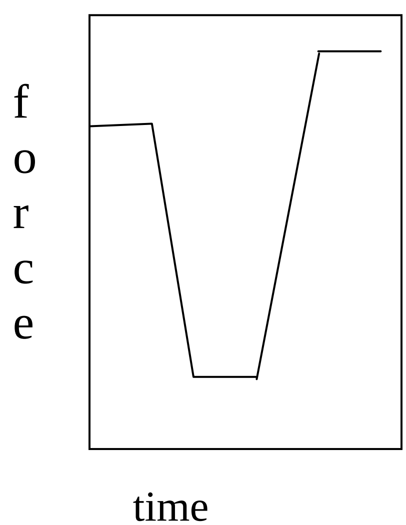
A.



B.

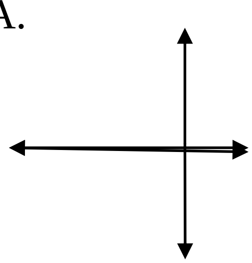


C

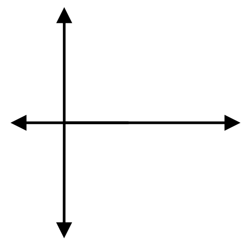


2. A cabinet is speeding up as it slides right across the room. Which of the following is a possible free body diagram?

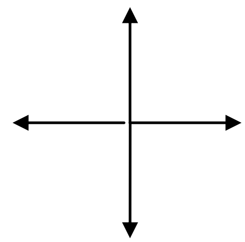
A.



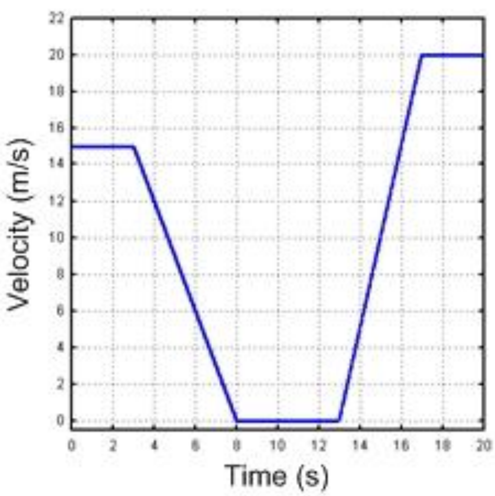
B.



C.



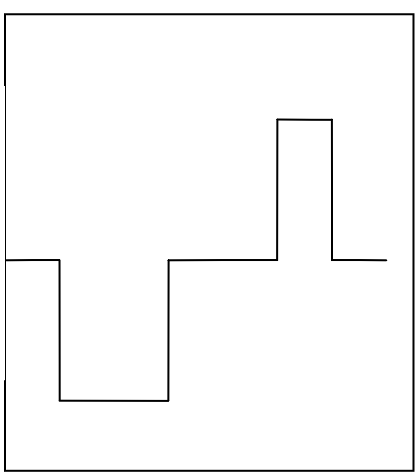
3. A car is traveling along a road. Its velocity is recorded as a function of time and is shown in the graph below.



Which would be the **force-time** graph?

A.

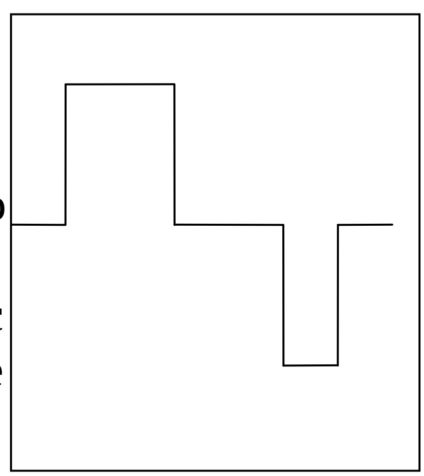
force



time

B.

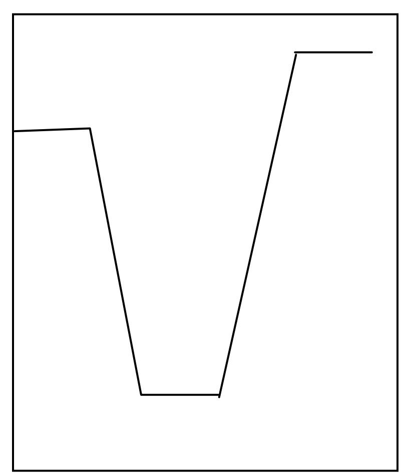
force



time

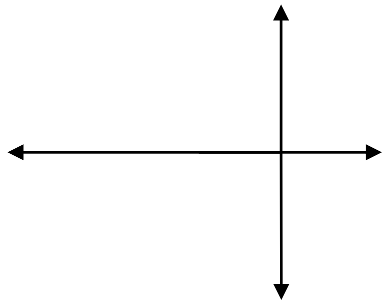
C

force

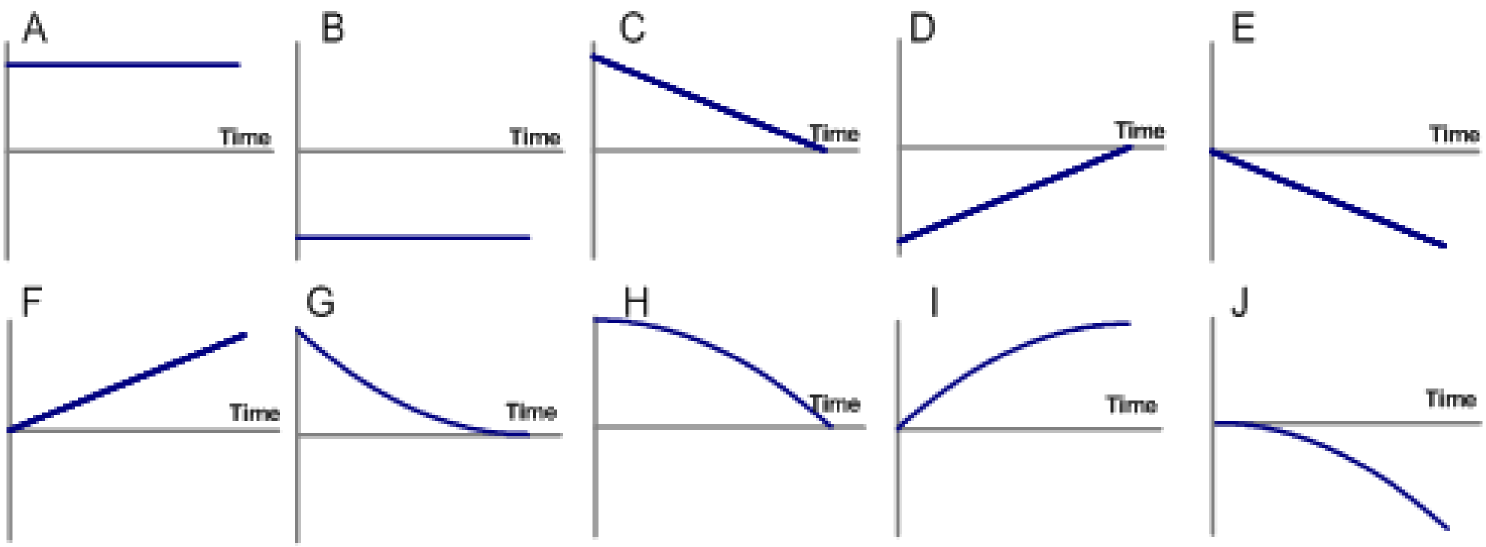


time

4. A car is moving towards the right and then a force is applied so that the free body diagram looks like.



Which ***position-time*** graph best depicts this motion?



Lesson plan for ***Ramp: Force and Motion*** Activities 1 and 2:
http://phet.colorado.edu

There are two activities. The first one is qualitative and the second is quantitative. There was simulation called "The Ramp", but our research showed that it had too many learning goals. The first tab of the sim is simplified and energy parts of the sim have been deleted as well. There are plans to design and produce an "Energy and Work" simulation.

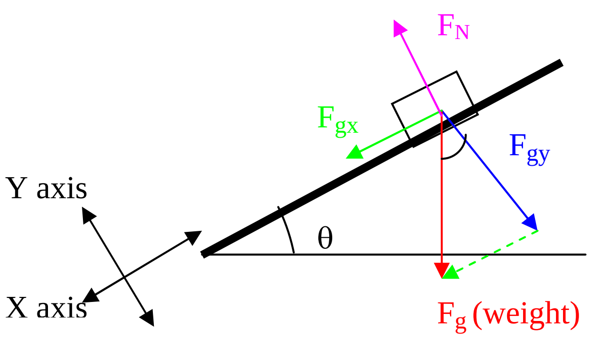
Learning Goals:
Activity 1. Students will be able to explain the motion of an object on an incline plane by drawing free body diagrams.
Activity 2. Students will be able to calculate the net force on an object on an incline.

Background:
We will have done the Moving Man and Forces and Motion activities.

***Ramp: Force and Motion* Introduction:**
I demonstrated that the data collection is for 30 seconds, but the investigation can continue without graphing. The coefficient of friction on the ramp surface is the same as the grass. Show them that you can simulate a horizontal surface by setting the angle at 0.

Lesson:
For the first lesson, have the students use the lab sheet for guidance. The activities are designed to be used in 50 minute periods including the class discussions.
Post lesson: There are 6 clicker questions

To start the second lesson, pose this question:
1. If Joe lifted the cabinet instead of using the ramp, how much force would he have to use? Have a discussion around why a ramp might be used. (We won't have studied work yet)
2. Then, open the sim on a projector for everyone to see. Ask the class to observe the value of Parallel Gravity force (on the graph) as the ramp angle is changing. Then pose: How can the force of gravity be changing? Help the class to understand that Parallel Gravity force is the portion of the weight that would cause the object to slide down the ramp. Draw the sketch below and have them copy it for future reference. I have chosen this particular diagram because this is how it is draw in our text. Have them calculate Parallel Gravity force (F_{gx} in our text) for several situations. Ask them what things might affect the value and run tests. (For example test: cabinet and fridge at different angles and locations)



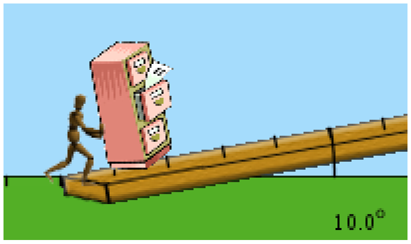
$F_{gy} = F_g \cos\theta$
$F_{gx} = F_g \sin\theta$

Student directions *Ramp: Force and Motion* activity 1: Using free body diagrams
http://phet.colorado.edu

Learning Goals: Students will be able to explain the motion of an object on an incline plane by drawing free body diagrams.

1. Joe is going off to college and is loading his file cabinet onto the moving truck by sliding it up a ramp like in the picture below.

   a. Sketch what you think the free body diagram would look like for the file cabinet and explain your reasoning.



   b. Use ***Ramp: Force and Motion*** to simulate Joe's situation. Compare your free body diagram to the simulation and make any corrections to your drawing and reasoning.

   c. Investigate the simulation to see what effects how hard Joe must push to move the cabinet up a ramp.

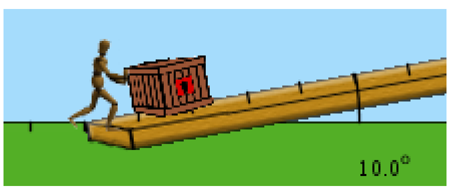
   d. Describe your experiments and results including the free body diagrams.

   e. Draw the free body diagrams for the cabinet if it were being pushed on a flat surface and if it were being lifted straight up. Compare those to the ones you observed on the ramp, and then describe the differences and similarities.

2. Next, Joe wants to load his crate of books.

   a. Predict what you think the free body diagram would look like.

   b. Explain what might cause similarities and differences between Joe moving the crate versus the file cabinet.



   c. Test your prediction and thoughts using the simulation.

   d. Describe your experiments and results including the free body diagrams.

3. Think of some other things that Joe might want to move using a ramp and explain what he would have to consider when thinking about how hard to push.

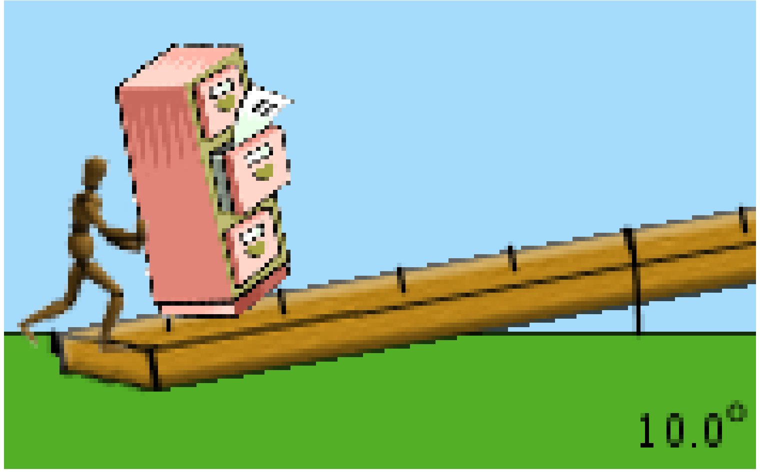
4. Joe has some friends that want to help, but they're not as strong. How do you think the ramp design be changed so they could help? Verify or adjust your ideas by experimenting with the simulation.

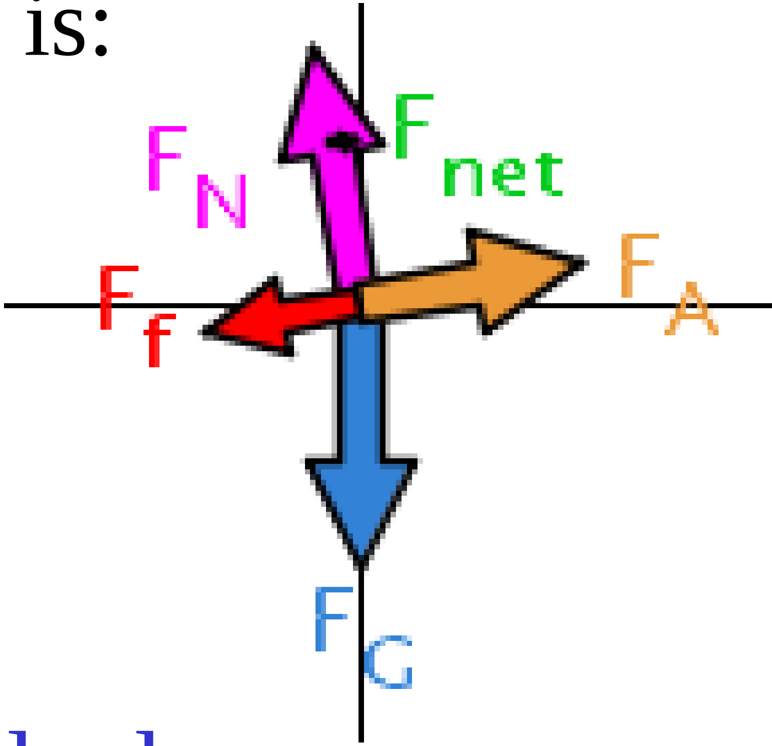
5. Joe wants to stop on the ramp to catch his breath. Would he be better off stopping on a rough spot on the ramp or a smooth spot? Verify or adjust your ideas by experimenting with the simulation.

Clicker questions for
Ramp- Force and Motion activity 1

If you want to make questions like I have where only one variable changes and you see what changes on the diagram: Play with the sim until you get a diagram you like. (you can go pass the spot) **Pause** the sim. Use the vertical bar to go back to a spot that you liked, then you can change variables (hit enter to make the change take place) and the changes will show on the diagram without having to run the sim.

1. If the free body diagram for Betty pushing her file cabinet is: What will happen?



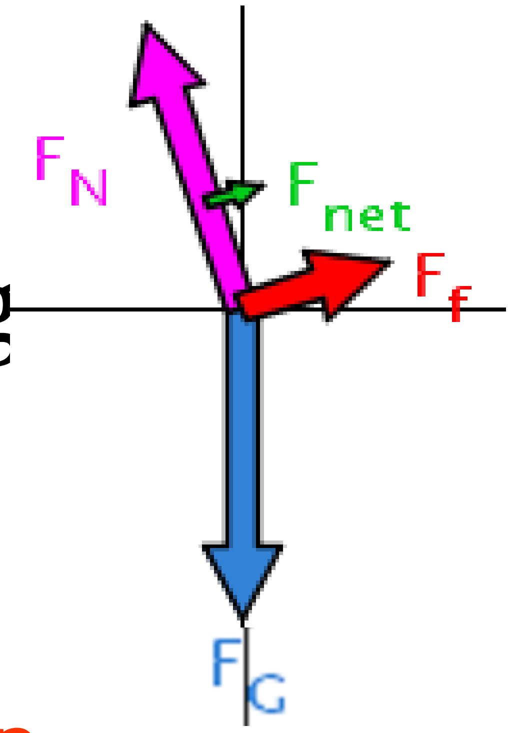


A. The cabinet will slide down

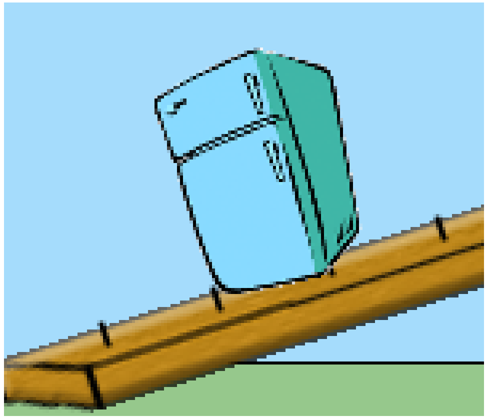
B. Betty will push it up the ramp

C. The cabinet won’t move

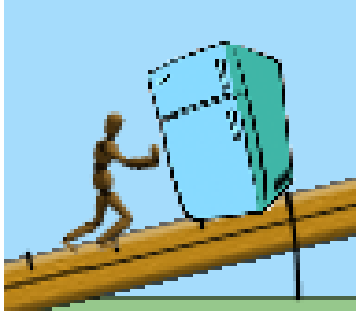
2. If this is the free body diagram for the fridge, what could be happening

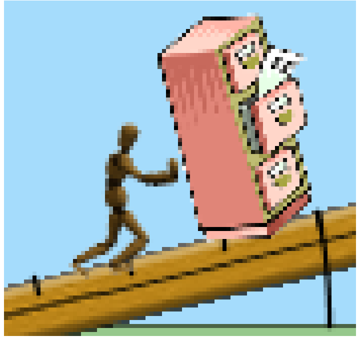


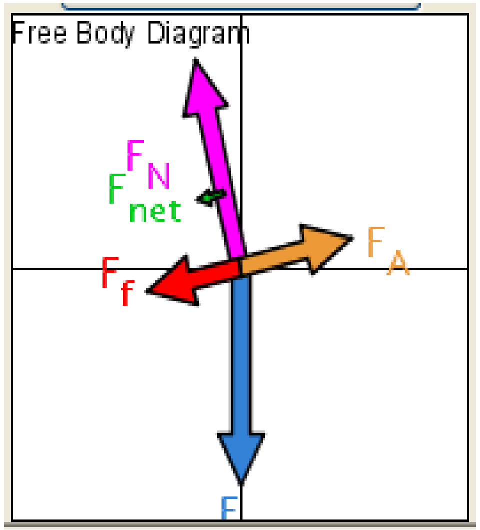
A. Someone is pushing it up the ramp
B. It is sliding down the ramp going faster
C. It is sliding down the ramp going slower
D. It is sitting still

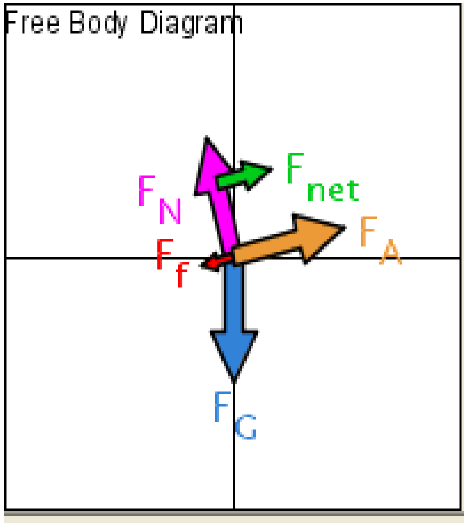


3. One of these diagrams is for a fridge (175 kg) and the other is for a file cabinet (100 kg). If all the conditions are the same, which is the fridge?







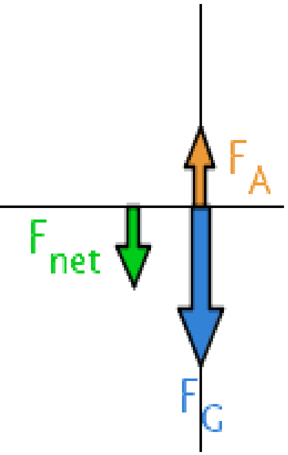


A

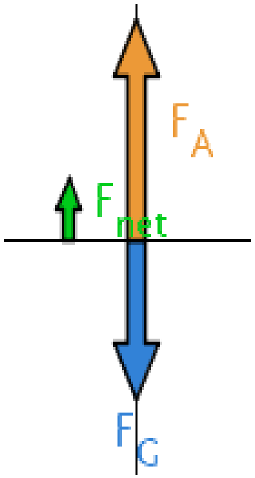
B

C no way to tell

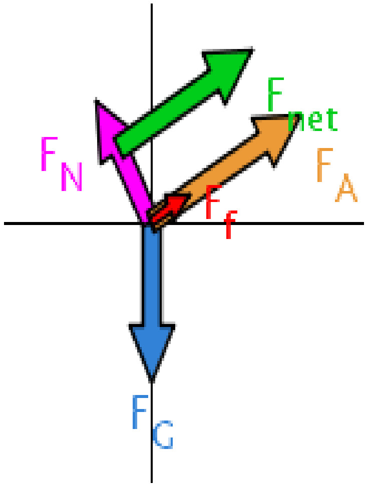
4. Which diagram could show a box of books being lifted straight up?



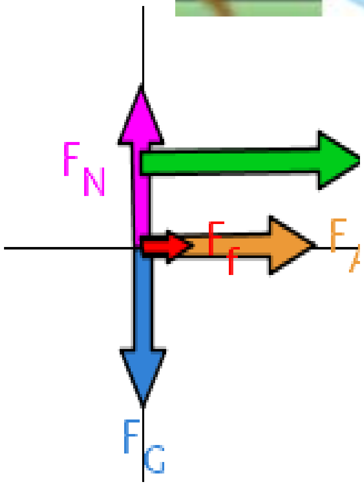
A



B



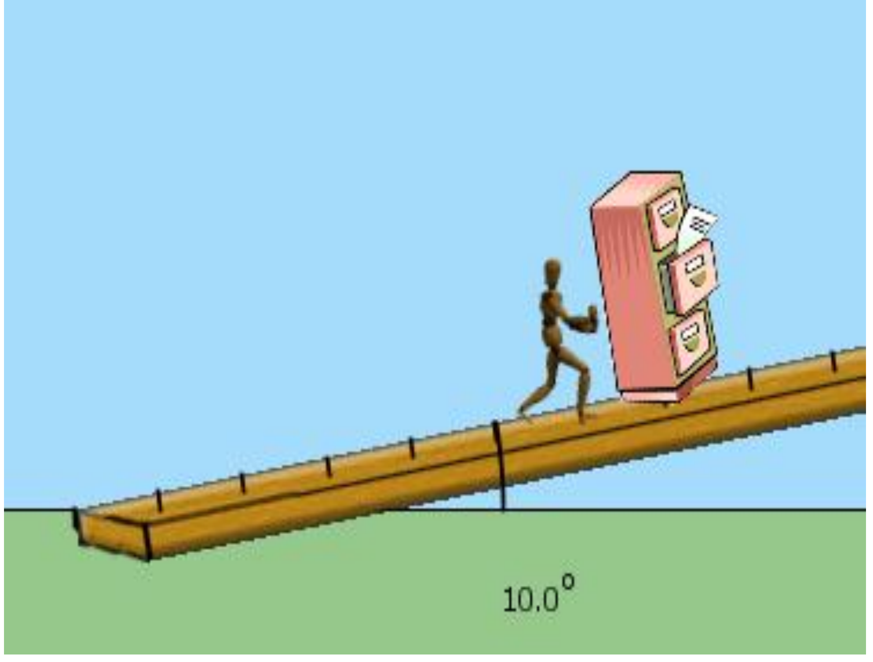
C



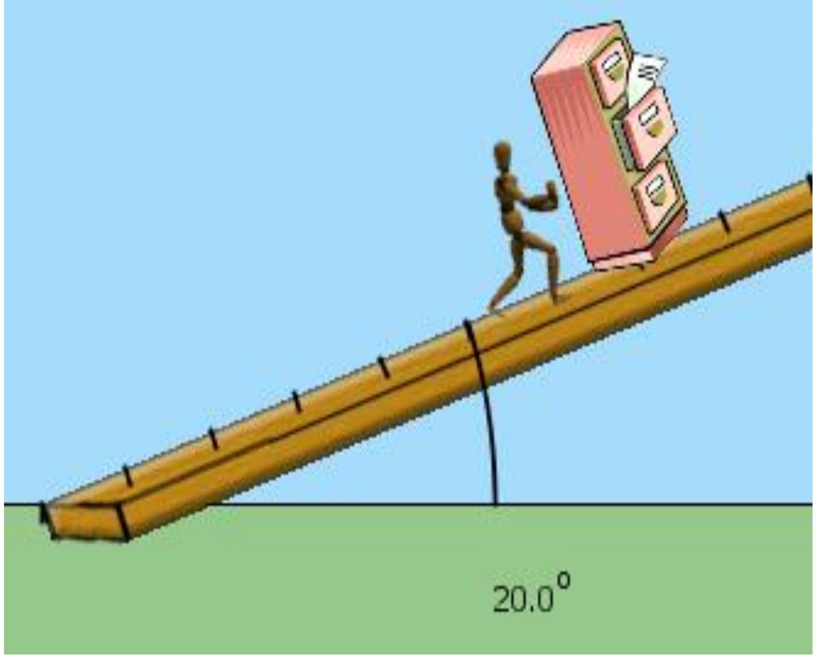
D

E no way to tell

5. Which would require less pushing force?



A



B

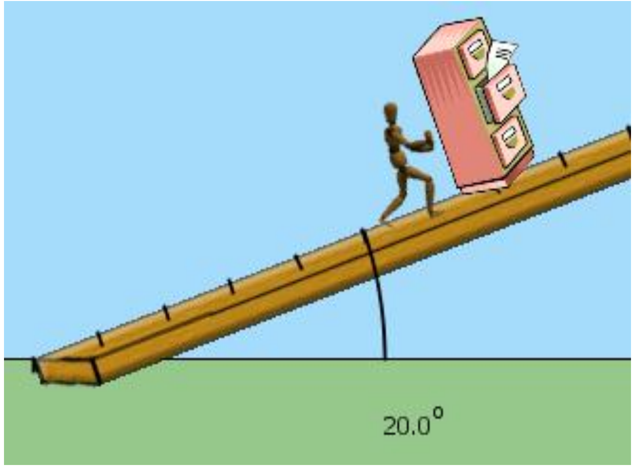
C no way to tell

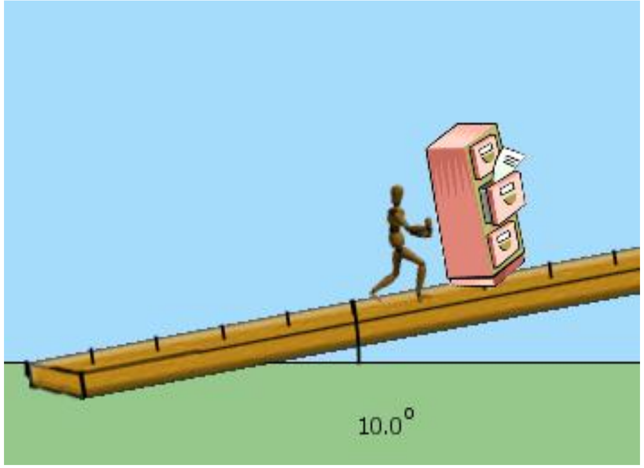
6.It could be easier to push on the 20° ramp, because

A. The friction force is less

B. The cabinet weighs less

C. It is easier to plant your feet



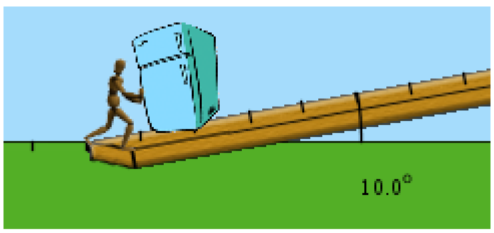


Student directions *Ramp: Force and Motion* activity 2: Calculating Net force on an incline
http://phet.colorado.edu 30 minutes

Learning Goal: Students will be able to calculate the net force on an object on an incline

1. Joe is moving his refrigerator to take to college and he begins by pushing it across the wooden kitchen floor.
On a flat surface like the floor, how do you calculate how hard he needs to push? Draw a free body diagram to help explain your answer and use the simulation ***Ramp: Force and Motion*** to check your ideas. Record the minimum force Joe would have to use to move the refrigerator on the kitchen floor.

2. Later, Joe is ready to load his refrigerator onto the moving truck.
   a. Explain how he would calculate how much force to use to lift the refrigerator straight up into a truck.
   b. Joe starts thinking about easier ways to get it in the truck and remembers he has some wood that he could use to make a ramp. How could he calculate the minimum force needed to push it up the ramp?



   c. Use the simulation to check your ideas by running experiments with different objects at several angles. Make a data table including several trials with the calculations.

Ramp angle	Weight (F_g)	$F_{gravity}$	$F_{friction}$	$F_{applied}$	Resulting motion (stationary, down ramp or up ramp)	Possible calculations to explain

Lesson plan for *Maze Game* 1: Using vector representations to move through a maze
Time for activity: homework for 20 minutes

Learning Goals: Students will be able to:

- Maneuver through the maze controlling position, velocity, or acceleration.
- Explain game strategies using physics principles.

Background: I used this activity at the end of Unit 3 Forces and the Laws of Motion (Chapter 4). The students will have completed 1D and 2D motion as well as applying the three laws in several situations.

Lesson: I gave this for homework like Perkins' did in the CU course. The link to Perkins' activity is http://phet.colorado.edu/teacher_ideas/view-contribution.php?contribution_id=478&referrer=/teacher_ideas/browse.php

Question 3: Perkins' wrote an example of a good answer:

> Acceleration is the (change in velocity)/(time elapsed). In this game, we have control over the acceleration vector whose direction indicates the direction in which the acceleration points and whose length indicates the magnitude of the acceleration. To minimize time, the puck must travel at a high average velocity. To achieve this under the acceleration control, a good strategy is to start with a large acceleration to the left until the puck is half way across the play area and moving fast. At that moment, reverse the acceleration so that it is large and to the right. The puck will continue to move left, but slow down at a steady rate. When the puck has slowed to a stop it should be nearly directly above the goal. Now accelerate rapidly in the direction of the goal.

Question 4: On any level, a collision with a wall, then reaching the goal says "**No Goal"**. However, if you backtrack over your collision icon, you erase it and then can get a **"Goal"**.

Post lesson: There are 4 clicker questions that could be used.

Student directions ***Maze Game*** activity 1: Using vector representations to move through a maze
Homework for 20 minutes

Learning Goals: Students will be able to

- Maneuver through the maze controlling position, velocity, or acceleration.
- Explain game strategies using physics principles.

Directions:

1. Use the **Practice** level of ***Maze Game*** to understand the controls for the game.

2. Play Level 1 using each of the 3 methods for control. To keep everyone on equal grounds, you must **Start Game,** from the **Reset** location. Keep track of your progress by filling out the table with at least three trials for each control. *You'll find that completing Level 1 under acceleration control is the most challenging, but is also a great way to gain an intuition for acceleration. The current record is 5.0 seconds!*

Type of control R (Position), V or A	Time or NG (no goal)	Number of Collisions	Score
R			
R			
R			
V			
V			
V			
A			
A			
A			

3. Describe your strategy for minimizing your time when using the acceleration control. Be sure to back your strategy with the physics principles.

4. Explain what you do to get **"No Goal"**. How can you get a **"Goal"** without selecting **Reset**?

5. Play with **Level 2** and track of your results in this table:

Type of control R (Position), V or A	Time or NG (no goal)	Number of Collisions	Score
R			
R			
R			
V			
V			
V			
A			
A			
A			

Maze game 1 clicker questions

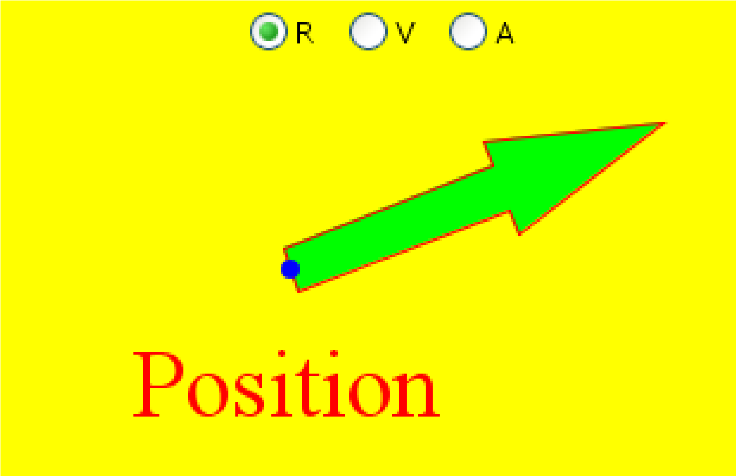
Learning Goals: Students will be able to

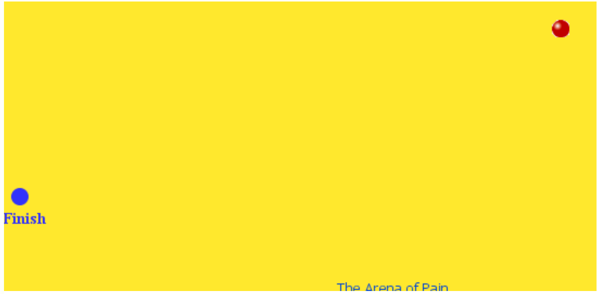
- Maneuver through the maze controlling position, velocity, or acceleration.

In activity, but not covered in clicker questions:

- Explain game strategies using physics principles.

1. Which one best shows where the red ball would be?



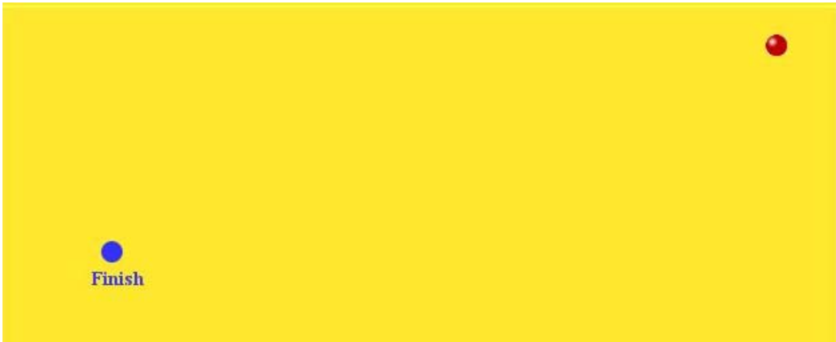


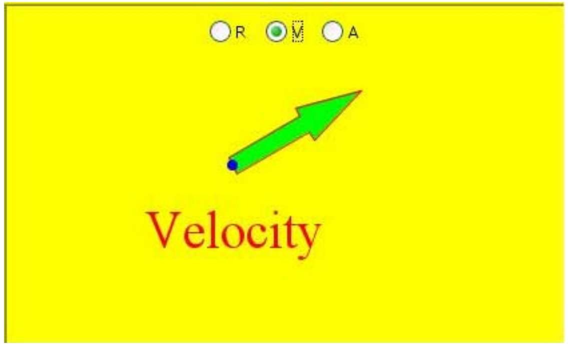
A

B

C

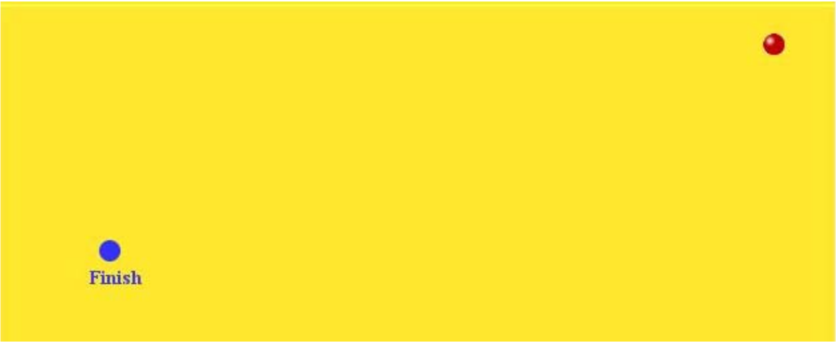
2. Which best describes how the red ball will move?



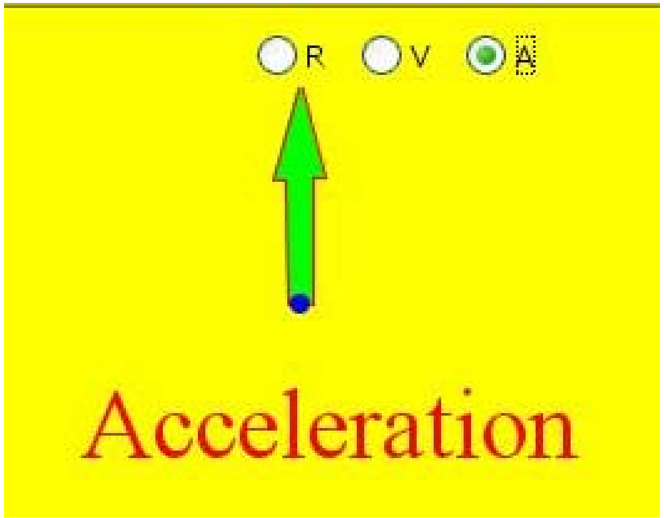


A. Up the page
B. Down the page
C. Toward the Finish
D. Away from the Finish
E. No way to predict

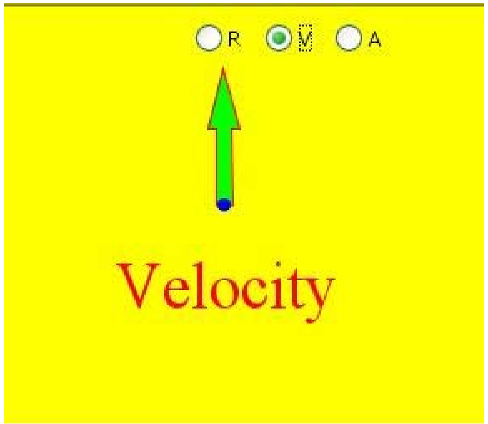
3. Which best describes how the red ball will move?



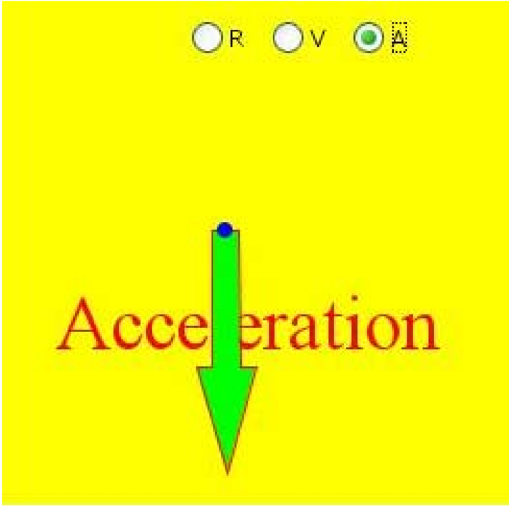
A. Up the page
B. Down the page
C. Toward the Finish
D. Away from the Finish
E. No way to predict



4. If you made the ball up down the page with this velocity vector, and the changed the acceleration to this vector, what would the ball do?



A. Change direction and go down the page immediately
B. Go up the page faster
C. Go up the page slower



Lesson plan for *Curve Fit*: How well does the curve describe the data?
Time for activity: 30 minutes (not yet tested)

Learning Goals: Students will be able to:

- Explain how the range, uncertainty and number of data points affect correlation coefficient and Chi squared.
- Describe how correlation coefficient and chi squared can be used to indicate how well a curve describes the data relationship.
- Apply understanding of *Curve Fitting* to designing experiments

Advanced optional goals:

- Differentiate between correlation coefficient and chi squared
- Use the equation for Chi squared to explain why a curve fit with a value near one describes the data well.
- Given a set of data without the χ^2 and r^2 displayed, (**No curve fit** selected to get a screen capture), predict which data will have a better curve fit.

Background:

I will use this in my College Physics course at Evergreen high school. The class covers first semester algebra based physics, but there is an emphasis on inquiry and lab design based on data evaluation. My students use Excel and TI graphing calculators to curve fit their data. We do not determine uncertainty in their labs. In the text, there is a short introduction and a few problems determining uncertainty. I plan to use this activity during their semester projects where they design an experiment and then try to improve the design. The improvement is generally measured by an improved r^2. I want to introduce them to Chi squared so that they will see that there are more complex tools to better describe science than r^2, but I do not expect them to digest the calculation.

I do not intend to address the advanced learning goals in the student directions or in my course, but I included them for other teachers to use.

***Curve Fitting* Introduction:**

The bars on the data points are labeled "error bars", but I decided to call them "uncertainty bars." Technically, the half-length of the error bar is equal to one standard deviation.

You can zoom in on any Flash sim to show something well by right clicking. Clicking on the Help shows many of the features. The bucket of points can be dragged to any location; I used this feature as I made screen captures. In my lesson, I thought it would be better for the students to start their exploration using the default uncertainty bars to help constrain the variables that they are investigating.

Lesson:

I will go over the learning goals and remind the students what "range" means and "known shape of curve". *Range is the spread of the x values. Range as it applies to experimental design, is the spread of the independent variable. By" shape", I mean Linear- a line, quadratic-parabolic, etc*

Lesson plan for *Curve Fit*: How well does the curve describe the data?
Time for activity: 30 minutes (not yet tested)

Also, I will point out that the directions encourage them to constrain the variables that they are using to investigate curve fitting by not varying the uncertainty bars until question 5. *Just like any good experiment.*

My students work in pairs with a printed copy of the student instructions for guidance. The activity should take my college physics students about 30 minutes. I have not used this lesson in class yet.

My notes about the questions:

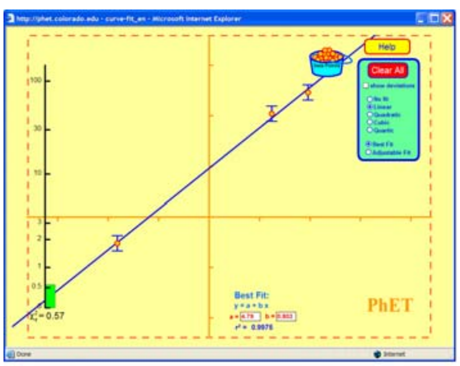
1: For each of the four types of curve fit, what is the minimum number of points *(using the default uncertainty bars)* to get a good correlation and a curve that demonstrates the known shape for the curve?

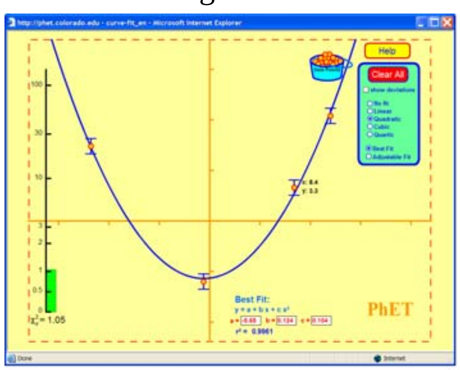
2 points give a perfect correlation for any curve, but the appropriate shape of the curve will not be see until you have one above the order. The correlation will still be one.

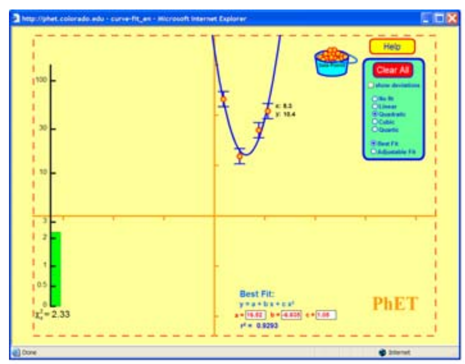
2: For each of the four types of curve fit, what is the minimum number of points*(using the default uncertainty bars)* to get in the green zone with a good correlation?

I can get in the green zone for linear with only three points if I have a wide range for the data.

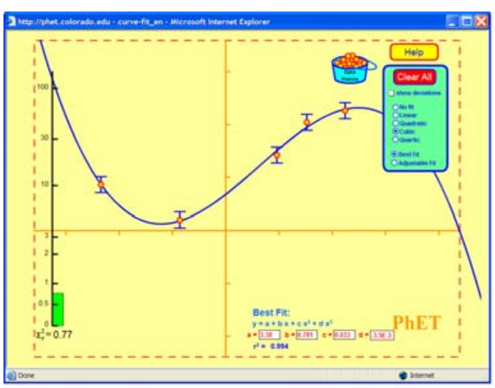
Quad 4 points. I started with wide range because it seemed reasonable, but I made another trial that worked with small range.

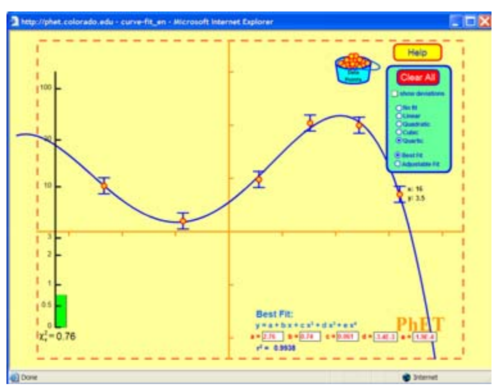






I made a good cubic easily with wide range with 5 points. And quartic with 6.





Lesson plan for *Curve Fit*: How well does the curve describe the data?
Time for activity: 30 minutes (not yet tested)

3: How can you desensitize the coefficient to change? In other words, if you collect data that would not fit on the line, under what conditions would r^2 stay nearly the same? Is χ^2 desensitized the same way?
Use more points with a wide range but χ^2 is still very sensitive with the default uncertainty bars; you would need to use larger uncertainty to desensitize χ^2 .

4: What is the relationship between the χ^2 red zone and the correlation coefficient?
There is not a mathematical relationship, but in general, if you are looking at the χ^2 and make changes to the data that increases the red zone, r^2 decreases. ie χ^2 getting larger when it is greater than one decreases r^2

5: Given two situations of data points, identify which is better and explain how the data variations changed the quality of the fit. (May need to add text boxes with r^2 if the values on question 5 are not readable)
If all the points lie on the curve there will be a poor χ^2 no matter what. But if the points do not lie on the curve, then increasing the uncertainty bars can improve χ^2 . I am hoping that the students will be able to discover this relationship without using the equation. [Using the equation: $y(x_i)$- y_i and σ (or Δy), the uncertainty, are more similar so more terms in the sum are closer to 1, if there are no deviations (points all lie on line), then the sum will be zero.]

a. Better fit on left. Same data points, so same r^2 but different uncertainty bars. Since the bars touch the curve the χ^2 will improve.
b. Better fit on right. The r^2 is improved because more data points lie near the line and χ^2 improved because more uncertainty bars touch the curve.
c. Better fit on right. The r^2 is improved because more data points lie near the line and χ^2 improved because more uncertainty bars touch the curve.

6: How does your of understanding χ^2 and r^2 help you with your experimental design?
We don't calculate data uncertainty in our labs, but the students should recognize that range should be maximized as well as the number of data points. Also that they can get a great r^2, but not really have determined an appropriate curve; it is important for them to consider how known physics can be used to decide on the order of the equation. Sophisticated experimental design would require determining uncertainty.

Advanced Learning goals:
1. Differentiate between correlation coefficient and chi squared
On a very basic level, both include deviation from the predicted y value, but Chi squared includes uncertainty of the data. The correlation coefficient depends heavily on the deviation. When the uncertainty and the deviations are similar, then Chi squared is near one and indicates a high quality of fit.

2. Use the equation for Chi squared to explain why a curve fit with a value near one describes the data well.

The reduced chi squared statistic is

$$\chi_r^2 = \frac{1}{N-f}\sum_i \frac{[y(x_i)-y_i]^2}{\sigma_i^2}$$

In an experiment, one measures a series of x-values: x_1 , x_2, x_3..x_i .. x_N. and corresponding y-values: y_1 , y_2, y_3... The i^{th} measurement is the pair (x_i , y_i). We assume that the uncertainties in the x-values are negligibly small; the uncertainty in y_i , due to uncertainties in the measurement, is given by σ_i (or Δy_i). The best-fit curve to the data is given by a function y = y(x) , so the quantity $y(x_i)$ is the predicted value of y (predicted by the best fit curve) at the x-value x_i. The difference [$y(x_i)$ - y_i] is the discrepancy between the measured y_i and the predicted value $y(x_i)$. This difference is called the *deviation*. For one point, we expect that the deviation is roughly equal to the uncertainty σ_i, so the ratio $[y(x_i) - y_i]/\sigma_i$ is about 1 and so also is the ratio-squared: $[y(x_i) - y_i]^2/\sigma_i^2$. If all N points were like this (ratio-squared ≈ 1) and you added up the N ratios for the N data points, and then divided by N : you would get $\frac{1}{N}\sum_i\left(\frac{y(x_i)-y_i}{\sigma_i}\right)^2 \approx 1$.

This situation is complicated by the fact that the function y = y(x) is not the *true* curve, but instead, it is the *best-fit* curve to the data. If there is very little data, the best fit curve will always fit the data well (it's the *best fit*, after all), regardless of the errors in the data. Because of this, the ratios $[y(x_i) - y_i]/\sigma_i$ are generally smaller than they would be if y(x) were the *true* curve. For instance, if there are only 3 data points (N = 3), and we perform a 3-parameter (quadratic) polynomial fit (f = 3), then the fit will always pass through the 3 points exactly, all the deviations will be zero, and the quantity $\sum_i\left(\frac{y(x_i)-y_i}{\sigma_i}\right)^2$ will be exactly zero. To compensate for the fact that y = y(x) is not the true curve, we must perform a fix: instead of dividing by N we divide by (N – f) where f is the number of degrees of freedom in the fit. The resulting quantity

$$\chi_r^2 = \frac{1}{(N-f)}\sum_i\left(\frac{y(x_i)-y_i}{\sigma_i}\right)^2$$

is called the *reduce chi-squared*. Because we divide by (N-f) instead of N, the reduced chi-squared is undefined unless N > f. For the case N>f, it turns out that the reduced chi-square is about one, as we expect.

