Momentum Instructional Packet - Physics 37

Google and watch **Bill Nye the Science Guy - S02E17 Momentum (22:55)**

Google "the physics classroom" to find the website (https://www.physicsclassroom.com). Select the "The Physics Classroom Tutorial" link.

On the website, select "Momentum and its Conservation"

Read and take notes on Lesson 1 The Impulse-Momentum Change Theorem. At the end of each section, try the Check Your Understanding questions and check your answers.

Complete the enclosed problem sheets.

- Momentum Worksheet 1
- Impulse Worksheet 1

Read and take notes on Lesson 2 The Law of Momentum Conservation. At the end of each section, try the Check Your Understanding questions and check your answers.

Complete the enclosed problem sheet.

- Elastic Collision Worksheet 1
- Inelastic Collision Worksheet 1

Complete the "Cart and Brick" CER assignment. The interactive can be accessed on "The Physics Classroom" website. Select the "Physics Interactives" link, then the "Momentum and Collisions" link.

Momentum Worksheet 1 Name ____________________

1. Calculate the momentum of a halfback with the mass of 60 kg moving eastward at speed of 9 m/s.

2. Calculate the momentum of a 1000-kg car moving northward at the speed of 20 m/s.

3. Calculate the momentum of a freshman with the mass of 40-kg moving southward at a speed of 2 m/s.

4. A ball is moving at a speed of 13 m/s to the east and has a momentum of 52 kgm/s eastwards. What is the ball's mass?

5. A automobile has a mass of 10,000 kg and is traveling at the speed of 8 m/s to the north. What is the automobile's momentum?

6. A child and his bike have a total mass of 65 kg and rides down the street at a speed of 5 m/s south. What is the momentum of the child and the bike?

7. A 2250 kg pickup truck has a velocity of 25 m/s to the east. What is the momentum of the truck?

8. A 21 kg child is riding a 5.9 kg bike with a velocity of 4.5 m/s to the northwest.
   - What is the total momentum of the child and the bike together?
   - What is the momentum of the child?
   - What is the momentum of the bike?

Impulse Worksheet 1 Name ____________________

1. A force of 50 N is applied to a hockey puck (with a mass of .170 kg) that is initially at rest for a time of 2.0 s. Calculate the impulse acting on the puck.

2. A force of 25 N acts on an object (with a mass of 2.0 kg) initially at rest for a time period of 5.0 s. What is the impulse acting on the object?

3. A car with the mass of 1400 kg moving westward with an initial speed of 15 m/s collides with a utility pole and is brought to rest (final speed = 0 m/s) in a time period of 0.30 s. Find the magnitude of the force exerted on the car during the collision.

4. A hockey puck has a mass of 0.170 kg and is initially at rest (Vi = 0 m/s). A force of 38 N is applied to the puck for a time of 0.2 s. What is the final velocity of the puck?

5. A boy on a bike with a total mass of 50 kg rides at the initial speed of 5 m/s heading east and drives into a snow bank and stops (Vf = 0 m/s) in 1.5 seconds. What is the impact force of the snow bank on the boy and bike?

6. A crate with a mass of 220 kg is moving horizontally at the speed of 4 m/s and plows into a bean bag chair and comes to a stop in a time of 0.5 s. What is the impact force on the bean bag chair?

7. A 1500 kg car initially at rest leaves a parking lot. Thirty seconds later it is moving along a highway at a velocity of 20 m/s.
   a. What is the car's momentum when it is moving down the highway?

   b. What average force does the motor produce to bring about this change in momentum?

8. A force of 8.0 N acts on a 2.0 kg mass initially at rest for 5.0 s.
   a. What is the change in momentum (or impulse) of the mass?

   b. What is the final velocity of the mass?

9. The mass of a car is 1600 kg. The car's velocity is 20 m/s.
   a. What is the car's momentum?

   b. How long must a force of 800 N act on the car to bring it to rest?

Elastic Collision Worksheet 1 Name ________________________

$m_1v_1 + m_2v_2 = m_1v_{1a} + m_1v_{2a}$

1. A billiard ball with a mass of .16 kg is traveling at the velocity of + 2 m/s and it collides with a second billiard ball at rest with the same mass of .16 kg. After the collision the first billiard ball comes to rest. What is the velocity of the second billiard ball?

2. A billiard ball with a mass of .16 kg is traveling at the velocity of + 1.5 m/s and it collides with a second billiard ball with the same mass of .16 kg traveling in the opposite direction with a velocity of – 2 m/s. After the collision the second billiard ball comes to rest. What is the velocity of the first billiard ball?

3. A cue ball with a mass of .17 kg is traveling at the velocity of + 4 m/s and it collides with a billiard ball at rest with the mass of .16 kg. After the collision the cue ball is moving at 1 m/s. What is the velocity of the billiard ball?