Student directions *Curve Fitting* activity: How well does the curve describe the data?
50 minutes untested

Learning Goals: Students will be able to:

- Explain how the range, uncertainty and number of data points affect correlation coefficient and Chi squared.
- Describe how correlation coefficient and chi squared can be used to indicate how well a curve describes the data relationship.
- Apply understanding of *Curve Fitting* to designing experiments

Directions:
Without changing any of the uncertainty bars, explore *Curve Fitting* to answer 1-4:

1. For each of the four types of curve fit, what is the minimum number of points to get a good correlation **and** a curve that demonstrates the known shape for the curve?

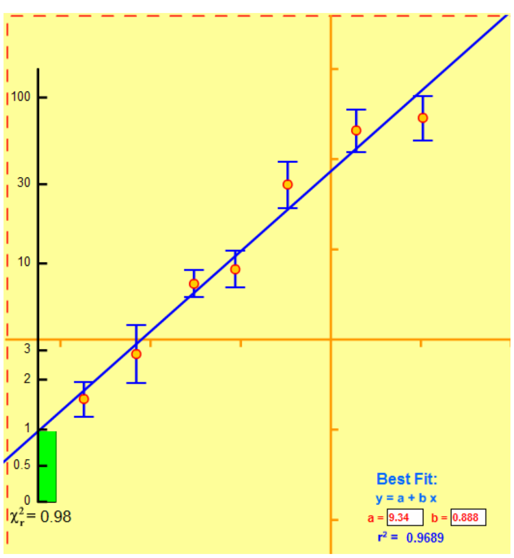
2. For each of the four types of curve fit, what is the minimum number of points to get in the green zone for χ^2 **and** a good correlation?

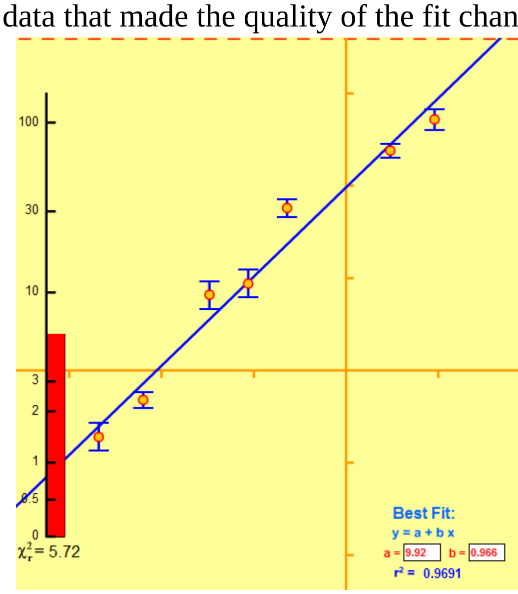
3. How can you desensitize the coefficient to variation in data? (In other words, if you collect data that would not fit on the line, under what conditions would r^2 stay nearly the same?) Is χ^2 desensitized the same way?

4. Summarize the relationship between the χ^2 red zone and the correlation coefficient. Include illustrations or screen captures to support your reasoning.

5. Explore how varying the uncertainty bars affects χ^2 and r^2 and then answer these questions.

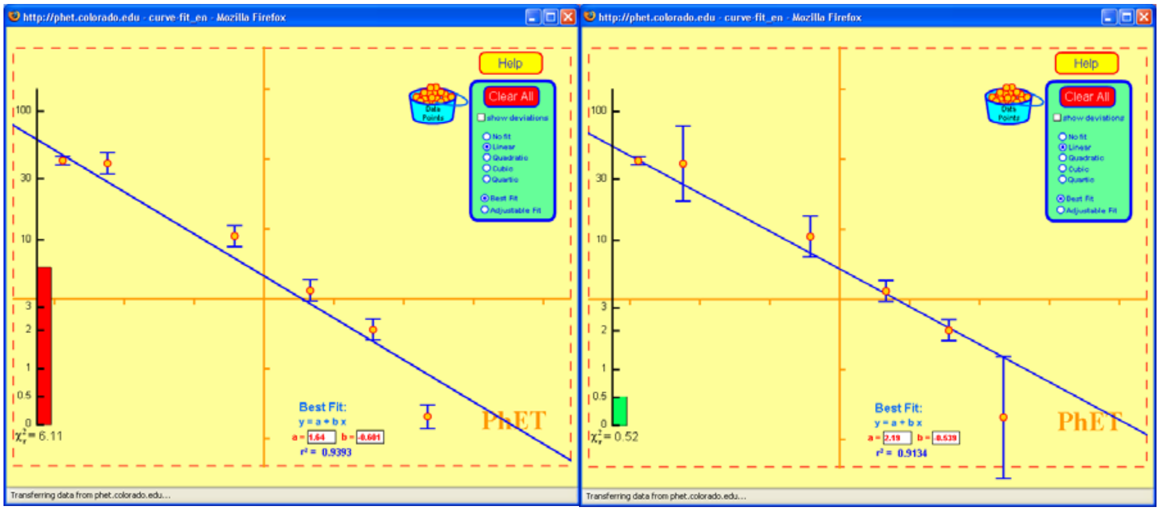
   a. Two experiments were run and these graphs show the results. Which experiment has a curve fit that describes the relationship the best? What is your reasoning? Describe what is different about the data that made the quality of the fit change.



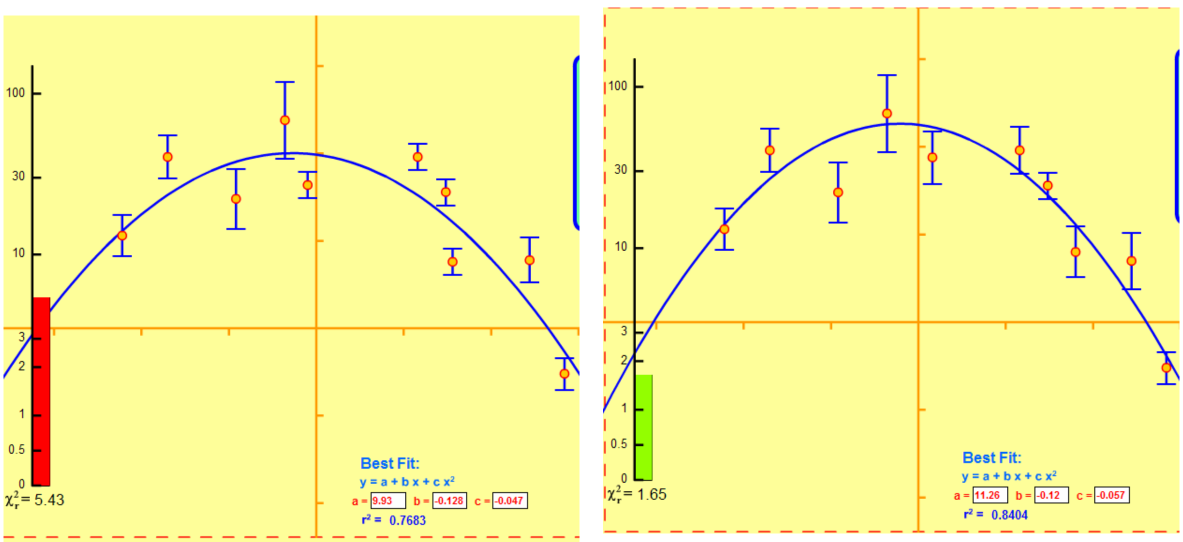


Student directions *Curve Fitting* activity: How well does the curve describe the data?
50 minutes untested

b. Which is best and why?



c. Which is best and why?



6. How does your understanding of χ^2 and r^2 help you with experimental design?

Unit 4: Conservation Laws/ Energy and Momentum

Learning goals-Students will be able to :

Collision Lab:

- Draw "before-and-after" pictures of collisions.
- Construct appropriate vector representations of "before-and-after" collisions.
- Identify what variables are conserved and under what conditions.
- What does "elasticity" mean?
- Identify vector and scalor quantities.

Energy Skate Park:

- Explain the Conservation of Mechanical Energy concept using kinetic and gravitational potential energy.
- Describe Energy -Pie, -Bar, and -Position Charts from position or selected speeds.
    - Explain how changing the Skater affects the situations above.
    - Explain how changing the surface friction affects the situations above.
- Predict position or estimate of speed from Energy -Pie, -Bar, and -Position Charts
- Look at the position of an object and use the Energy -Pie, -Bar, and -Position charts to predict direction of travel or change in speed.
- Calculate speed or height from information about a different position.
- Describe how different gravity fields effect the predictions.

Masses and Springs:

- Explain the Conservation of Mechanical Energy concept using kinetic, elastic potential, and gravitational potential energy
- Understand how the mass of an object is determined using spring balances and use the balance to determine the mass of an unknown object.

Work and Energy

Work

- Recognize the difference between the scientific and the ordinary definitions of work.
- Define work, relating it to force and displacement.
- Identify where work is being performed in a variety of situations.
- Calculate the net work done when many forces are applied to an object.

Energy

- Identify several forms of energy.
- Calculate kinetic energy for an object.
- Distinguish between kinetic and potential energy.
- Calculate the potential energy associated with an object's position

Conservation of Energy

- Identify situations in which conservation of mechanical energy is valid.
- Recognize the forms that conserved energy can take.
- Solve problems using conservation of mechanical energy.

Work, Energy, and Power

- Apply the work-kinetic energy theorem to solve problems.
- Relate the concepts of energy, time, and power.
- Calculate power in two different ways.
- Explain the effect of machines on work and power.

Momentum and Collisions

Momentum and Impulse

- Compare the momentum of different moving objects.
- Compare the momentum of the same object moving with different velocities.
- Identify examples of change in the momentum of an object.
- Describe changes in momentum in terms of force and time.

Conservation of Momentum

- Describe the interaction between objects in terms of the change in momentum of each object.
- Compare the total momentum of two objects before and after they interact.
- State the law of conservation of momentum.
- Predict the final velocities of objects after collisions, given the initial velocities.

Elastic and Inelastic Collisions

- Identify different types of collisions.
- Determine the decrease in kinetic energy during perfectly inelastic collisions.
- Compare conservation of momentum and conservation of kinetic energy in perfectly inelastic and elastic collisions.
- Find the final velocity of an object in perfectly inelastic and elastic collisions.

7/20/2013 Many of the learning goals are adapted from Holt Physics Serway and Faughn, 2000.

Unit 4 Semester 1
Work, Energy, Momentum and Collisions; Lab reports Introduction, sample calculations and using Excel for calculations

1 Notes: Momentum and impulse
Lab 1: Linear elastic Find momentum of a cart with very different speeds
In an Excel document: Make a table, show calculations, get instructor's signature
Lab2: *Collision Lab* 1PhET
Do: read and do text problems, questions

2 Notes: conservation of momentum, linear elastic collisions, Intro to labs and sample calculations
Lab 3: Linear elastic collision Lab part 2
Design a variety of collisions to compare: vary the speed of first cart, the mass of the first cart, and the mass of the second cart (Five trials per collision include each trial in data table)
Turn in: Header/Footer, Introduction (thesis and background), Summary data table, Sample calculations for p_i, p_f, and % error, Discussion (thesis, results, how the results relate to known physics, error analysis).
Do: read and do text problems, questions

3 Notes: Writing introductions and discussions, Inelastic and 2D collisions
Lab 3: Write elastic collision lab
Do: read and do text problems, questions

4 Notes: Energy forms and conservation of mechanical energy, work calculations
Lab 4: *Energy Skate Park* Activity 1 PhET
Do: read and do text problems, questions

5 Notes: Calculations for kinetic energy, and potential energy, clicker questions act 1
Lab 5: *Energy Skate Park* Activity 2 PhET
Do: read and do text problems, questions; finish *Energy Skate Park* Activity 2 PhET

6 Reflect on returned labs, clicker questions activity 2
Lab 6: Potential energy to kinetic using carts and photogates
Turn in: Header/Footer, Introduction (background, & thesis), Procedure with diagram of equipment, Summary data table of 30 trials, Final graph of KE vs PE with an equation with r^2, Discussion (thesis, results, how the results relate to known physics, error analysis)
Do: read and do text problems, questions

7 Lab 6: finish PE KE lab

8 Notes: Energy in collisions, Power
Labs7 and 8: Quick lab running up stairs, *Energy Skate Park* Activity 3 PhET
Do: read and do text problems, questions

9 Notes: clicker questions activity 3, Discuss semester projects, Research background.
Lab 9: *Masses and Springs* Conservation of Energy PhET

10 Notes: clicker questions *Masses and Springs*
Lab 10: *Energy Skate Park* Activity 4 PhET
Do: read chapter summaries, read and do text problems,

11 Review study & test taking skills, clicker questions activity 4,
Lab: Sign up for a project, write materials list. (**Thesis Due test day)**
Do: questions and standardized testing practice

12 **TEST**

09-10 7/7/2013 optional p 329 (21,24,26,30,55)

Lesson plan for *Collision Lab*: Introduction to One Dimension collisions

http://phet.colorado.edu

I used this for a home work.

Learning Goals:

- Draw "before-and-after" pictures of collisions.
- Construct appropriate vector representations of "before-and-after" collisions.
- Identify what variables are conserved and under what conditions.
- What does "elasticity" mean?
- Identify vector and scalor quantities.

Background:

The students will be doing a lab in class using physics carts (low friction and allow fairly elastic collisions) and photogates to determine the momentum of a single cart from the velocities and then some "before and after" momenta for carts of varying mass. I am using the sim to help them understand which measurements are vectors and which are scalors, and also to enable them to distinguish between conserved quantities and those that are not. This is the first conservation law that we are encountering in the semester sequence.

Collision Lab **Introduction:**

Restart is helpful for the students to replay an experiment. **Reset All**, will set the sim back to 2D. The Tips for Teachers for this sim may be helpful.

Lesson:

This is a home work assignment; my students can do PhET activities in pairs if they want and many use the school computers to do online homework. I expect to write some clicker questions to use as a post-lab. This lesson was used when the sim was still in development. I expect to do some revisions.

PhET Collision Lab: Introduction in One Dimension

Homework assignment which may be done with a partner

Learning goals:

- Draw "before-and-after" pictures of collisions.
- Construct appropriate vector representations of "before-and-after" collisions.
- Explain what variables are conserved and under what conditions.
- What does "elasticity" mean?
- Identify vector and scalar quantities.

Directions:

1. Experiment with one-dimension elastic collisions **(Check 1d and set elasticity at 100%).** Make a table like this to help you organize your thoughts about collisions; use landscape layout so you can fit everything; "x" means there would not be a drawing in that box. Try varying mass and initial speed (including some initial zero velocity). I am expecting several trials. The ***Restart*** button is handy for replaying an experiment.

	Mass 1	Mass 2	Initial velocity 1	Initial velocity 2	Initial total velocity	Initial total momentum	Kinetic energy initial	Final velocity 1	Final velocit y 2	Final total velocity	Final total momentum	Kinetic energy final
Trial 1												
Pictures of balls with vector	x	x					x					x
More trials												
Pictures of balls with vector	x	x					x					x

2. Think about the relationships you observed and then answer these questions:
    a. What the difference between the quantities that have vector drawings and the ones that don't?
    b. In your own words, what does "elastic collision" mean?
    c. List quantities that have the same value (and direction if a vector) before and after the collision. If a quantity has the same value (and direction if a vector), it is said to be "conserved"
    d. What quantities are not "conserved"?
    e. Run one more experiment to check your answer to 2c and 2d. Describe your experiment and explain how it supports your answers.

3. Try some of the experiments again, varying the elasticity. Record your results in a similar data table, but add a column for "elasticity".

4. Describe:
    a. Any changes you need to make to your definition of "elastic collision" from 2b.
    b. Adaptations to your ideas about quantities that are conserved when the elasticity is varied.

Lesson plan 1 for *Energy Skate Park:* Introduction to Conservation of Mechanical Energy
Time for activity 50 minutes http://phet.colorado.edu

Learning Goals: Students will be able to

- Explain the Conservation of Mechanical Energy concept using kinetic and gravitational potential energy.
- Design a skate park using the concept of Mechanical energy

Background:

Students, in general, know about conservation of energy. For example, they can tell you that energy comes from the sun and is converted by plants into food. It is unlikely that my students have done any quantitative analysis. In class lecture, kinetic, elastic potential, and gravitational potential energy will be defined accompanied by common demonstrations. This is the first of 4 Energy Skate Park activity and I also used an activity with Masses and Springs. My students are familiar with Excel and so I decided to use the term "chart" for the graphs and chart like it does.

PreLesson: There are some Pre-lesson questions (see the power point associated with this lesson) adapted from Karen King's lesson published in the activity database.

1. Say: "Draw pictures showing something that has a lot of potential energy and something that does not." Display the ppt that goes with this lesson. (slide 1)
2. Explain why you think the object on the left has more potential energy. (slide 2)
3. Now draw pictures for kinetic energy. (slide 3)
4. Explain why you think the object on the left has more kinetic energy. (slide 4)

(The other slides are clicker questions for after the students do the lab)

***Energy Skate Park* Introduction:**

I think I'll show how to add track and the **Return Skater** and **Clear Heat** buttons are really handy for repeating experiments or running an experiment once the Skater doesn't leave the track. Also, if you can resize the windows when you open the graphs and charts, to make them fit.

***Energy Skate Park* Helpful hints for teachers**:

1. I often make a track that I want to project for class discussion and then save it.
2. You can Pause the sim and then put the Skater wherever you like easily. Then the **Return Skater** will let you rerun the scenario.
3. When the Skater lands on the track, the vertical component of his kinetic energy is converted to thermal energy. You can do experiments where there is only PE and KE by making sure he doesn't leave the track. One way to do that is to right click on a track, you can make in into roller coaster mode.
4. The thermal energy can be "zeroed" using the **Clear Heat** button.
5. **Return Skater** and **Bring Back the Skater** *(name changes with the character)* buttons puts the character at the location that the user last let go.
6. The **Energy Position Graph** erases, but you can **Pause** the simulation and the graph will not change. The **Copy** button will let you freeze the graph to compare different scenarios, but it cannot be saved as a file. If you Zoom, the graph clears; you can make a new graph by rerunning your scenario using **Return Skater**.

7. **Step** is a good way to incrementally analyze. It is very useful to have the students make predictions. The button next to **Play** in the large window moves the character forward in time. The button in the **Energy Time** window moves the vertical curser on the graph (Steps through the Playback).
8. If you use the **Show Path** feature, then you can click on the purple dots and show quantitative information about the energies. Click again to hide. Height refers to height from Potential Energy Reference line.

Lesson: Have the students use the lab sheet for guidance. The activity took my honors physics students about 40 minutes.

Post lesson:
I have written some clicker questions. I saved the tracks that are in the questions so I can easily prove the answers. Go through questions 1-4 and then show the answers using the saved track. Go through 5-7, then show the answers using the second saved track.

Next lesson: Energy Skate Park activity 2. The learning goals are specific to chart interpretation and chart prediction.

Student directions *Energy Skate Park* activity 1:
Introduction to Conservation of Mechanical Energy
http://phet.colorado.edu

Learning Goals: Students will be able to

- Explain the Conservation of Mechanical Energy concept using kinetic and gravitational potential energy.
- Design a skate park using the concept of Mechanical energy

1. Investigate what affects the skater's path and discuss your ideas with your partner. You should try adding some track, changing shapes or building jumps. (There's no friction on the track)

2. Explain how you could use your investigation to plan a track that is fun, challenging and one that is relatively safe. You might think for example: When does he: fly off an end? make it to the top a hill? or land a jump?

3. Build a good track and sketch it. Then use the Energy Graphs to study the Skater's energy.
   - Decide which graphs or chart best helps you understand what makes your track successful
   - Look in your textbook to find out what the Conservation of Mechanical Energy means and explain it in your own words.
   - Explain why your track is successful in terms of Conservation of Mechanical Energy. Include drawings of the Chart or Graphs to help explain your reasoning.

4. Using the Law of Conservation of Mechanical Energy, explain what things need to be considered when designing **any** successful track.

Prelesson first question

Lots of Potential Energy	Not a lot of Potential Energy

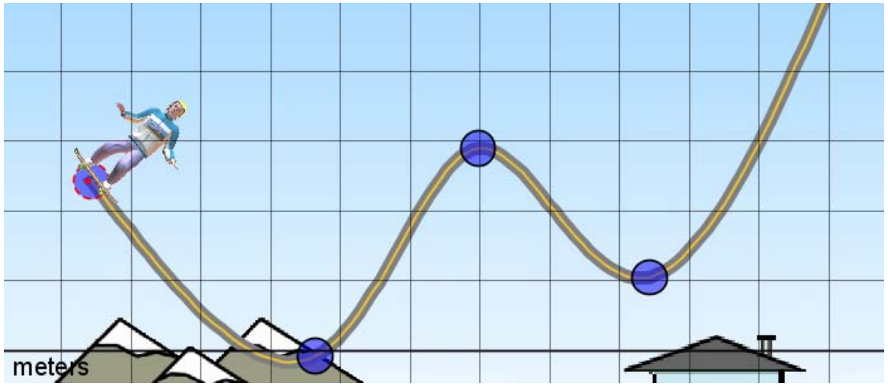
Explain why you think one has more potential energy

Prelesson third question

Lots of Kinetic Energy	Not a lot of Kinetic Energy

Explain why you think one has more kinetic energy

1. Do you think the Skater will make it over the first hump?

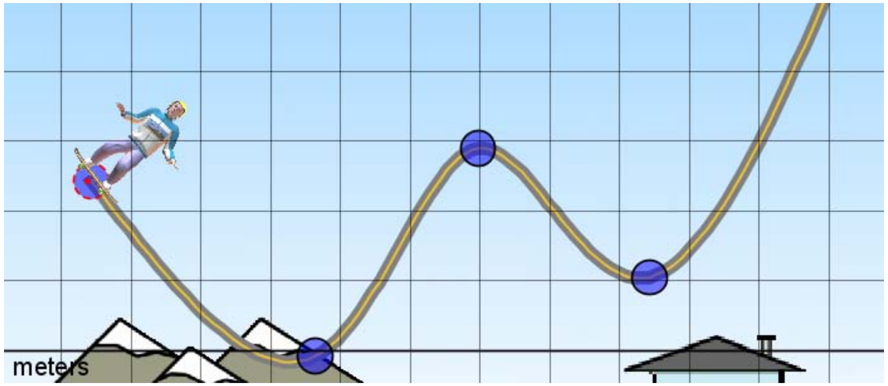


(No friction on the track)

A. No, because his potential energy will be converted to thermal energy
B. No, because he doesn’t have enough potential energy
C. Yes, because all of his potential energy will be converted to kinetic energy
D. Yes, because some of his energy will be potential and some kinetic

2. Do you think the Skater will make it over the first hump?

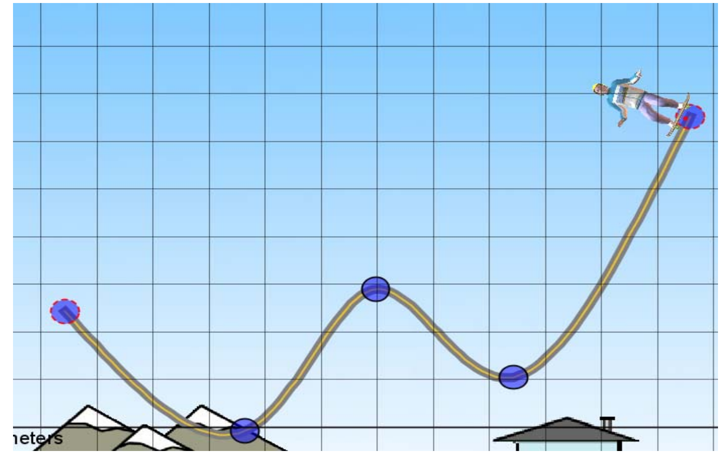
(lots of track friction)



A. No, because his potential energy will be converted to thermal energy
B. No, because he doesn't have enough potential energy
C. Yes, because all of his potential energy will be converted to kinetic energy
D. Yes, because some of his energy will be potential and some kinetic

3. Do you think the Skater will make it over the first hump?

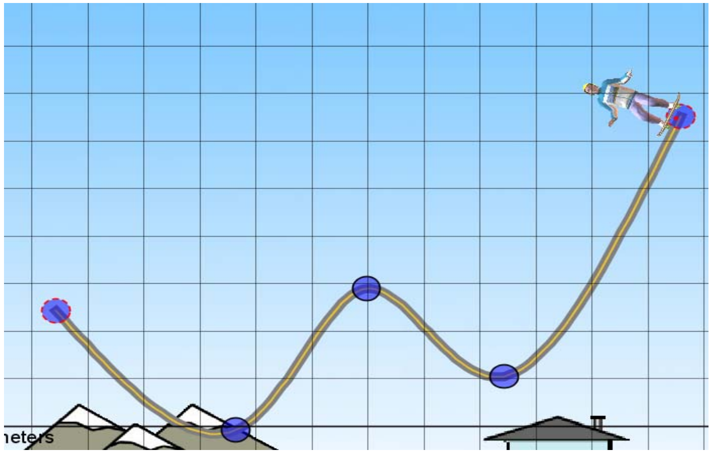
(No friction on the track)



A. No, because his potential energy will be converted to thermal energy
B. No, because he doesn't have enough potential energy
C. Yes, because all of his potential energy will be converted to kinetic energy
D. Yes, because some of his energy will be potential and some kinetic

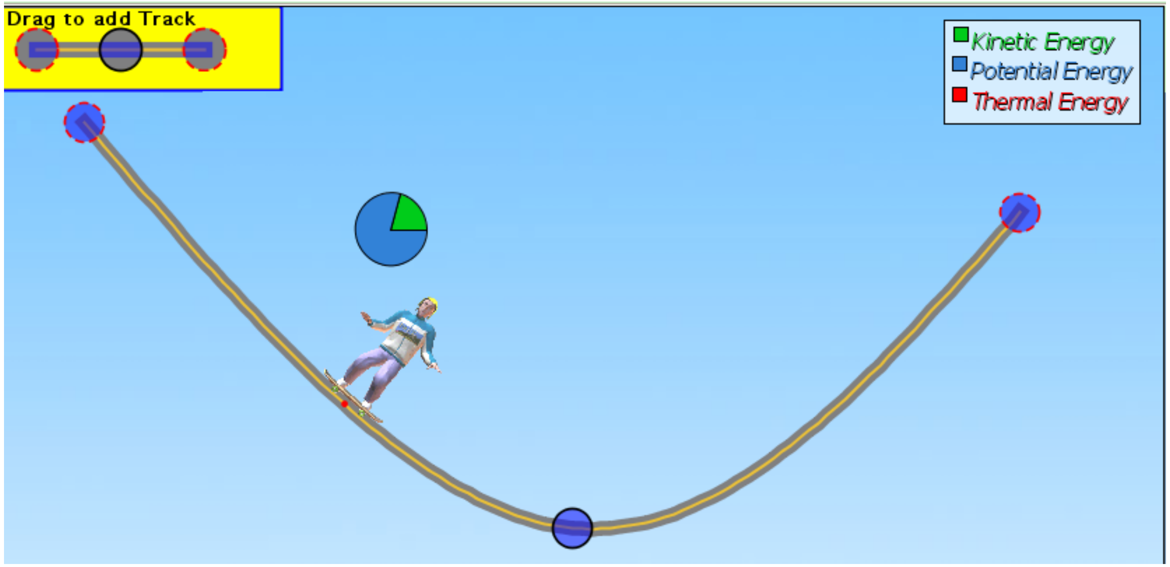
4. Do you think the Skater will make it over the first hump?

(lots of track friction)



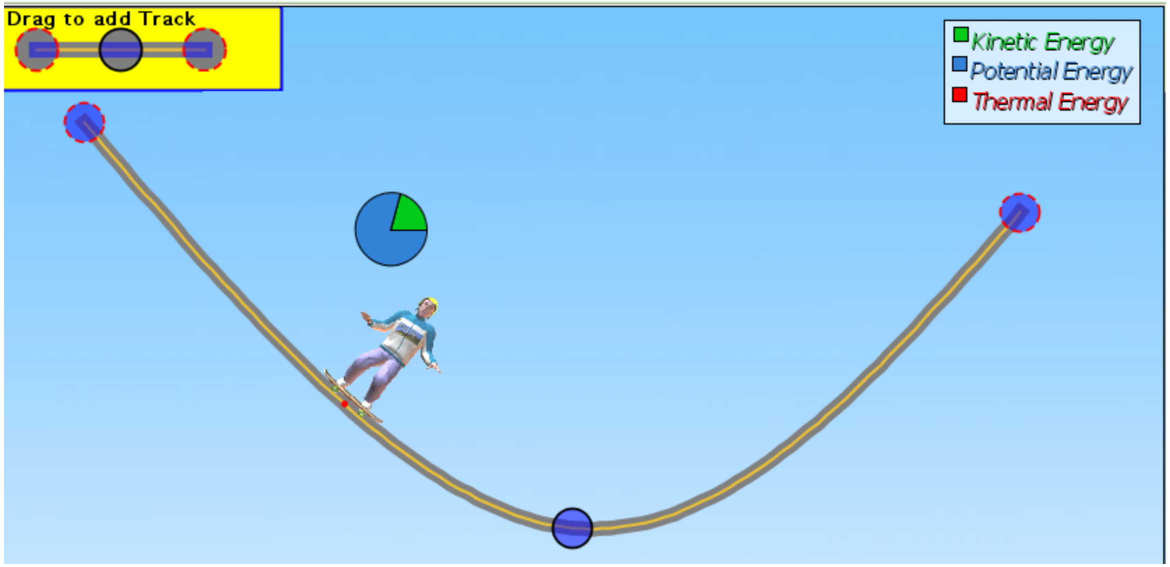
A. No, because his potential energy will be converted to thermal energy
B. Yes, if not too much energy is converted to thermal
C. Yes, because all of his potential energy will be converted to kinetic energy
D. Yes, because some of his energy will be potential and some kinetic

5. In the next moment, the KE piece of the pie gets larger, then



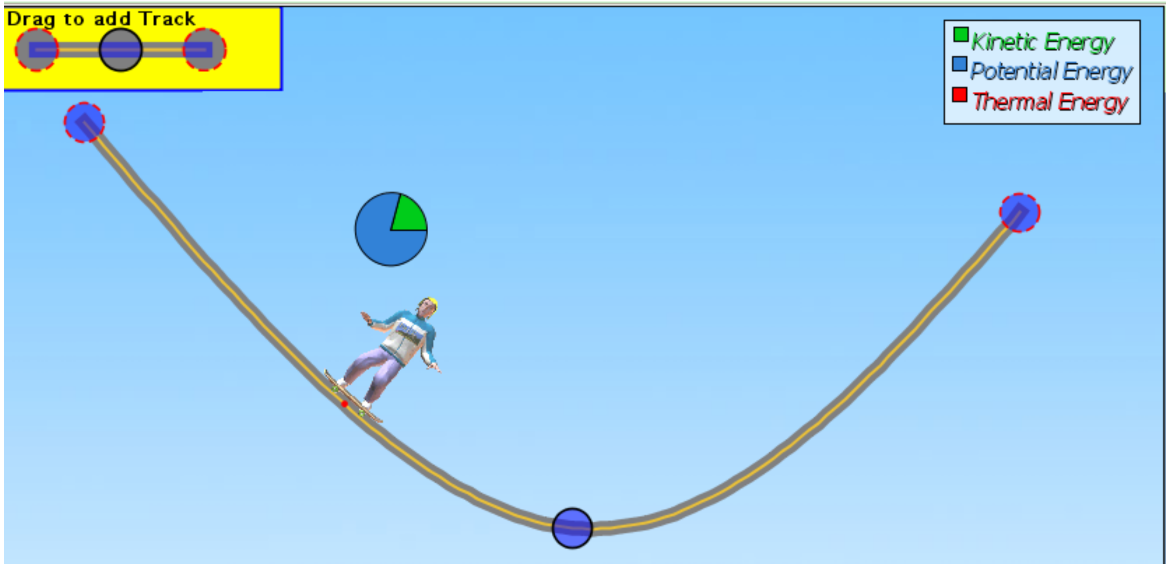
A. The Skater is going up hill (left)
B. The Skater is going down hill (right)
C. There is no way to tell

6. In the next moment, the KE piece of the pie gets larger, then



A. The PE part stays the same
B. The PE part gets larger too
C. The PE part gets smaller
D. There is no way to tell

7. In the next moment, the KE piece of the pie gets larger, then



A. The Skater will be going faster

B. The Skater will be going slower

C. There is no way to tell

Lesson plan for *Energy Skate Park* Activity 2:
Relating Graphs, Position and Speed (no time graphs)

Time for activity 100 minutes

Learning Goals

Students will be able to:

1. Describe Energy -Position, -Bar, and -Pie Charts from position or selected speeds. *My thoughts about "selected" are zero, maximum, ½ max, etc*
    a. Explain how changing the Skater affects the situations above. *The simulation treats all the objects the same (the same contact area and center of mass is one the track), so changing the type only changes the mass.*
    b. Explain how changing the surface friction affects the situations above.
2. Predict position or estimate of speed from Energy -Position, -Bar, and -Pie Charts
3. Look at the position of an object and use the Energy -Position, -Bar, and -Pie charts to predict direction of travel or change in speed. *By "change in speed" I mean increasing or decreasing if for example the graph shows increasing PE, decreasing KE etc.*

Possible Extension: How does changing PE affect chart?

Background:

My students will have done Energy Skate Park Activity 1 and some concept questions from the text.

Energy Skate Park **Introduction:**

Since my students will have done my first lesson, I won't have to show much how to use the simulation. I'll show a track with the Energy-Position chart and discuss the purpose of the vertical line. If you use Pause and Step this is easy to explain. In the first lesson plan, there are some hints that might be useful. My students are familiar with Excel and so I decided to use the term "chart" for the graphs and chart like it does.

Pre-Lesson: I projected clicker questions 1-3 to have the students think about their present understanding, but I wouldn't go over the answers until the post-lesson. The track is saved under CQ 1-3.

Lesson:

Have the students use the lab sheet for guidance. The activity took my honors physics students about 100 minutes.

Post lesson: Use the clicker questions with the simulation during discussion of the answers. I would open Skater and the track for questions 1-3 before class and change the character to the female one because the track saves with the male skater. The blue dots on the questions were drawn in paint and I couldn't make the same track using track pieces to get the blue dots. The track for the next questions are saved too.

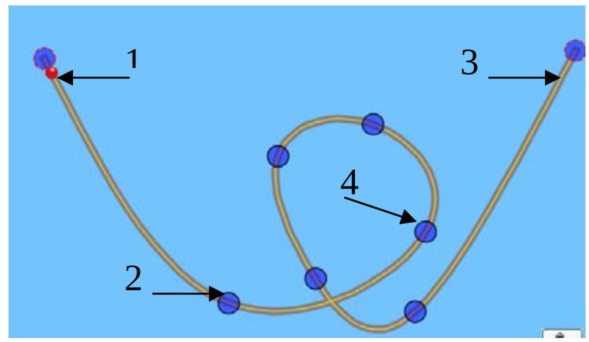
Next lesson: Energy Skate Park 3 Speed and Height calculations.

Student directions *Energy Skate Park* Activity 2:
Relating Graphs, Position and Speed (no time graphs)
http://phet.colorado.edu

Learning Goals: Students will be able to:

1. Describe Energy -Pie, -Bar, and -Position Charts from position or selected speeds.
   a. Explain how changing the Skater affects the situations above.
   b. Explain how changing the surface friction affects the situations above.
2. Predict position or estimate of speed from Energy -Pie, -Bar, and -Position Charts
3. Look at the position of an object and use the Energy -Pie, -Bar, and -Position charts to predict direction of travel or change in speed.

1. Josie made a *frictionless* hot wheel track that looks like the one shown. She placed a red rubber ball on the left top of track at 1.
   a. Make a data table like the one below
   b. Fill in the Prediction column by sketching what you think the Pie chart will look like for the ball at points 1-4.
   c. Use the **Loop Track** with the **Ball** Skater to test your ideas and make any adjustments



	Pie chart		
	Prediction	Simulation	Explain differences
1			
2			
3			
4			

2. Pretend that Josie can magically change the ball to different things like the simulation can.
   a. What do you think would change about the Pie Charts?
   b. Explain why you think the charts would similar or different.
   c. Check your reasoning using the simulation and make corrections if necessary.

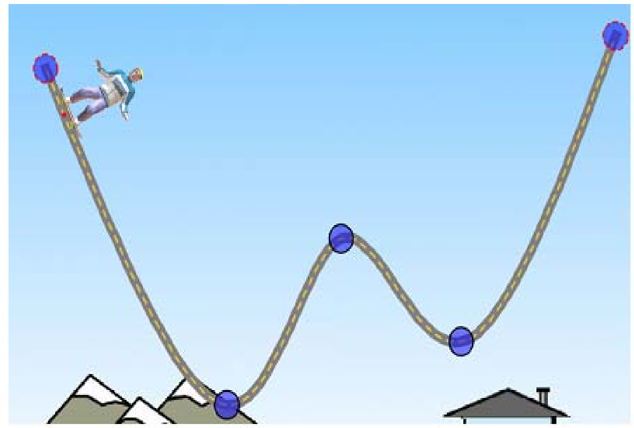
3. Josie has a friend, Phillip that can magically change the friction on the track like the simulation can.
   a. What do you think would change about the Pie Charts?
   b. Explain why you think the charts would similar or different.
   c. Check your reasoning using the simulation and make corrections if necessary.

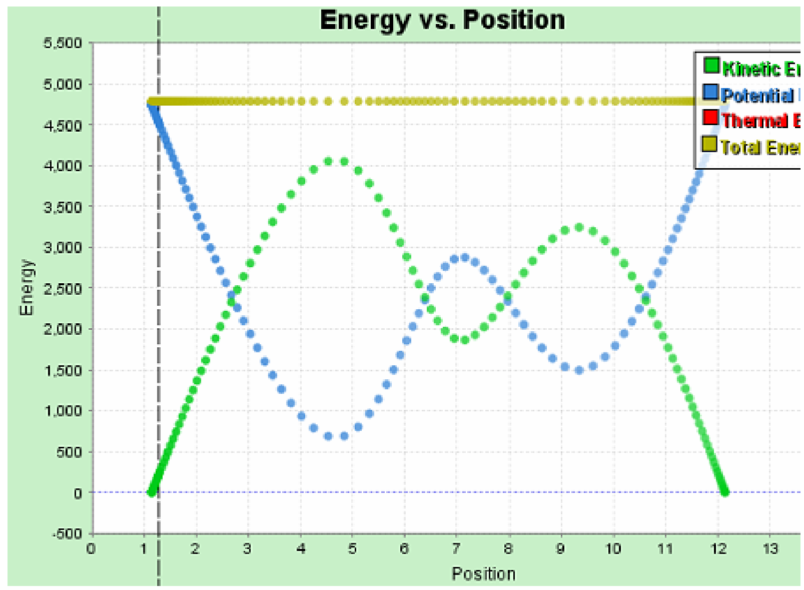
4. Work with your partner to build a track and sketch it.
   a. Make a table like the one you did for question 1.
   b. Predict what you think the charts will look like.
   c. Use the simulation to check your ideas.
   d. Test your ideas from questions 2 and 3. Make changes to your answers if necessary.

5. Explain how you can use what you understand about pie charts to predict bar charts.

Student directions *Energy Skate Park* Activity 2:
Relating Graphs, Position and Speed (no time graphs)
http://phet.colorado.edu

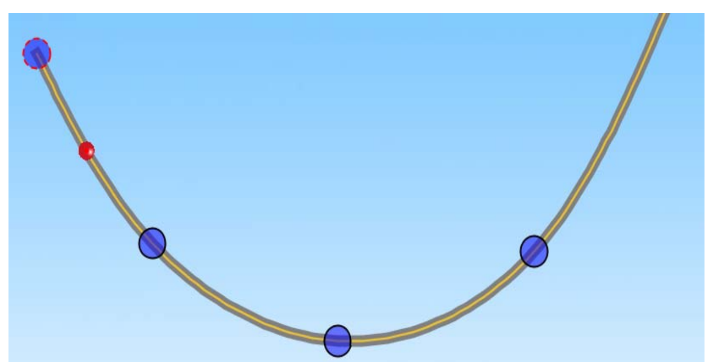
6. Sketch this track and label where the 5 spots could be.
    a. He is at his maximum speed
    b. He is stopped
    c. He is going his average speed
    d. He is going slow
    e. He is going fast





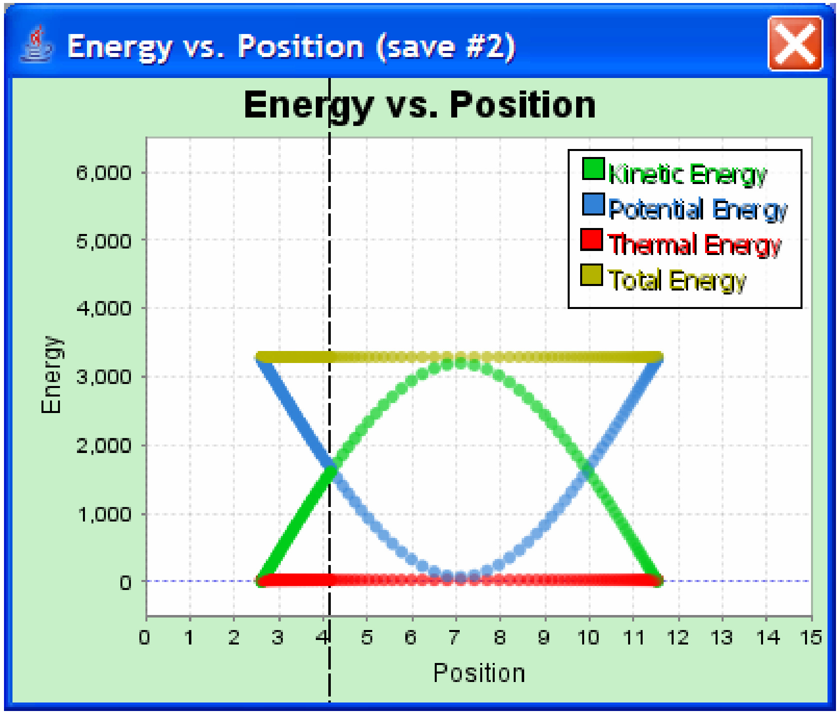
7. Sketch this energy-position graph and label where you think the same 5 spots are.
    a. Test your ideas using the **Double Well Roller Coaster** track.
    b. If one of your friends in the class asked you for help making sense of this type of graph, what would you say?

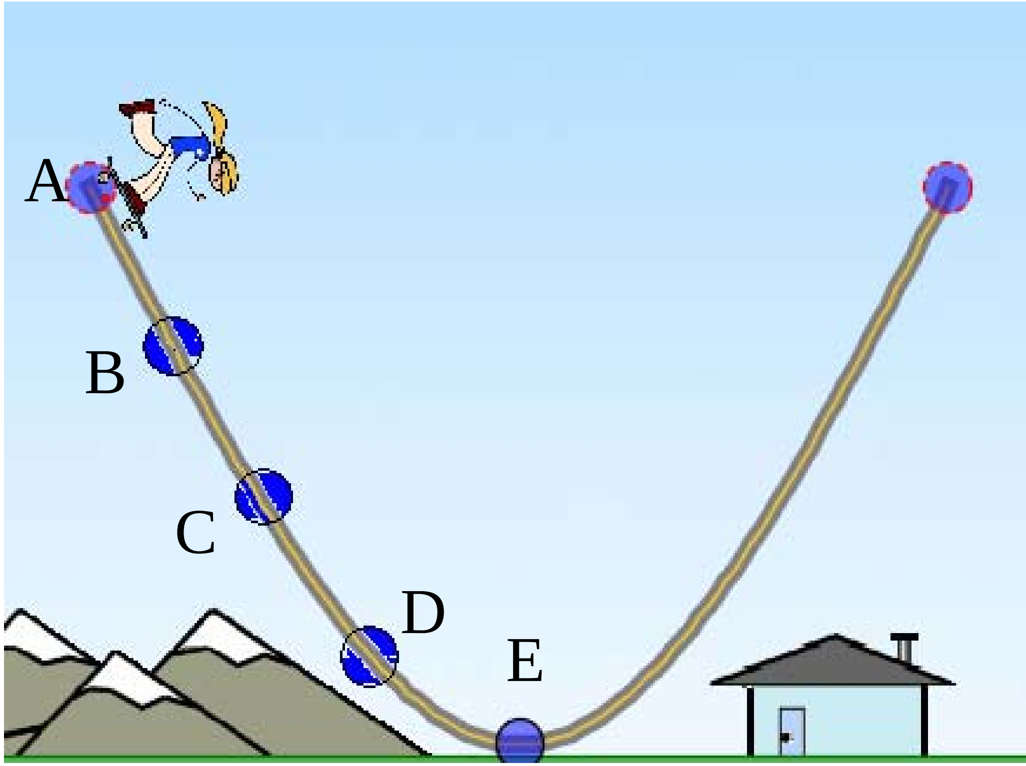
8. Talk about how you could use the Energy -Pie, -Bar, and -Position charts to predict direction of the ball is rolling.
    a. Check your ideas using the simulation.
    b. Talk about how you could tell if the ball is going to be moving faster, the same, or slower.
    c. Pretend you are writing a test for this unit.
        Type a question that includes at least one type of graph and a Skater on a different track.
        Then, give it to another group to see if they can predict the direction and changing speed of the ball.
        Make sure to attach your question.

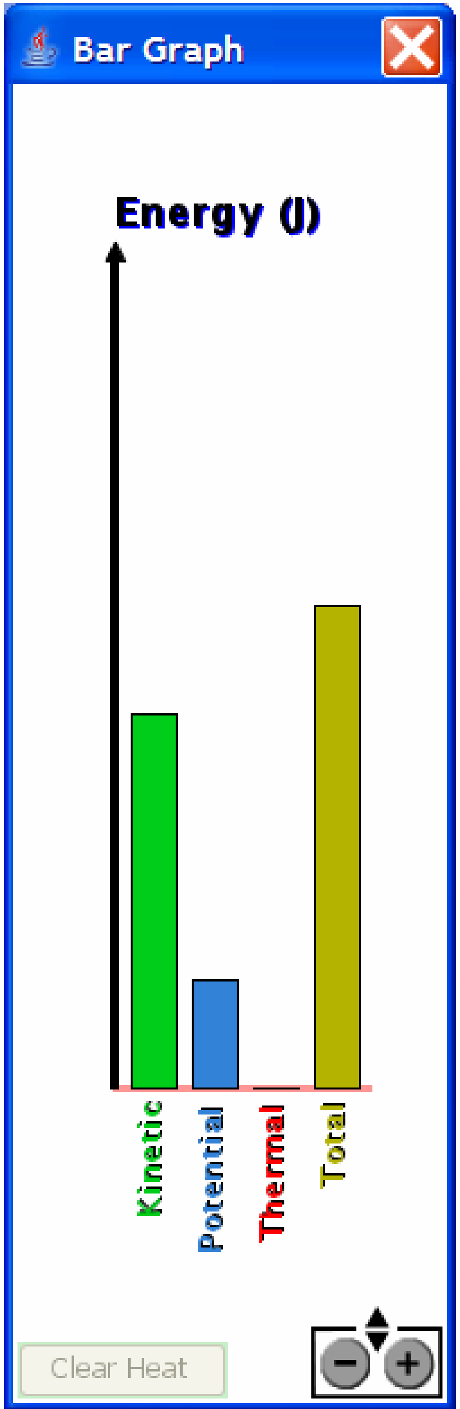


Energy skate park 2

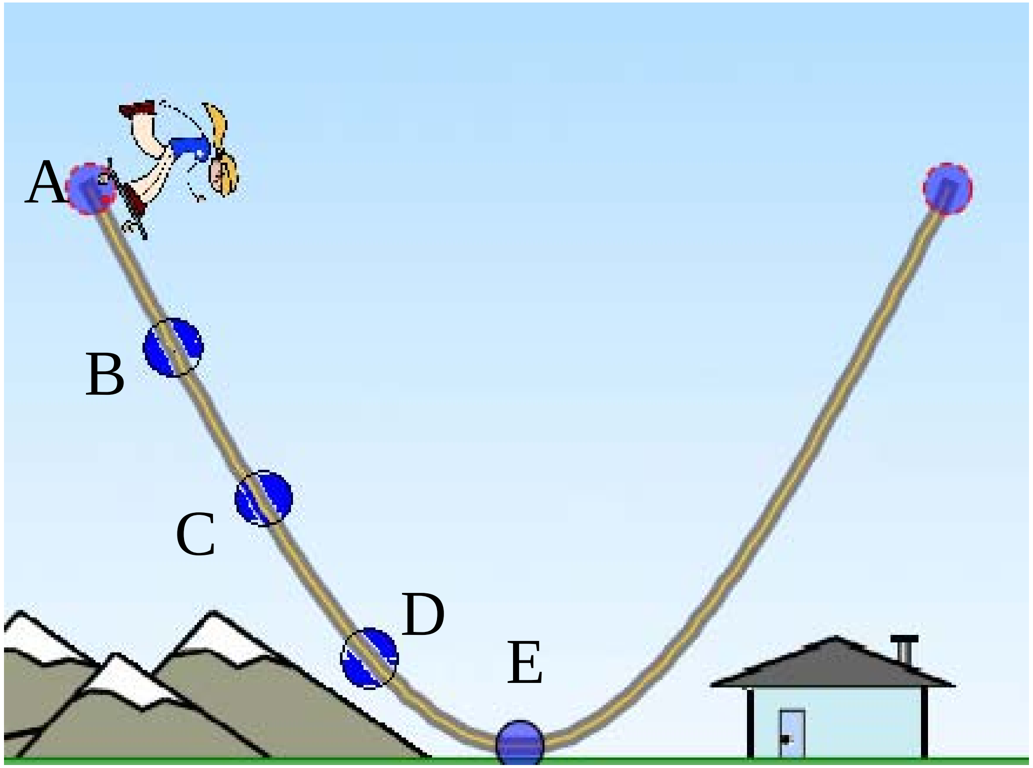
1. The dotted line on the chart shows the energy of the Skater, where could she be on the track?



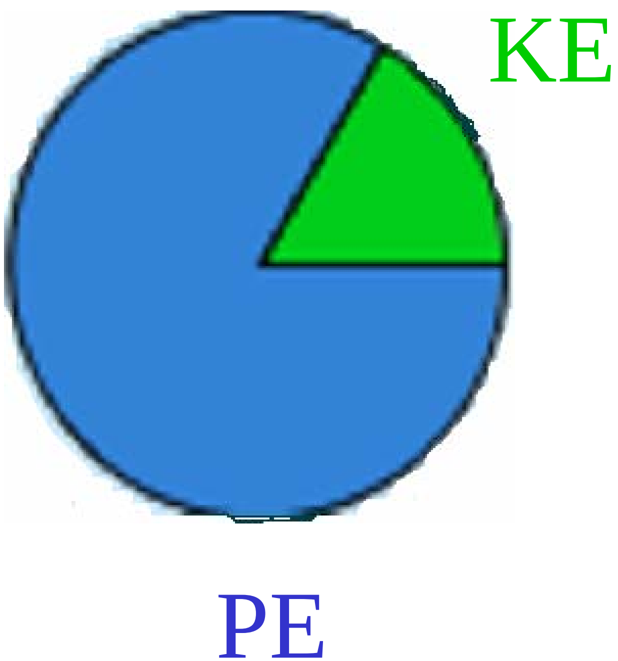


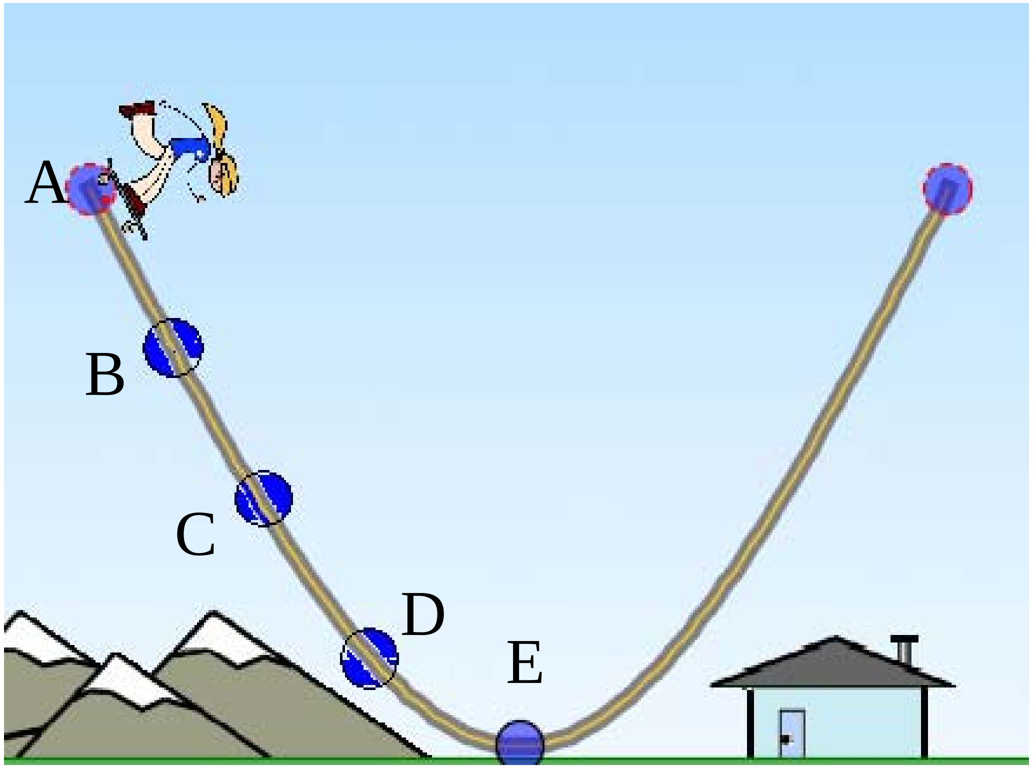


2. The bar graph shows the energy of the Skater, where could she be on the track?



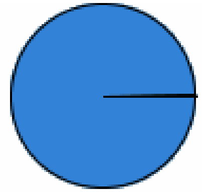
3. The pie graph shows the energy of the Skater, where could she be on the track?

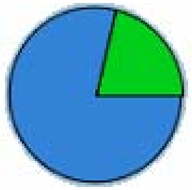


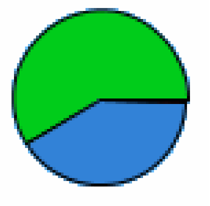


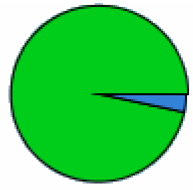
4. If the ball is at point 4, which chart could represent the ball's energy?

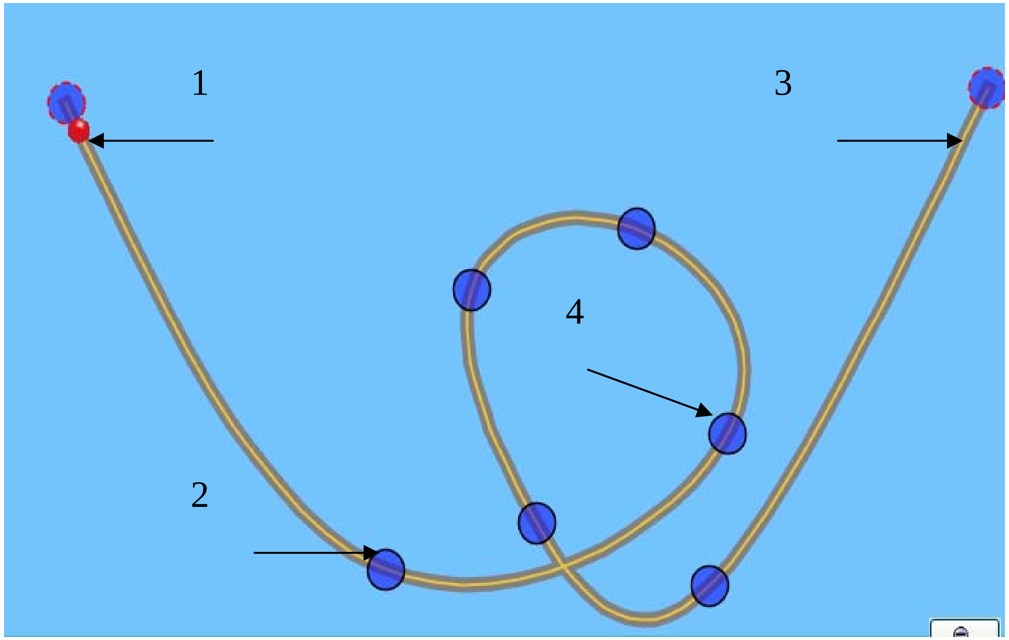
PE KE

A. 

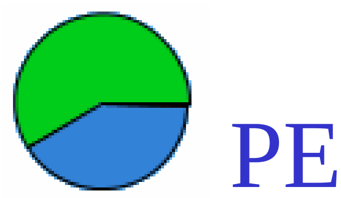
B. 

C. 

D. 



5. If a heavier ball is at point 4, how would the pie chart change?

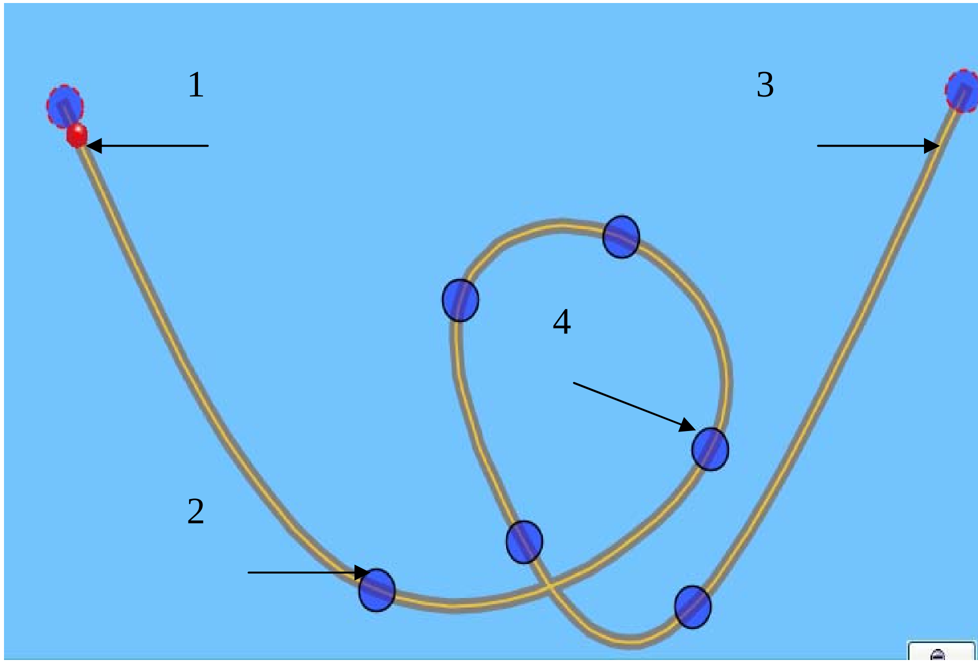


A. No changes

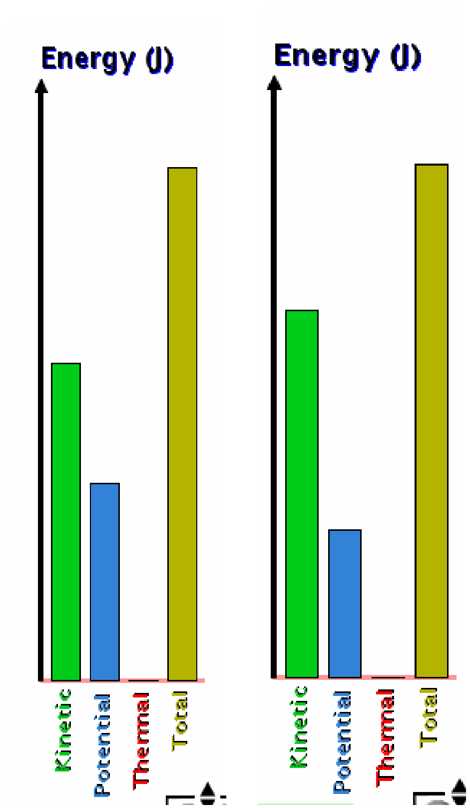
B. The pie would be larger

C. The PE part would be larger

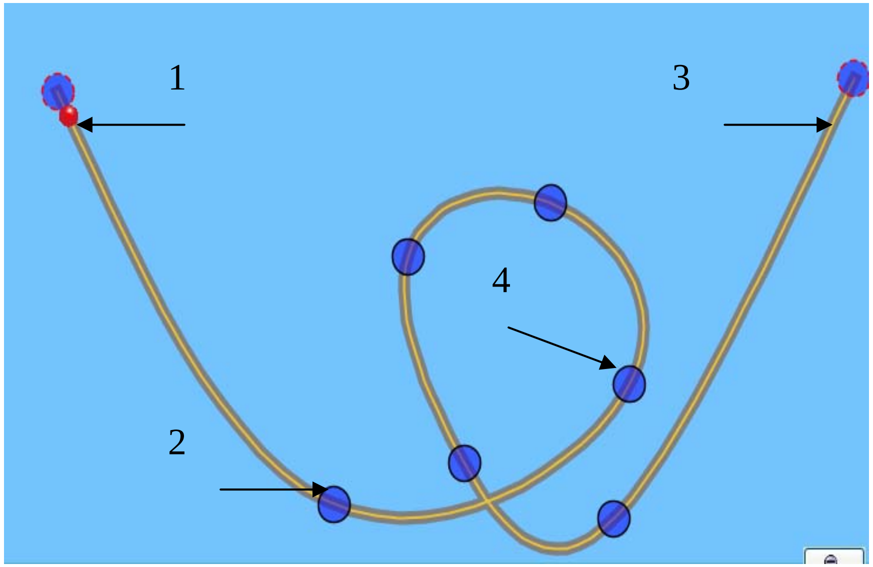
D. The KE part would be larger



6. As the ball rolls from point 4, the KE bar gets taller. Which way is the ball rolling?



At 4 Next step

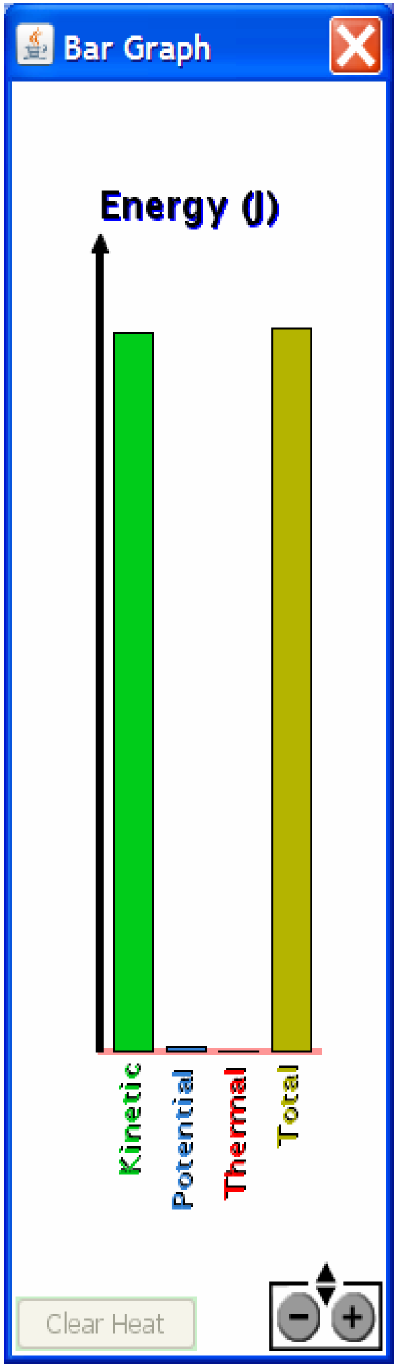


A. Up

B. Down

C. not enough info

7. The Energy chart of a boy skating looks like this →



How would you describe his speed?

A. He is at his maximum speed

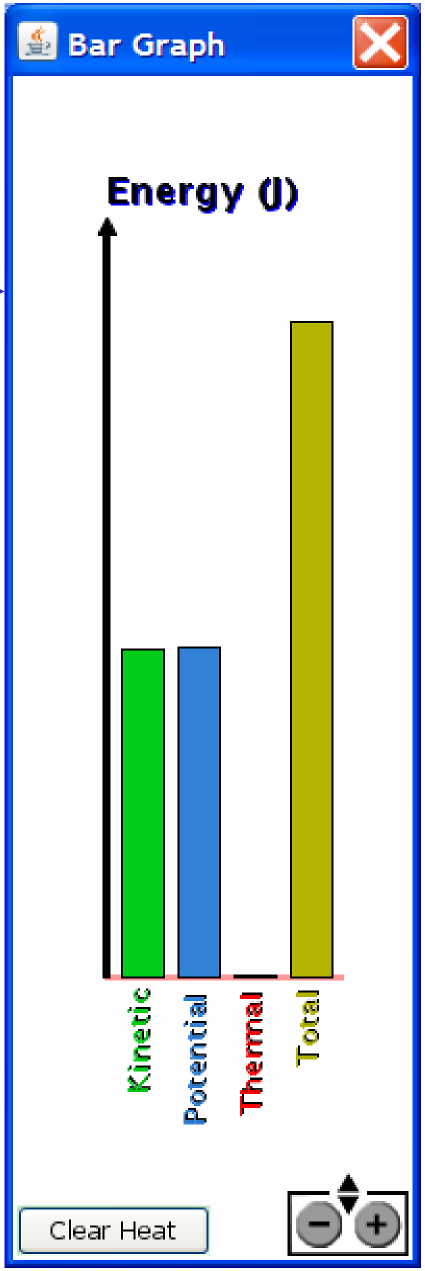
B. He is stopped

C. He is going his average speed

D. He is going slow

E. He is going fast

8. The Energy chart of a boy skating looks like this →



How would you describe his speed?

A. He is at his maximum speed

B. He is stopped

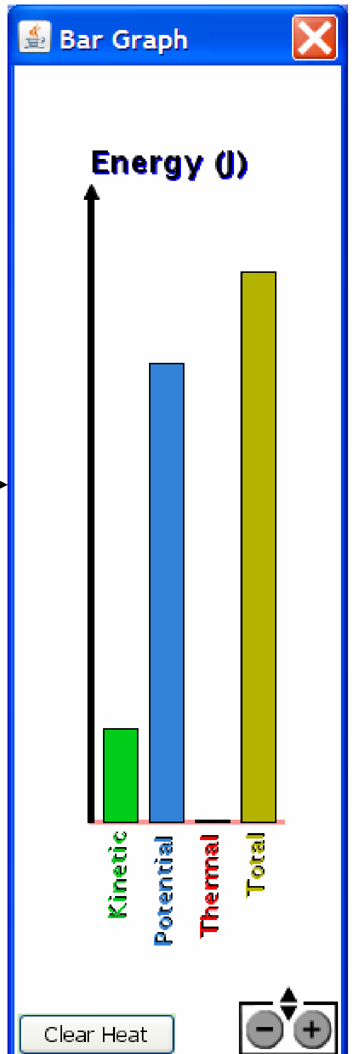
C. He is going his average speed

D. He is going slow

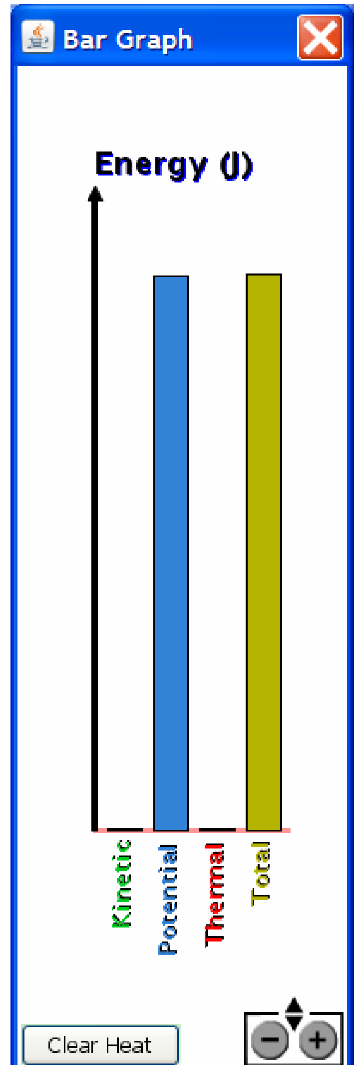
E. He is going fast

9. Select a letter for each: stopped, slow and fast

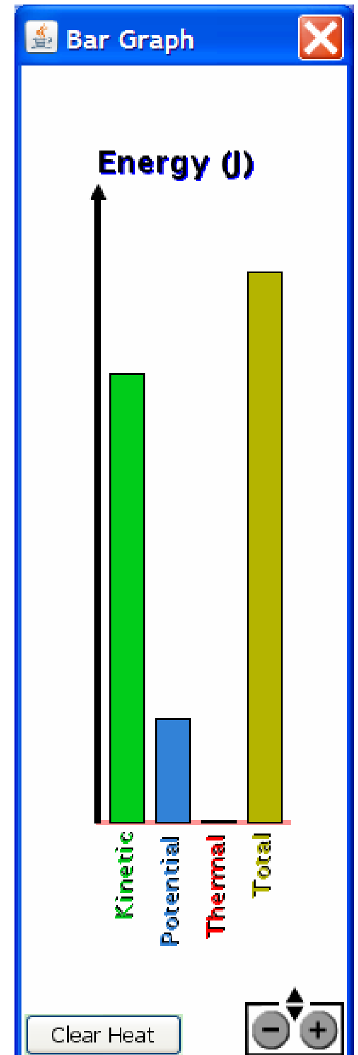
A



B



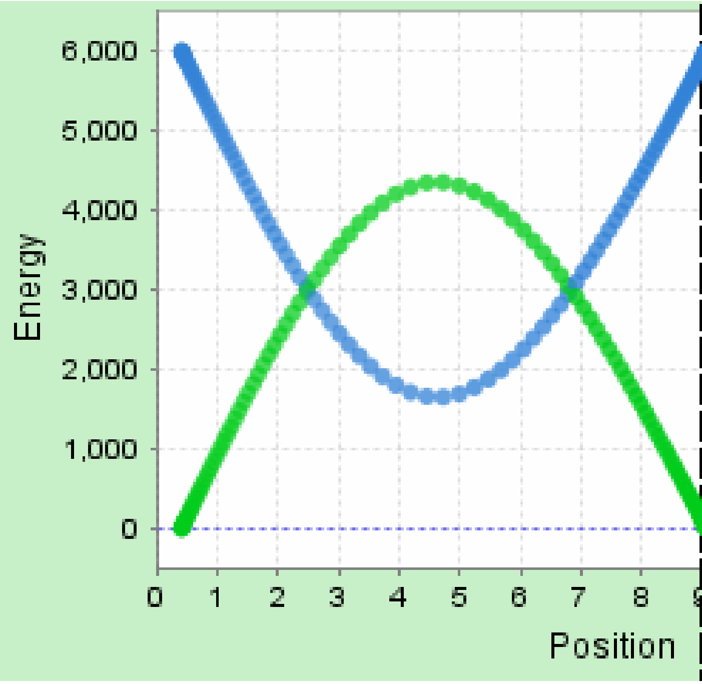
C



10. Sketch this energy position graph. Label where the 5 spots, A-E, could be

Energy vs Position

PE KE



A. He is going his maximum speed
B. He is stopped
C. He is going his average speed
D. He is going slow
E. He is going fast

Lesson plan for *Energy Skate Park* Activity 3:
Calculating Speed and Height (no time graphs)

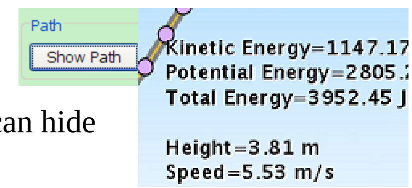
Time for activity

Learning Goals:
Students will be able to

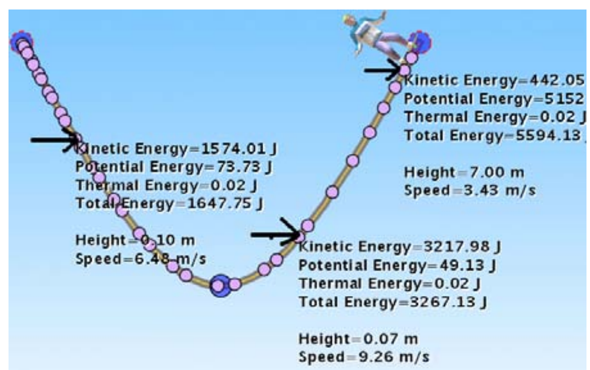
- Calculate speed or height from information about a different position.
- Describe how different gravity fields effect the predictions.
- Describe how changing the PE reference effects the predictions. *I decided to leave this goal out of the students' directions and either discuss it with the class or omit it.*

Background:
My students will have done Energy Skate Park Activity 1 & 2 and some concept questions from the text.

Pre-Lesson: I projected clicker questions 1-4 to have the students think about their present understanding, but I wouldn't go over the answers until the post-lesson.



Lesson: Have the students use the lab sheet for guidance. You may want to show the students how to get data from the Skater by using the **Show Path** button. Then they can **Right Click** on any purple spot to see measurements about the Energy, Height (relative to the PE reference line), and speed. You can hide the data by **Right Click** on the dot again**.**



Simulation hints: The data recorded at the purple dot is in reference to the PE reference line with the variables that have been selected like mass; the data does not change if you make changes. The example here was made by showing the path, and then I paused the sim and moved the PE line, paused and moved the line again. The data does not make sense if you do not pay attention to the changes. I advised the students to clear the path if they want to look at how variables effect the measurements or take careful notes. Remember that changing the Skater only changes the mass.

Post lesson: Use the clicker questions with the simulation during discussion of the answers. I would open Skater and the track for questions 1-3 before class and change the character to the female one because the track saves with the male skater. The blue dots on the questions were drawn in paint and I couldn't make the same track using track pieces to get the blue dots. Also, I have included some clicker questions that I adapted from those used at University of Colorado for the first year algebra based course.

I may have a class discussion around the last learning goal. I did include a challenge to find the PE reference in the Masses and Springs activity that I will be using on the following class period.

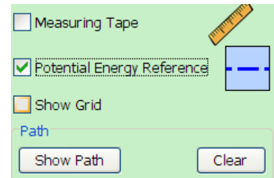
Next lesson: I also have a conservation of energy homework activity using *Masses and Springs.* I think it is better to use after the students are familiar with PE gravitational and KE.

Student directions *Energy Skate Park* activity 3: Calculating Speed and Height (no time graphs) 50 minutes untested

Learning Goals: Students will be able to

- Calculate speed or height from information about a different position.
- Describe how different gravity fields effect the predictions.

Helpful hints: You can take measurements by using the **Show Path** button, then click on any purple dot to see the values. Make sure if you change any variables (like mass, location, character, etc) that you clear the path to get new purple points.

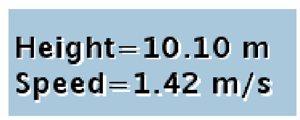


1. Play with the features shown to the right and the purple dot data to understand what the data means. Then,
   a. Explore how the values change when you move the **PE reference line**.

   b. Explore how the values change when you change the **Skater**. *Remember that changing the Skater only changes the mass.*

2. Explain what is meant by the value called **Height** .



3. Consider the following situation: You put the Skater on a track, **Show Path** and display the purple dot data. How could you predict the values for another place on the track?
   a. Describe what you would have to measure.
   b. Show an example of your proposed calculations for each value: KE, PE, TE, speed.
   c. Test your ideas and include a screen capture with the purple dot data shown for both points that show that your calculations are correct. *Show a corrected example of calculations if the data didn't match your ideas.*

4. Describe what you think will change in your calculations if you move the Skater to Jupiter.
   a. Describe what you would have to measure.
   b. Show an example of your proposed calculations for each value: KE, PE, TE, speed.
   c. Test your ideas and include a screen capture with the purple dot data shown to support your calculation or show corrected examples.
   d. How do your calculations change if you take the Skater to the moon? Test your ideas and correct if necessary.

Lesson plan for *Energy Skate Park* Activity 4:
Calculations with Conservation of Mechanical Energy using time graphs

Time for activity

Learning Goals:

Students will be able to use **Energy-Time** graphs to… at a given time.

- Estimate a location for the Skater on a track.
- Calculate the speed or height of the Skater *Friction and frictionless.*
- Predict energy distribution for tracks with and without friction.

In activity 2, one of the goals was*:* Predict direction of travel or change in speed. *By "change in speed" I mean increasing or decreasing if for example the graph shows increasing PE, decreasing KE etc." I decided not to repeat this goal because I want to avoid making the activities feel repetitive. I think it would be ok to use these ideas for clicker questions*

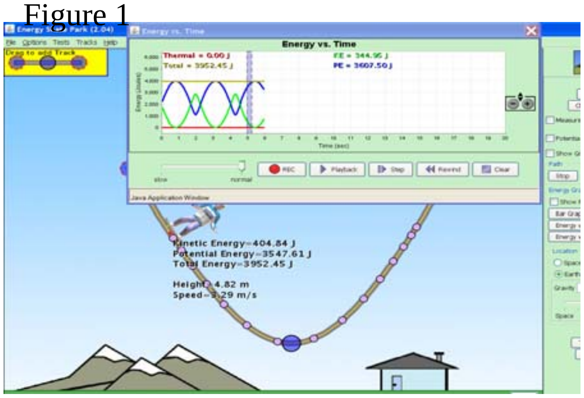
Background:

My students will have done my Energy Skate Park Activity 1, 2, 3 and some reading and questions from the text. The students will have used conservation of energy equations to solve text problems after having done activity 3. In a textbook, the learning goals for Activity 3 and 4 are often taught concurrently because using equations to solve energy/motion problems is the predominate goal. I feel like the ability to relate the time graph to the play space requires complex visualization, so I wanted a separate activity.

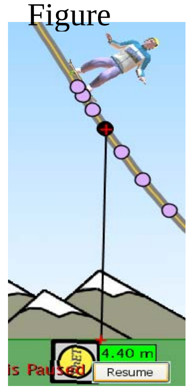
Simulation hints: Make sure to read the hints in Activity 3. *If you have trouble getting a purple dot to show data, you can **Pause** the sim and move the **PE line** and track out of the way. The values shown reflect the settings when the dot was made.*

To make the figures below: I started the sim (or **Reset)** then **Paused,** moved the **PE Reference** line to the bottom of the track, opened the **Energy-Time Graph,** and **Show Path ,** then **Play.** After getting one cycle, **Pause** again and click on the Purple dot (figure 1)

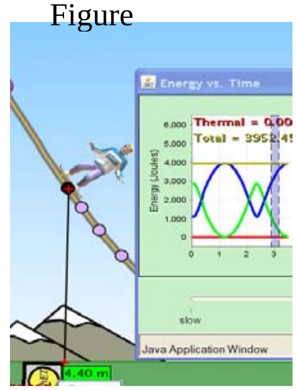
Figure 1



Figure



Figure



The **Total Energy** will vary a little depending on where you put the **PE Reference** line.

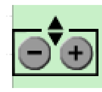
You can **Clear** the graph before you run a trial to use a different situation; if you put the Skater where you want before you press **Play**, you'll be able to simplify your graph like mine.

Lesson plan for *Energy Skate Park* Activity 4:
Calculations with Conservation of Mechanical Energy using time graphs

Time for activity

To relate the data to the **Energy-Time** graph, (remember the window can be moved to help viewing) I selected a purple dot to get the Height and Speed then I used the **Measuring Tape** to mark the dot's location. (figure 2). Then I moved the vertical bar so that the Skaters red dot was on top of the tape (figure 3).

Lesson: Have the students use the lab sheet for guidance. I handed out the directions and had them make predictions.



For question 1, I opened the simulation, **Paused**. Then I moved the **PE line** to the bottom of the track, pressed **Return Skater**, selected the **Energy-Time** graph and zoomed so 3500 was the max y value. Then I pressed **Play** and let the sim run 11 seconds and then **Paused**. *One of the nice things about using the default track and initial Skater position is that it is very quick to rerun trials with variation by **Return Skater.*** His place on the track is at the time shown by the vertical bar on the graph.

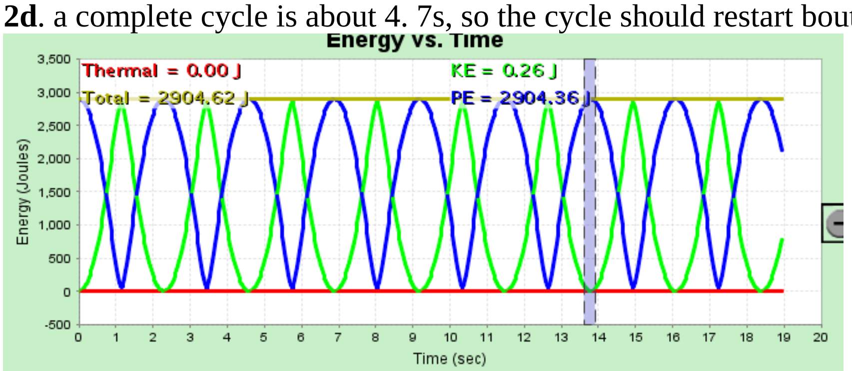
Answers: (I'm expecting estimates the first time around and then more exact when they do #2). The picture on the student directions shows total energy at 2918J. When the students sun their trials, the **Total Energy** will vary a little depending on where they put the **PE Reference** line. I used acceleration = 9.81 m/s^2 in my calculations.

2a. 0 =left side, same height; 7s=same place; 8s=bottom; 5s= on way back down from right side at about 80% of original height (PE = 2500 which is about 2500/2918 =85% of max)

2b. 0 and 7s = 4m; 8s=0; 5s= 3.4m (85% of 4m)

2c. 0 and 7s = 0; 8s= 8.8m/s (KE= 2918= $1/2mv^2$= $.5*75*^2$); at 5s= 3.6m/s (KE=500=$1/2*75*3.6^2$)

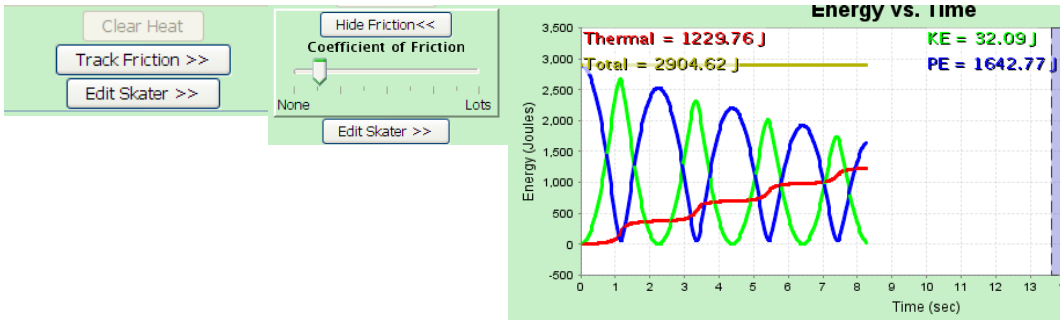
2d. a complete cycle is about 4. 7s, so the cycle should restart bout 14s.



Lesson plan for *Energy Skate Park* Activity 4:
Calculations with Conservation of Mechanical Energy using time graphs

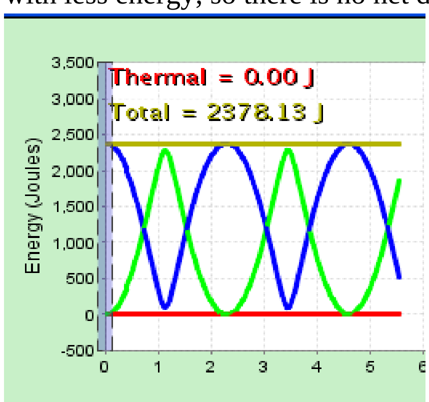
Time for activity

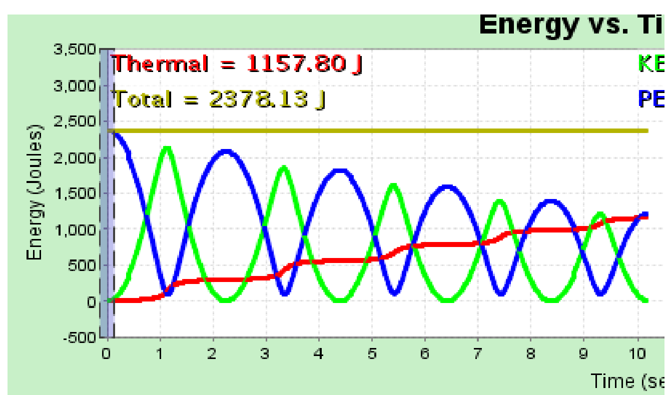
3. I made this graph by setting the **Friction** on the first tick. The only thing that changes on the graph is that **Total Energy** decreases along with max PE and KE.



Notice that the max, min points are still at the same time, so the Skater is at the same horizontal location, but not going as high. The calculations for speed and height should reflect the lower PE and KE values. I didn't give answers because the amount of friction that the students use will matter.

4. If you use the **Return Skater** button after changing the Skater (which really only changes the mass), the only thing that changes is that **Total Energy,** max PE and KE are less. It may be important to help students see that the time for max and min are still the same and that both the horizontal and vertical location at any time is the same whether there is friction or not. Students make think Track Friction that she will go higher or faster because the Skater has less mass and therefore less Friction force, but she started with less energy, so there is no net difference.





Post lesson: Use clicker questions (yet to be written)

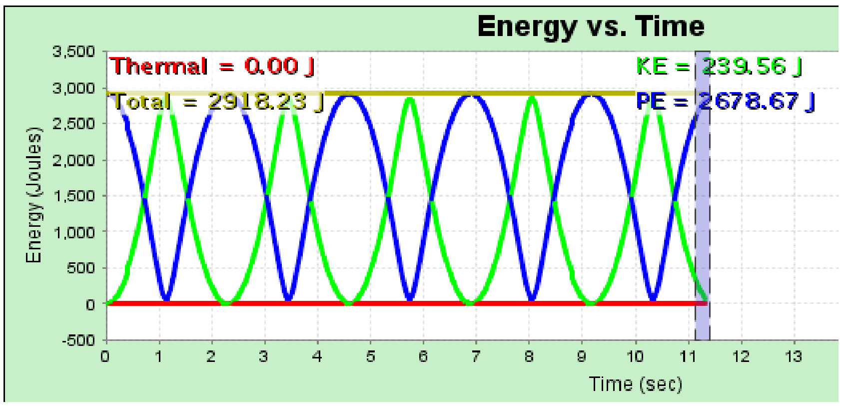
Student directions *Energy Skate Park* activity 4:
Calculations with Conservation of Mechanical Energy using time graphs

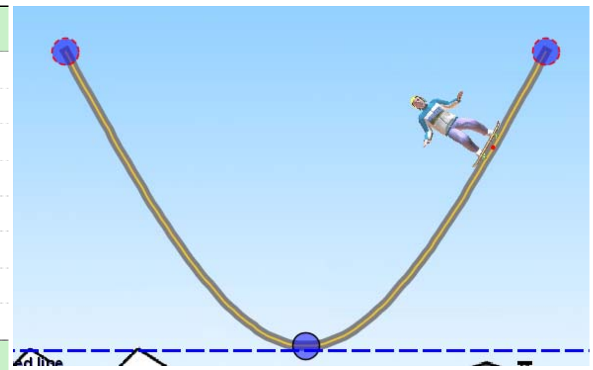
Learning Goals: Students will be able to use **Energy-Time** graphs to… at a given time.

- Estimate a location for the Skater on a track.
- Calculate the speed or height of the Skater
- Predict energy distribution for tracks with and without friction.

Directions:

1. This graph was made with the 75 kg Skater Guy riding on the track shown. Without using the simulation, talk with your partner to predict the answers to these questions. Record your predictions!





   a. Where was he at time zero? At 7 seconds? At 8 seconds? 5 seconds?
   b. If his maximum height is 4 m, what is his height at time zero? At 7 seconds? At 8 seconds? 5 seconds?
   c. What is his speed at time zero? At 7 seconds? At 8 seconds? 5 seconds?
   d. Sketch what the graph would look like between 13 and 15 seconds.

2. Use the Skate Park simulation to check your answers and make corrections. *Show examples of calculations by giving the formula and substitution.*

3. Without using the simulation, talk with your partner to predict the answers to these questions about the <u>same</u> Track, Skater and Starting point as #1. Record your predictions!

   a. Sketch what the graph might look like between 0 and 9 seconds if the **Track Friction** was turned on.
   b. How do you think his location will be affected? Think about both horizontal and vertical location.
   c. How do you think his speed on the track will be affected?
   d. Test your ideas using the simulation and make corrections to your predictions.

4. Consider if the 60kg Skater Gal rode on the <u>same</u> Frictionless Track and Starting point.
   a. How do you think her position, speed and energy will compare to the Guy's?
   b. Sketch what the graph might look like between 0 and 5 seconds.
   c. If you used the same amount of track friction, how would your answers to question three compare?
   d. Test your ideas using the simulation and make corrections to your predictions.

Energy Skate Park 4

Learning Goals:

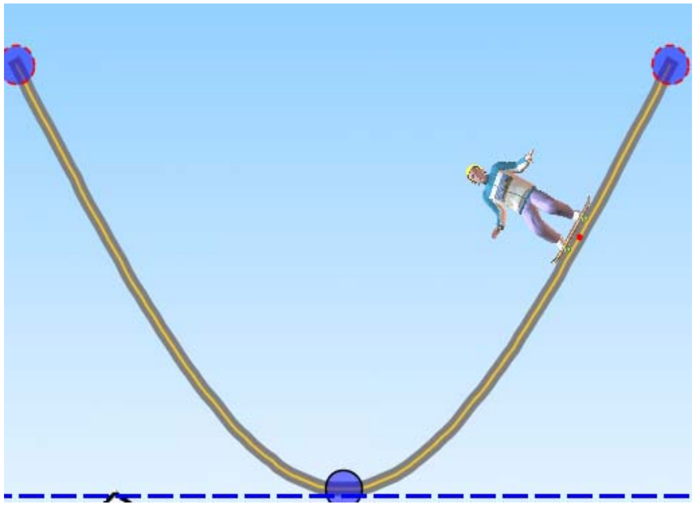
Students will be able to use **Energy-Time** graphs to… at a given time.

- • Estimate a location for the Skater on a track.
  - Calculate the speed or height of the Skater *Friction and frictionless.*
  - Predict energy distribution for tracks with and without friction.

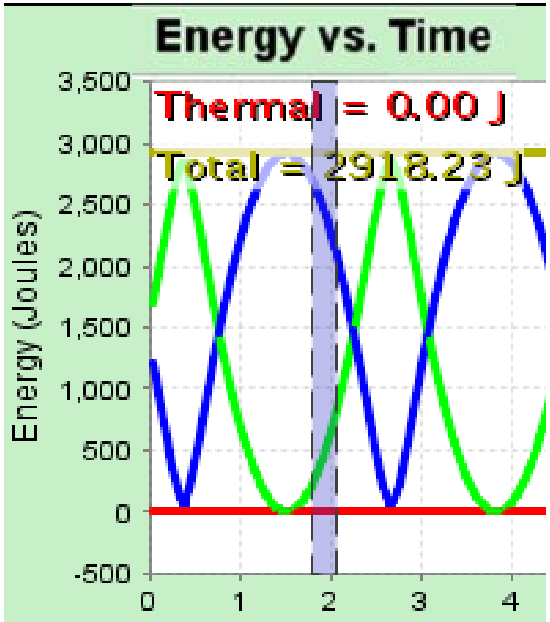
By Trish Loeblein updated July 2008

The Friction concepts are not addressed in these clicker questions. Some screen images are included, but it would be better to have the sim running. I have used tracks that are the default or under Track menu for easy reproduction.

1. What will the speed of the 75kg Skater be at 2 seconds?



PE = 0 at dotted line



Total =2918 J

KE=509 J

PE=2408 J

A. 14m/s B. 8.8m/s C. 8.0m/s D. 3.7m/s

Comments for question 1: This is the default track with the PE line moved up to the track

KE= $1/2mv^2$

$509=1/2*75*v^2$

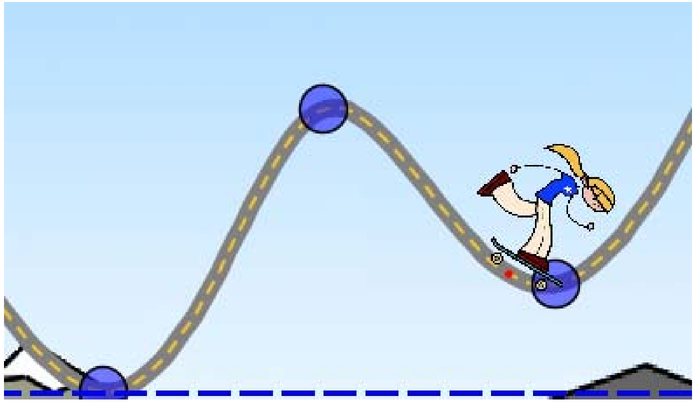
$$v = \sqrt{\frac{509*2}{75}} = 3.7m/s$$

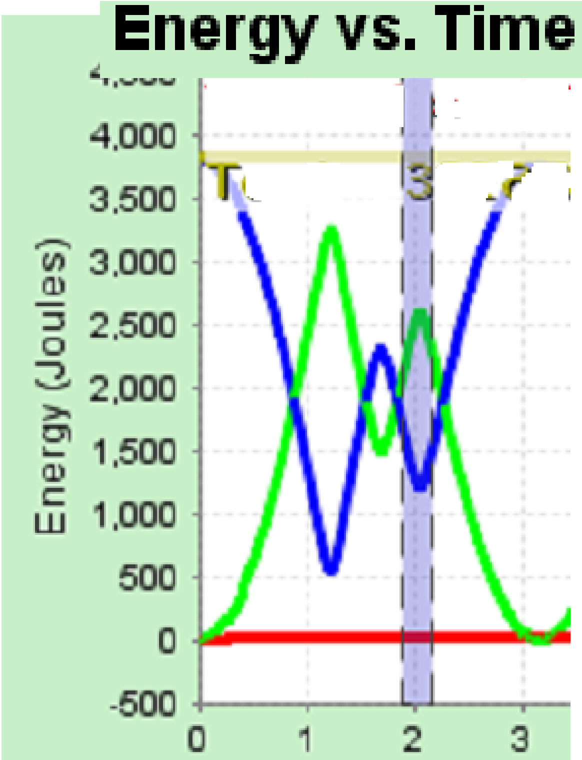
14 is no sqrt

8 uses PE

8.8 uses Total E

2. At what height is the 60kg Skater at 2 seconds?





Total =3829 J

KE=2429 J

PE=1365 J

A. 6.5m B. 4.2m C. 2.3m D. 1.9m

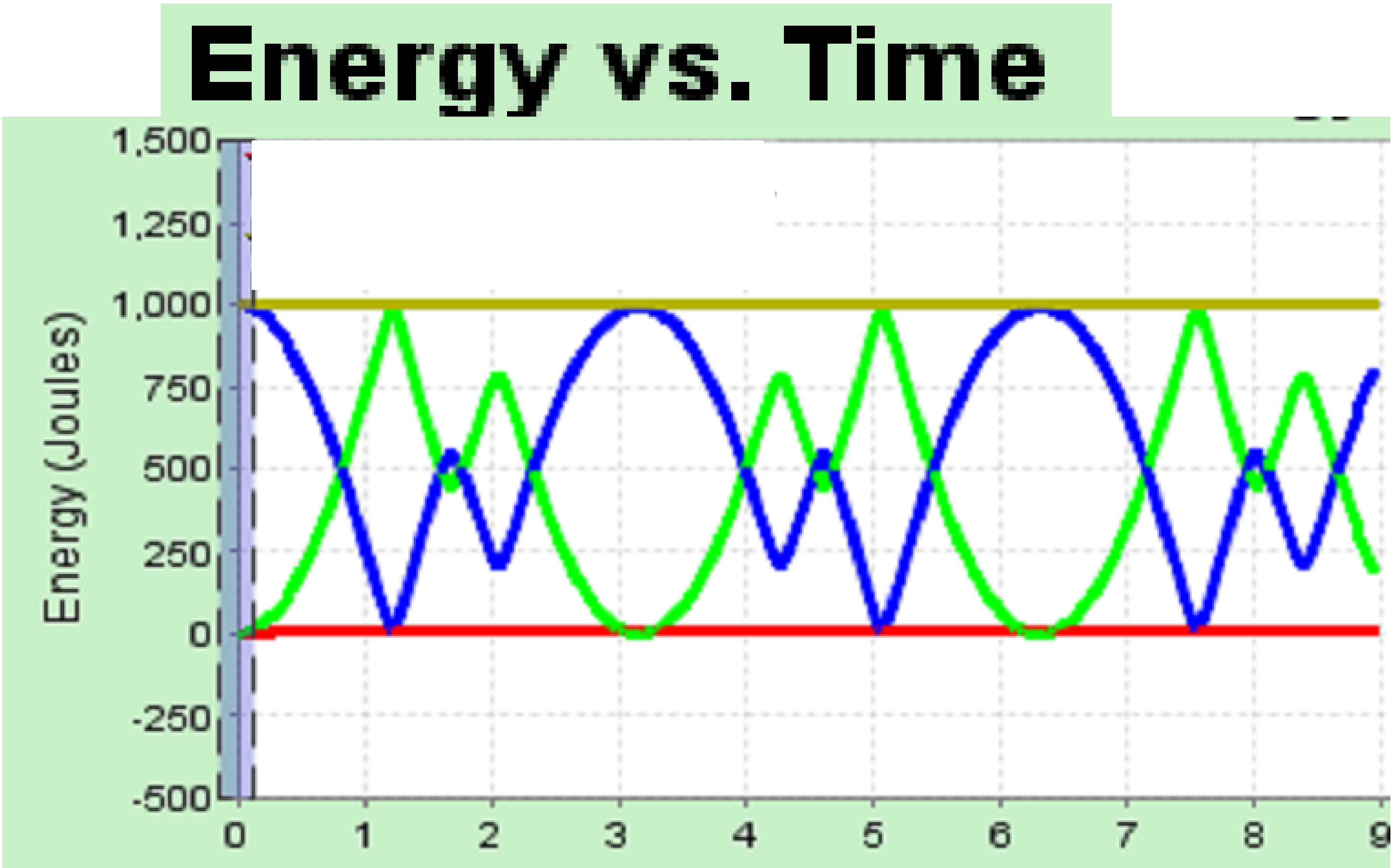
Comments for question 2: I used the Double well roller coaster track with the Skater changed to the girl and I moved the PE line to the bottom of the first well. Then I started from the “Return Skater” position.

Comments about #3. I would show the slide, have the students make a drawing and then show the options on the next slide.

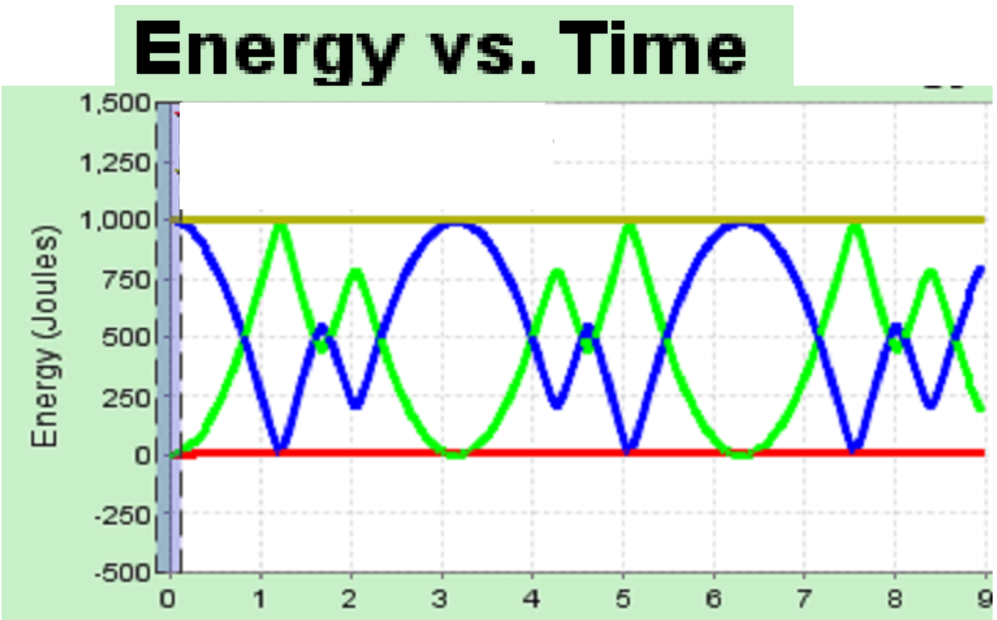
$$h = \frac{PE}{mg} = \frac{1365}{60 * 9.81} = 2.3m$$

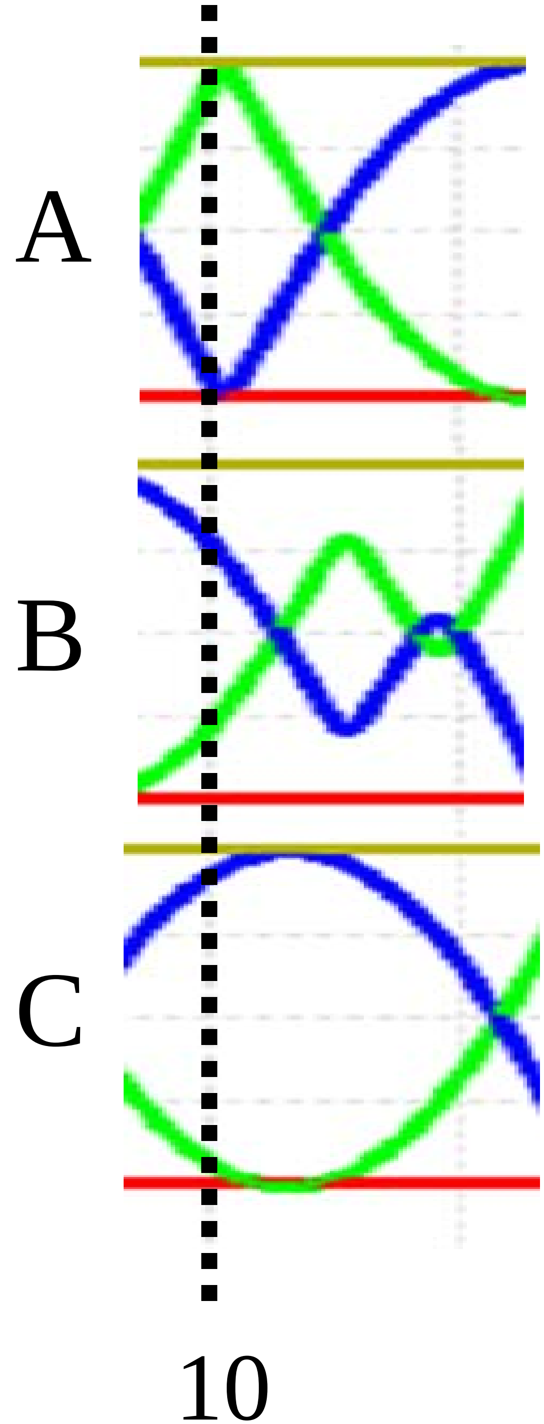
6.5 uses Total E, 4.2 uses KE, 1.9 uses mass of 75,

3. Draw what you think the energy graph look like at 10 seconds.

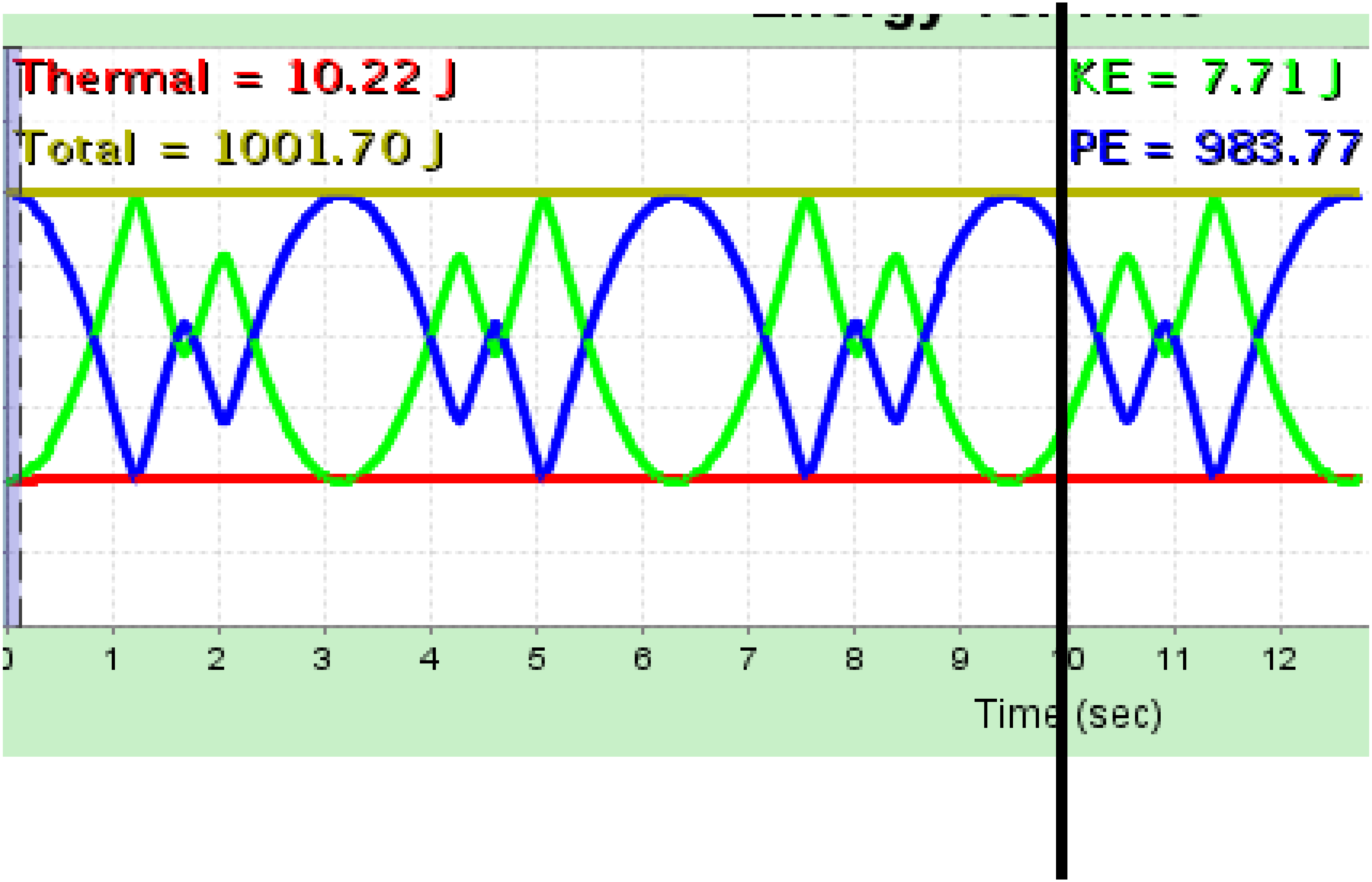


3. The energy graph at 10 s:



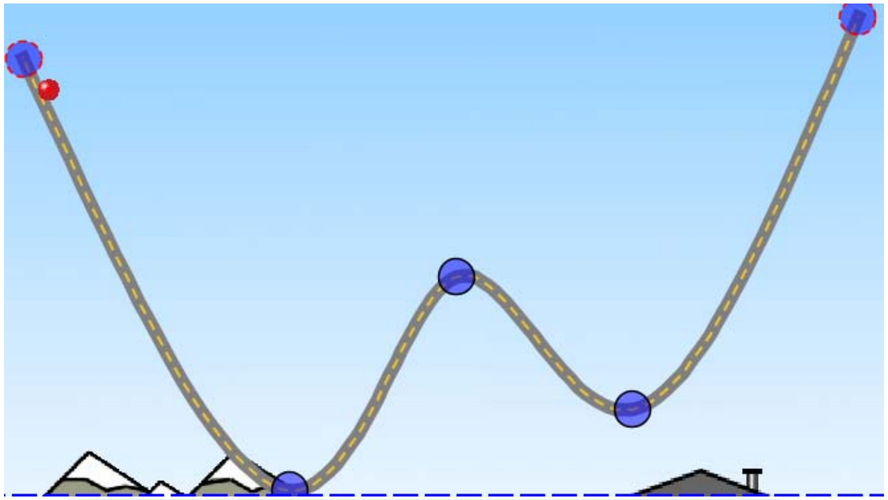


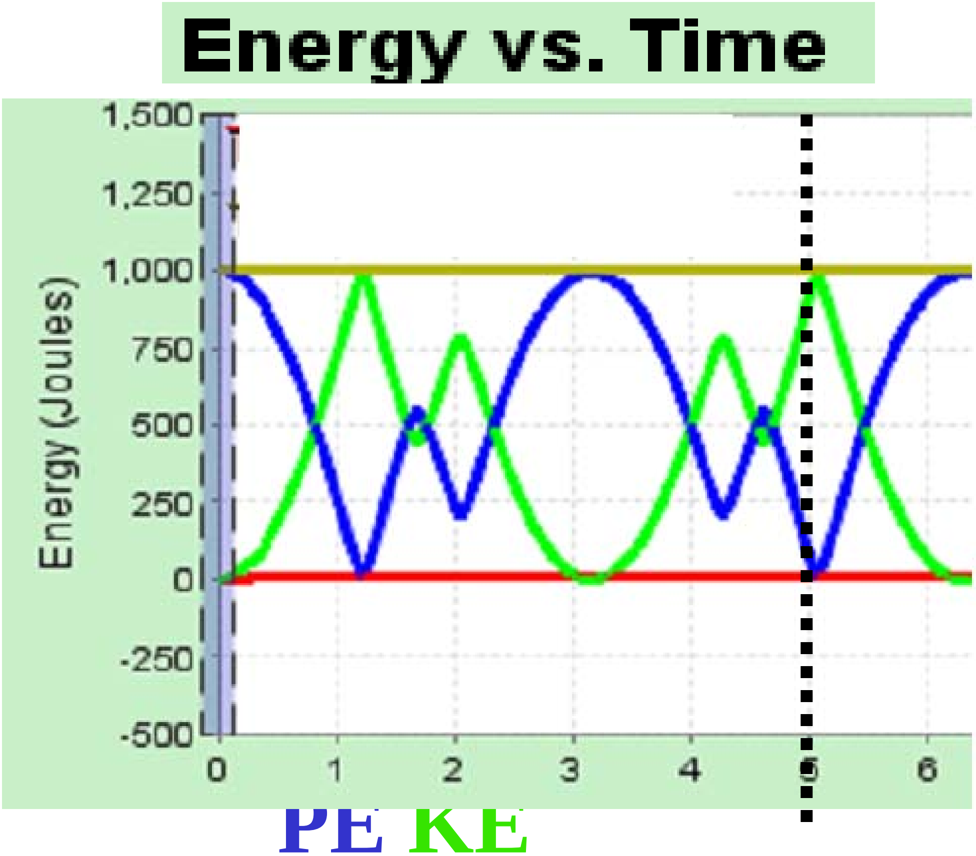
Comments and answer to 3: I used the double well roller coaster again with a ball at 18 kg for #3 and #4



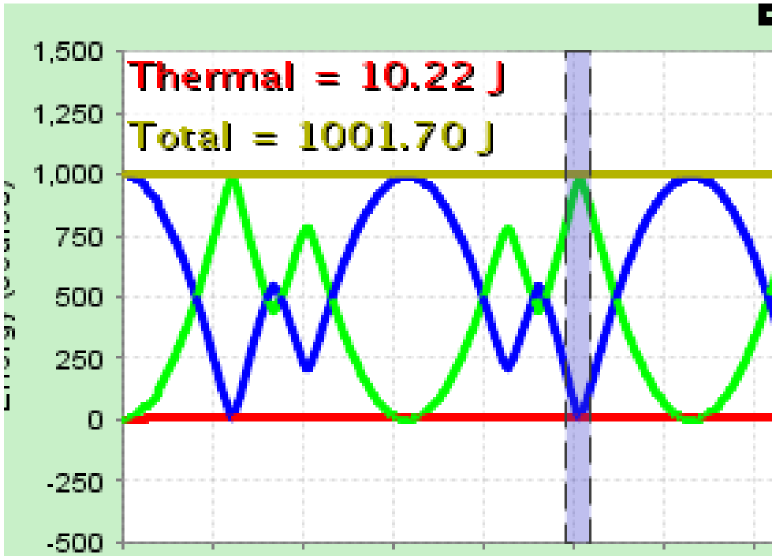
4. What might the ball be doing at 5 seconds?

A. Going left to right at the lower dip
B. Going right to left at the lower dip
C. Going left to right at the higher dip
D. Going right to left at the higher dip

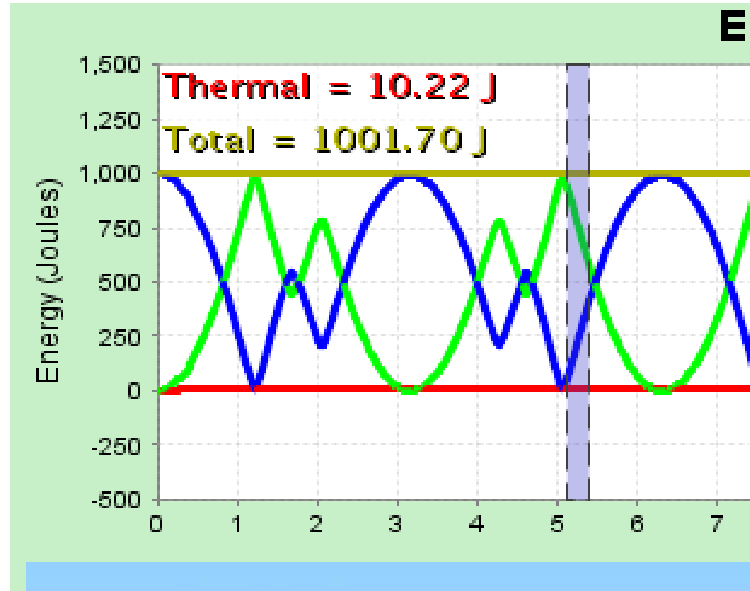




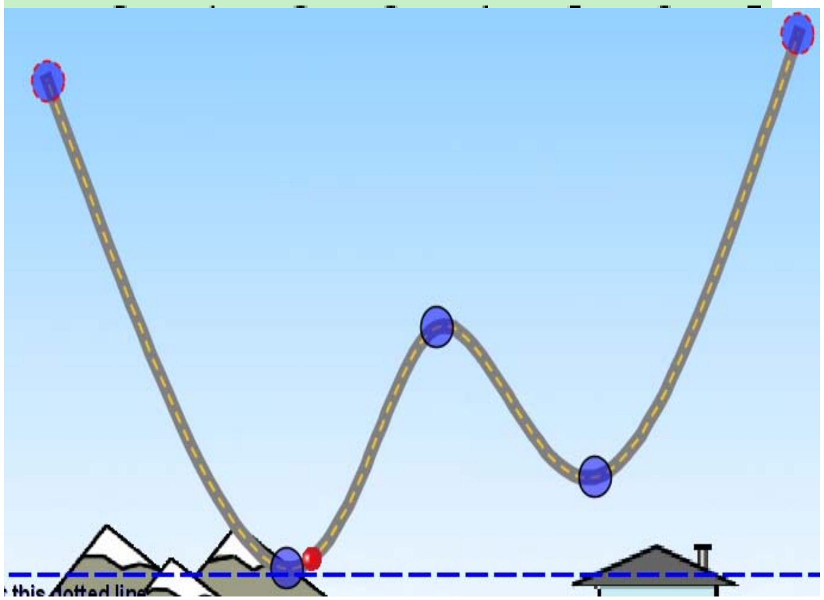
Answer to 4

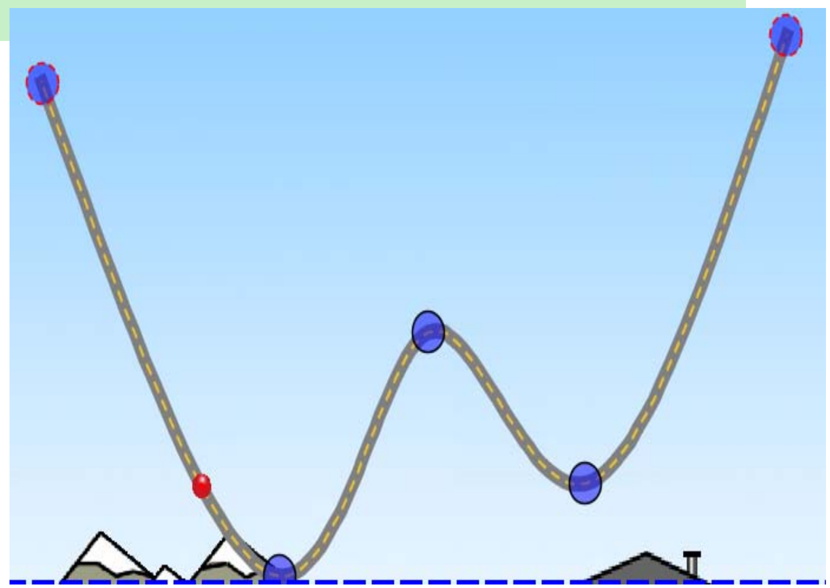


Thermal = 10.22 J
Total = 1001.70 J
1,500
1,250
1,000
750
500
250
0
-250
-500



Thermal = 10.22 J
Total = 1001.70 J
Energy (Joules)
1,500
1,250
1,000
750
500
250
0
-250
-500
0
1
2
3
4
5
6
7





Lesson plan for *Masses and Springs* for Conservation of Energy

phet.colorado.edu

Learning Goals: Students will be able to explain the Conservation of Mechanical Energy concept using kinetic, elastic potential, and gravitational potential energy.

Background: My students will have done at least the first three of my Energy Skate Park activities.

Masses and Springs Introduction: I plan to get out some spring scales and hang some objects that are familiar on them so the students know what the sim is demonstrating. I am not going to show how to use the sim.

Some helpful hints about the sim:

- The zero position for Potential Energy is just below the “table top” where the masses sit.
- All the springs have the same characteristics by default. The stiffness of spring number three can be varied. Put the slider in the middle to reset.
- To reset the energy graph, take the mass off the spring. If it is hard to release a mass, slow it down by adjusting time or a slider.
- Move the friction slider to none for this activity.
- Keep the masses in the window for thorough energy analysis because the PE for the graph is calculated as an absolute value.
- The KE will not be calculated if you are moving the cylinder with the mouse

Lesson: There is a pre/post test: one version written in Word and one in Power point version for clickers. I plan to use the clicker questions after the activity and the pretest as a warmup. Have the students use the lab sheet for guidance to learn the objective. The classroom activity will take about 60 minutes. The homework version is shorter and assumes that the *Energy Skate Park* activity has been completed.

Post Lesson: Go to the PhET site(http://phet.colorado.edu), launch *Masses and Springs* from the *Motion* bullet on the left. Turn on the *Show Energy* box to see the energy graph. Have a mass and spring; hold the setup so that the zero PE position is even with the demonstration table. Pull the mass so it oscillates to show what the sim is simulating. Using the sim, demonstrate that the position of a mass that gives zero gravitational potential energy is beyond the screen window using a variety of masses and springs. Discuss with the group where they think zero is. Ask them how the demonstration could be changed to match the window. I will probably ask for a volunteer to show the “improved” demonstration of the sim.”

Student directions for Conservation of Mechanical Energy using *Masses and Springs* simulation
Homework assignment phet.colorado.edu

Learning Goals: Students will be able to explain the Conservation of Mechanical Energy concept using kinetic, elastic potential, and gravitational potential energy

Directions: Move the friction slider to none for this activity. Keep the cylinders visible in the screen window for calculations. You can use **Pause** or change the Time Rate for closer analysis

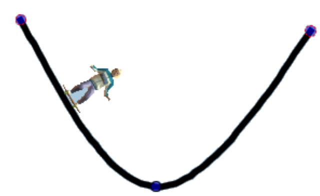
1. By investigation, determine when the Elastic Potential Energy is zero. Make sure you test your idea with several masses, all three springs and vary the stiffness of spring three. Write down how you determined the zero location(s) and explain why the position for zero makes sense.

2. Why did you need to use varying conditions?

3. By investigation, determine when the Kinetic Energy is zero. Make sure you vary the conditions for your experiment. Write down how you determined the zero location(s) and explain why the position for zero makes sense. *Simulation hint: The KE will not be calculated when you are moving the cylinder with the mouse*

4. Put a mass on a spring and observe the total energy graph as it oscillates. Pay attention to details of the energy distribution. Think about why the energy is distributed differently for several situations. For example: When is there only kinetic energy? What makes the elastic energy increase?
   - Test your ideas with varying conditions; write down your observations and conclusions.

5. Suppose you have a skater going back and forth on a ramp like this. How does his energy distribution as he rides compare and contrast to that of the mass moving on a spring? You can run the *Energy Skate Park* simulation to test your ideas.



Masses and Springs: Conservation of Energy

Learning Goals: Students will be able to explain the Conservation of Mechanical Energy concept using kinetic, elastic potential, and gravitational potential energy.

1. The main difference between kinetic energy, KE, and gravitational potential energy, PE_g, is that

A. KE depends on position and PE_g depends on motion

B. KE depends on motion and PE_g depends on position.

C. Although both energies depend on motion, only KE depends on position

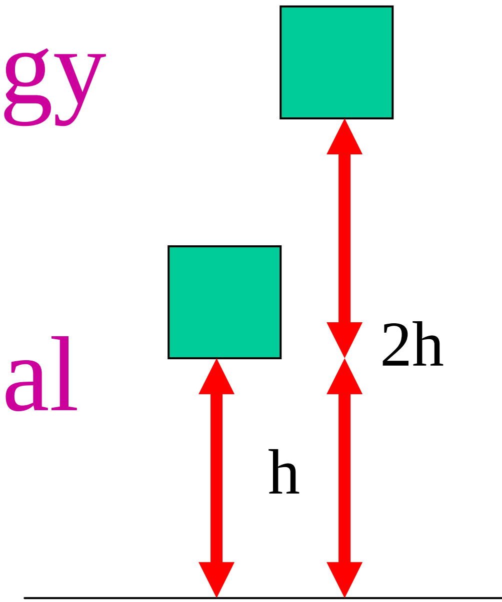
D. Although both energies depend position, only PE_g depends on motion

2. Joe raised a box above the ground. If he lifts the same box twice as high, it has

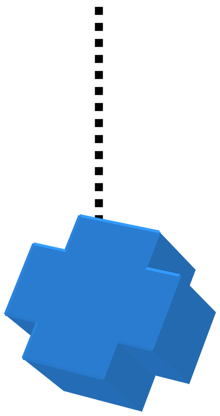
A. four times the potential energy

B. twice the potential energy

C. there is no change in potential energy.



3. As any object free falls, the gravitational potential energy

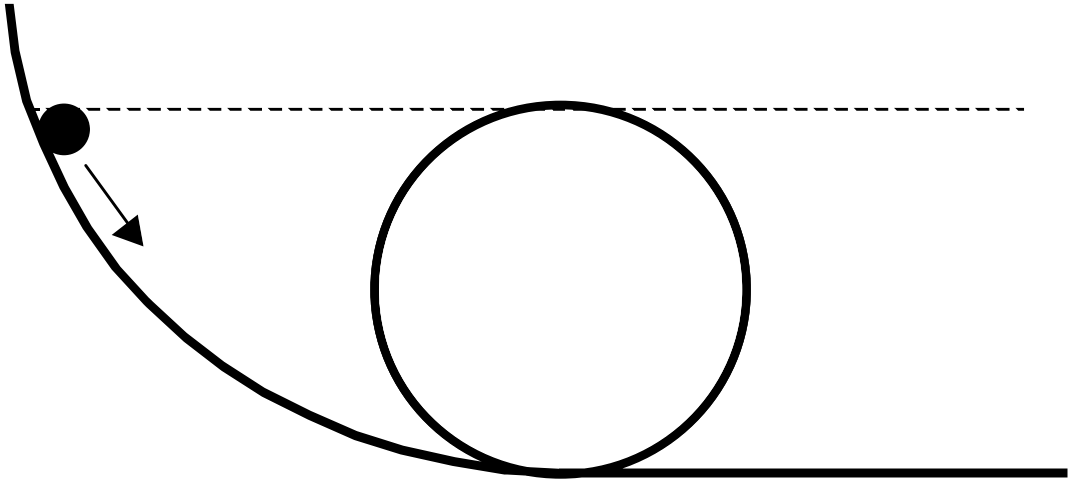


A. vanishes

B. is immediately converted to kinetic energy

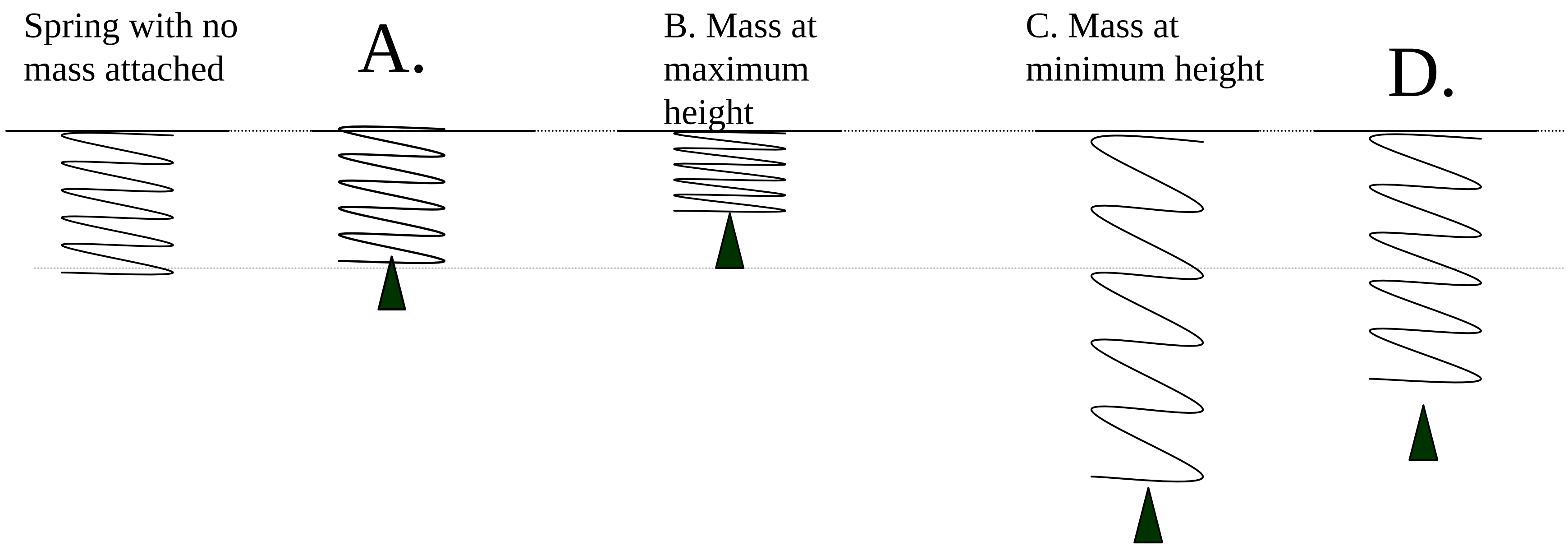
C. is converted into kinetic energy gradually until it reaches the ground

4. A small mass, starting at rest, slides without friction down a rail to a loop-de-loop as shown. Will the ball make it to the top of the loop?



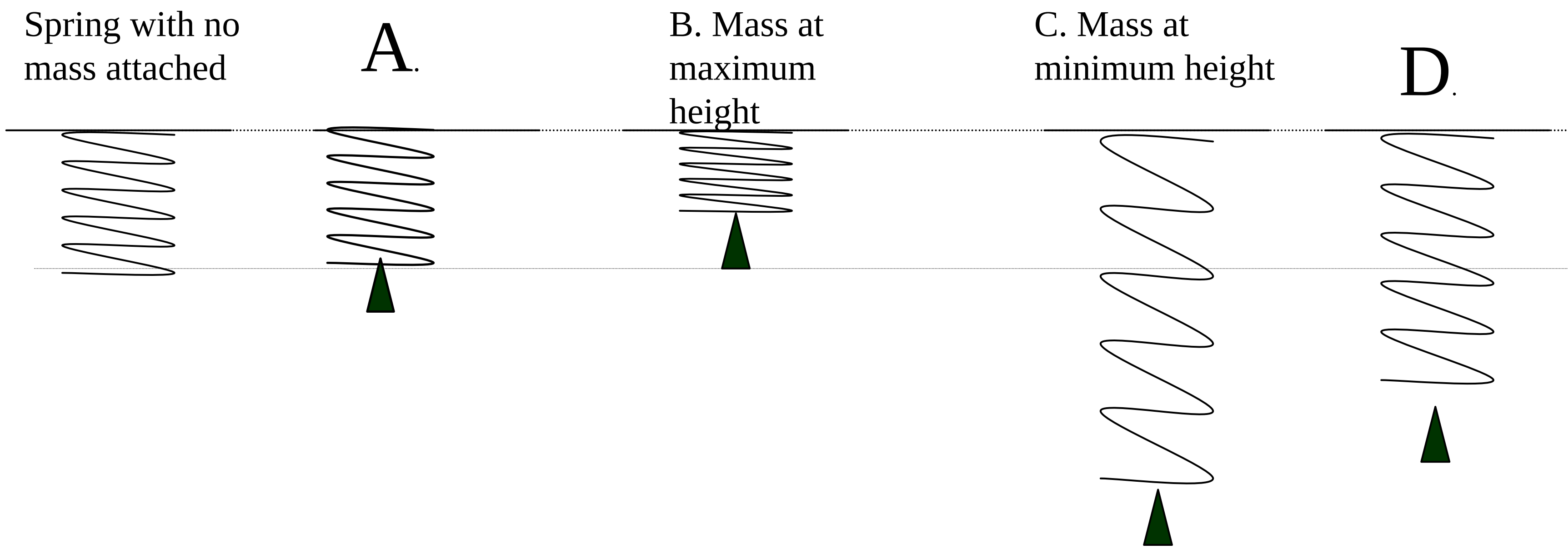
A. Yes B. No

A spring is hanging from a fixed wire as in the first picture on the left. Then a mass is hung on the spring and allowed to oscillate freely (with no friction present). Answers A-D show different positions of the mass as it was oscillating.



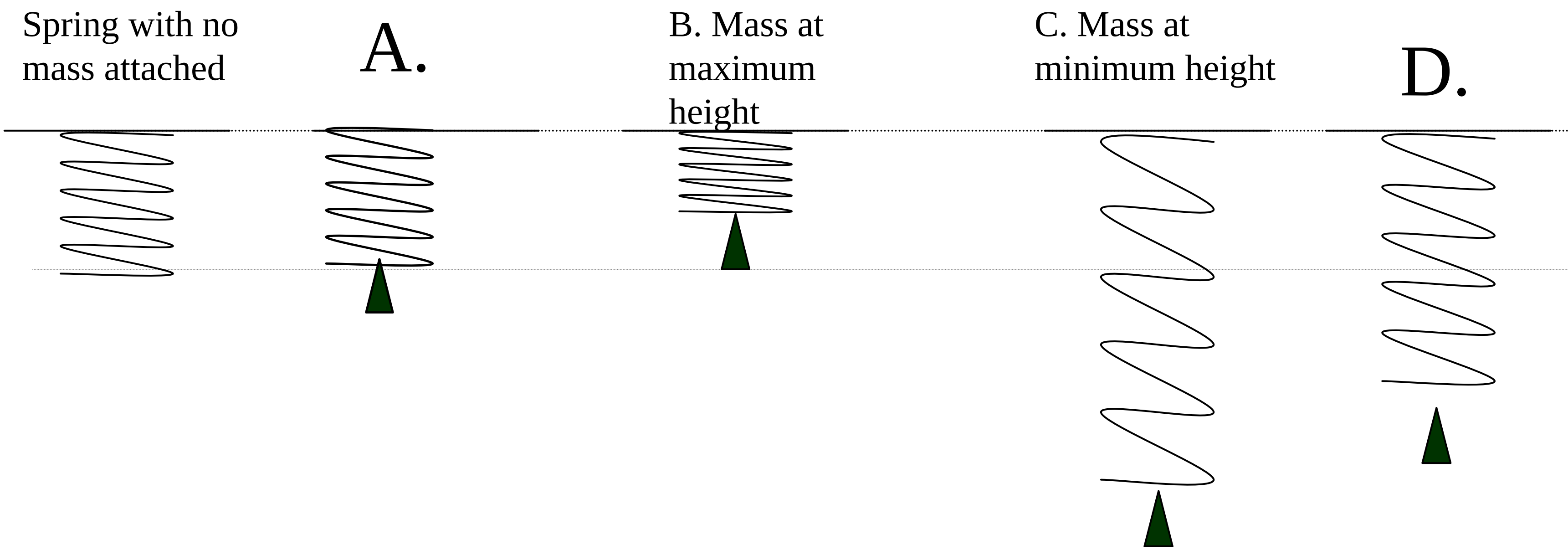
5. Where does the spring have maximum elastic potential energy?

A spring is hanging from a fixed wire as in the first picture on the left. Then a mass is hung on the spring and allowed to oscillate freely (with no friction present). Answers A-D show different positions of the mass as it was oscillating.



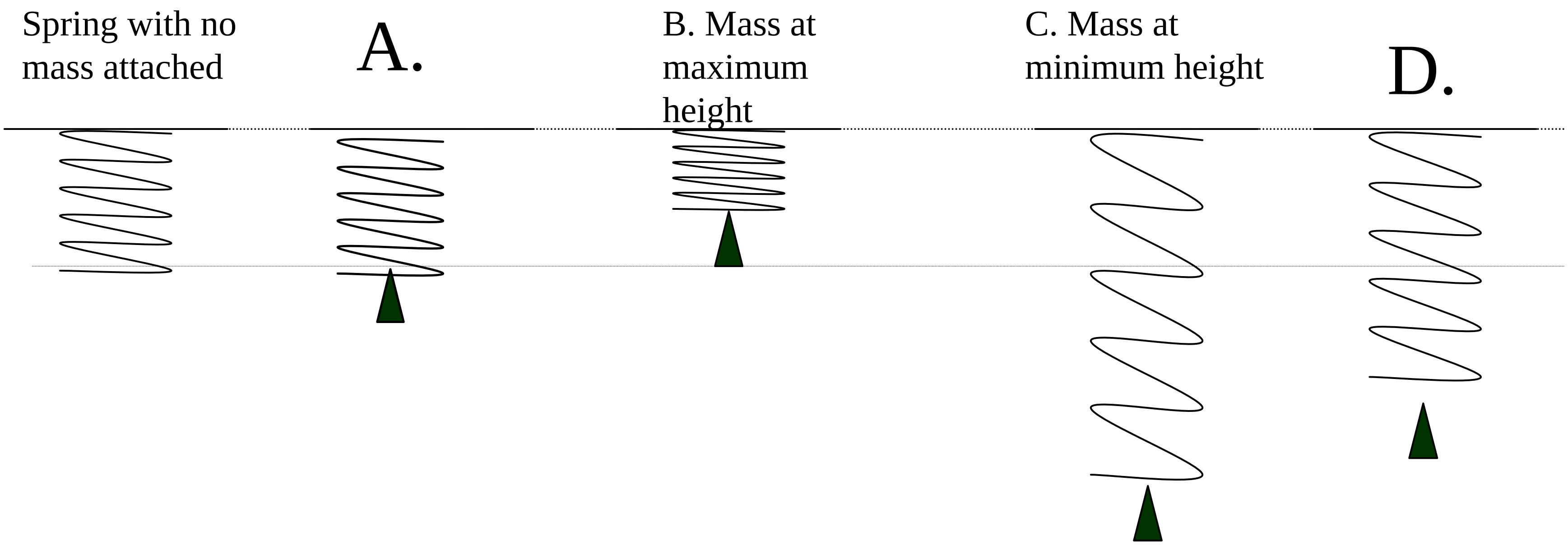
6. Where is the gravitational potential energy the least?

A spring is hanging from a fixed wire as in the first picture on the left. Then a mass is hung on the spring and allowed to oscillate freely (with no friction present). Answers A-D show different positions of the mass as it was oscillating.



7. Where is the kinetic energy zero?

A spring is hanging from a fixed wire as in the first picture on the left. Then a mass is hung on the spring and allowed to oscillate freely (with no friction present). Answers A-D show different positions of the mass as it was oscillating.



8. Where is the elastic potential energy zero?

Rotational Motion and the Law of Gravity

Learning goals-Students will be able to :

Pendulum:

- Design experiments to describe how variables *(length, mass, angle and gravity field)* affect the motion of a pendulum.
- Use a photogate timer to determine quantitatively how the period of a pendulum depends on the variables (*length, mass, angle and gravity field).*
- Determine the gravitational acceleration of "Planet X"

Gravity Force Lab:

- Describe how the force on a small mass compares to the force on a larger mass.
- Describe how force between two masses changes with mass and distance.
- Design experiments that allow you to derive an equation that relates mass, distance, and gravitational force.
- Use measurements to determine the universal gravitational constant.

Lady Bug Revolution:

- Explain the kinematics' variables for rotational motion by describing the motion of a bug on a turntable. The variables are:
  - Angular displacement, speed, and acceleration
  - Arc length
  - Tangential speed
  - Centripetal and tangential acceleration
- Describe how the bug's position on the turntable affects these variables.

Ladybug 2D:

- Draw motion vectors (position, velocity, or acceleration) for an object is moving while turning.

Masses and Springs:

- Explain how the mass of an object is determined using spring balances.
- Use the spring balance to determine the mass of an unknown object
- Find the gravity on Planet X and describe their experiment

Rotational Motion and the Law of Gravity

Measuring rotational motion

- Relate radians to degrees.
- Calculate angular displacement using the arc length and distance from the axis of rotation.
- Calculate angular speed or angular acceleration.
- Solve problems using the kinematic equations for rotational motion.

Tangential and centripetal acceleration

- Find the tangential speed of a point on a rigid rotating object using the angular speed and the radius.
- Solve problems involving tangential acceleration.
- Solve problems involving centripetal acceleration.

Causes of circular motion

- Calculate the force that maintains circular motion.
- Explain how the apparent existence of an outward force in circular motion can be explained as inertia resisting the force that maintains circular motion.
- Apply Newton's universal law of gravitation to find the gravitational force between two masses.

Unit 5 Semester Project, Circular Motion, and Universal Gravity

1 **Procedure Draft Due**
Lab: collect data
Do: ***Pendulum Lab 1 activity PhET***

2 Lab: collect data
Do: read and do text problems, questions; ***Gravity Force Lab PhET1***

3 Lab: collect data
Do: read and do text problems, questions; ***Pendulum Lab 2 activity PhET*,**

4 **Introduction draft (excluding improvements) due**
Lab: collect data
Do: read and do text problems, questions

5 Lab: collect data
Do: read and do text problems, questions; ***Ladybug Motion 2D PhET***

6 Lab: collect data
Do: read and do text problems, questions; ***Lady Bug Revolution activity PhET***

7 **Draft First procedure (have sample calculations) due**
Lab: collect data

8 Lecture: Rotational equations
Do: ***Masses and Springs PhET homework: Determine unknown mass***

9 Lab: collect data

10 Finish paper
Do: ***Gravity Force Lab PhET2***

11 **Turn in projects**
Get back old tests, type equation sheet, unit concept questions

12 Review for phynal , Clicker questions from students past
Do: read and do text problems, questions and standardized testing practice

13 Clicker questions for Lady bug, Pendulum
Turn in review assignment and typed equation

14 Review

Loeblein Comment: In my school district this is when I give the semester final. I do the next 2 units after winter break. Other teachers have found that they can complete all the topics in one semester.

15 **Take the long question part of phynal and turn in review assignment**

116 **Physics Phynal multiple choice**

Semester 1 Project Grade Sheet **Final grade out of 150________**
Names____Pd_______

Objective: Determine the relationship for a set of motion variables using probes and camera, then improve the control of the system to get better accuracy and precision. Then write a technical report especially comparing the probe versus the camera results

	A	B maximum
Management (Meeting due dates, classroom behavior, & including edited pages in appendix*)	Thesis *_____ Introduction*____ First Procedure*____ Report on time____ No off task marks Raw data in appendix (15+30 trials)*___ **20**	Anything one day late (-2) If later, you may lose all 20 points Off tasks marks 2 points/ occurrence 16 or less
Contents		
Introduction	Robust background discussion, Thesis, good improvements in process **18 17 16**	Background discussion, Thesis and improvements in process **14** or less
Procedure	Detailed Explicit about improvements Shows improved control of system Includes camera and probe procedure Drawing of setup **20 19 18**	Detailed but missing a few concepts Includes improvements Shows improved control of system Includes camera and probe procedure Drawing of setup **16 or less**
Results	Data in tables with titles, units Sample calculations Accurately treated data Shows improved accuracy and precision **30 29 28 27**	Data in tables with titles, units Sample calculations Few treatment errors Shows some improvement **24 or less**
Graphs	Uses Excel well for all graphs Multiple graphs showing comparisons with at least 8 variations on x-axis Equations for curves appropriate R values given **20 19 18**	Uses Excel for graphs 2 graphs showing comparisons with at least 8 variations on x-axis Equation for curve appropriate R value given **16 or less**
Discussion	Thesis Comprehensive summary of results Multiple equations with r^2 (demonstrating improvements) Discuss improvements with regard to specific controls Includes thorough and correct interpretation relevant to known physics Comprehensive error analysis discusses precision and accuracy with regard to equipment and procedure **30 29 28 27**	Thesis Main results summarized 2 equations with r^2(demonstrating improvements) Discuss improvements with regard to controls Some correct interpretation included Error analysis discusses error with regard to equipment only **24 or less**
Report mechanics	Proper header Sensible page breaks Organized by contents Full sentences, appropriate punctuation and spelling **12**	Less than standard 9 or 0

* These need to be included in appendix 11/11/10

Lesson plan for *Pendulum Lab*1: Introduction to Pendulums

Time for activity

Learning Goals:

Students will be able to:

- Design experiments to describe how variables *(length, mass, angle and gravity field)* affect the motion of a pendulum.
- Use a photogate timer to determine quantitatively how the period of a pendulum depends on the variables (*length, mass, angle and gravity field).*

Background:

I am assigning this as homework in my College Physics class. My students will have finished the unit on Conservation of Energy and completed the four Skate Park activities and the Masses and Springs Conservation of Energy activity (homework version) that I wrote. Also, they will have designed several labs and used a photogate. In addition, they will have done the Curve Fitting activity. Because of the earlier emphasis on energy conservation, this activity only addresses the first two learning goals written by the sim design team. You can read the other goals at Learning Goals for Pendulum. I plan to use this as an introduction to circular motion. I will use the Masses and Springs Determine the Unknowns activity at the end of this same unit during the semester review. I have an activity for determining g using *Pendulum Lab* that I am going to use in the Wave unit.

***Pendulum Lab* Introduction:** Here are some of the Tips written by PhET; for the complete document see the "teachers guide" under Teaching Tips for Pendulum. I probably won't show these to the students, but the information might be handy to remember as I help individuals.

- If you want to do an experiment, **Pause** the sim, set up your experiment, then start it.
- If you want to compare two variables like length, check **Show 2nd Pendulum**, **Pause** the sim, set up your experiment, then start it.
- The **Photogate Timer** operates as a triggered mechanism, which starts when the pendulum crosses the vertical dotted line. The period will be displayed after one cycle.
- All the tools are draggable: the timer, stop watch, ruler and tape measure
- The initial angle is marked by a tick mark the color of the pendulum mass
- As you move the pendulum, the angles are constrained to be exactly whole numbers.
- Students may change the mass or length while the experiments are running. It is possible that they may not realize it.

Lesson: I plan to use some clicker questions to help with class discussion during the semester review time at the end of the unit.

Student directions *Pendulum Lab* activity 1: Introduction to Pendulums

Learning Goals: Students will be able to:

- Design experiments to describe how variables affect the motion of a pendulum.
- Use a photogate timer to determine quantitatively how the period of a pendulum depends on the variables you described.

Directions:

1. Play with ***Pendulum Lab*** to figure out what variables affect the motion of a pendulum and write qualitative descriptions for each variable. For example using the ***Skate Park*** simulation, you might have written "The type of Skater doesn't effect the how high the Skater goes even if track friction is on"

2. Design experiments to find the best equation for the relationship for length and period. Include a spreadsheet and chart with a trendline from Excel.

3. Based on your understanding from the Curve Fitting activity, discuss how well you think the equation really describes the relationship.

4. Design experiments to find the best equation for the relationship for initial angle and period. Include a spreadsheet and chart with a trendline from Excel.

5. Based on your understanding from the Curve Fitting activity, discuss how well you think the equation really describes the relationship.

Pendulum Lab Activity 1

Learning Goals: Students will be able to:

•Design experiments to describe how variables affect the motion of a pendulum.

•Use a photogate timer to determine quantitatively how the period of a pendulum depends on the variables you described.

I plan to have the sim open to demonstrate the answers, but I have included the results from the photogate timer just for precise evidence.

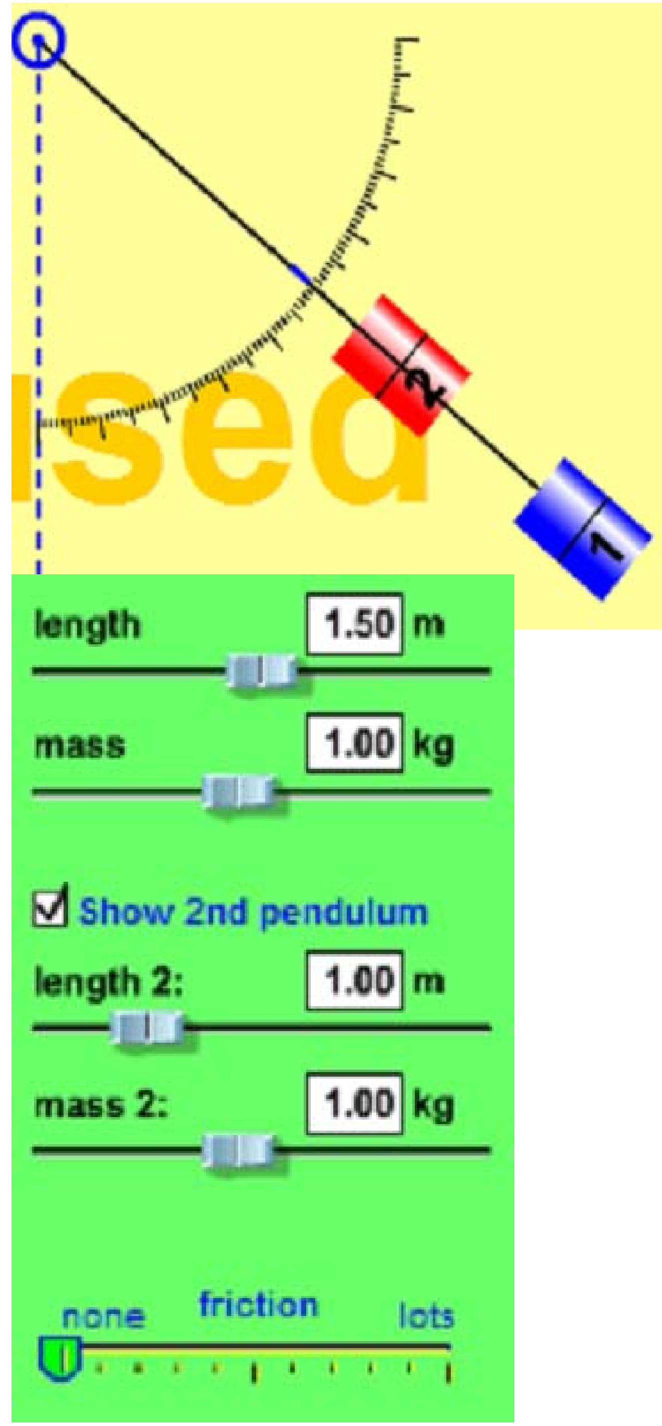
Trish Loeblein updated 7/20/2008

1. Which one swings faster?

A. They go the same speed

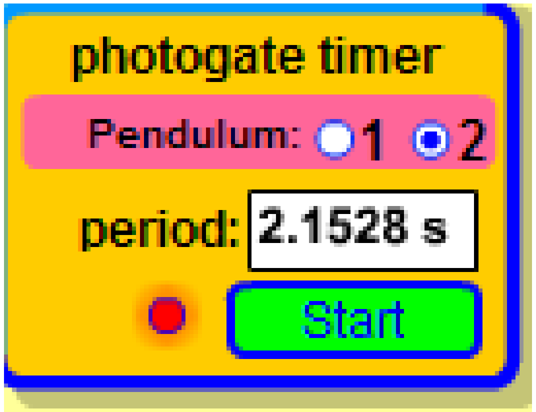
B. 1 is faster

C. 2 is faster



Answer to 1


photogate timer
Pendulum: 1 2
period: 2.6366 s
Start

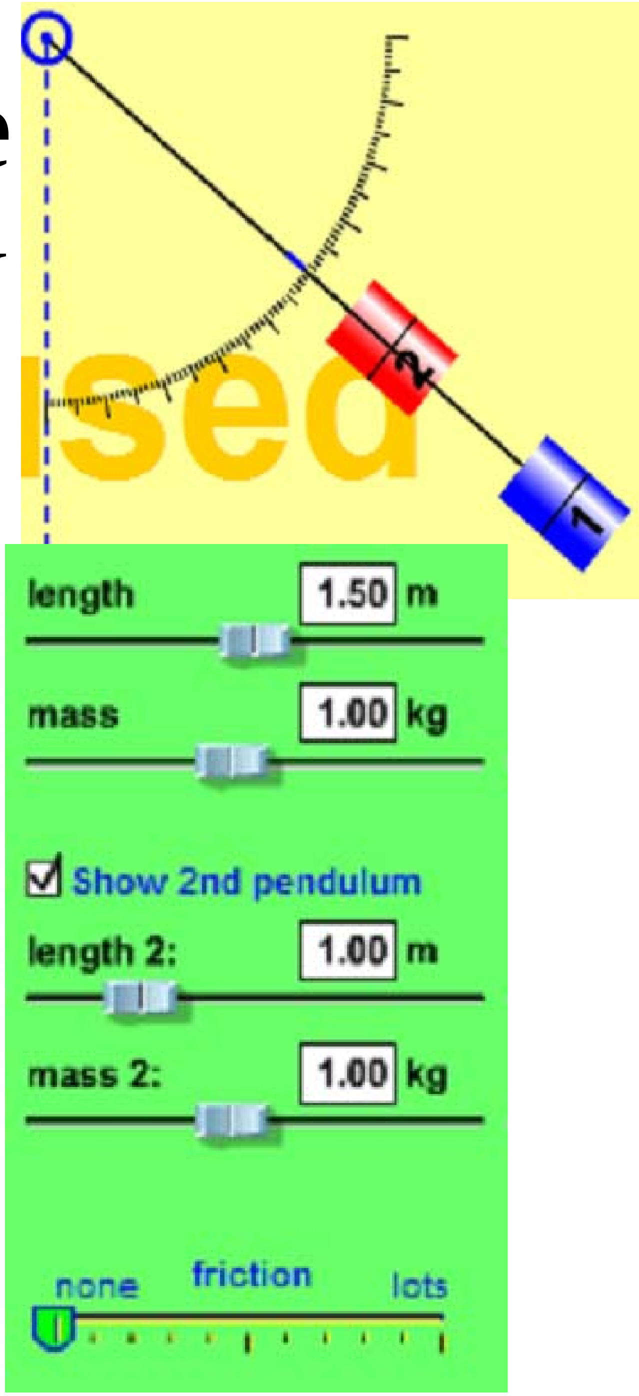

photogate timer
Pendulum: 1 2
period: 2.1528 s
Start

2. What is true about the maximum angle as they swing left?

A. They have the same max angle

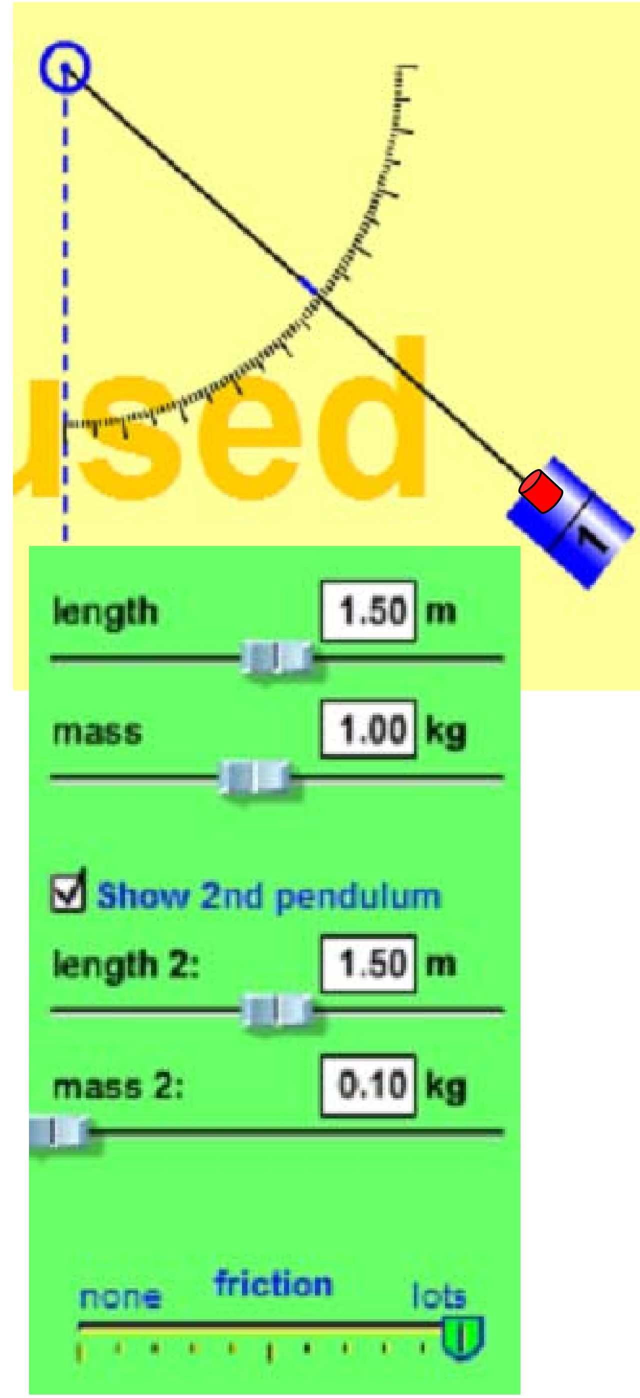
B. 1 swings to a greater angle

C. 2 swings to a greater angle



3. What will be the differences in the swinging patterns?

A. There are no differences
B. 1 swings higher; stops last
C. 1 swings higher; stops first
D. 1 swings lower; stops first
E. 1 swings lower; stops last

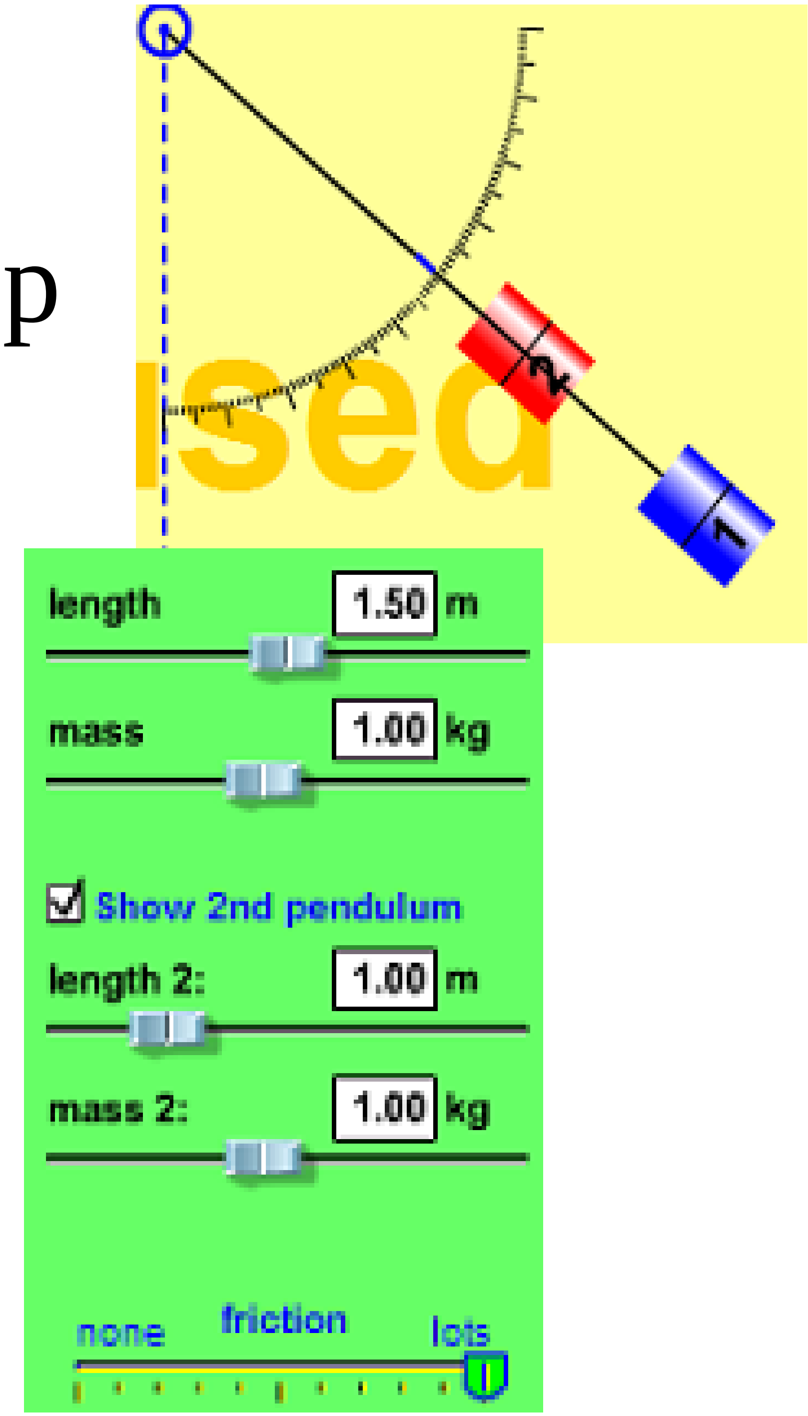


4. Which one will stop first?

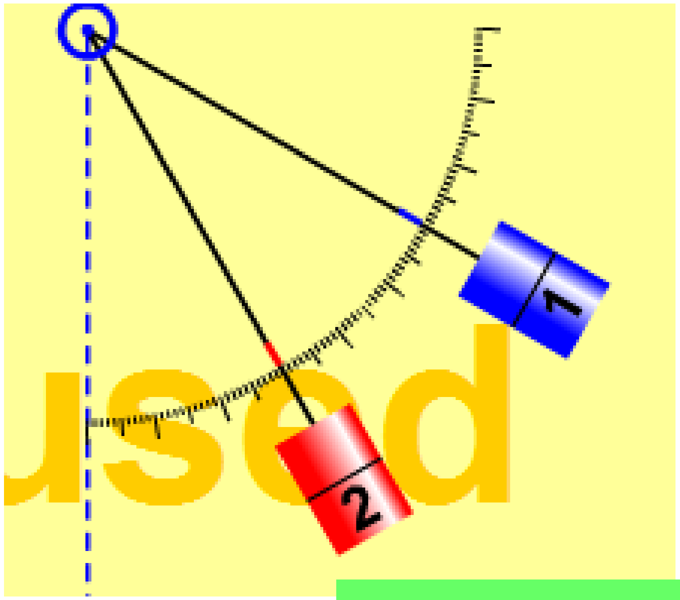
A. They stop at the same time

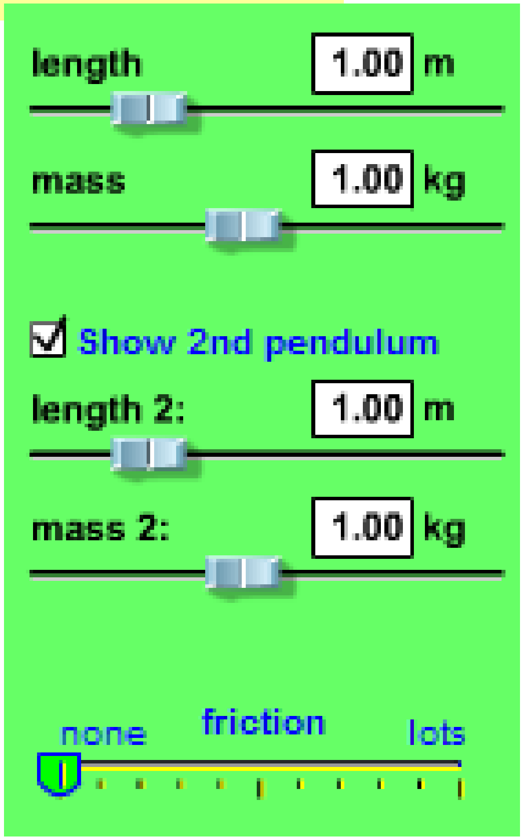
B. 1 stops first

C. 2 stops first



5. Which has the shortest period?



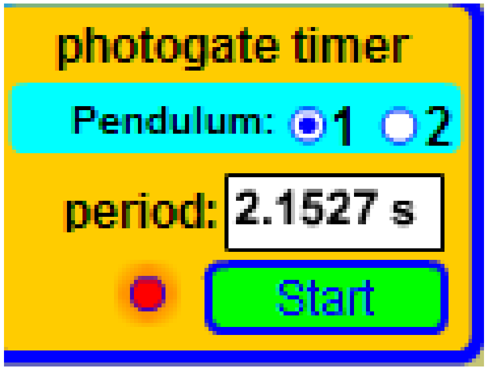


A. They have equal periods

B. 1 has a shorter period

C. 2 has a shorter period

Answer to 5


photogate timer
Pendulum: 1 2
period: 2.1527 s
Start


photogate timer
Pendulum: 1 2
period: 2.0408 s
Start

Lesson plans for *Gravity Force Lab* Activities 1 and 2 :

Homework

Learning Goals:
Students will be able to:

Activity 1- Introduction

- Describe how force between two masses changes with mass and distance.
- Describe how the force on a small mass compares to the force on a larger mass. *"Identify action-reaction pairs" is what this is called in my text*
- Compare the force of gravity between planets to the force of gravity between objects like rocks or people.

The following goal could be addressed, but I chose not to put it on the homework because I didn't want this assignment to take too long. I plan to use the sim to do a textbook problem in a class discussion

- Use the simulation to check textbook problems that ask to find the gravitational force between two masses. *I had "applies Universal Law of Gravity", but I decided that was too much help with other goals.*

There are other learning goals for the unit under "Lab Skills", but are not explicitly included in all activities. See my webpage for unit learning goals.
http://jeffcoweb.jeffco.k12.co.us/high/evergreen/science/loeblein/learninggoals/physics_lg.html

Activity 2- Advanced

- Design experiments that allow you to derive an equation that relates mass, distance, and gravitational force.
- Use measurements to determine the universal gravitational constant.

Background:
I am assigning this during the last unit of the semester. My students will have had many opportunities to design experiments and evaluate curve fit. If you would like to see how this fits in the scope of my course, see http://phet.colorado.edu/teacher_ideas/view-contribution.php?contribution_id=358

Activity 2 could be used anytime during the year when you are trying to help students with experimental design. I have other activities scheduled that use other sims during this unit, so I do not plan to use Activity 2 this year:

Pendulum Homework http://phet/teacher_ideas/view-contribution.php?contribution_id=563
Pendulum 2 Find g on Planet X Homework
http://phet/teacher_ideas/view-contribution.php?contribution_id=564
Masses and Springs: Determine Mass of unknown Homework
http://phet.colorado.edu/teacher_ideas/view-contribution.php?contribution_id=4

***Gravity Force Lab* Introduction:**
You may want to check out the Teaching Tips.

Lesson:
These are designed for homework assignments.

Student directions *Gravity Force Lab* activity 1a

Learning Goals: Students will be able to:

- Describe how the force on a small mass compares to the force on a larger mass.
- Describe how force between two masses changes with mass and distance.

1. How does the gravitational force that a small mass has towards a large mass compare to the force that a large mass has towards a small mass? What physics law could you have used to predict the answer?

2. Design experiments to find the best equation for the relationship for mass and gravitational force.

   a. Include a spreadsheet and chart with a trendline from Excel.
   b. Describe how you chose whether mass or force should be used for the x- axis
   c. What law of physics did you use to help you chose an appropriate trendline? How do your results compare to the expected curve?

3. Design experiments to find the best equation for the relationship for gravitational force and distance.

   a. Include a spreadsheet and chart with a trendline from Excel.
   b. Describe how you chose whether distance or force should be used for the x- axis
   c. What law of physics did you use to help you chose an appropriate trendline? How do your results compare to the expected curve?

Student directions *Gravity Force Lab* activity 2-Advanced

homework

Learning Goals: Students will be able to:

- Design experiments that allow you to derive an equation that relates mass, distance, and gravitational force.
- Use measurements to determine the universal gravitational constant.

Directions: You will turn in a paper that has 4 parts.

1. Make a data table(s) that includes information that you used to determine the relationships between mass, distance between centers, and gravitational force.

2. Write a procedure that another student could follow to verify your results. The procedure should be in paragraph form.

3. Write a paragraph that explains your reasoning for the procedure design.

4. Use the simulation to find the universal gravitational constant and describe how you determined it.

Lesson plan for *Pendulum Lab* 2: Finding g with a Pendulum

Time for activity

Learning Goals:

Students will be able to determine the gravitational acceleration of "Planet X"

Background:

I plan to use this as a review of periodic motion. I used $T = 2\pi\sqrt{\frac{L}{g}}$ as a basis for my calculations. I only varied the planet, so I used $T^2_{earth}\, g_{earth} = T^2_{planet}\, g_{planet}$.. The equation is only good for small angles, so the students will have to experiment using Jupiter or the Moon to discover what "small" means or they might be able to find some advice in a literature search.

***Pendulum Lab* Introduction:** Here are some of the Tips written by PhET; for the complete document see Teaching Tips for Pendulum. I probably won't show these to the students, but the information might be handy to remember as I help individuals.

- If you want to do an experiment, **Pause** the sim, set up your experiment, then start it.
- If you want to compare two variables like length, check **Show 2nd Pendulum**, **Pause** the sim, set up your experiment, then start it.
- The **Photogate Timer** operates as a triggered mechanism, which starts when the pendulum crosses the vertical dotted line. The period will be displayed after one cycle.
- All the tools are draggable: the timer, stop watch, ruler and tape measure
- The initial angle is marked by a tick mark the color of the pendulum mass
- As you move the pendulum, the angles are constrained to be exactly whole numbers.
- Students may change the mass or length while the experiments are running. It is possible that they may not realize it.

Some facts: Jupiter's gravity is about 2.6 times Earth and the Moon is about 1/6 times.

Lesson: I plan to use some clicker questions to help with class discussion during the semester review time at the end of the unit. I am not publishing the answer.

Student directions *Pendulum Lab* activity 2: Finding g on Planet X homework

Learning Goals: Students will be able to determine the gravitational acceleration of "Planet X"

1. Research to find equations that would help you find g using a pendulum. Design an experiment and test your design using Moon and Jupiter. Write your procedure in a paragraph that another student could use to verify your results. Show your data, graphs, and calculations that support your strategy.

2. Use your procedure to find g on Planet X. Show your data, graphs, and calculations that support your conclusion.

3. Give your conclusion and write an error analysis.

Lesson plan for *Ladybug Motion 2D* activity 1: Vector controls for circular motion Homework

Learning Goals: Students will be able to draw motion vectors (position, velocity, or acceleration) for an object is moving while turning.

Background: I have not used this activity and plan to put it as a homework in Unit 5 Rotational Motion in my College Physics course (an algebra based physics course for which the students get credit for first semester College Physics)
Ladybug Motion 2D came out in spring of 2009 and I wrote this activity as a replacement for one that used the Maze Game. The students will do the Lady Bug Revolution activity next. You can go to my school website to see how I incorporated this into my course.
http://jeffcoweb.jeffco.k12.co.us/high/evergreen/science/loeblein/phys_syl/Sem1Unit5.html

Lesson: I assigned this for homework. Also, I called this Activity 1 because there will be a game tab added to this simulation. I will write a lesson for when the game is available.

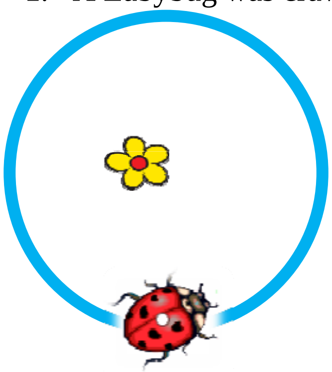
Post lesson: some of the clicker questions from Maze game might still be useful.
http://phet.colorado.edu/teacher_ideas/view-contribution.php?contribution_id=548

Student directions ***Ladybug Motion 2D*** activity 1: Vector controls for circular motion
Homework

Learning Goals: Students will be able to draw motion vectors (position, velocity, or acceleration) for an object is moving while turning.

Directions:

1. A Labybug was crawling in a circle around a flower like in the picture below.



a. Sketch what you think the velocity and acceleration vectors would look like.

b. If the flower is the "zero" position, what would the position vector look like?

c. Use ***Ladybug Motion 2D*** to check your ideas. Make corrections if necessary

2. Suppose the bug crawled along concentric circles like Figure 1.

a. Draw what you think the **position** vectors would look like at the locations shown in Figure 2.

Figure 1

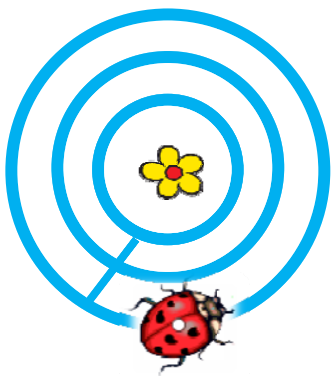


Figure 2

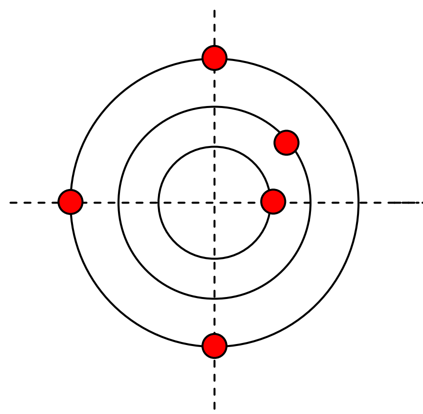
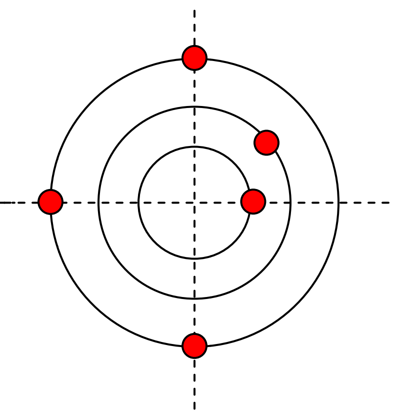


Figure 3 (corrections)



b. Use ***Ladybug Motion 2D*** to check your ideas. Make corrections if necessary on Figure 3.

c. Draw what you think the **velocity** vectors would look like at the locations shown in Figure 4.

d. Check your ideas and make corrections on Figure 5. You may want to use ***Ladybug Revolution*** simulation too.

Figure 4

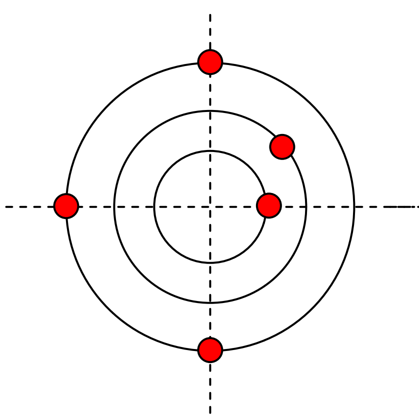
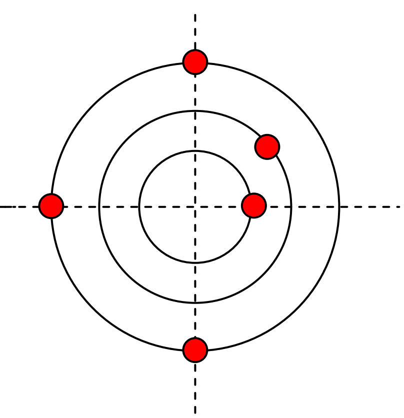


Figure 5



Student directions ***Ladybug Motion 2D*** activity 1: Vector controls for circular motion
Homework

e. Draw what you think the **acceleration** vectors would look like at the locations in Figure 6.
f. Check your ideas and make corrections on Figure 7. You may want to use ***Ladybug Revolution*** simulation too.

Figure 6

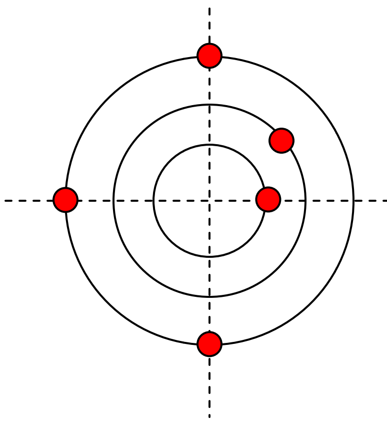
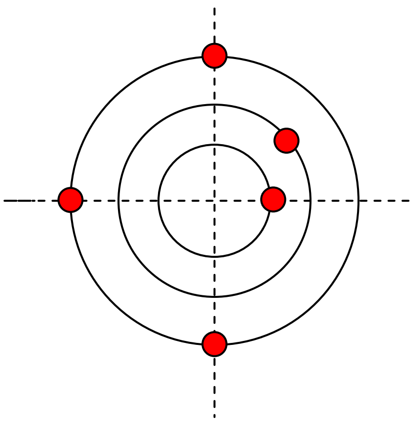


Figure 7



3. A Labybug was crawling in an elliptical path around a flower like in the picture below.
   a. Sketch what you think the position, velocity, and acceleration vectors would look like on Figure 8-10 at the red dots.

   b. Use ***Ladybug Motion 2D*** to check your ideas. Make corrections if necessary

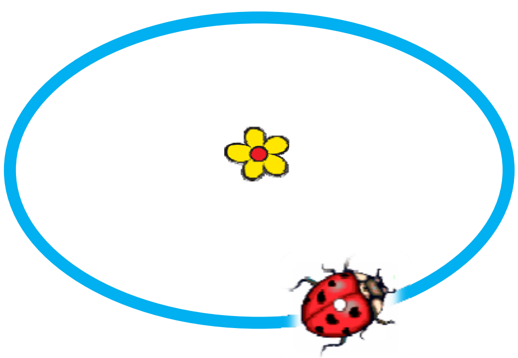


Figure 8 Position

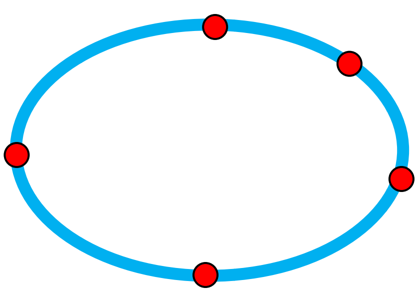


Figure 9 Velocity

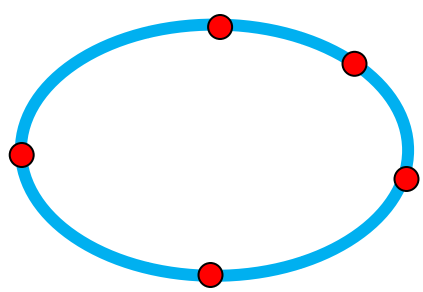
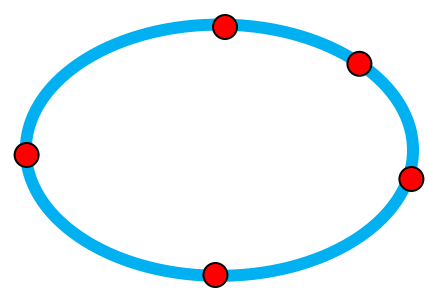


Figure 10 Acceleration



4. Compare and contrast what you saw between circular and elliptical motion in terms of vectors.

Ladybug Motion 2D

Learning Goals: Students will be able to draw motion vectors (position, velocity, or acceleration) for an object is moving while turning.

Open ***Ladybug Motion 2D*** and ***Ladybug Revolution*** before starting the questions.

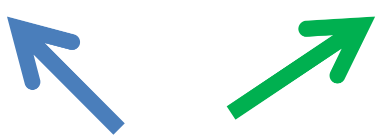
Trish Loeblein July 2009 to see course syllabi :
http://jeffcoweb.jeffco.k12.co.us/high/evergreen/science/loeblein/phys_syl/syllabus_p.html

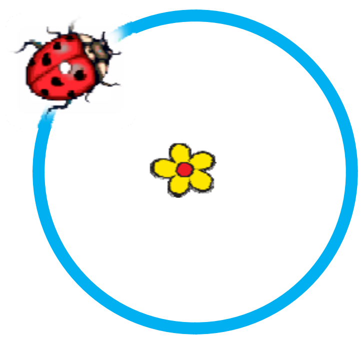
1. What could the **position** and **velocity** vectors look like?

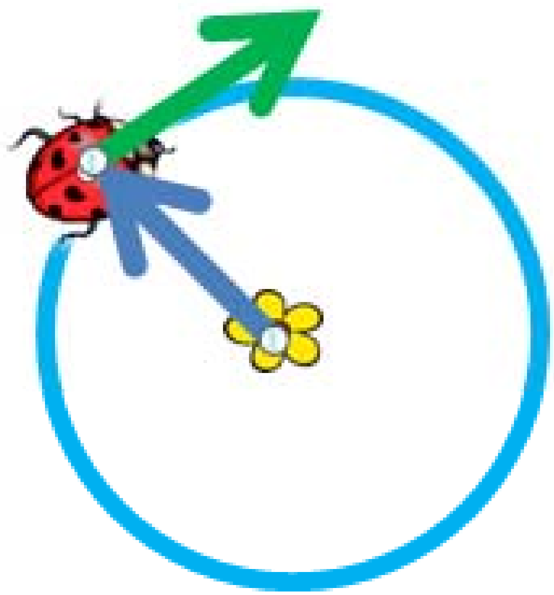
A. 

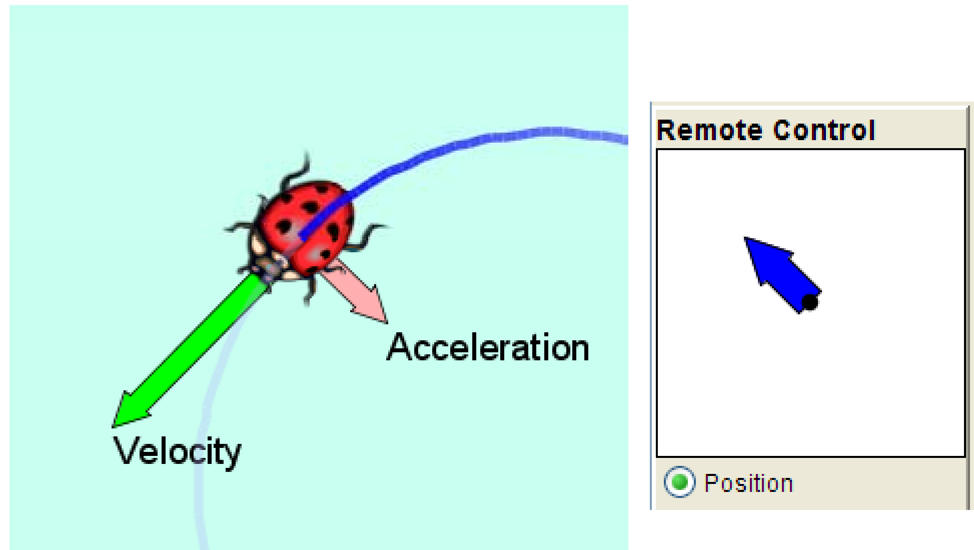
B. 

C. 

D. 







You could run the sim and discuss that in this situation the bug is traveling clockwise as opposed to counter clockwise in the sim. The velocity vector could be a different length depending on speed, but that the direction is correct.

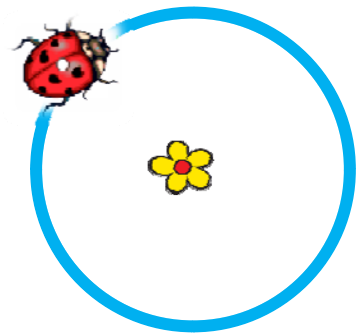
2. What could the acceleration and velocity vectors look like?

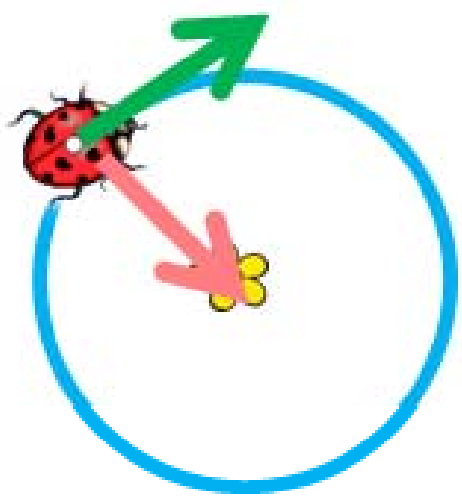
A. 

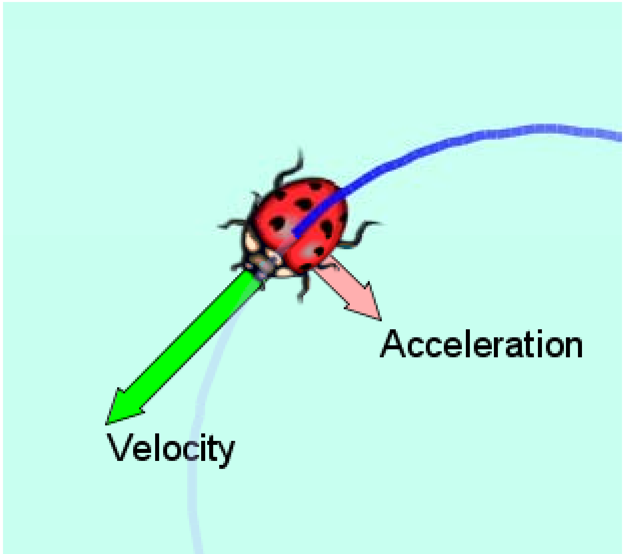
B. 

C. 

D. 







You could run the sim and discuss that in this situation the bug is traveling clockwise and that speed affects both velocity and acceleration vector length, but that the direction is correct.

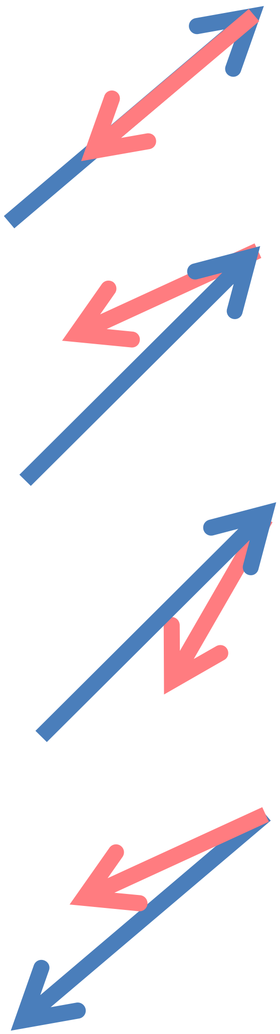
3. What could the **position** & **acceleration** vectors look like?

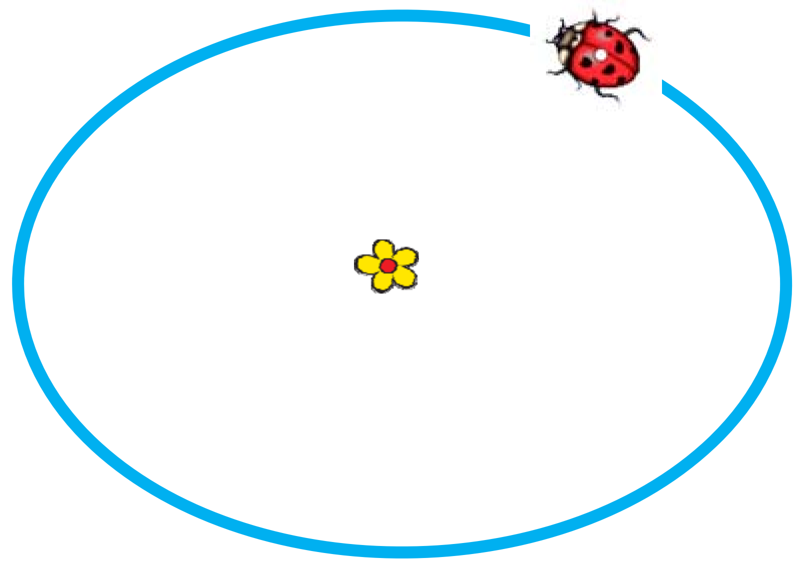
A.

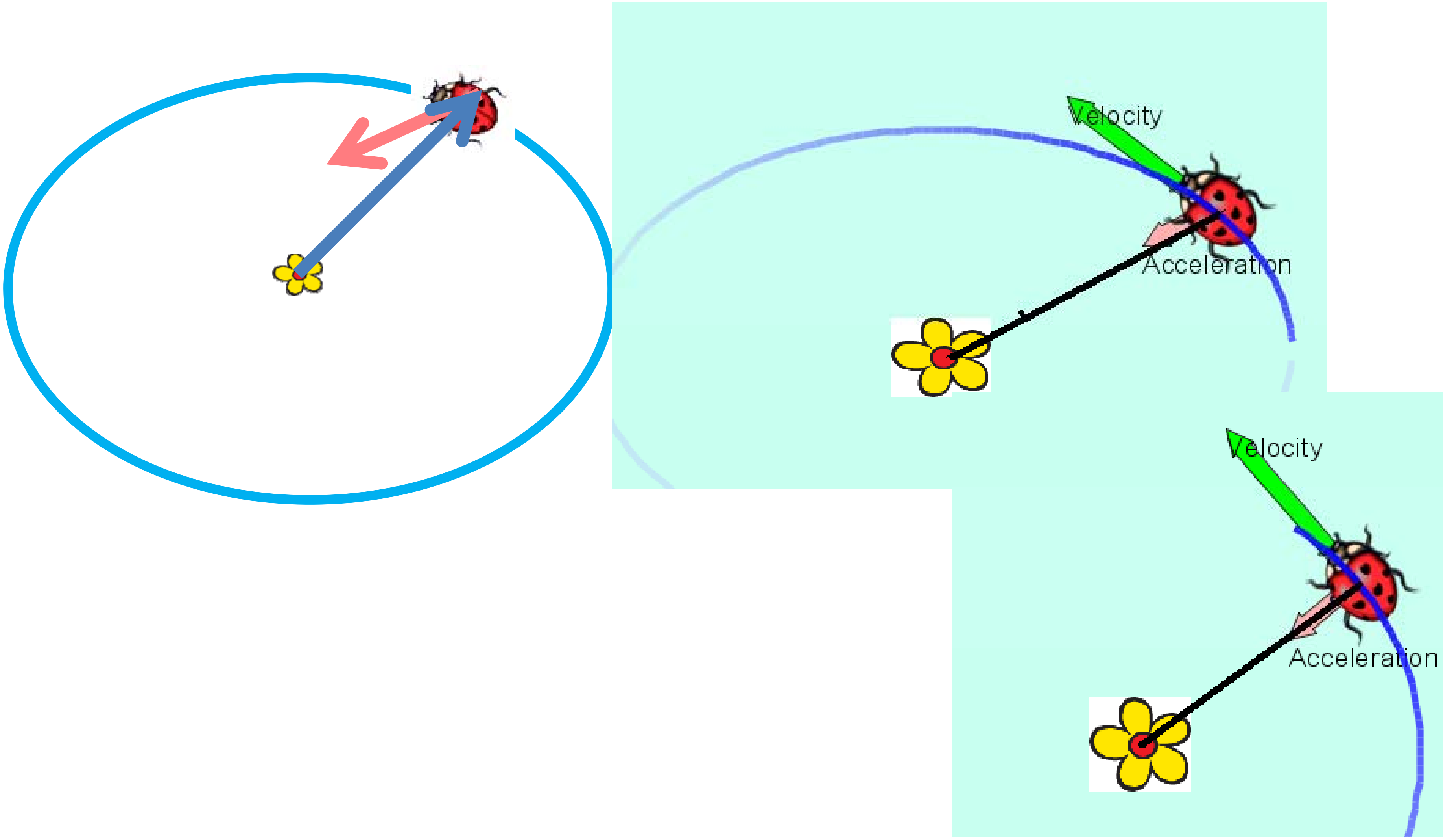
B.

C.

D.



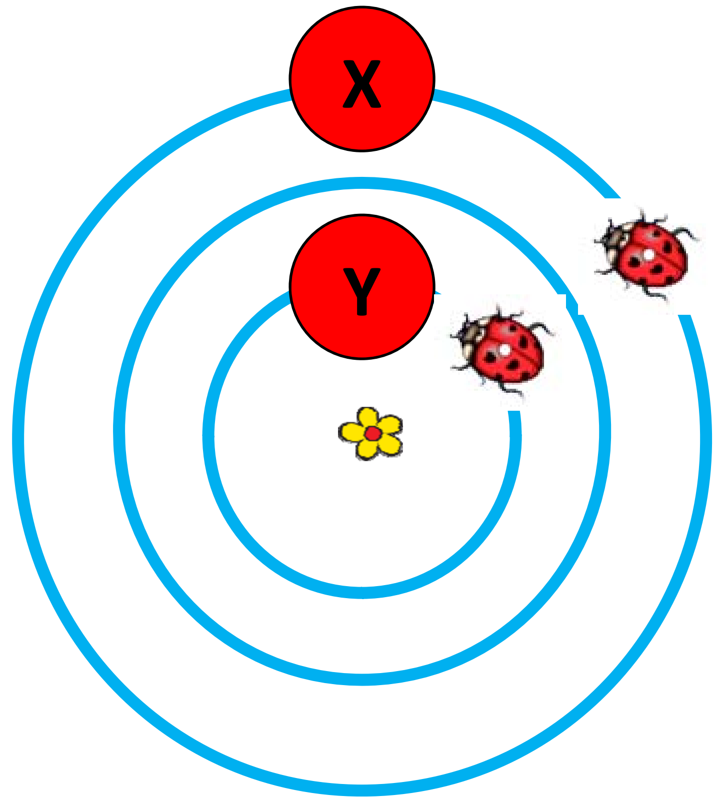


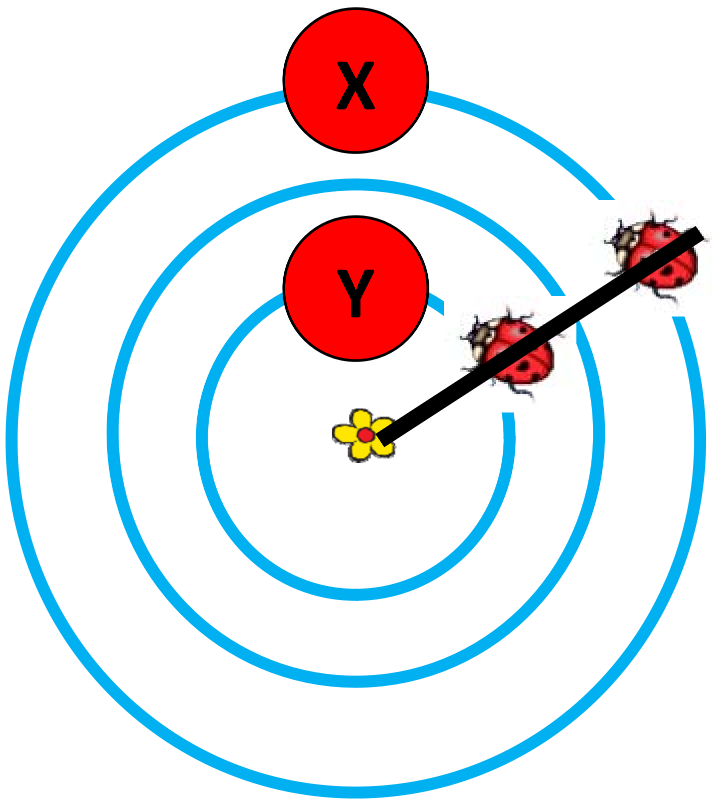


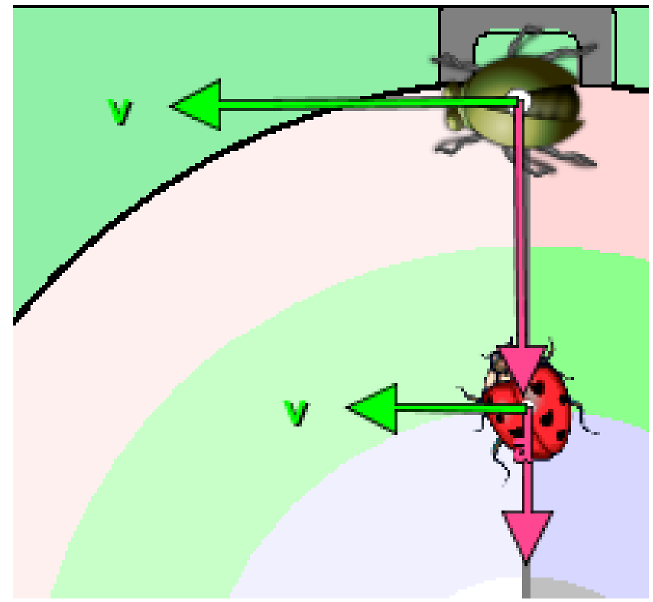
The acceleration would not be radial or the path would be circular. This is very difficult to see in the sim.

4. If you had two bugs moving in circles like this, what could the **velocity** vectors at point X vs point Y look like?

	X	Y
A	←	←
B	←	←
C	←	←
D	Any of the above	
E	None of the above are possible	







IF they were connected with a bar so they had to go around together, it would be like in Ladybug Revolution, but otherwise there is no way to know the vector length relationship, but the vectors would be parallel. I am thinking that the bugs might arrive at X and Y at different times.

Lesson plan for *Ladybug Revolution* : Exploring rotational motion
Time for activity: 5 for intro and 30 for students

Learning Goals:
Students will be able to:

- Explain the kinematics' variables for rotational motion by describing the motion of a bug on a turntable. The variables are:
    - Angular displacement, speed, and acceleration
    - Arc length
    - Tangential speed
    - Centripetal and tangential acceleration
- Describe how the bug's position on the turntable affects these variables.

To look at varying tangential velocity, use the Torque simulation

Background:
My students are using Physics, Serway and Faughn , Holt First Edition 1999. I have not lectured at this point in the unit. They will have read sections 7-1 and 7-2 and done several practice problems involving the following learning goals:

Chapter 7: Rotational Motion and the Law of Gravity

7-1 Measuring rotational motion

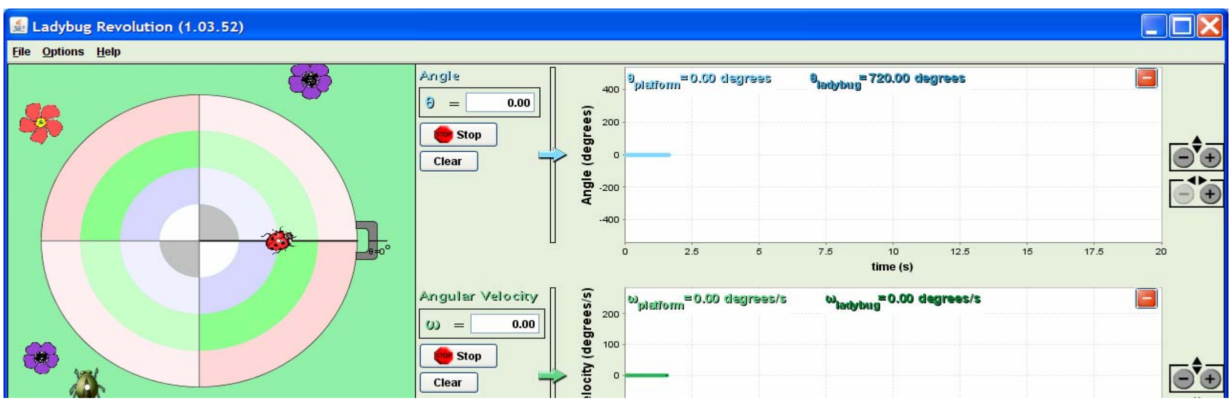
- Relate radians to degrees.
- Calculate angular displacement using the arc length and distance from the axis of rotation.
- Calculate angular speed or angular acceleration.
- Solve problems using the kinematic equations for rotational motion.

7-2 Tangential and centripetal acceleration

- Find the tangential speed of a point on a rigid rotating object using the angular speed and the radius.
- Solve problems involving tangential acceleration.
- Solve problems involving centripetal acceleration.

Ladybug Revolution **Tips for Teachers:**

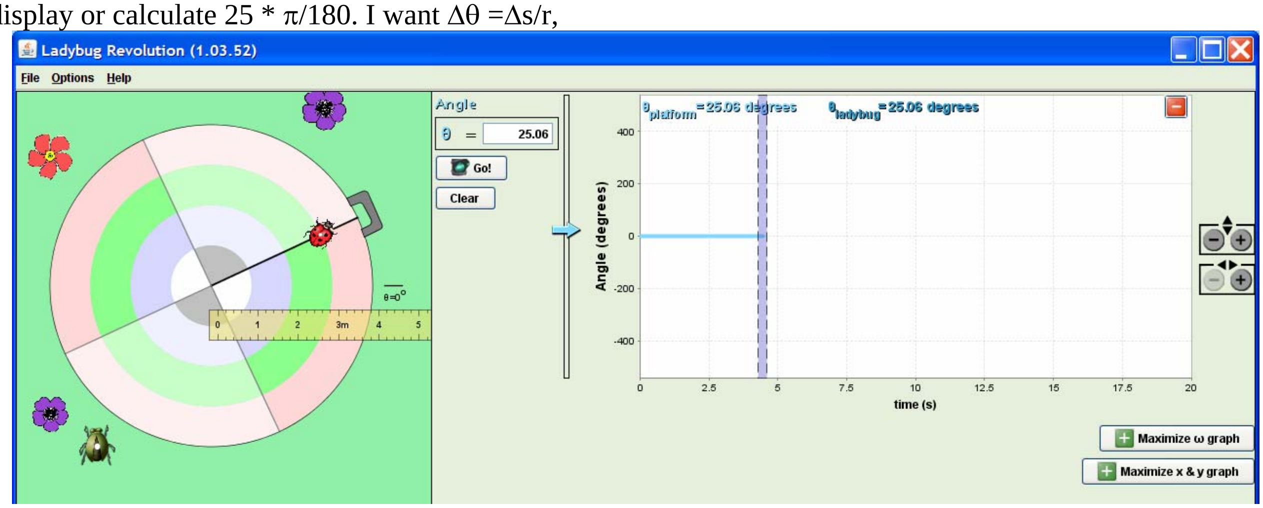
1. It is easy to get the bug to be one or more rotations off from the table in 1.03.52. if you use the angle slider too fast. The difference between to 2 is not resolved when you select Reset. Below is an example where I have used the slider too fast and then hit Reset. I'll project the sim and demonstrate the bug. Then I'll ask how they could move the bug to "fix the problem" themselves. (you can just pick up the bug and move her clockwise)



Lesson plan for *Ladybug Revolution* : Exploring rotational motion
Time for activity: 5 for intro and 30 for students

2. The bugs have basically no mass, but have infinitely high attraction to the table. There are two different ones so that you can compare location easily.
3. The acceleration vector denotes the centripetal acceleration, not the tangential.

Lesson:
1. Go over #1 if the bug is not fixed.
2. I told my students that the bugs are riding on a platform like a merry-go-round and were so sticky that they don't slide.
3. Explain to the students what I mean by: "In this activity, you must use values that you measure to write your stories." Open the slide show and go over first three slides. I will project the simulation, show how to turn on the ruler and show how they could determine the distance that the bug has traveled using the ruler and angle (I made this by turning on the ruler, closing all the other graphs, then I grabbed the handle and moved the table 25 degrees counterclockwise.) On the board, I'll write : To find the distance traveled: (ask for ideas from class). Our book has $\Delta\theta = \Delta s/r$, $\Delta\theta$ is in radians so they need to change the display or calculate 25 * π/180. I want $\Delta\theta = \Delta s/r$,



Have the students use the lab sheet for guidance. The activity took my honors physics students about 30 minutes.

Student directions *Ladybug Revolution* activity 1: Exploring rotational motion
30 minutes

Learning Goals: Students will be able to:

- Explain some of the variables for rotational motion by describing the motion of a bug on a turning platform.
- Describe how the bug's position on the turning platform affects these variables.

Directions: In this activity, you must include values that you <u>measure</u> **and** <u>show sample calculations</u> to support your answers to the questions. Include examples that use both bugs in different locations.

1. Write a story about the bugs rotating on the turntable. In your story, include how to find the distance the bug travels, the arc length and angular displacement.

2. In your text, the author states: "All points on a rigid object have the same angular acceleration and angular speed."
   - How could you use the bugs in *Ladybug Revolution* to test this idea?
   - Is the angular displacement also the same or does it differ? Explain your reasoning.

3. How is tangential speed represented in *Ladybug Revolution?* Explain how your ideas support the information in the text.

Lesson plan for Homework activity for Masses and Springs: Determine unknowns

Learning Goal: Students will be able to

- explain how the mass of an object is determined using spring balances.
- use the spring balance to determine the mass of an unknown object
- find the gravity on Planet X and describe their experiment

Background: I tried to do this as a homework for two years with only the first 2 goals, but the results were poor. The next year, my class became a college class and the students were more responsible and also more began to be able to run the simulations at home. In this coming year, The fourth year of doing this activity, I decided to put it at the end of the semester as a homework and add the third goal. They will have found the gravity on Planet X of Pendulum lab, so I think it is reasonable to add. (the two Planets are different) Results are pending.

Masses and Springs **Introduction:** Because we will have already used the sim, I'll will have shown them the springs, but I left my notes here for others to use.
I plan to get out some spring scales and hang some objects that are familiar on them so the students know what the sim is demonstrating. I am not going to show how to use the sim.

Lesson: Have the students use the lab sheet for guidance to learn the objective.

Here are some ideas from Perkins' **Masses and Springs Homework SIM Answer Key** written for physics 1010 at CU that could be added.

> **d)** Classic footage of the Apollo 11 astronauts show them taking large leaps bounding around the surface of the moon. By transporting this simple springs and mass system to the moon, we can measure the force of gravity exerted by the moon on people at its surface and compare it to the force of gravity exerted by the earth on people at its surface.
>
> > **i)** (1 pt) Use the apparatus to measure the force of gravity exerted by the moon on the 50 g mass. What is the value of this force? **Be careful with units**
> > In the part c, we measured the spring constant for the Spring #3 on the softest setting. The found that the 50 g mass stretched the spring by 13.2 cm, giving a measured spring constant (k) was 3.7 N/m.
> > If we know change planets and go to the moon, we find that the 50 g mass only stretches the spring 2.2. cm. If the mass is stationary, we know that the force of gravity acting down on the mass must exactly balance the force of the spring up on the mass. So we have the equality:
> > Fgravity + Fspring = 0
> > Fgravity on the moon= kx = (3.7 N/m) (0.022 m) = 0.0814 N
> >
> > **ii)** (1 pt) If this mass is dropped from 10 m high, at what rate does this mass accelerate towards the surface?

Fgravity on moon = mass x g (on the moon)
g (on the moon) = (Fgravity on moon)/m = (0.0814 N)/(0.05 kg) = 1.63 m/s^2 straight downwards.

iii) (1 pt) If you can jump to a height of 2 ft on earth, explain why the change in gravity enables you to jump much higher on the moon? Be sure to identify the physics principles you use and how you apply them to the situation.
Gravity exerts a force on you in the downward direction. When you are airborne this is the only force acting on you, so the net force is equal to the force exerted by gravity. This net force results in an acceleration pointing in the downward direction, following the equation Fnet = mass x acceleration. Since the force of gravity on the moon is smaller than the force of gravity on earth, the acceleration due to gravity on the moon is smaller than the acceleration due to gravity on the earth.
We know acceleration tells us how rapidly the velocity will be changing:
Acceleration = (change in velocity)/(time elapsed).
So the **(time elapsed) = (change in velocity)/acceleration.**
If the acceleration is smaller, more time will elapse before the velocity decreases from the initial upwards velocity to 0 m/s at the top of your jump. If this process takes a longer amount of time, you will jump higher. NOTE, if your initial upwards velocity is the same, the average velocity will be the same.
distance traveled = (average velocity) x time

Masses and Springs: Determine the Unknowns

Go to the PhET site(http://phet.colorado.edu), launch *Masses and Springs*

Learning Goals: Students will be able to

- explain how the mass of an object is determined using spring balances.
- use the spring balance to determine the mass of an unknown object
- find the gravity on Planet X and describe their experiment

Directions: Investigate how the simulation works by "mousing around." Then, use the tools to determine the masses of the three unmarked cylinders. You will turn in a paper that has 3 parts.

1. Make a data table that includes information that you used to determine the mass of the unknowns. Record the determined masses in the table as well.

2. Write a procedure that another student could follow to verify your results. The procedure should be in paragraph form.

3. Write a paragraph that explains your reasoning for the procedure design.

4. Find the gravity on Planet X and describe how you determined it.

Simulation helpful tips: All the springs have the same characteristics by default. The stiffness of spring number three can be varied; put the slider in the middle to reset.

Fluids

Learning goals-Students will be able to :

Fluid Mechanics

- Define a fluid
- Distinguish a liquid from a gas
- Determine the magnitude of the buoyant force exerted on a floating object or a submerged object
- Explain why some objects float and some objects sink
- Calculate the pressure exerted by a fluid
- Calculate how pressure varies with depth in a fluid
- Describe fluids in terms of temperature

PhET Activities

Density:

use macroscopic evidence to:

- Measure the volume of an object by observing the amount of fluid it displaces or can displace.
- Provide evidence and reasoning for how objects of similar:
    - mass can have differing volume
    - volume can have differing mass.
- Identify the unknown materials by calculating density using displacement of fluid techniques and reference tables provided in the simulation.

Buoyancy

- Use combinations of tools to find density of both liquids and solids
- Describe the forces that act on a completely or partially submerged object
- Describe what *Buoyancy* is and how it affects the *apparent weight* of an object in a fluid.
- Predict whether an object will sink or float when placed in a liquid, given densities of the object and liquid
- Predict the *apparent weight* of a completely or partially submerged object of known mass and volume in fluids for which the density is known

Balloons and Buoyancy

- Explain why a rigid sphere would float or sink
- Describe the differences between the balloon, rigid sphere, and helium balloon
- Explain why a hot air balloon has a heater
- Determine what causes helium balloon to rise up or fall down in the box

Fluids
(Fluids are typically in semester 1, but our district has a short first semester, so I do this second semester.)

1 **FCI standardized mechanics test**
Lab 1: Use a pressure probe and a syringe to determine the relationship between the volume and pressure of a gas *Turn in: data table, graph with equations and* r^2*, discussion (make sure to include how results relate to known physics law; research will be required use appropriate cite)*
Do: read and do text problems, questions

2 Notes: Ideal Gas Properties and Density
Lab 2: *Density PhET*
Do: read and do text problems, questions

3 Notes: Fluid Pressure
Do: read and do text problems, questions

4 Demos
Lab 3: *Buoyancy PhET*

5 Lab4: *Balloons and Buoyancy PhET*,
Do: read and do text problems, questions

5 Lab5: *Under Pressure PhET*
Do: Write one clicker question, Lab 6: Estimation activity PhET

6 Review study & test taking skills
Do: read and do text problems, questions and standardized testing practice

7 Test

Lesson plan for *Density*: How Does Density Relate to Mass &Volume and an Objects Interaction with Water?

http://phet.colorado.edu

Learning Goals:
Students will be able to use macroscopic evidence to:

1. Measure the volume of an object by observing the amount of fluid it displaces or can displace.

2. Provide evidence and reasoning for how objects of similar:
   a. mass can have differing volume
   b. volume can have differing mass.
3. Identify the unknown materials by calculating density using displacement of fluid techniques and reference tables provided in the simulation.

Background:
My students are in Honors Physics, a first year junior-level high school course with a pre-requisite of B or better in math and science and minimum math concurrent enrollment in Algebra II. They took Physical Science as 8th graders, so this lesson is meant to be a refresher for density and to help them think about what they already know about density and apply their ideas to how density affects how objects act/interact when placed in water.

***Density* Introduction:**
I did not give any demonstration of the sim.
Tips for Teachers Guide for this simulation is at http://phet.colorado.edu/files/teachers-guide/density-guide.pdf. These seem to be very useful teacher hints:

Tips for controls:
- You can put the blocks in the water. If an object floats, you can hold it under water to measure its volume.
- Use the scale and the volume of water displaced to calculate the density of the mystery objects.
- Use the table to determine the identity of the mystery objects.

In addition, I think that my students may struggle with the behavior of the water block as is noted in the Insights into student use, so I decided to address this specifically in the lesson. I am expecting them to determine that in the "Same Mass" mode, the block will stay wherever the student puts it because the density of the blue block is the same as that of water.

Lesson:
I plan to use this as an introductory lesson to Buoyancy and followed by my activity for Balloons and Buoyancy.

Student Directions *Density*: How Does Density Relate to Mass &Volume and an Objects Interaction with Water?

http://phet.colorado.edu

Learning Goals:
Students will be able to use macroscopic evidence to:

1. Measure the volume of an object by observing the amount of fluid it displaces or can displace.
2. Provide evidence and reasoning for how objects of similar:
   a. mass can have differing volume
   b. volume can have differing mass.
3. Identify the unknown materials by calculating density using displacement of fluid techniques and reference tables provided in the simulation.

Directions:

1. Explain how you use the simulation to measure the volume that an object can displace. Also:
   a. What is similar or different from the volume that the blocks displace naturally? How might a scientist explain the behavior?

   b. Explain why you think the blue block on the “Same Mass” setting can be placed anywhere in the water.
2. Design experiments to demonstrate the learning goal #2. Provide tables for evidence and use specific examples from your data to provide the reasoning.
3. Design an experiment to identify the 5 Mystery blocks using the Table in the simulation.
   a. Write your procedure in paragraph form.
   b. Identify each block using specific evidence to support your conclusions.

[Density](#) Concept Question

by Trish Loeblein

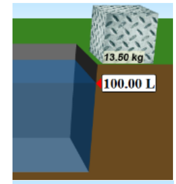
used with [Density Activity](#)

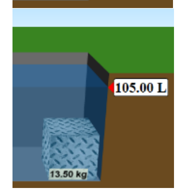
Learning Goals:

Students will be able to use macroscopic evidence to:

- Measure the volume of an object by observing the amount of fluid it displaces or can displace.
- Provide evidence and reasoning for how objects of similar:
  - mass can have differing volume
  - volume can have differing mass.
- Identify the unknown materials by calculating density using displacement of fluid techniques and reference tables provided in the simulation.

1. **You put in a pool with 100 L of water. Then you drop an aluminum block in and the volume rises to 105 L. What is the volume of the block?**





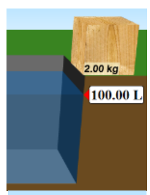
A. 5L

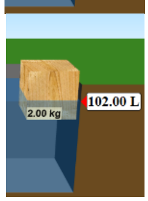
B. 105 L

C. Depends on block shape

D. Not enough information

2. **You put in a pool with 100 L of water. Then you drop an wood block in and the volume rises to 102 L. What is the volume of the block?**





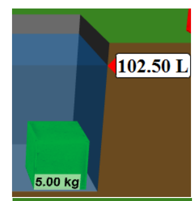
A. 5L

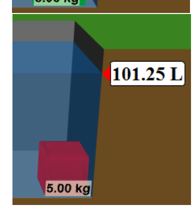
B. 105 L

C. Depends on block shape

D. Not enough information

3. **Two different blocks, both with a mass of 5 kg have different volumes. How is it possible?**





A. One is more dense

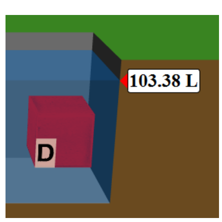
B. They are made of the same material

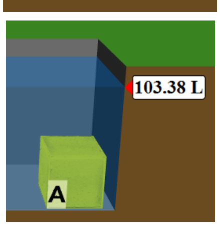
C. They are made of different material

D. More than one of these

E. None of the above

4. **Two different blocks, both with a volume of 3.38L have different mass. What would be a good explanation?**





A. A is more dense

B. D is more dense

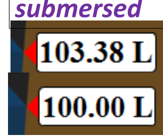
C. A sinks

D. D floats

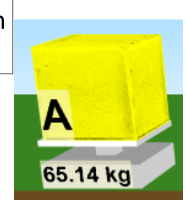
E. More than one of these

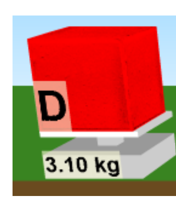
Some information for 4

Volume changes when *submersed*



Mass found using scale

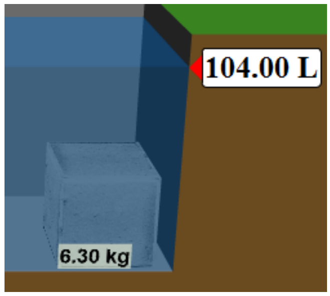




It is true that D floats, but it is irrelevant to question. The important thing is that A is more dense – it's mass is greater even though volume is the same.

5. What is the density of the block?

A. 0.63 L/kg
B. 1.6 L/kg
C. 0.63 kg/L
D. 1.6 kg/L

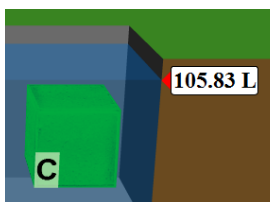


6. **Joe was doing a lab. He massed an object and then pushed it into some water. He recorded- 3.5 kg and 5 L. What might the object be?**

	Material	Density (kg/L
A.	Wood	0.40
B.	Apple	0.64
C.	Gasoline	0.70
D.	Diamond	3.53
E.	Lead	11.3

7. What is the mass of the block if it has a density of 0.86?

A. 5.0 kg
B. 91 kg
C. 0.15 kg
D. 6. kg



Lesson plan for *Buoyancy*: How Does Buoyant Force Act on Objects in a Fluid?
http://phet.colorado.edu

Learning Goals: needs
Students will be able to:

1. Use combinations of tools to find density of both liquids and solids
2. Describe the forces that act on a completely or partially submerged object
3. Describe what *Buoyancy* is and how it affects the *apparent weight* of an object in a fluid.
4. Predict whether an object will sink or float when placed in a liquid, given densities of the object and liquid
5. Predict the *apparent weight* of a completely or partially submerged object of known mass and volume in fluids for which the density is known

Background:
My students are in Honors Physics, a first year junior level high school course with a pre-requisite of B or better in math and science and minimum math concurrent enrollment in Algebra II. They will have done an activity with the Density sim and read some materials in their texts. See my webpage for more information about scope and sequence of this unit.
http://jeffcoweb.jeffco.k12.co.us/high/evergreen/science/loeblein/phys_syl/Sem2Unit5.html
The students did my Density activity, https://phet.colorado.edu/en/contributions/view/3406, the day before this one.

***Buoyancy* Introduction:**
I used the Teacher Tips http://phet.colorado.edu/files/teachers-guide/buoyancy-guide.pdf to see what I might need to know about the tools. I did not see the need to show the students anything.

Lesson:
I plan to use this as an introductory lesson to Buoyancy . They will do Balloons and Buoyancy activity afterwards https://phet.colorado.edu/en/contributions/view/3407.

Student Directions for *Buoyancy*: How Does Buoyant Force Act on Objects in a Fluid?
http://phet.colorado.edu

Sim Tip: The scales can be moved!

Learning Goals:
Students will be able to:

1. Use combinations of tools to find density of both liquids and solids
2. Describe the forces that act on a completely or partially submerged object
3. Describe what *Buoyancy* is and how it affects the *apparent weight* of an object in a fluid.
4. Predict whether an object will sink or float when placed in a liquid, given densities of the object and liquid
5. Predict the *apparent weight* of a completely or partially submerged object of known mass and volume in fluids for which the density is known

Directions:
Intro Tab:

1. How can you use a block and the other tools on the **Intro** tab to determine the density of the "Oil"?

2. Determine what forces act on an object when is it in a fluid. How are the forces similar and different when the object sinks, floats immersed in the fluid, and when it is only partially submerged.

3. Give specific examples that you could use to explain what *buoyancy* is and how an objects *weight* can appear to change when in a fluid. Make sure to include situations where the object sinks, floats immersed in the fluid, and when it is only partially submerged.

Playground Tab:

4. Explain how you can use the information about the block and the fluid to determine if the block will sinks, floats immersed in the fluid, and when it is only partially submerged.

5. How can you determine the apparent mass of an object if you know the density of the object and the density of the fluid?

6. **Challenge**: Explain how an object that is more dense than water can be kept afloat by placing it on an object that is less dense than water

Lesson plan for *Balloons and Buoyancy* : How do gases in different containers behave in gases fluids?

Time for activity 35 minutes

Learning Goals: Students will be able on a molecular level to

1. Explain why a rigid sphere would float or sink.
2. Determine what causes helium balloon to rise up or fall down in the box.
3. Describe the differences between the hot air balloon, rigid sphere, and helium balloon.
4. Explain why a hot air balloon has a heater.

Background:

My students used Gas Properties to help develop a molecular model during a heat and thermodynamics unit earlier in the semester. They were introduced to buoyancy through the text. In particular, they did some simple problems finding buoyant force of an object floating or suspended in a fluid like a boat on water, a solid object in a liquid, and gas balloons in air. They did a Density sim activity https://phet.colorado.edu/en/contributions/view/3406 and a Buoyancy sim activity, https://phet.colorado.edu/en/contributions/update-success/3408

***Balloons and Buoyancy* Introduction:**

I talked about how pressure is a result of the molecules colliding with the container. I think this caused some extra confusion because many of the student answers about why some things float and some sink had references to pressure as opposed to density. I think next time, I'll omit this discussion.

Also, the sim can run very slowly if there are molecules. Several times, I saw students' computers running very slowly and I discovered that they had left previous tabs running with high numbers of molecules or temperature. I made an announcement after a few students starting having difficulty rather than add another tip.

Lesson:

The first year I did this lesson 2010, the Density and Buoyancy sims did not exist and the students had some difficulties. I am hopeful that doing the other activities will make this go better for them.

Post-Lesson There are clicker questions to follow.

Student directions: *Balloons and Buoyancy* **How do gases in different containers behave in gases fluids?**

phet.colorado.edu

Learning Goals: Students will be able on a molecular level to

1. Explain why a rigid sphere would float or sink.
2. Determine what causes helium balloon to rise up or fall down in the box.
3. Describe the differences between the hot air balloon, rigid sphere, and helium balloon.
4. Explain why a hot air balloon has a heater.

Directions:

- Make sure that you put some gas in the sphere, balloons and container so that you are representing real situations.
- Don't vary the gravity for this activity.
- For each learning goal, do experiments and then use specific examples to write in paragraph form with illustrations explanations to demonstrate the goal. Include data to support your ideas.

Balloon and Bouyancy

Learning Goals: Students will be able on a molecular level to

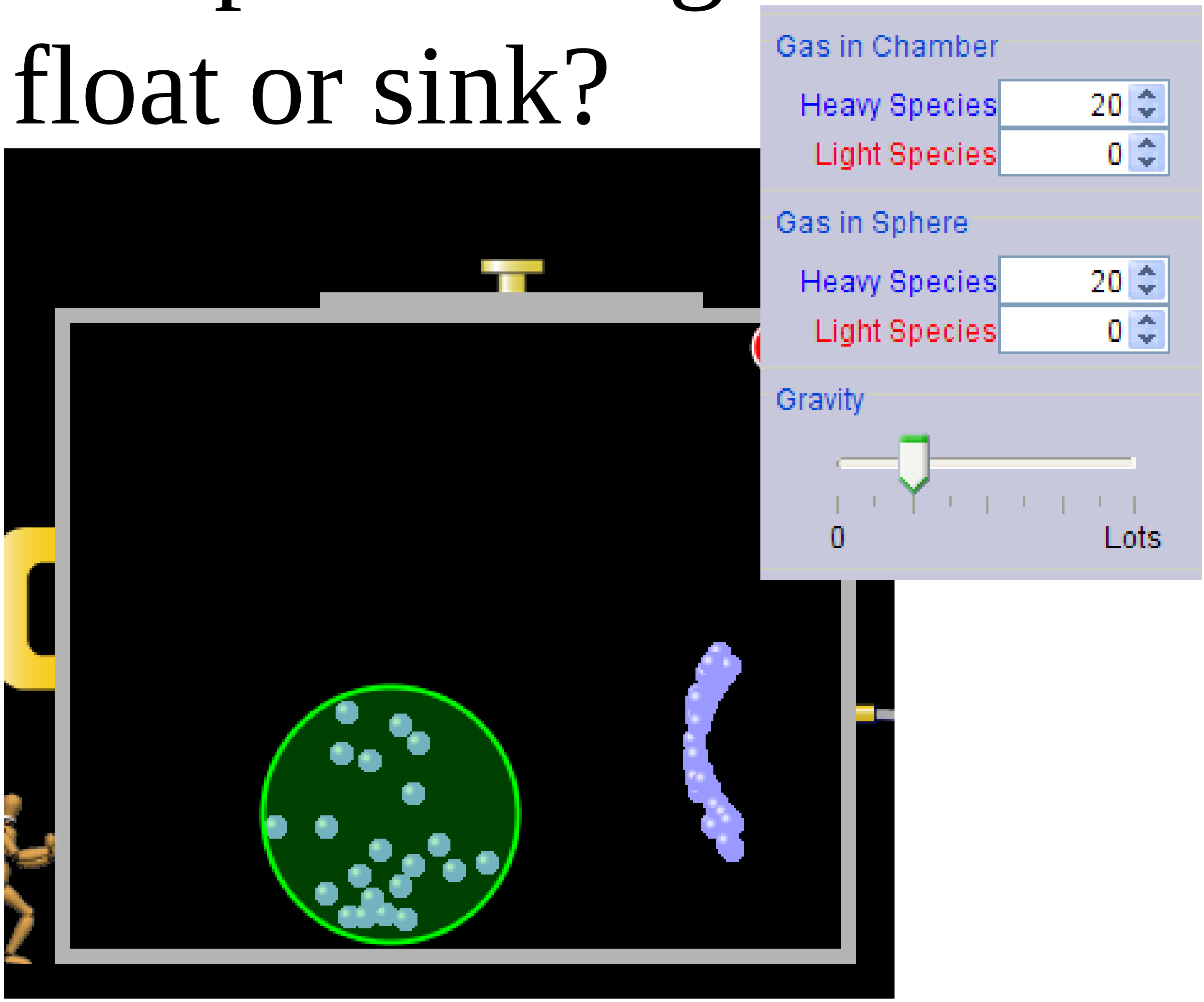
1. Explain why a rigid sphere would float or sink.
2. Determine what causes helium balloon to rise up or fall down in the box.
3. Describe the differences between the hot air balloon, rigid sphere, and helium balloon.
4. Explain why a hot air balloon has a heater.

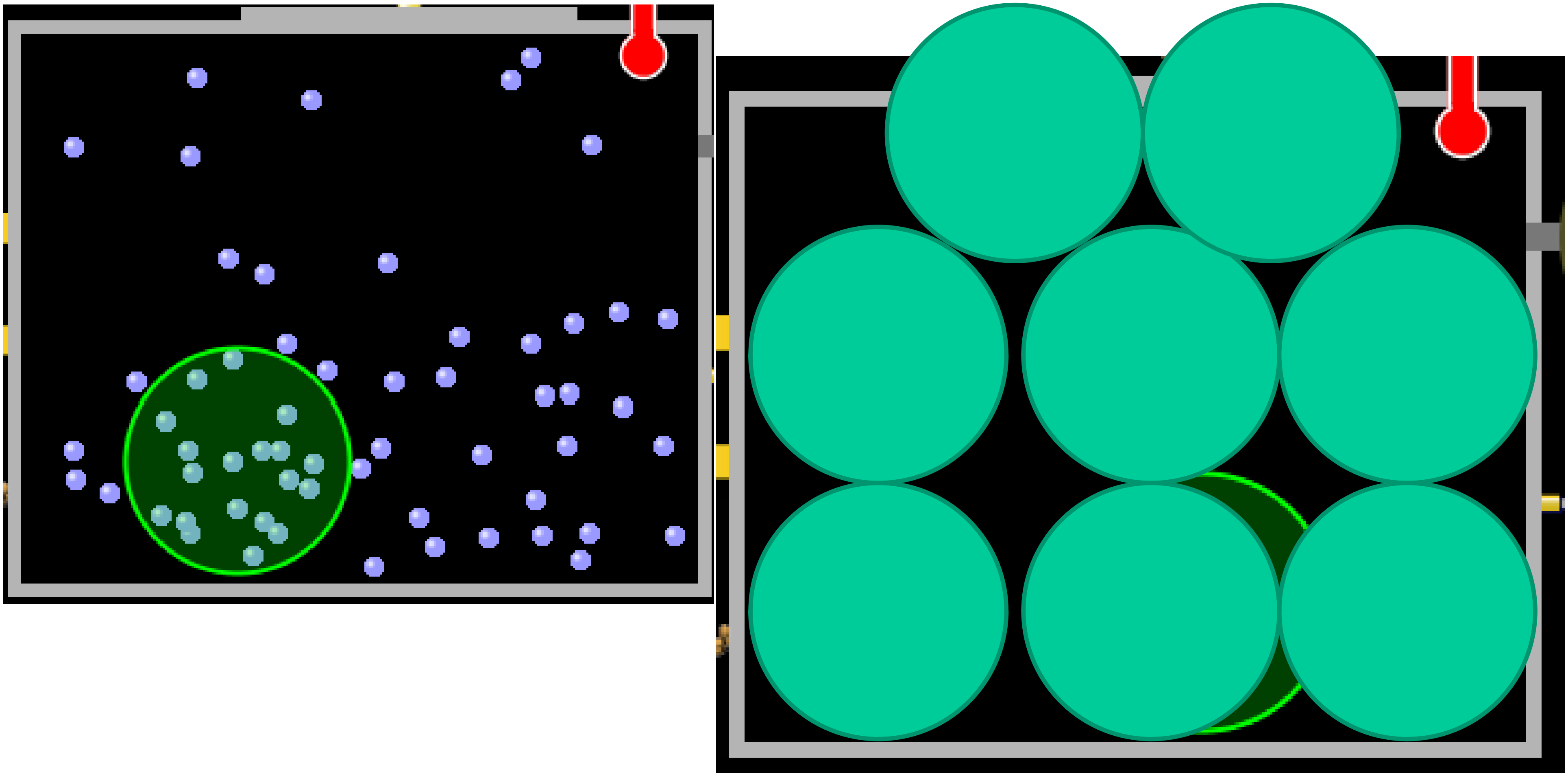
Teacher note: If you are going to use the simulation to demonstrate, remember that Reset only clears the box of particles, it does not change any settings.

Would you expect the rigid sphere to float or sink?

A. Sink

B. Float



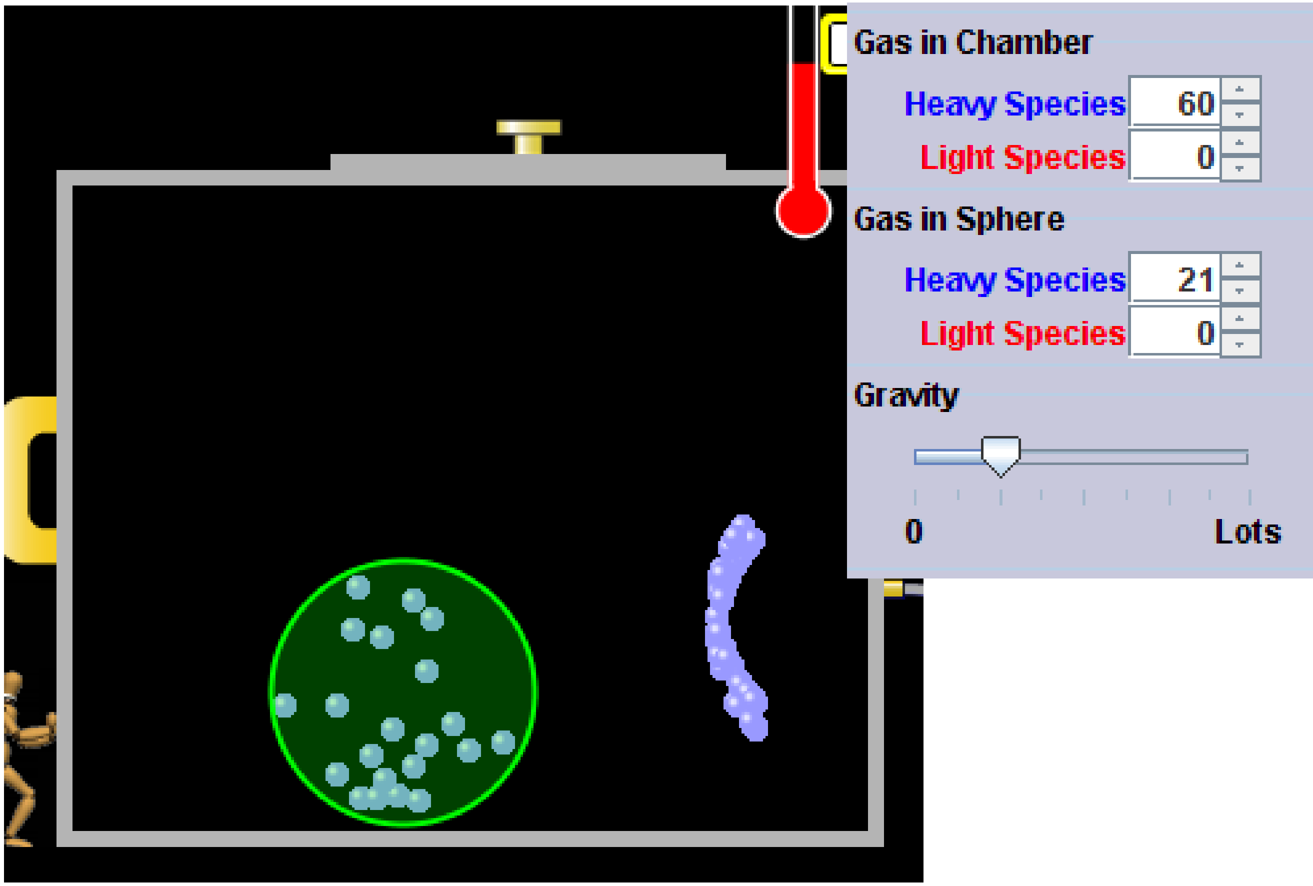


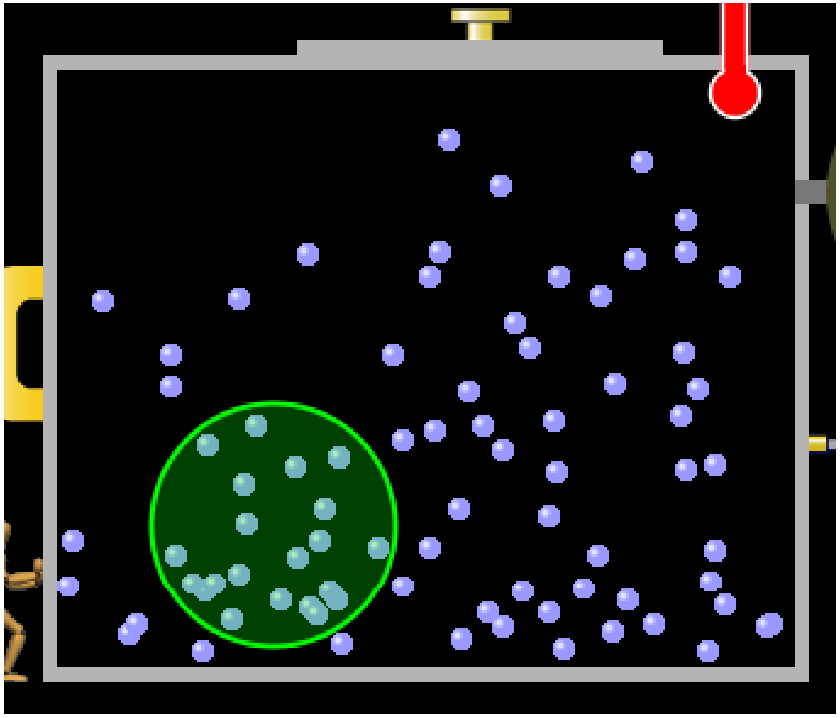
The container is about 8 times larger so the density is much greater in the sphere

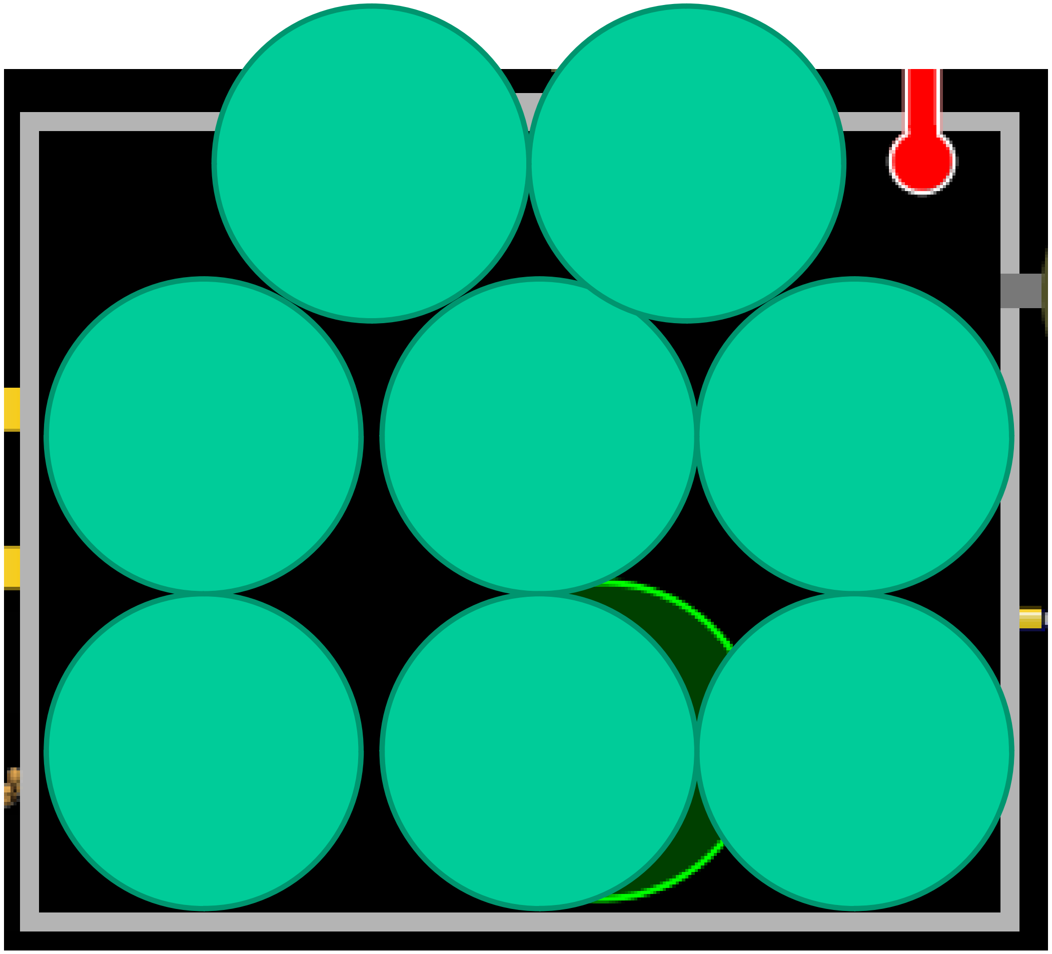
Would you expect the rigid sphere to float or sink?

A. Sink

B. Float







The container density would be about 60/8 = 7.5 and 20/1 because the box is about 8 times larger. The more dense sphere would sink

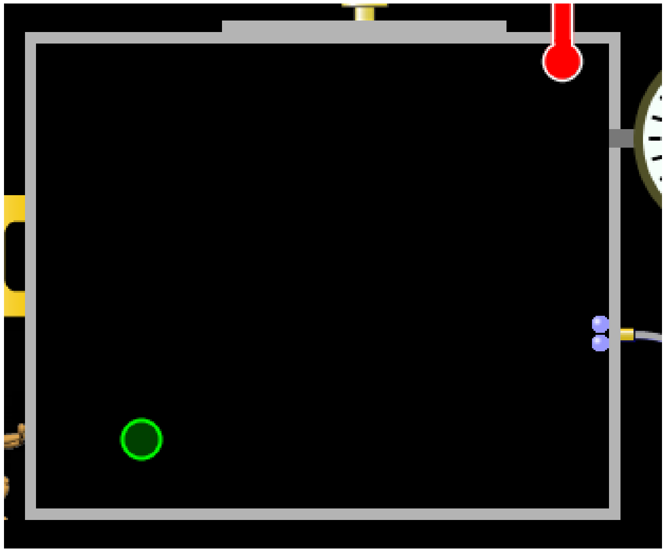
What will the hydrogen balloon do?

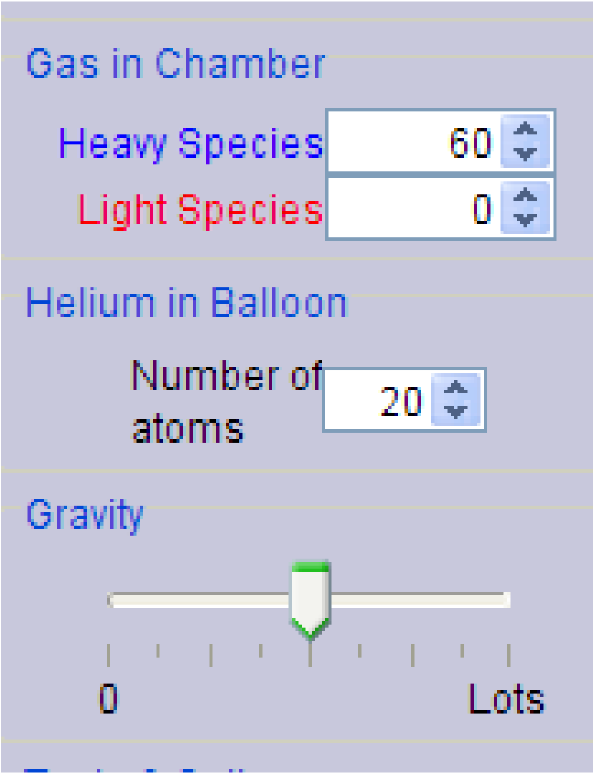
A. Expand and float

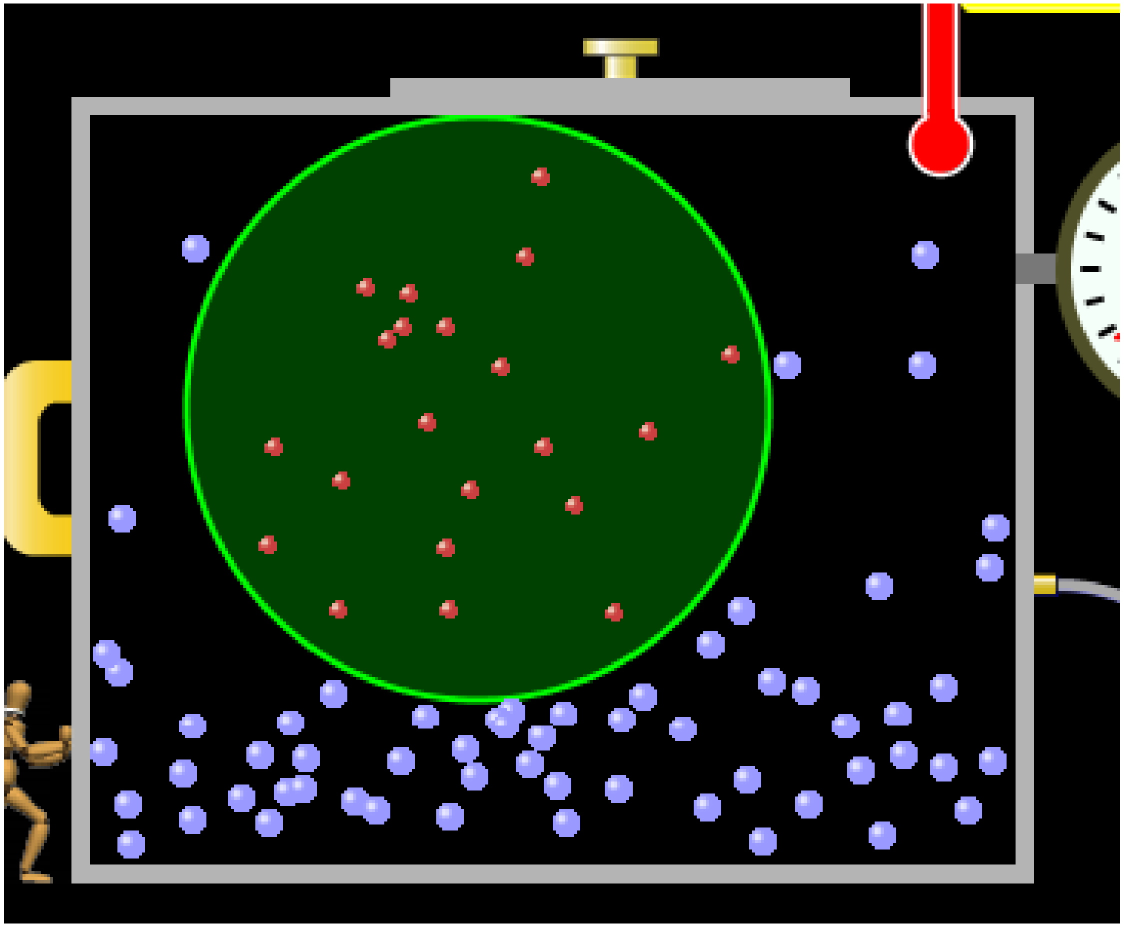
B. Expand and sink

C. Stay the same size and float

D. Stay the same size and sink

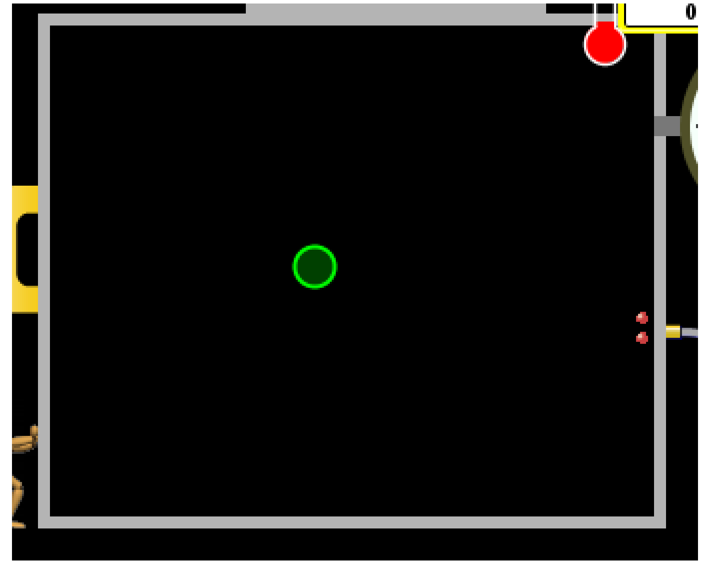


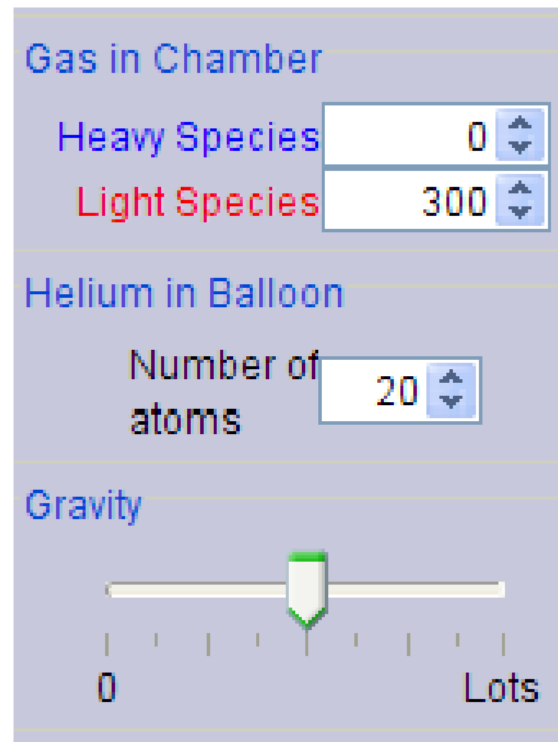


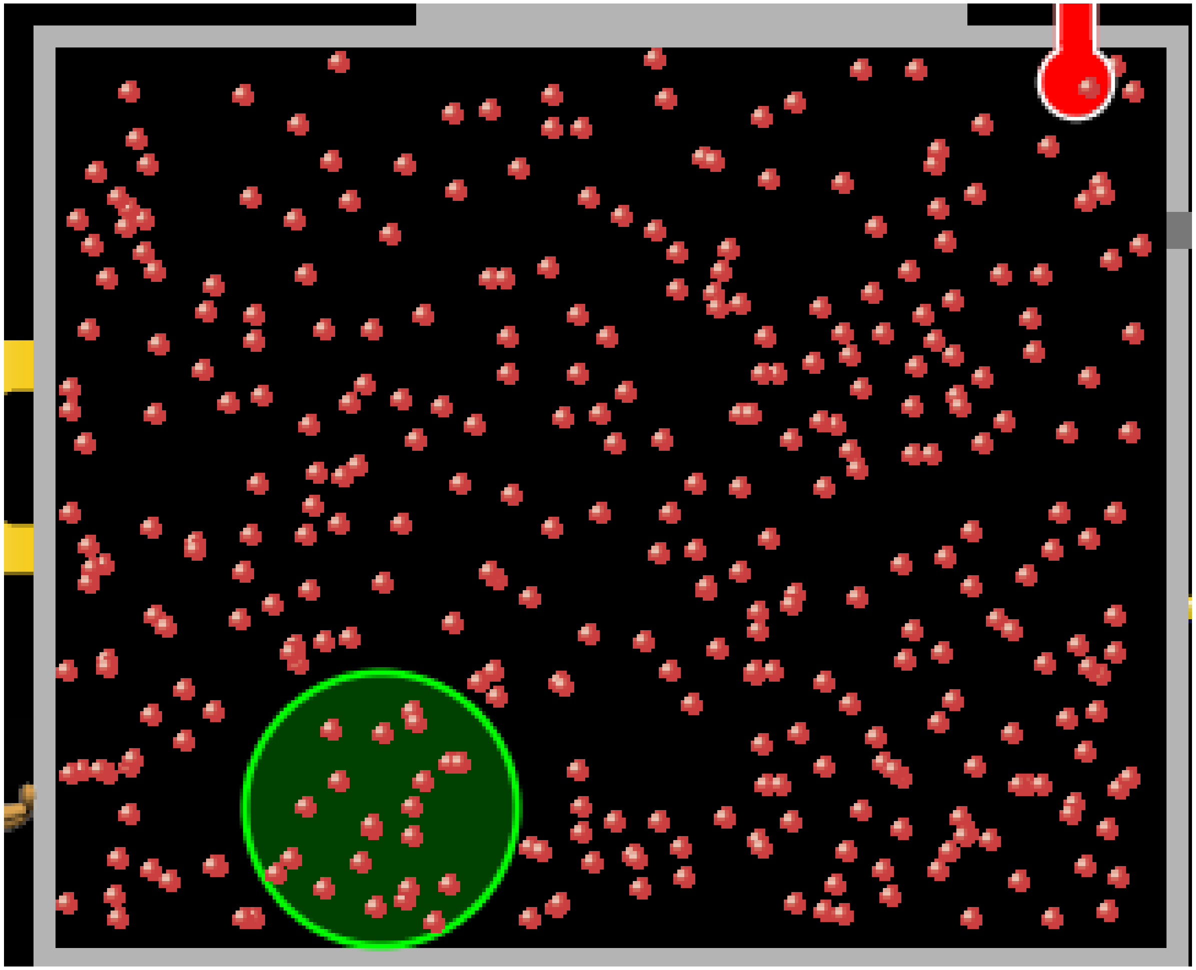


What will the hydrogen balloon do?

A. Expand and float
B. Expand and sink
C. Stay the same size and float
D. Stay the same size and sink

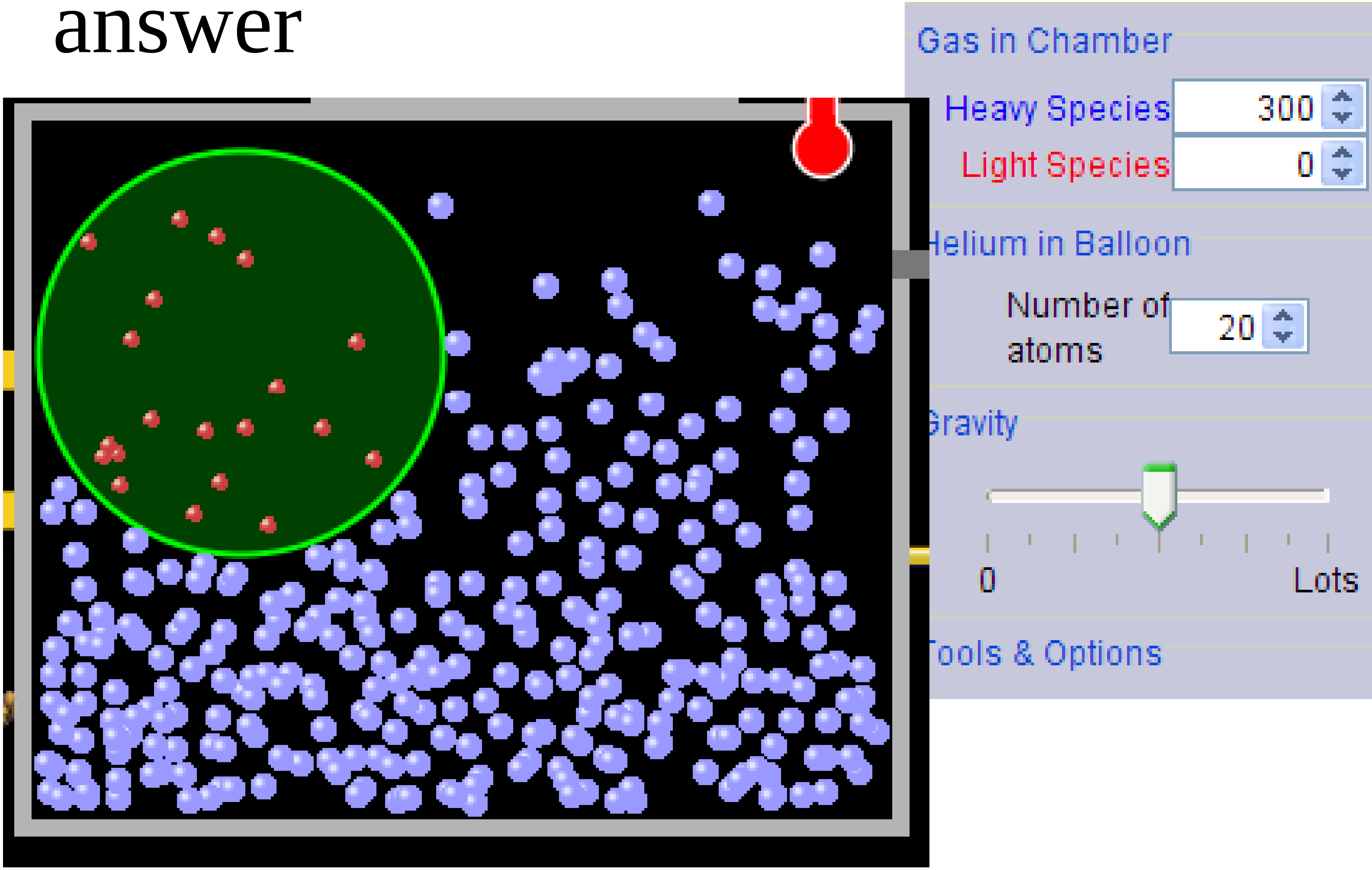






Discussion: Would the results be different if the outside molecules were the heavier species?

answer

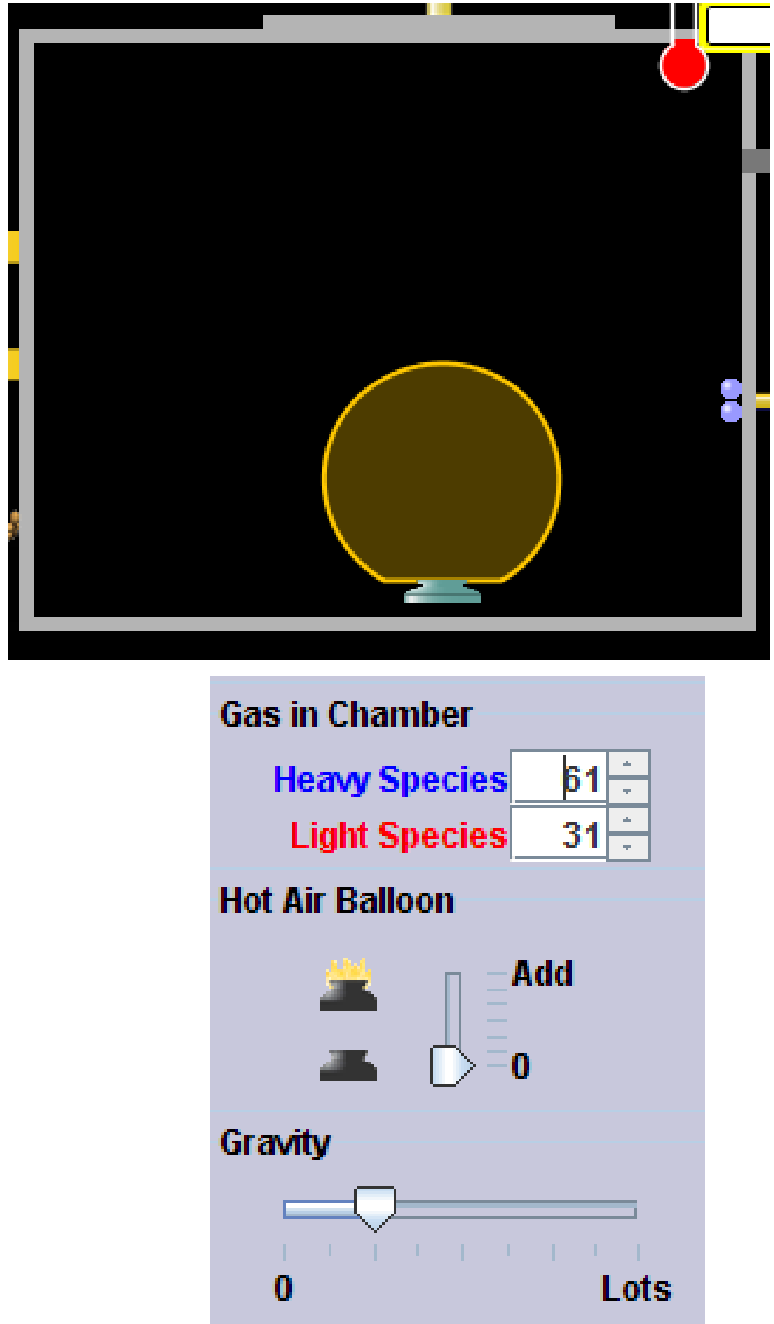


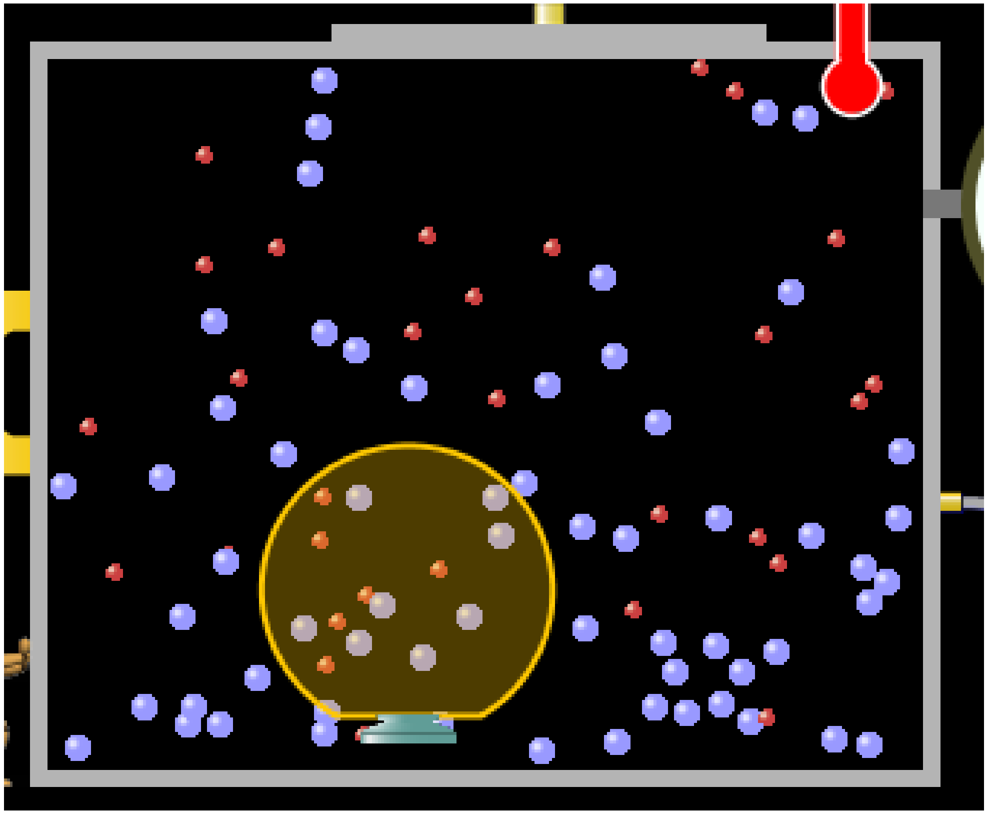
Gas in Chamber
Heavy Species
300
Light Species
0
Helium in Balloon
Number of atoms
20
Gravity
0
Lots
Tools & Options

Would you expect the hot air balloon to float or sink?

A. Sink

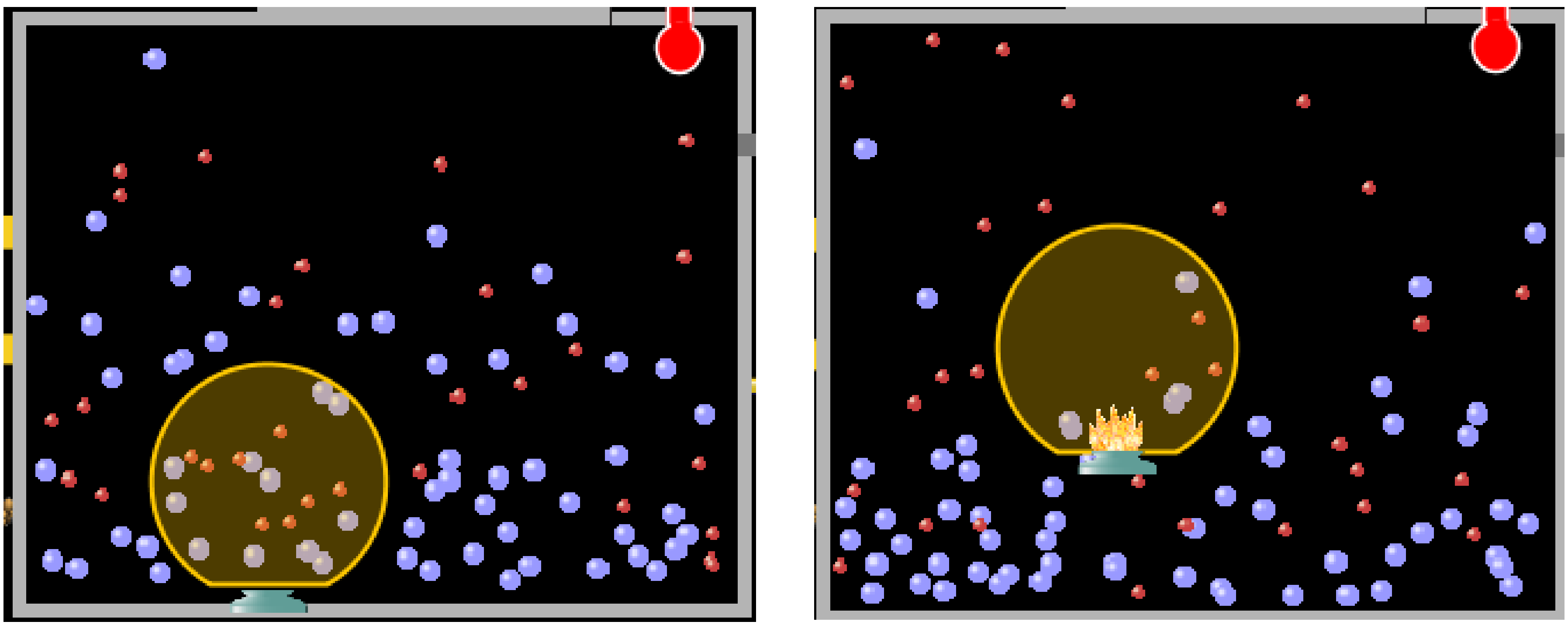
B. Float





Discussion: Would there be a molecular combination that would allow the balloon to float?

Why did the hot air balloon float after the heater was used?



Discussion question

Lesson plan for *Under Pressure* (or first tab of Fluid Pressure and Flow)

http://phet.colorado.edu

Learning Goals: Students will be able to:

1. Investigate how pressure changes in air and water.
2. Discover how you can change pressure.
3. Predict pressure in a variety of situations

Background:

This is meant to be an introduction to fluid pressure. This sim is also the first tab of Fluid Pressure and Flow. One reason to use the simplified version of the sim is to help students focus on the basic principles of static fluids before exploring fluids in motion. I wrote this assuming that students had experience and knowledge about gravity and density. The Density simulation has several Gold Star activities (meaning that the activities follow PhET's Guided Inquiry Strategies Guide) that could be done before to give students a real-world sense for fluid and solid relative density. The sensors are very sensitive, so I expect some variations in answers.

Under Pressure **Introduction:**

Interviews showed that students could use the simulation with little guidance. Check the Tips for Under Pressure for Teachers from the PhET team for specific ideas about the tools. You may want to read the Tips for Fluid Pressure and Flow as well.

Pre-Lesson: I am expecting that my students will have had some experience with floating objects in water and also have a good grasp of density, so I do not plan to do any type of demo.

Lesson: I plan to use this as a homework prior to lecture and problem practice. It also could be used as an in-class activity with the students working in small groups.

Post-Lesson: There are clicker questions to use to check student understanding.

Follow-up sims: Other ideas are to use **Buoyancy** **Activity by Trish Loeblein** and/or **Fluid Pressure and Flow** Activity by Trish Loeblein.

Student directions *Under Pressure*:

http://phet.colorado.edu

Learning Goals: Students will be able to qualitatively:

1. Investigate how pressure changes in air and water.
2. Discover how you can change pressure.
3. Predict pressure in a variety of situations

Directions:

1. Explore the simulation to find out how pressure changes in air and water.
2. Describe your findings and include specific data from your explorations to support your ideas.
3. Test your ideas by predicting what the air pressure would be 2 meters above sea level and 2 meters under water.
    a. Use the sim to check and then make corrections to your ideas if necessary.
    b. How would your values compare if the pool of water was in Denver (The "Mile High" city)?
    c. How does the shape of the pool affect your values?
4. Discover how you can change pressure in the simulation.
    a. Describe your findings and include specific examples.
    b. Check to see how your answers to #3 change as you change the things that affect pressure. Describe qualitatively
    c. Are there things that could affect pressure that were not included in the sim? Cite references for your ideas.
5. Prepare for clicker questions that will give specific situations by testing a variety of situations.

Under Pressure (also Fluid Pressure Flow- Pressure tab)

by Trish Loeblein June 2012

Learning goals:

Students will be able to

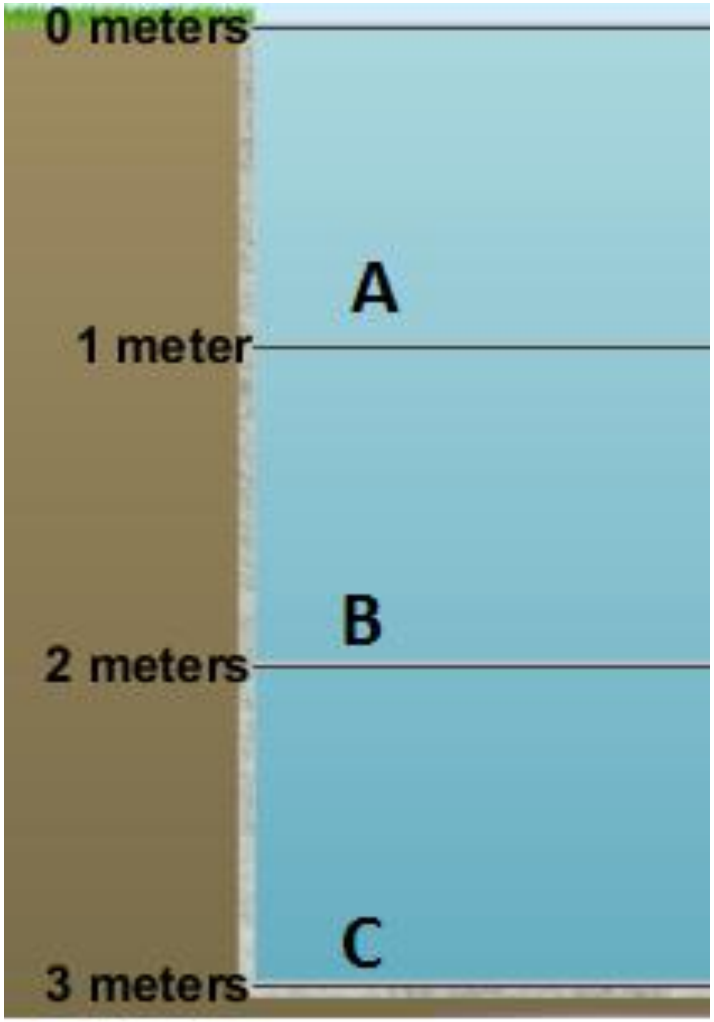
1. **Investigate how pressure changes in air and water.**
2. **Discover how you can change pressure.**
3. **Predict pressure in a variety of situations**

1. Order from lowest to highest pressure.

A. A<B<C

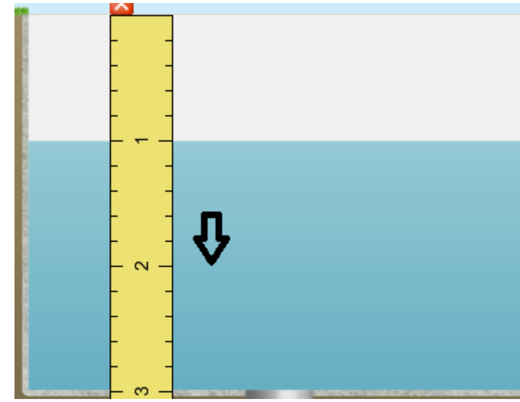
B. C<B<A

C. all are equal

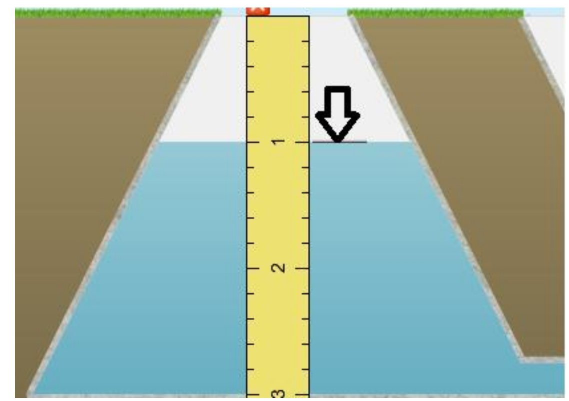


2. Look at the markers. Order from lowest to highest pressure.

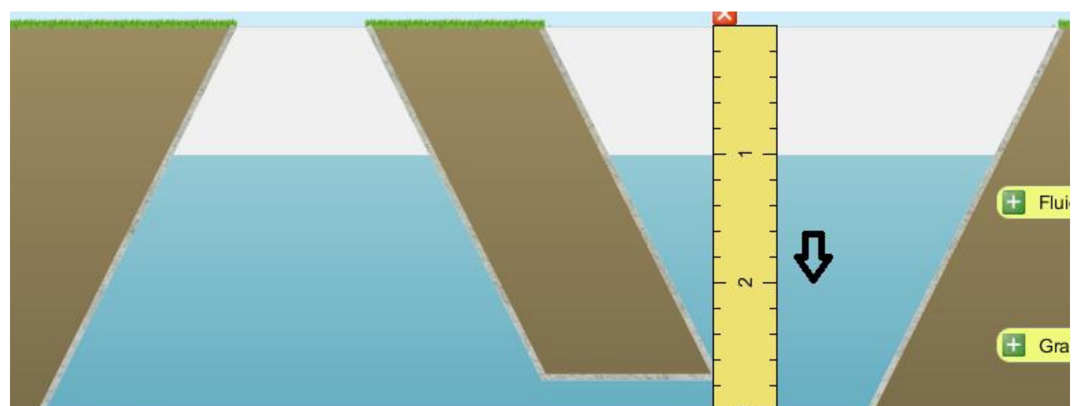
X



Y



Z



A. Y<Z<X

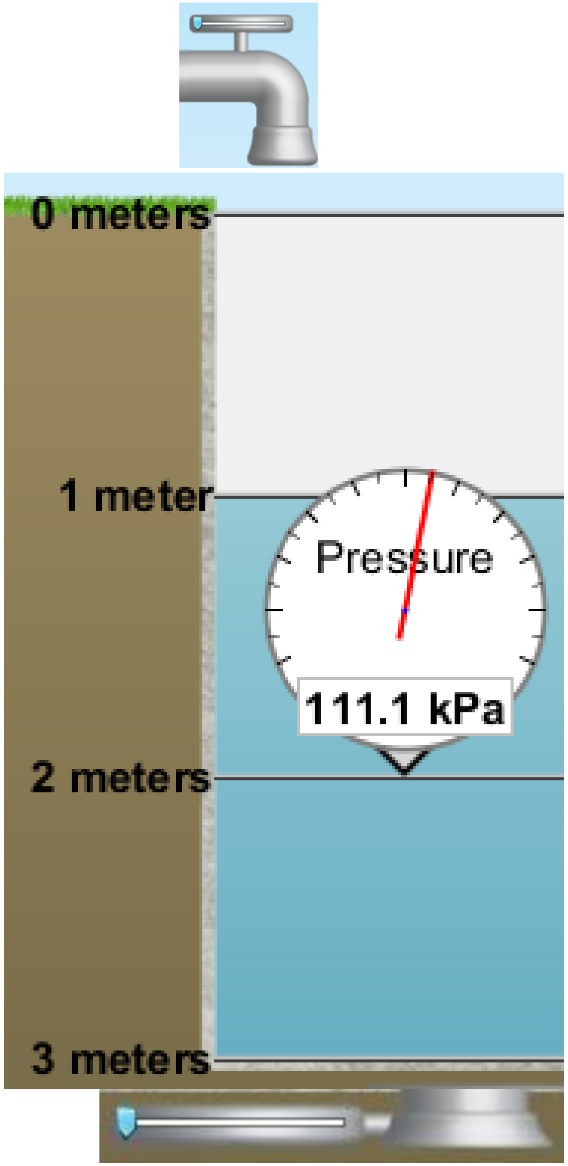
B. Y<X<Z

C. Z<X<Y

D. X<Z<Y

E. two are equal

3. What will happen to the pressure if more water is added?

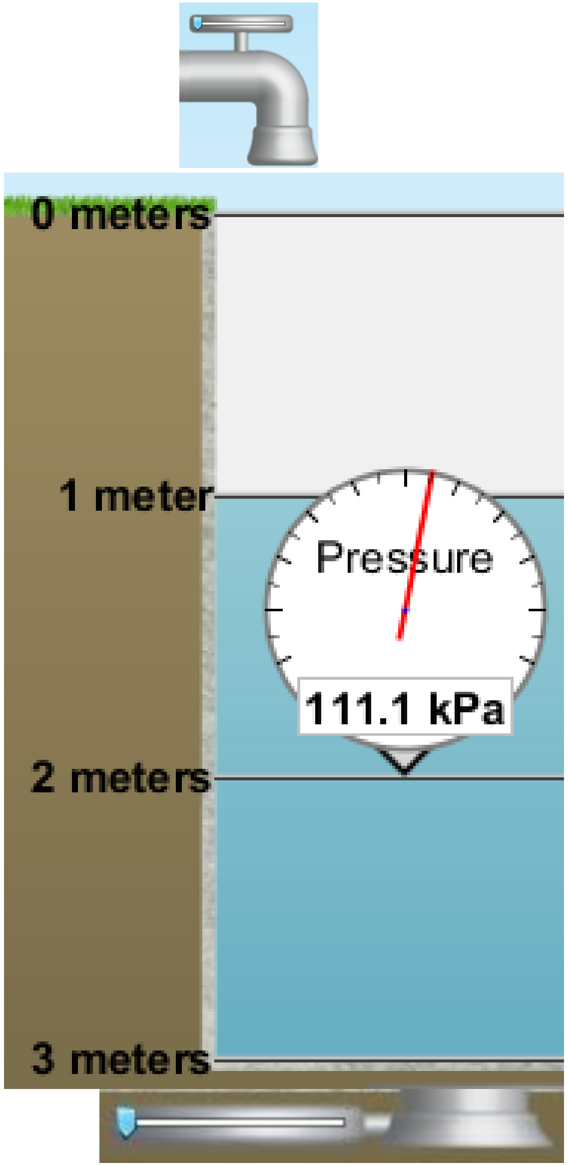


A. increase

B. decrease

C. stay the same

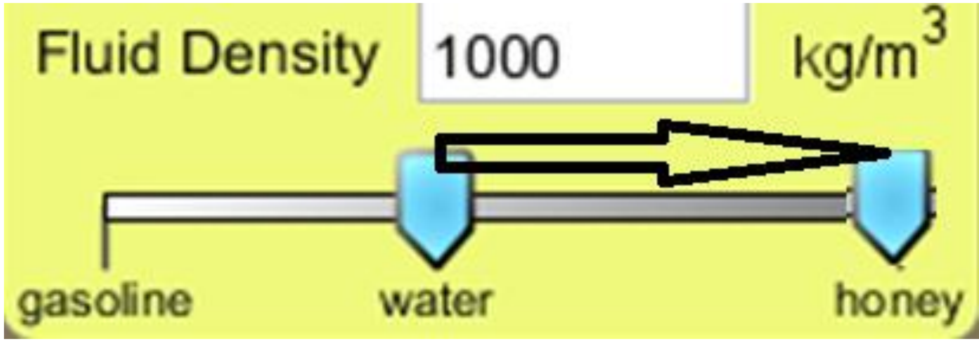
4. What will happen to the pressure if more water is added while the same amount is removed?



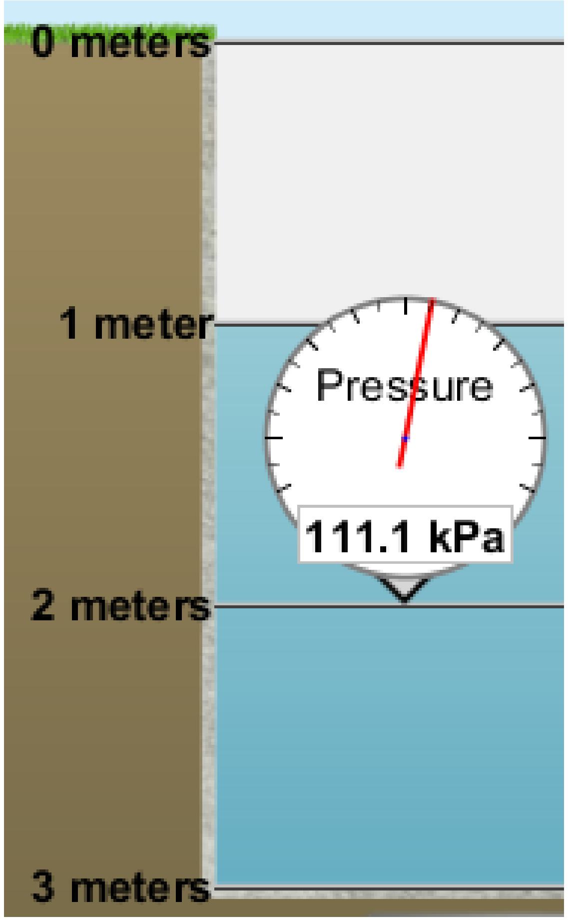
A. increase

B. decrease

C. stay the same



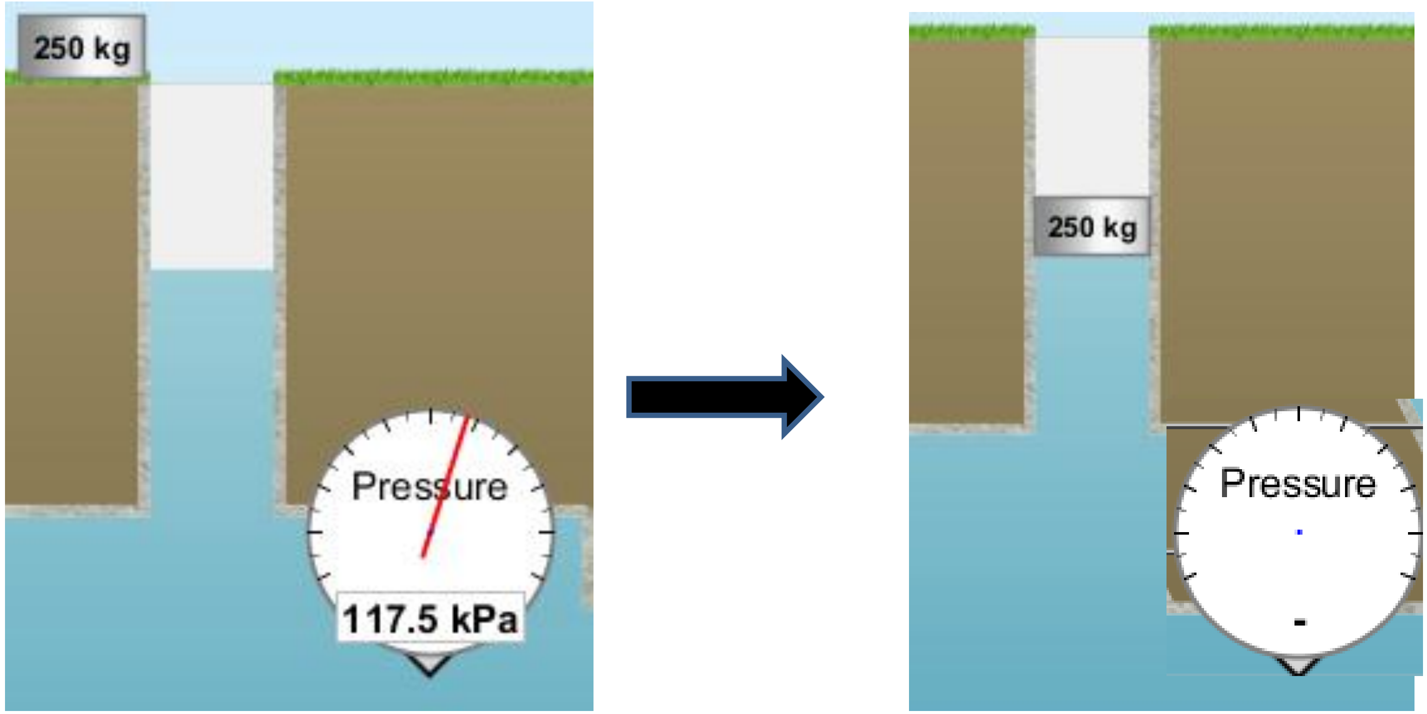
5. What will happen to the pressure if the fluid were changed to honey?



A. increase

B. decrease

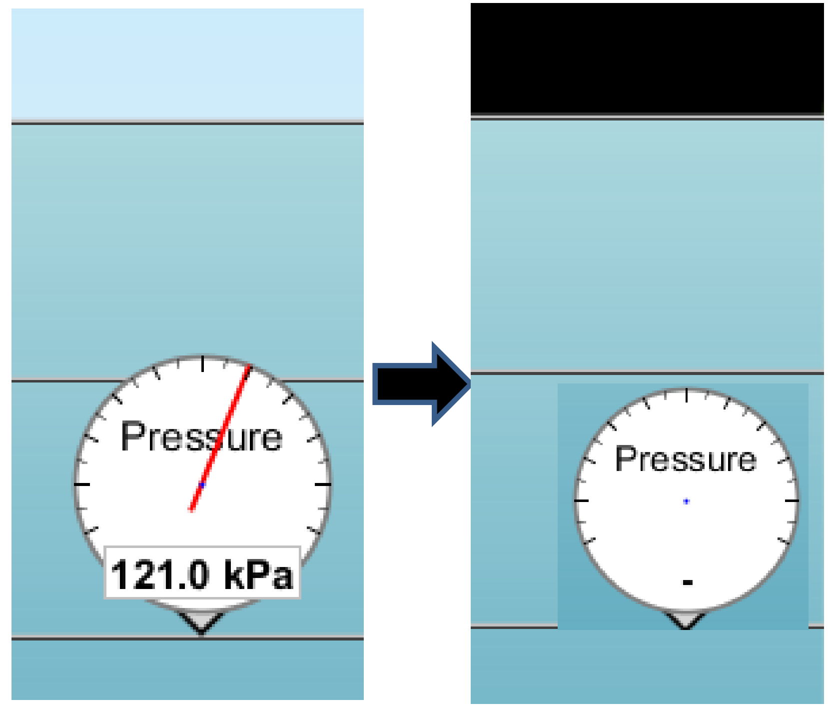
C. stay the same



6. If the 250 kg mass was put on the water column, what will happen to the pressure?

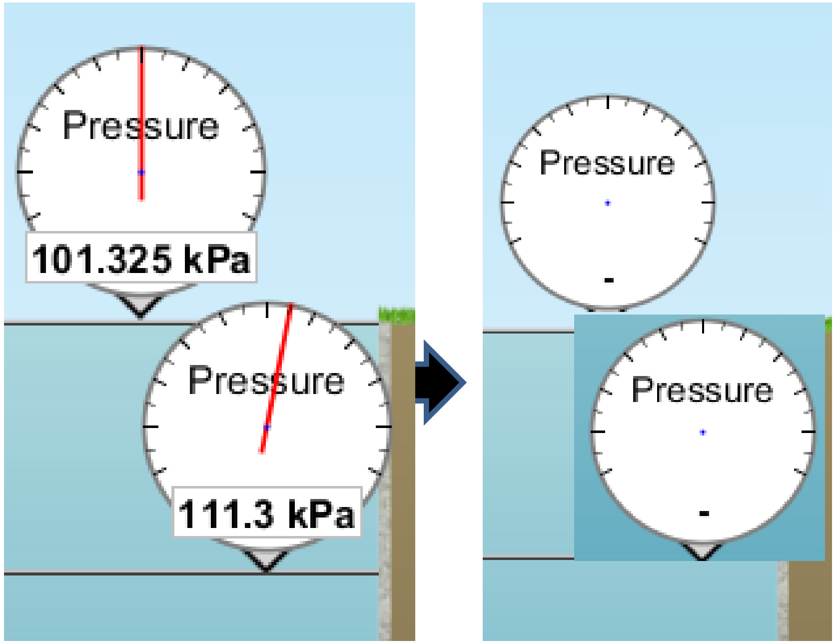
A. increase
B. decrease
C. stay the same

7. If the only change was to remove the air pressure , what will happen to the pressure?

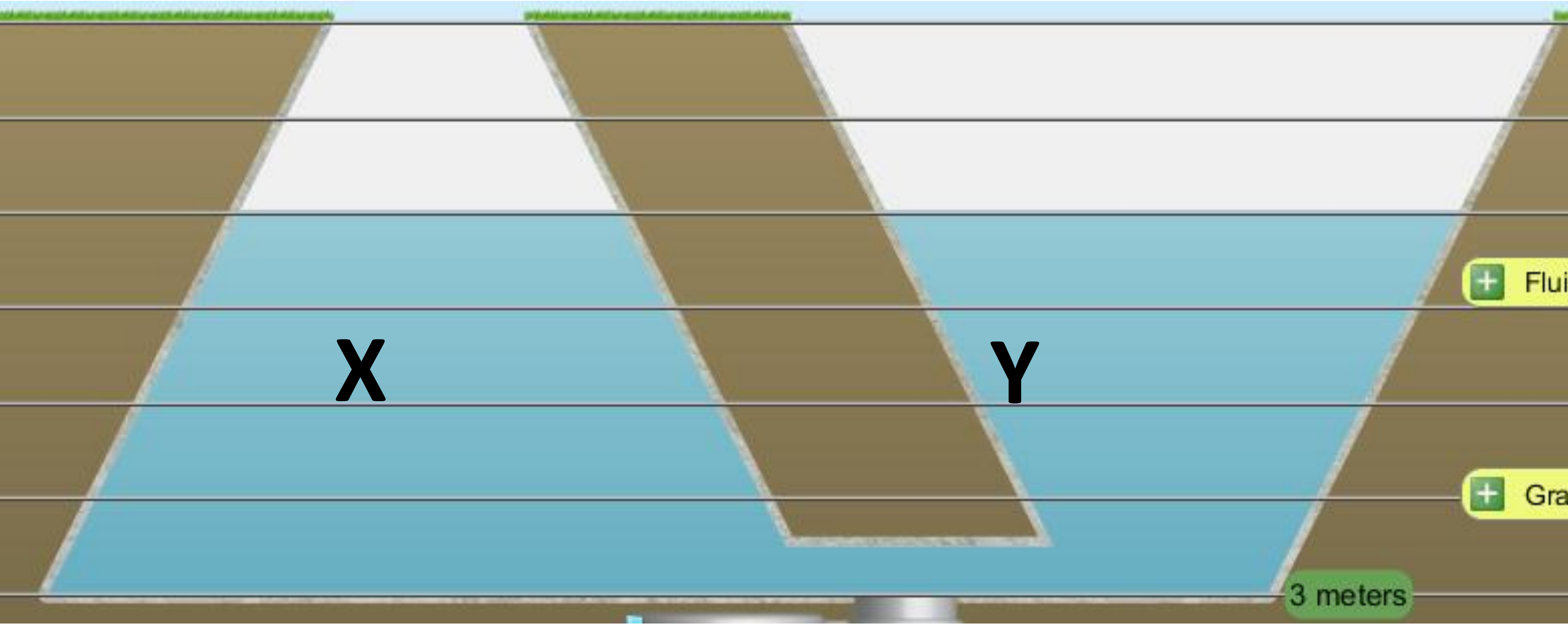


A. increase by 101.3 kPa
B. decrease by 101.3 kPa
C. stay the same
D. Something else

8. If the only change was to go to a place where the gravity was doubled, what will happen to the pressure?



A. Both pressures would double
B. Only the air pressure would double
C. The air pressure would double, and the water pressure would increase some
D. Something else



9. How do the pressures at the two locations compare?

A. X>Y
B. Y>X
C. They are the same

Estimation Game by Beki Toussaint
http://phet.colorado.edu/en/contributions/view/3066

Estimation Game:
This could be used as an introduction to a unit on estimation.
Learning Goals:
- Fine tune estimation skills
- Practice estimating various objects that are useful in everyday life

Estimation Game
As you know estimation is an important part of life. You do not always have a tape measure or any other measuring devise or a calculator handy so you have to estimate. Have you ever tried to tell someone how far something was away from you or how big something was? Did you measure it or estimate it? Or if you were trying for a better story maybe you exaggerated it! Today we are going to practice estimating different objects and lengths.

1. When have you used estimation recently? List and explain at least 3 times.

2. What are 3 other times that you can think of that someone may want to or need to estimate something?

3. GO to the phet website, click on Play with Simulations, then open the math tools. Next open the Estimation sim.

4.Play a round of game on level 1, if you do well try level 2 or even level 3.

5. Of the different things you had to estimate, which one was the easiest? Why do you think this is?

6. Which one was the most difficult? Why do you think this is?

7.Can you relate any of the objects that you estimated in the game to your life? Which one(s)?

8. If you could add any objects to this game that would be useful to practice estimating what would it be? List as many as you can think of.

<u>Learning Goals: Heat and Thermodynamics</u>

Learning goals-Students will be able to:

<u>Friction PhET</u>

- Describe a model for friction a molecular level.

<u>Gas Properties and States of Matter PhET:</u>

- Describe matter in terms of molecular motion. The description should include
- Diagrams to support the description.
- How the particle mass and temperature affect the image.
- How the size and speed of gas molecules relate to everyday objects
- What are the differences and similarities between solid, liquid and gas particle motion

<u>Heat</u>

Temperature and thermal equilibrium

- Relate temperature to the kinetic energy of atoms and molecules.
- Describe the changes in the temperature of two objects reaching thermal equilibrium.
- Identify the various temperature scales, and be able to convert from one scale to another.

Defining Heat

- Explain heat as the transfer of energy between substances that are at different temperatures.
- Relate heat and temperature change on the macroscopic level to participate to particle motion on the microscopic level.
- Apply the principle of energy conservation to calculate changes in potential, kinetic, and internal energy.

Changes in temperature and phase

- Perform calculations with specific heat capacity.
- Perform calculations involving latent heat.
- Interpret the various sections of a heating curve.

Controlling heat

- Explain how energy is transferred by heat through the process of thermal conduction.
- Recognize how heat can be controlled with clothing.

<u>Thermodynamics</u>

Relationships between heat and work

- Recognize that a system can absorb or give up energy by heat in order for work to be done on or by that system, and that work done on or by a system can result in energy transfer by heat.
- Compute the amount of work done by a thermodynamic process.

Thermodynamic processes

- Illustrate how the first law of thermodynamics is a statement of energy conservation.
- Calculate heat, work, and the change in internal energy by applying the first law of thermodynamics.
- Apply the first law of thermodynamics to describe cyclic processes.
- Recognize why the second law of thermodynamics requires two bodies at different temperatures for work to be done.

Entropy

- Relate the disorder of a system to its ability to do work or transfer energy by heat.
- Identify systems with high and low entropy
- Distinguish between entropy changes within systems and the entropy change for the universe as a whole.

Thermodynamics

How is temperature and phase described on a molecular level? How are the Laws of Thermodynamics used to predict changes? How does heat transfer occur?

(Thermodynamics is typically in semester 1, but our district has a short first semester, so I use second semester)

1 PhET Activity: Introduction to Kinetic Molecular Theory using *Gas Properties* and *States of Matter*

2 Notes: Clicker questions PhET activity, KMT introduction, Temperature, Thermal equilibrium, scales, Heat, Conservation of Energy, Demonstration of water and food color mixing, Quick lab- expand a rubber band quickly and then describe the change in temperature
Lab: PhET Friction
Do: read and do text problems, questions

3 Notes: Beyond the Particle model , Specific heat capacity
Lab: Quick lab- put hands in cold and warm water and then into tepid water. Describe the feeling.
Do: worksheet 1

4 Notes: Phase change, demo low temperature boiling water
Lab: **Phase change I** Learning goal: Students will be able to explain a heating curve.
Directions: Use the temperature probes to observe heating about 100 ml of ice water through boiling. Copy the graph and type a summary paragraph describing what is happening on a macroscopic and microscopic level for each section of the graph.
Do: read and do text problems, questions, Read the lab for **Phase change II** and type your lab design.

5 Lab: **Phase change II** Students will be able to determine the 1. Energy rate of a heater 2. L_v for water
Directions: Design a lab to use the temperature probe to determine the energy rate of the heater in J/s and determine L_v for water. Check your plan with Ms. Loeblein before proceeding. Include in your paper: lab design, graph from probeware, calculations, and discussion
Do: worksheet 2

6 Notes: Calorimetry
Lab: **Determine Specific Heat** for a calorimeter, a piece of metal and a rubber stopper (full write-up)
Do: read and do text problems, questions, worksheet 3

7 Lab: work on specific heat lab

8 Notes: PV Work and Heat transfer
Lab: finish specific heat lab
Do: read and do text problems, questions

9 Notes: Second Law of Thermodynamics review and entropy
Lab: Newton's Law of Cooling
Do: read and do text problems, questions, worksheet 4

10 Review study & test taking skills
Do: read and do text problems, questions and standardized testing practice

11 **TEST**

Lesson plan using *Gas Properties* and *States of Matter* for understanding Kinetic Molecular Theory

Uses *Friction* as part of post-activity

Time for activity 40 minutes, the next day took 50 minutes

This activity replaces one that used Microwaves in December 2008.

Learning Goals: Students will be able to describe matter in terms of molecular motion. The description should include

- **Diagrams to support the description.**
- **How the particle mass and temperature affect the image.**
- **How the size and speed of gas molecules relate to everyday objects**
- **What are the differences and similarities between solid, liquid and gas particle motion**

Background:

I plan to use this activity on the first day of second semester honors physics. My students have limited understanding of particles or temperature.

Sim use hints*:* While my students were using *Gas Properties*, it bothered them that the molecules were moving when the temperature was 0K. We talked about that the temperature was rounded to 0. Many of them knew about the Bose condensate, so they expected that to be modeled. The discussions were lively and the students were excited that they could question the accuracy of the simulation.

The first year that I used *Stated of Matter,* we used the original activity and I asked my students to see if they thought that *States of Matter* or *Microwaves* was better for helping them understand liquids and solids while they played with both. All the students agreed that *States of Matter* was much clearer.

As I went around the room, I noticed that many people were not supporting their explanations with illustrations. I raised the issue with the whole class and said that the drawings were essential for credit.

Lesson: I talked about that second semester would involve describing models with illustrations.

Next day:

1. I had everyone draw a model for gas, liquid and solid on their paper. We talked about how we could show the various motions of particles. The students came up with creative ways. Next, we looked in the text to see how the author showed the three types of motion and how he showed different speeds. Several students drew gases as spheres and used water molecules for solid and liquid.

Some concepts that students might have missed and should be brought up in class discussion:

- At the same temperature are the molecules all going the same speed? *Use Gas Properties to demonstrate.*
- You can demonstrate vibrational, translational and rotational motion using *States of Matter*.

(My original plan #1: Have a group of students come to the board and share their molecular model from the activity. I would make it clear that we are going to review the explanation, so the group that volunteers needs to be comfortable with the process. Ask about things that could be added.)

Lesson plan using *Gas Properties* and *States of Matter* for understanding Kinetic Molecular Theory

Uses *Friction* as part of post-activity

Time for activity 40 minutes, the next day took 50 minutes

2. They wrote down: theory, fact, model, law, and principal. Understanding these is a thread for my class. During second semester, we focus on the students understanding modeling. We reviewed the meaning of each.

3. I also used the *Friction* sim. First, have the students rub their hands together and write down what they think is happening on a molecular level. Then open the sim and I gently rub the two layers together so that the students can see the rise in temp and the increase in molecular motion. If you rub too vigorously or have the layers too close together, the molecules have so much energy that they leave the surface. This is probably distracting.

4. Give everyone a rubber band. Have them get an idea of its temp by touching to upper lip. Then, have them vigorously stretch and test temp again. It should feel warmer. Have them write what they think is happening on a molecular level.

5. We talked about different ways we know how to change temperature. (haven't studied PV work yet)

6. My text assumes that the students know the Kinetic Molecular Theory (KMT). I'll put this on an overhead and we'll compare what we wrote to the "textbook" version.

   1. Matter is made up of particles having negligible mass are in constant random motion (vibrate, rotate, translate)
   2. The particles are separated by great distances
   3. The particles collide perfectly elastically (there are no forces acting except during the collision)
   4. The temperature of a substance is related to the molecular velocity.

7. We talked about how thermal equilibrium is reached through molecular collisions.

8. There is a "quick lab" in our text that we did. You have three water containers (hot, cold and room temperature). They put both hands in the room water for a few minutes, and then they place one hand in hot and one in cold. They write a paragraph explaining what they feel and include a molecular model.

9.There are some clicker questions too.

Student Directions for Understanding KMT using *Gas Properties* and *States of Matter*

phet.colorado.edu

Learning Goals: Students will be able to describe matter in terms of particle motion. The description should include

- **Diagrams to support the description.**
- **How the particle mass and temperature affect the image.**
- **How the size and speed of gas particles relate to everyday objects**
- **What are the differences and similarities between solid, liquid and gas particle motion**

1. Open *Gas Properties* and then use the pump to put a little gas into the box.
   a. Observe gas particles' behavior.
   b. Pump in some lighter particles and talk about the similarities and differences that you see between heavy and light particles.
   c. Use the simulation to see how changing the temperature affects the behavior of the gas particles.
   d. Write a description for a gas based on your observations; include diagrams to help with your description.

2. How fast do you think the air particles in this room are moving compared to a car going 50 mph (about 22m/s)? Put your answer is in the form, 'a molecule travels ___ as fast as a car"

3. Using the simulation, test your idea from question 2 and give evidence to support or revise your thoughts. For evidence, include how you used the simulation to collect data, and any calculations.

4. Determine the size of the heavy particle using the simulation tools and then relate molecule size to something you are familiar with. A common way to relate two things is to say something like: 1000 particles of sand fit in the palm of your hand. Show your calculations with the units clearly labeled.

5. Open *States of Matter*; use the simulation to determine how well liquids and solids match your description of gas particles.

6. Write a paragraph that explains the differences and similarities between solid, liquid and gas particle motion; include drawings to help with your explanations.

*1 nm is one billionth of a meter

Understanding KMT using *Gas Properties* and *States of Matter*

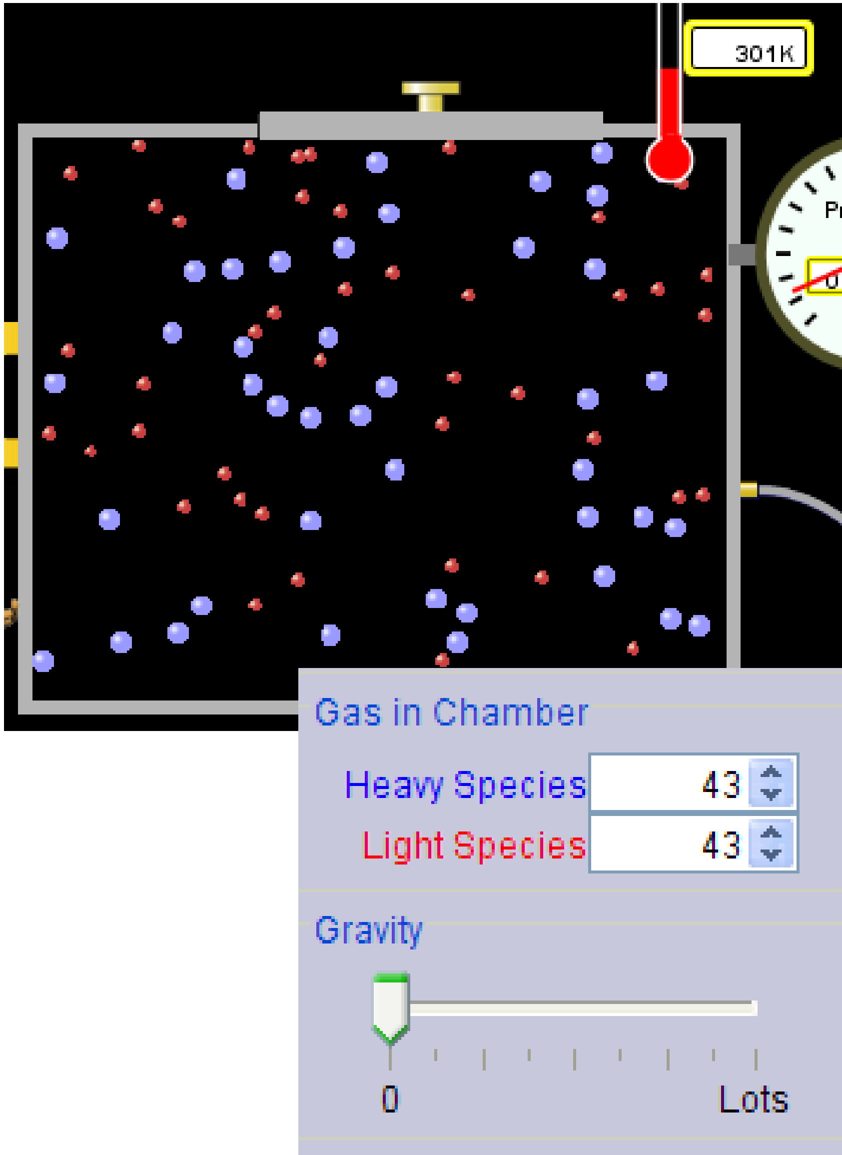
Trish Loeblein
PhET/ Evergreen High School
http://jeffcoweb.jeffco.k12.co.us/high/evergreen/science/loeblein/phys_syl/syllabus_p.html

Learning Goals: Students will be able to describe matter in terms of particle motion. The description should include

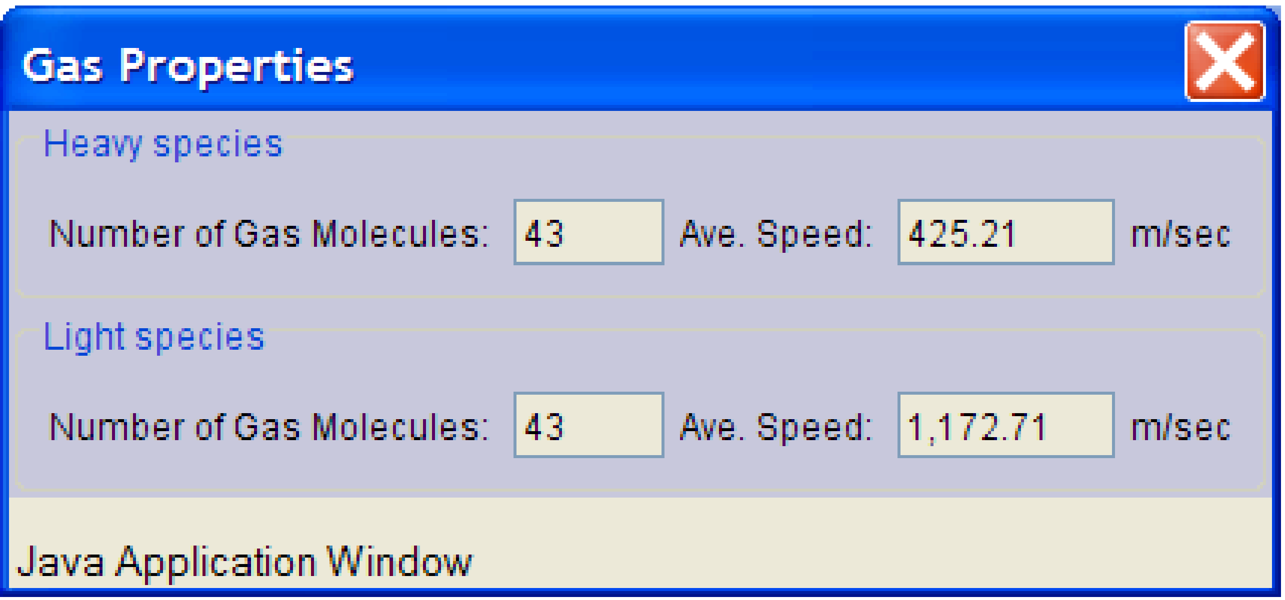
- **Diagrams to support the description.**
- **How the particle mass and temperature affect the image.**
- **How the size and speed of gas particles relate to everyday objects**
- **What are the differences and similarities between solid, liquid and gas particle motion**

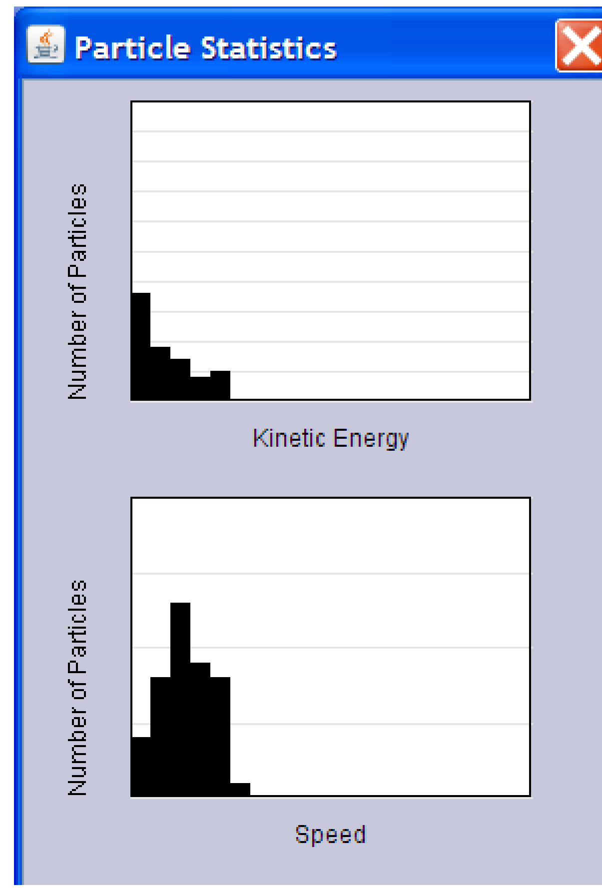
If you have a bottle with Helium & Nitrogen at room temperature, how do the speed of the particles compare?

A. All have same speed
B. The average speeds are the same
C. Helium particles have greater average speed
D. Nitrogen particles have greater average speed



Light and heavy gas at same temperature 300K

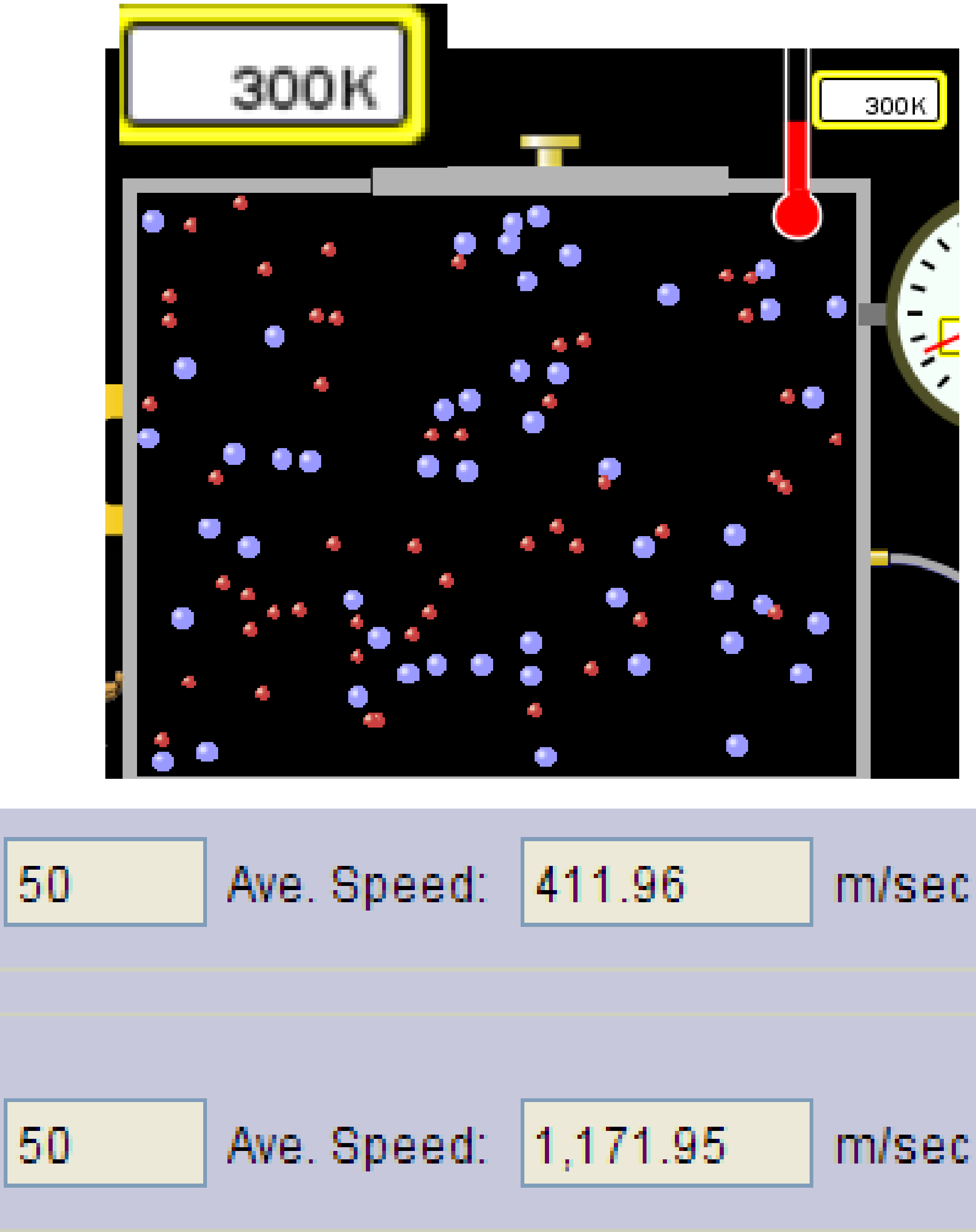


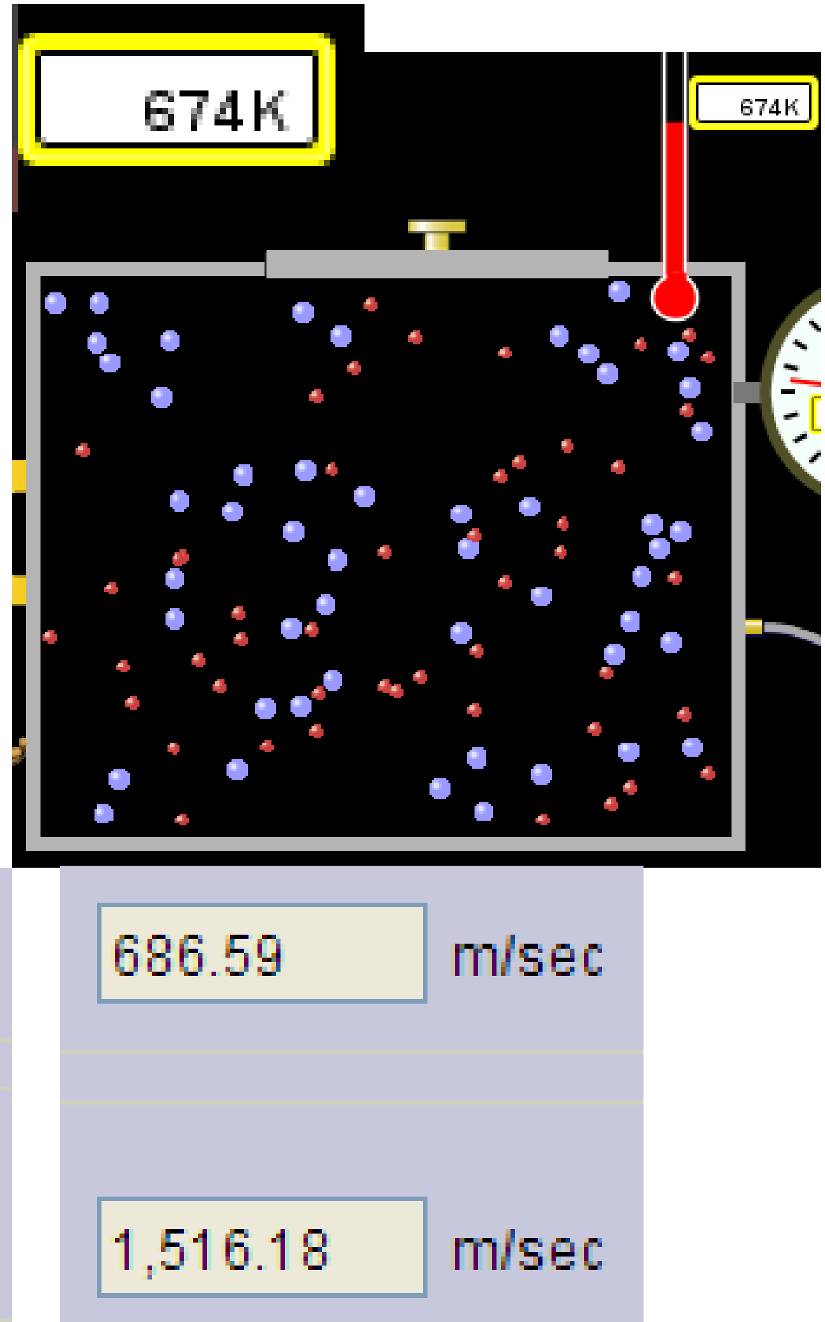


Speed of each particle varies!!

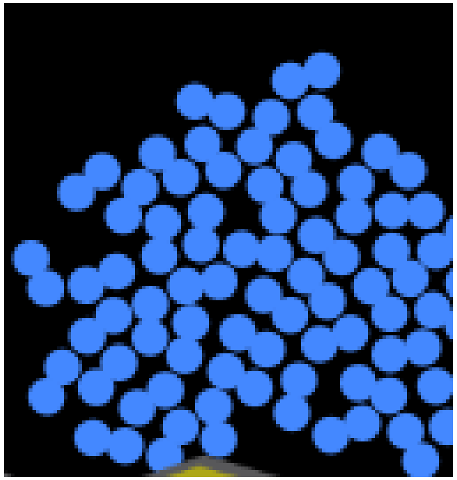
What happens if you add energy using the heater?

A. All atoms speed up
B. All atoms speed up about the same
C. The lighter ones speed up more
D. The heavier ones speed up more

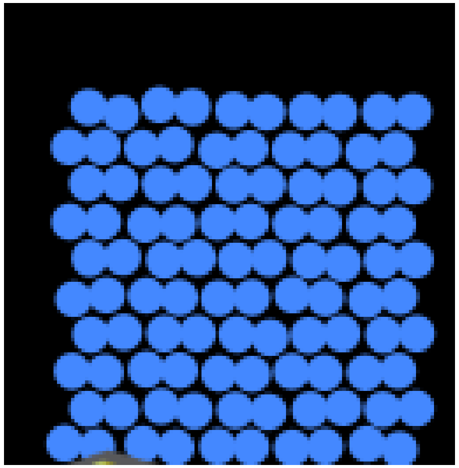

300K
300K
50
Ave. Speed:
411.96
m/sec
50
Ave. Speed:
1,171.95
m/sec


674K
674K
686.59
m/sec
1,516.18
m/sec

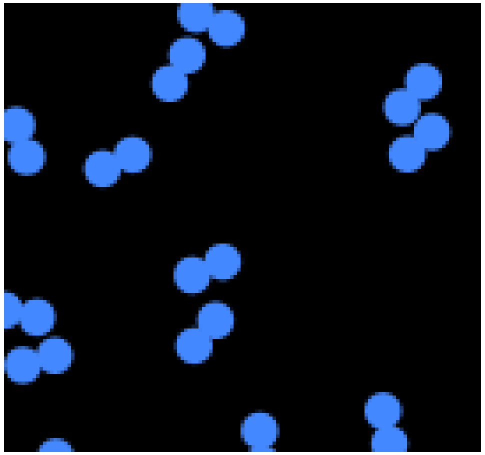
Which is most likely oxygen gas?



A

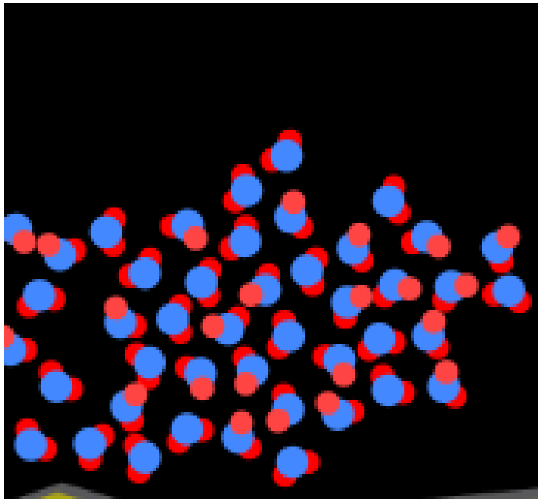


B

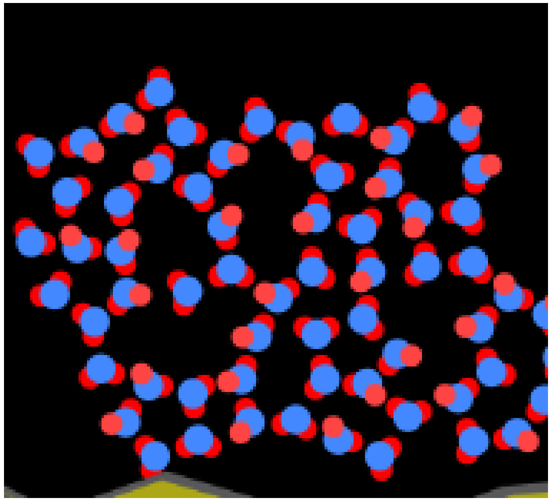


C

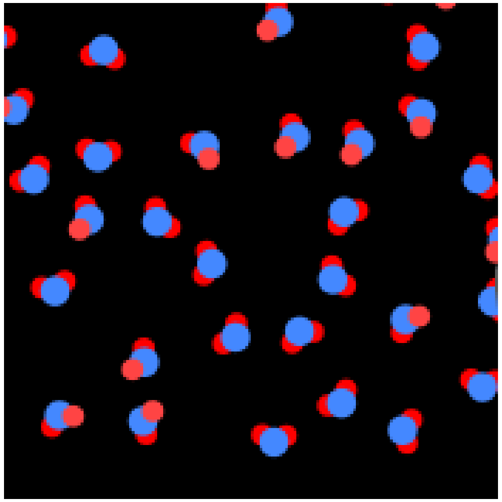
Which is most likely liquid water?



A



B



C

How many water molecules are in a raindrop(.5 cm diameter). *The molecules are about .1nm*

If we just look at how many are across .005m/.1E-9m = 5E7 or 50 million.

To show vibration

- http://chemeddl.org/collections/molecules/index.php
- Check **Spin Molecule** to see 3D rotation
- Show vibration under **Normal modes of vibration** (toggle down to see bond length changing)

KMT summary:

- Matter is made up of particles having negligible mass are in constant random motion (vibrate, rotate, translate)
- The particles are separated by great distances
- The particles collide perfectly elastically (there are no forces acting except during the collision)
- The temperature of a substance is related to the molecular velocity.

Lesson plan for *Friction* as a demo
http://www.colorado.edu/physics/phet

Learning Goals: Students will be able to describe a model for friction a molecular level.

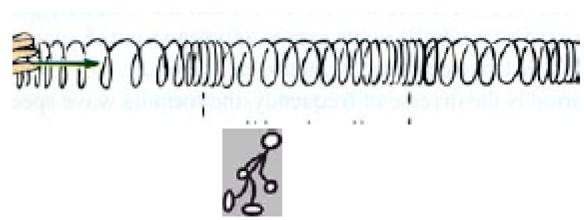
Background:
This will be part of an introduction to the chapter on friction. We will have used forces to explain visible phenomena like moving an object.

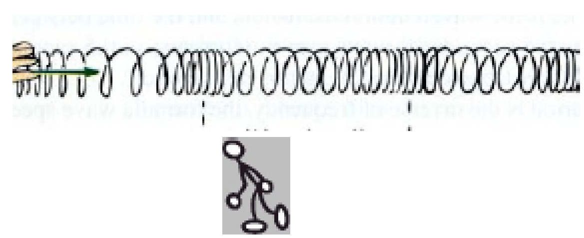
Friction Introduction:
The curser movement could be more closely tied to the visuals. You can't move the books with the curser, just go lower on the screen and the curser will change to a hand. Right now you can move the hand almost anywhere and the yellow part moves. The books don't go up and down like the molecular model does. I don't think this is a problem if used as a demo, only if the students are going to do an activity on their own.

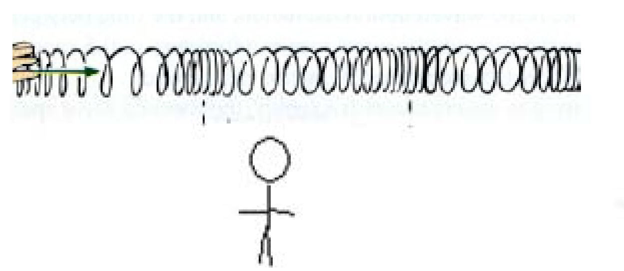
Lesson:
1. Have the students rub their hands together and describe what they feel. (warming)
2. Have them write down what they think is happening. Have a few students share their thinking as part of the class discussion.
3. Open the *Friction* sim. Tell them to write observations as you rub the two books together. Hit RESET to do this several times. (I may have them at computers or I may have it on large display)
4. Have them reflect on their answer to #2, write down how their thinking has changed, and have a class discussion.

Relativity Review

In which picture is the slinky moving the fastest in relation to the person?

A. 

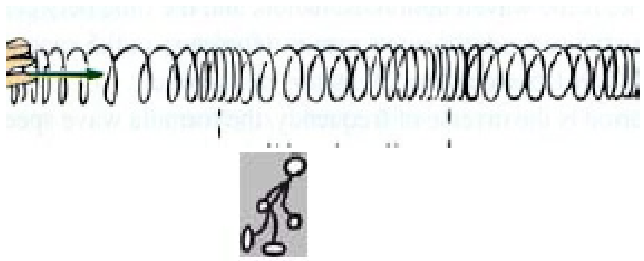
B. 

C. 

Person is standing still

What is the speed of the slinky in relation to the person in picture 1 compared to that of picture 3?

1



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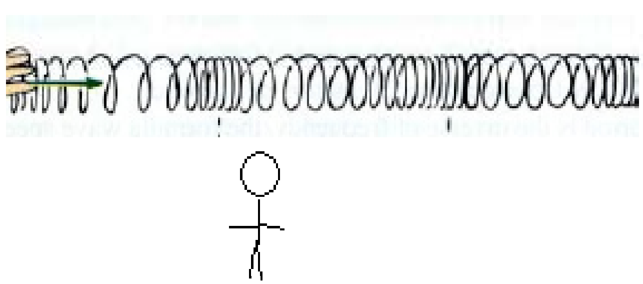
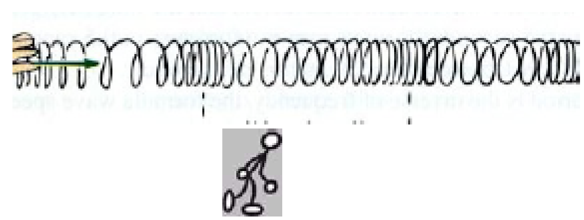
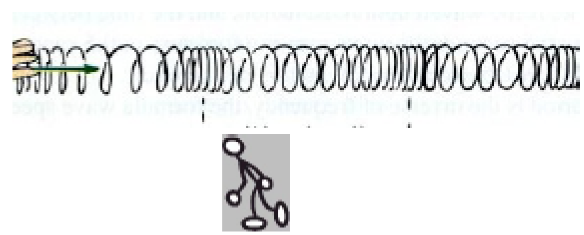


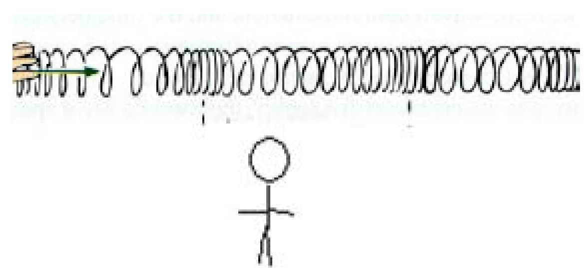
Person is standing still

A. The same
B. Faster
C. Slower
D. Impossible to tell

In which picture is the slinky moving the slowest in relation to the person?

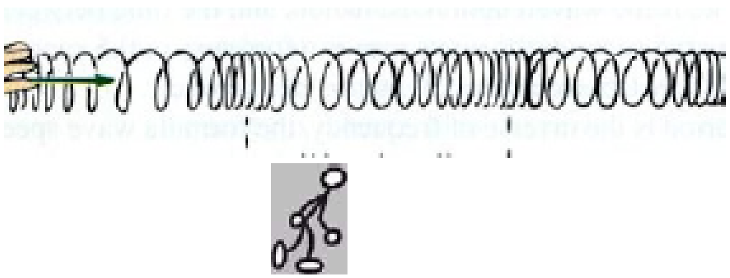
A. 

B. 

C. 

Person is standing still

What is the speed of the slinky in relation to the person in picture 1 compared to that of picture 2?

1


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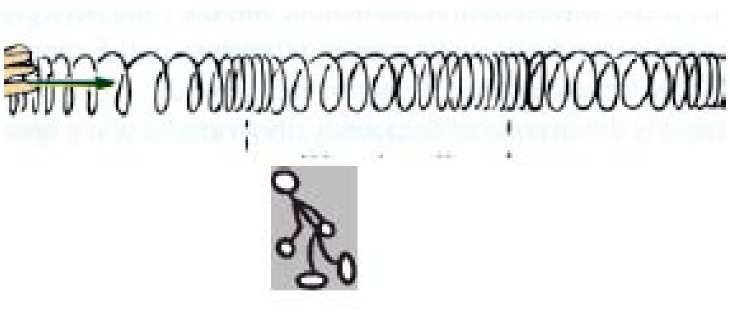
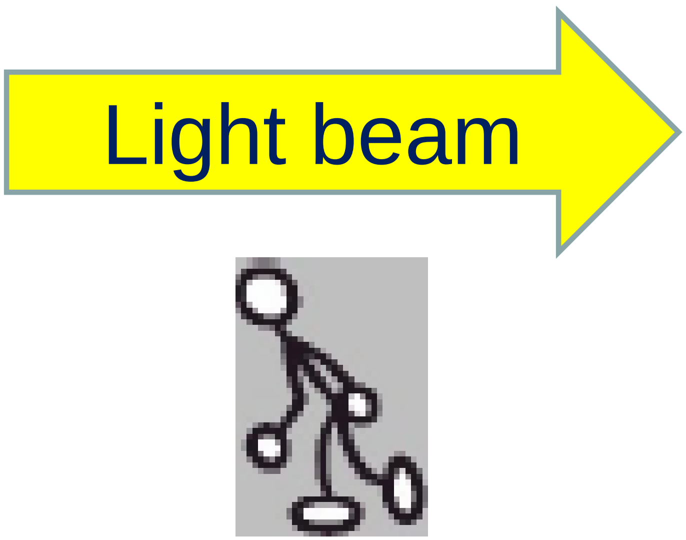


A. The same
B. Faster
C. Slower
D. Impossible to tell

Time Dilation

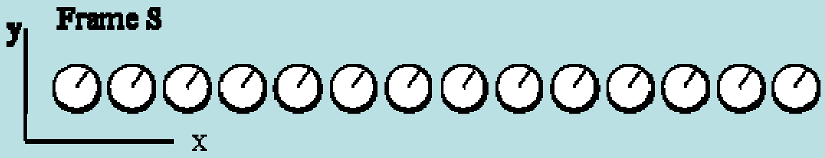
Concept Test

Is the speed of light faster or slower when you are going the opposite direction of the light?



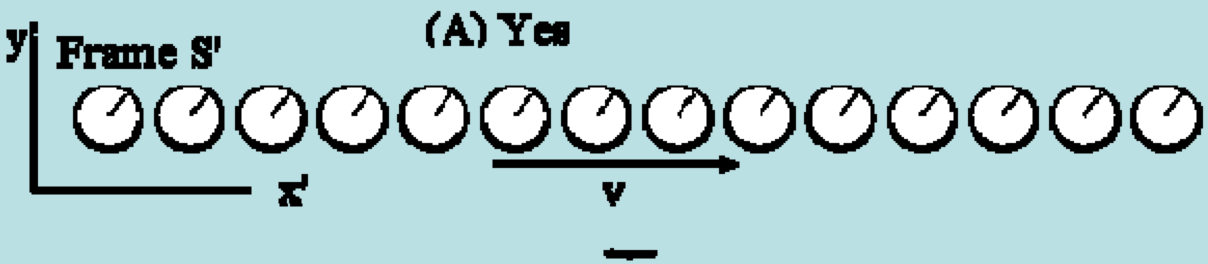
A. Slower
B. Faster

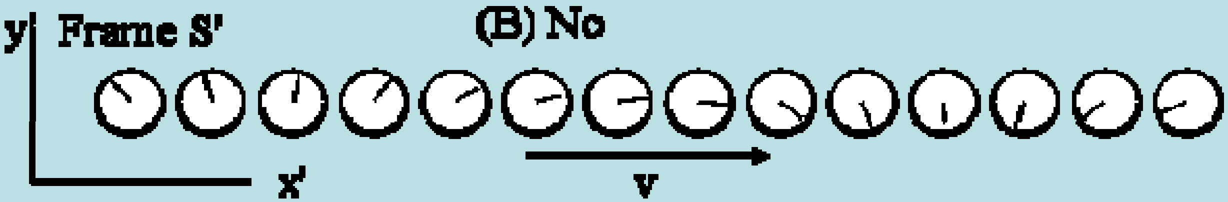
A long row of clocks (all at rest in Frame S) are synchronized. So, all clocks strike 2 o'clock simultaneously in Frame S.



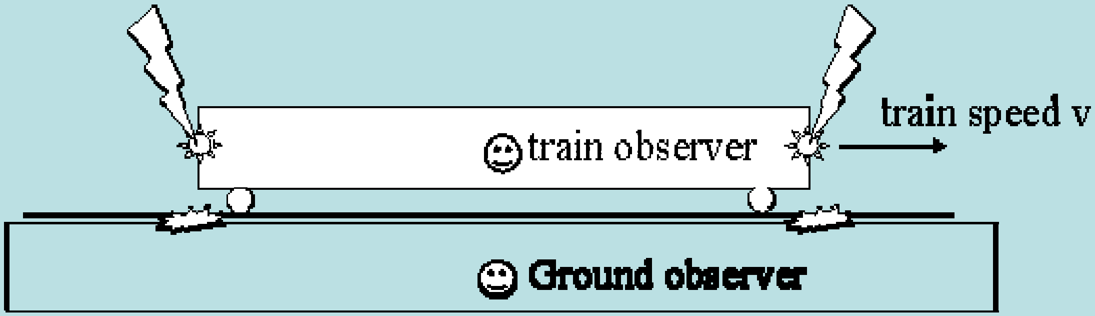
The same row of clocks is observed from Frame S' which is moving to the left relative to S with speed v. So in S', the clocks are moving to the right at speed v.

Are the clocks synchronized in S' ?





A person on the ground, watching a train go by, observes two simultaneous lightening strikes: one strike hits the front of the train and the other hits the back of the train. The strikes ignite bright fires on the front and back of the train and scars the tracks. The ground observer is halfway between the strikes when they occur. There is a train observer in the center of the train car.



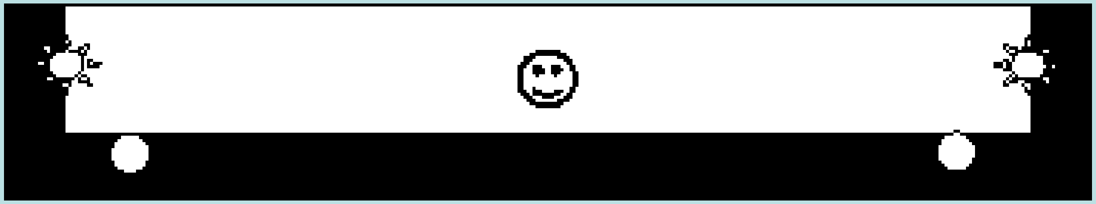
According to the **ground** observer, which strike's light rays reach the **train** observer first?

A) The front strike B) the back strike

C) Both strikes reach the train observer at the same time

Both observers agree on these events:

- lightening struck the front of the train (event A)
- lightening struck the back of the train (event B)
- both sides of the train observer were lit up (event C).



According to the train observer, which strike occurred first?

A) The front strike B) the back strike

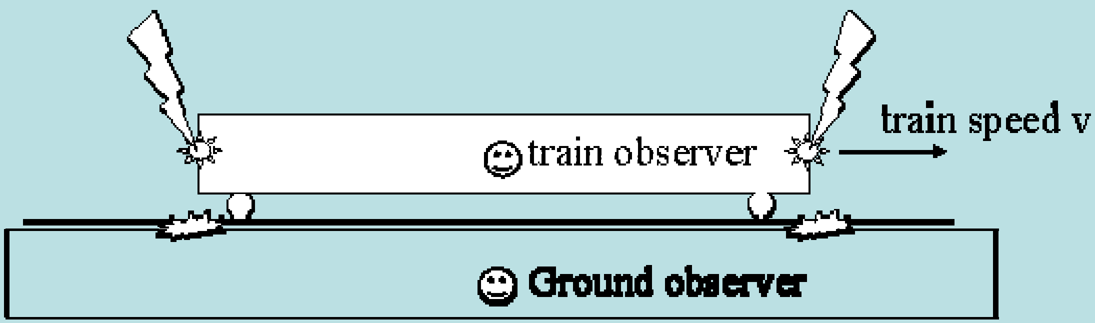
C) Both strikes reach the train observer at the same time

According to the ground observer, the distance between the track scars is equal to the length of the train. According the train observer, the distance between the track scars is ________ the length of the train.

A) greater than

B) less than

C) equal to



Kinematics and Energy Clicker questions written by students

My students signed a waiver enabling me to use these

Which of the following is *not* an example of projectile motion.

A. A volleyball served over a net
B. A baseball hit by a bat
C. A hot-air balloon drifting toward Earth
D. A long jumper in action

Two roller skaters stand facing each other. One of their masses is 80kg, the other is 72kg. If they both push each other at the same time, what happens to their momentum?

a. The lighter skater has a higher momentum
b. The heavier skater has a higher momentum
c. Their momenta are equal but opposite
d. The lighter skater has a higher velocity

A passenger on a bus traveling west sees a man standing on a curb. From the passengers perspective the man appears to be…

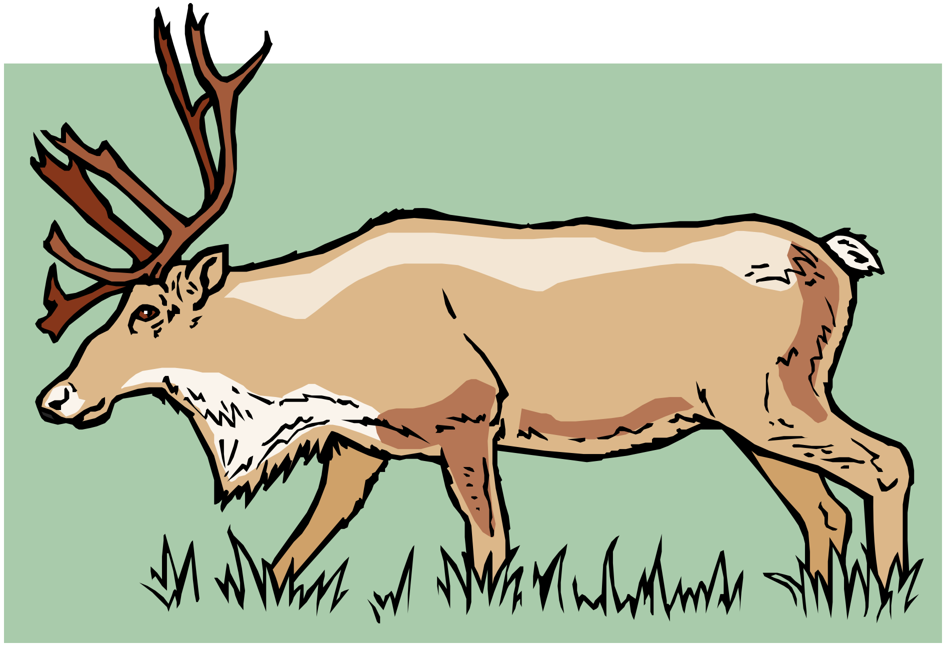
A. Standing still.

B. Moving to the East at a speed *greater* than the bus.

C. Moving East at a speed *equal* to the bus.

D. Moving west at a speed *equal* to the bus.

A snowmobile with a mass of 500 kg is moving 40 m/s in the Alaskan wilderness. Suddenly a Caribou galloped into the track of the snowmobile. Fearing for his life the driver applied the brakes to the snowmobile with a force of 235 N. How long does it take the sled to come to a complete stop.

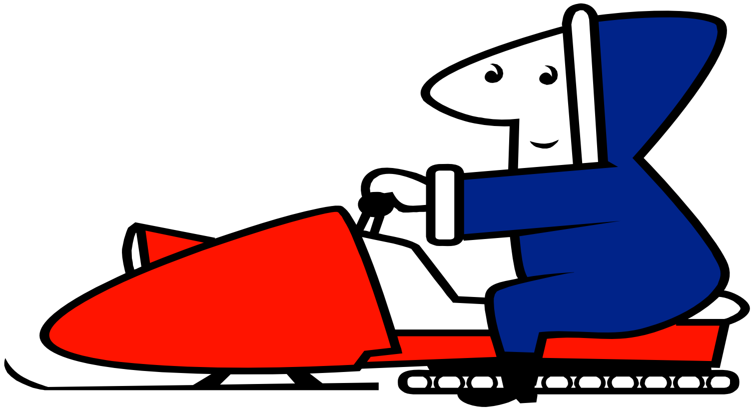


A. 120 seconds

B. 85 seconds

C. 76 seconds

D. 8.5 seconds



What is the tangential speed of a boy on a Ferris wheel a distance of 10 meters from the center when he moves 3 radians in 15 seconds?

A. 0.5 m/s
B. 1 m/s
C. 2 m/s
D. 4.5 m/s
E. 450 m/s

A 50.0 N crate starts at rest and slides down a 10.0 m long ramp inclined at 40.0° to the horizontal. The force of friction between the crate and the ramp is 9.0 N. What is the net force (in N)?

a. 23

b. 46

c. 29

d. 41

- A wakeboarder with a mass of 60 kg is accelerated across a smooth lake at 1.5 m/s^2. What net force acts on the wakeboarder horizontally?

a. 3 n　　b. 90 n

c. 75 n　　d. .03 n

A free body diagram of a ball falling in the presence of air resistance would show

A. only a downward arrow to represent the force of air resistance

B. Only a downward arrow to represent the force of gravity

C. A downward arrow to represent the force of gravity and an upward arrow to represent the force of air resistance

D. An upward arrow to represent the force of gravity and a downward arrow to represent air resistance

The length of a force vector represents the

A. Cause of force
B. Direction of force
C. Magnitude of force
D. Type of force

A boat having a mass of 30 kg is accelerated across a level road at 2.0 m/s. what net force acts on the boat horizontally?

A. 15 n
B. 10 n
C. 60 n
D. 32 n

- A hiker travels south along a straight path for 1.5 hours with an average velocity of .75 km/h, then travels south for 2.5 hours with an average velocity of .90 km/h. what is the hiker's displacement for the total trip?
- A. 2.5 km to the south C. 3.4 km to the south
- B. 2.2 km to the south D. 4.0 km to the south

- A rock is thrown up from the top of a cliff with an initial speed of 2.0 m/s. If it hits the ground after 2.0 seconds , what is the height of the cliff? (disregard air resistance)
- A. 6m
- B. 15.6m

C. 22.6m

D. 34m

A car starts traveling 10km from EHS, 2 minutes later it is 16km from the school and 5 minutes later it is 25km away. What is the car’s displacement in the first 2 minutes?

A. 16

B. 6

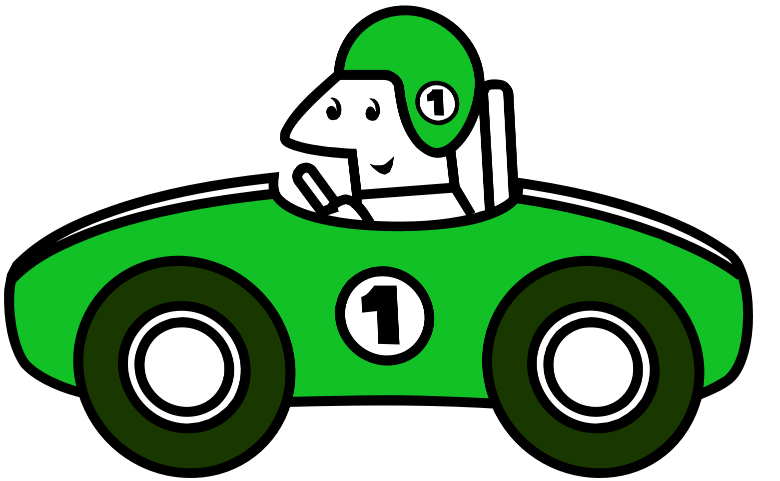
C. 25

D. 15

An athlete runs 110m across a level field at an angle of 30 degrees north of east. What are the east and north components of her displacement, respectively?

A. 55m, 95m
B. 190m,64m
C. 64m, 190m
D. 95m, 55m

- A car travels 15 km during the first half hour, then travels 45 km in the second half hour of the trip. The average velocity for the trip is (in km/hr)…….
- A. 60 C. 30
- B. 70 D. 50



Which item does not represent circular motion?

A) The earth’s orbit around the sun.

B) The Ferris Wheel as it moves with riders.

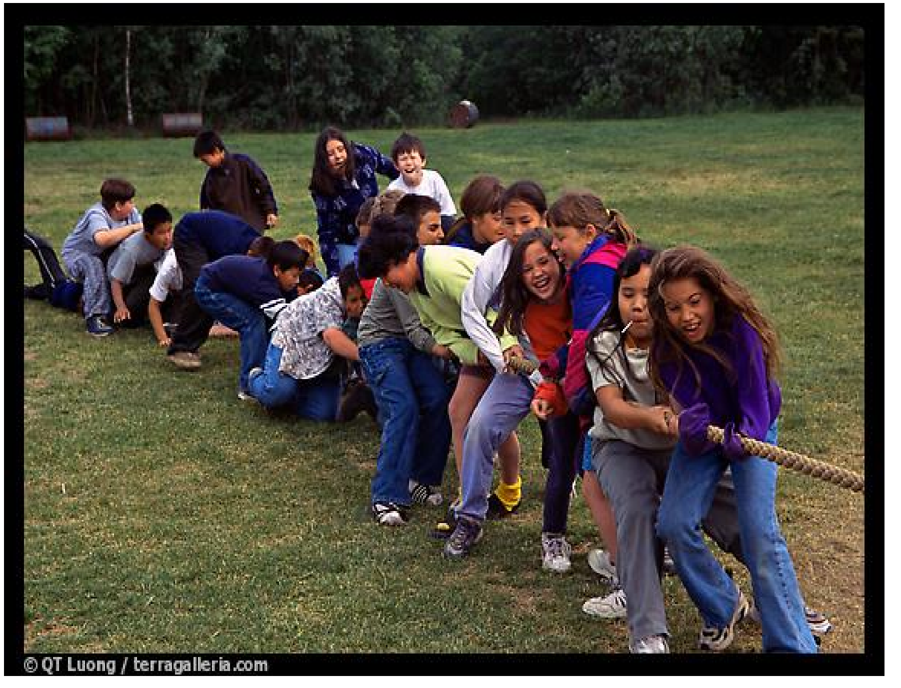
C) A bicycle tire going down hill.

D) A car sliding down a hill after being rolled.

E) A battleship circling an island.

If two teams are playing tug-of-war, a rope is pulled by a force of 80 N to the left and by a force of 70 N to the right. What is the magnitude and direction of the net horizontal force on the rope?

A. 10 N to the right
B. 150 N to the right
C. 10 N to the left
D. 150 N to the left



Centripetal Acceleration

A girl sits on a tire that is attach to a tree and her father pushes her with a tangential speed of 4.8 m/s, and she travels in a horizontal circle 8m. What is the centripetal acceleration of the girl?

A) 5.76 m/s/s

B) 92.16 m/s/s

C) 38.4 m/s/s

D) 19.2 m/s/s

A Rufous Hummingbird flies with a constant velocity of 10 m/s. What is its acceleration?

A) 20 m/s/s

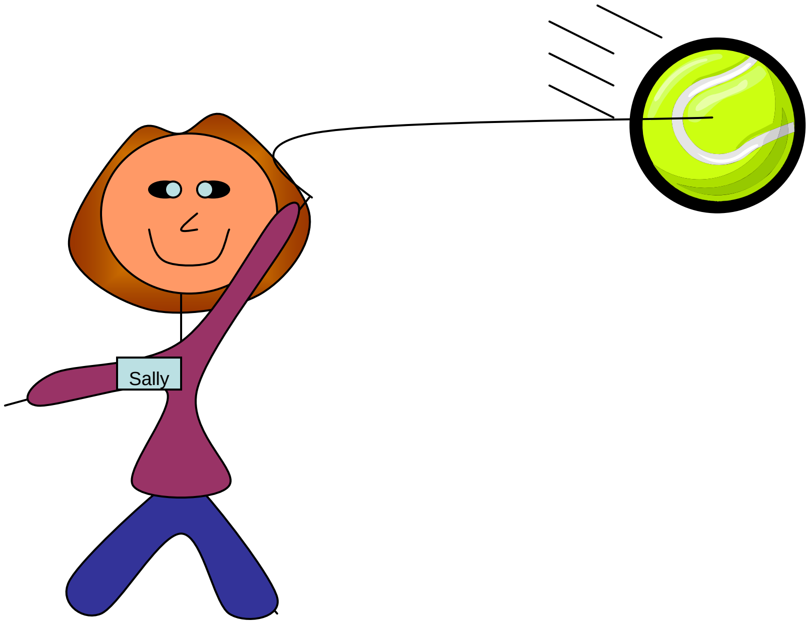
B) 10 m/s/s

C) 0 m/s/s

D) 1 m/s/s

A Tennis Ball with a mass of .057 kg is tied to a string that is 8.0 meters long and spun over Sally's head for four full rotations in 2 seconds. What is the force that maintains the circular motion over Sally's head?

a) 2.6 N
b) 2.7 N
c) 2.8 N
d) 2.9 N
e) 3.0 N



What is the gravitational potential energy of a 152 kg car falling off a 12 m high bridge?

A. 15,533.5 J
B. 11,436.7 J
C. 17,893.4 J
D. 9,652 J

Which objects have the highest coefficient of friction

1. Skis on ice
2. Skateboard on pavement
3. Line coming off a fishing reel
4. Climber’s shoes on a rock wall

A lizard, looking for a mate, travels 2.5 meters southward. Hearing a call from behind, he speeds up north, with a velocity of 2 Meters/Second for five seconds before finding nothing. Depressed, he moves two meters south to his favorite rock. What is his displacement?

A: 5.5 M North

B: 3.8 M South

C: 6.5 M North

D: 6.2 M North.

In a baseball game where does the ball have the most potential energy?

A. In the hand of the pitcher
B. When it makes contact with the bat
C. Top of a pop fly
D. When its caught in the out felid

Lois decides to go for a run. The velocity time graph given relates to her velocities during her run.

The distance traveled between 5 & 10 seconds is:

A.30 meters

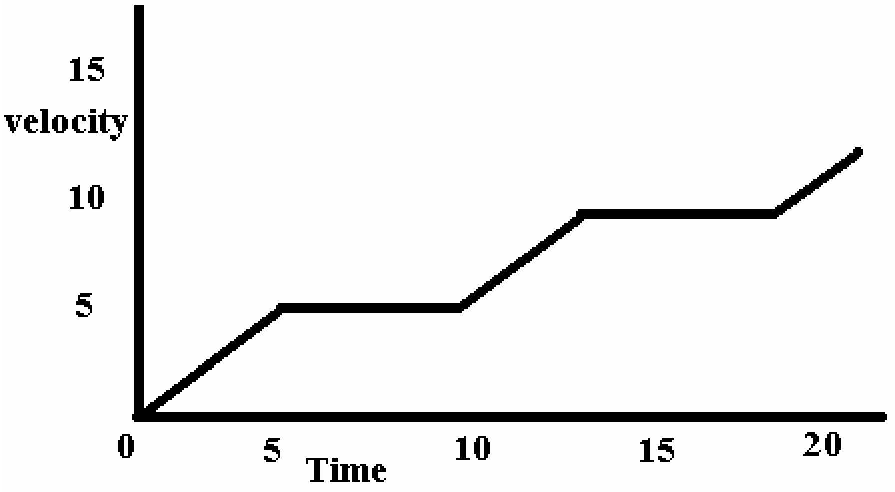
B.40 meters

C.25 meters

D.20 meters

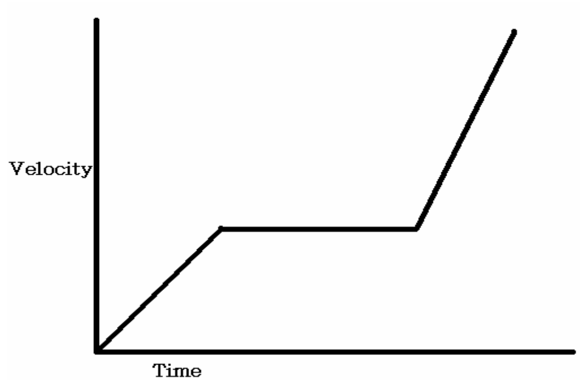
E.None of the above

Velocity (m/s) vs time (s)

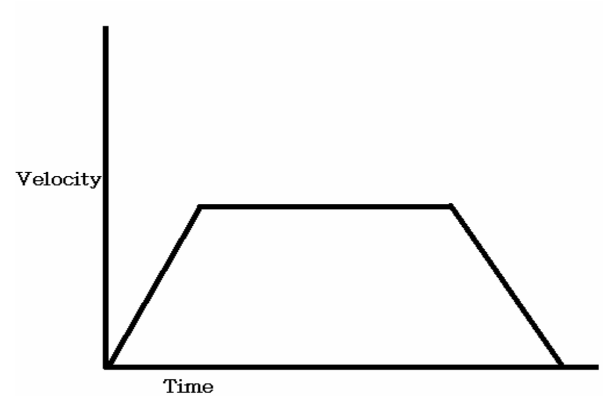


A sketch of a velocity-time graph of a man that walks forward at a constant speed, stops for a short time, and then continues in the direction he was going at a faster constant speed would look like which one?

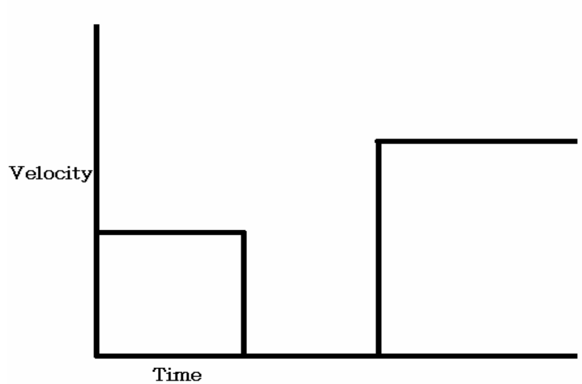
- A)



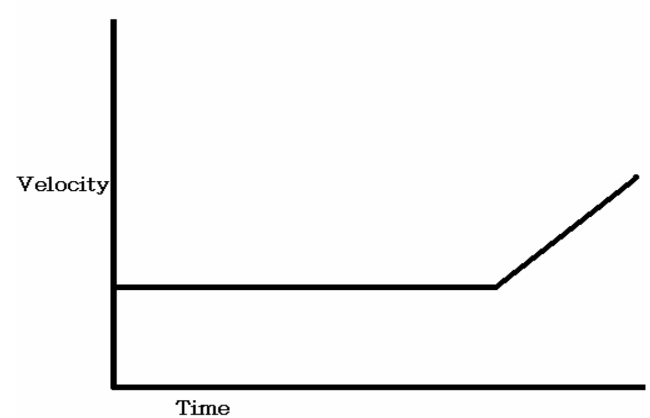
- C)



- B)



- D)



A Peregrine Falcon hovers at 1000 meters above the ground. It suddenly dives down 500 feet. Its potential energy…

A) Increases

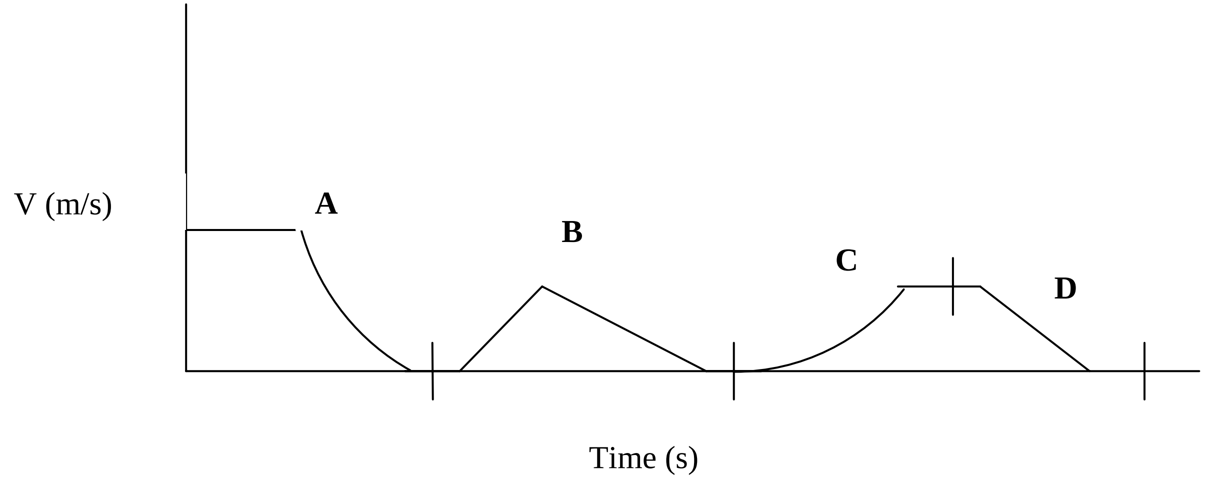
B) Decreases

C) Stays the same

D) Doesn't exist

Distance Time Graph

A man is walking from work to his house. He spots a 20 dollar bill lying on the ground so he slows down at an increasing rate to a stop and picks it up. What part of the graph represents this action best?



What is the tangential acceleration of a 4 cm wide rolling pin with an angular acceleration of 3 rad/s^2

A 0.12 m/s^2

B 6m/s^2

C 0.06m/s^2

D 12m/s^2

A group of band kids were marching in a perfect circle with a radius of 2 meters during one of their shows. If they march a total of π radians in 5 seconds what are their angular and tangential velocities?

A. .125 rad./s and .251 m/s

B. 1.26 rad./s and .628 m/s

C. .628 rad./s and 1.26 m/s

D. .251 rad./s and .502 m/s

E. Band kids can't march in perfect circles.

Two men are working together to move a heavy cabinet by pulling on ropes. If one is pulling towards the North with a force of 32 N and the other is pulling towards the South with a force of 42 N,
What is the total force exerted on the cabinet and in which direction will the cart move?

A. 10 N, north
B. 74 N, south
C. 74 N, north
D. 10 N, south