Elastic Collison Class Sample Problems $m_1v_1 + m_2v_2 = m_1v_{1a} + m_1v_{2a}$

4. A car with the mass of 1000 kg traveling at 20 m/s to the right collides with a truck with the mass of 3000 kg at rest. If the car travels to the left after the collision with a speed of 10 m/s. What is the magnitude and direction of the velocity of the truck after the collision?

5. A truck with a mass of 3000 kg travels to the right at the speed of 20 m/s and collides with a car of mass 1000 kg that is at rest. After the collision, the truck moves to the right with a speed of 10 m/s. What is the magnitude and direction of the velocity of the car after the collision?

6. A car with a mass of 1000 kg moves to the right with a speed of 20 m/s and collides with a truck moving to the left with a speed of 20 m/s. After the collision, the car is moving to the left at a speed of 40 m/s. What is the magnitude and direction of the velocity of the truck after the collision?

Name ___________________

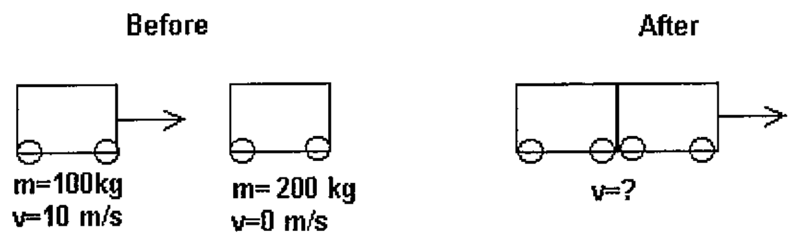
Inelastic Collision Word Problems

1. A fish with the mass of 10 kg is swimming at the speed of 6 m/s. Another fish of mass 2 kg is at rest. Find the speed of the fish after the first fish swallows the second fish.

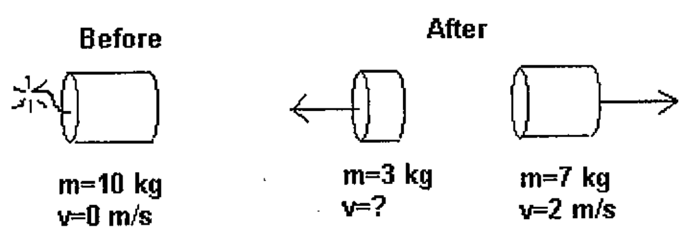
2. A car on the momentum track has a mass of 10 kg and has the speed of 4 m/s. This car collides and sticks together with another car of mass 2 kg that has the speed of 8 m/s in the opposite direction. What is the speed of the two cars after impact.

3. A 0.080 kg bullet strikes a 3.0 kg wooden block (that is at rest) and embeds itself in the block. The block and bullet fly off together at 8 m/s. What was the original speed of the bullet?

4. A 100 kg cart moving at 10 m/s collides with a 200 kg cart at rest as shown below. If the collision is inelastic, what is the speed of the two carts after the collision?



5. A 10 kg firecracker explodes into two pieces, one with a mass of 3 kg and the other with a mass of 7 kg. The firecracker was at rest before the explosion. If the 7 kg piece moves to the right with a speed of 2 m/s after the explosion what is the velocity of the 3 kg piece?



The Cart and the Brick Interactive

Background:

In this Interactive, you will analyze a collision in order to determine the total momentum of a system before and after the collision. Your goal is to gather evidence that supports the law of conservation of momentum. The collision involves the collision between a stationary brick that is *dropped upon* a moving cart. The brick lands upon the cart and travels at the same speed as the cart after the collision. A ticker tape is attached to the cart and pulled along with the cart through a ticker tape timer. Ticks (dots) are placed upon the tape every 1/60-th of a second, leaving a trace of the cart's position over the course of time. Analysis of the ticker tape allows one to determine the velocity of the cart before and after the collision. The Interactive offers a short tutorial on the analysis of the ticker tape. The tutorial is highly recommended to those unfamiliar with ticker tape analysis; it can be accessed from the first screen of the widget.

Purpose:

To analyze a collision in order to accumulate evidence that supports the law of conservation of momentum.

Discussion of Procedure:

There are 18 collisions to analyze. Each collision differs in terms of the mass of the cart, the mass of the brick, and the pre-collision speed of the cart. It is not necessary to analyze all 18 trials. Select two or three trials to analyze or analyze those collisions that were assigned to you by an instructor (if completing the activity as a class assignment).

Select the trial from one of the two **Experimental Conditions** screens. Observe the animation; repeat it if necessary. Then tap the **Analyze Data** button. The ticker tape is displayed with a centimeter-ruler positioned below it. The collision point is indicated. Measure the distance associated with 6 spaces (or 12 spaces) between dots on the pre-collision side of the tape. Record the distance and the time on the pre-collision side of the data table. The time is 0.10 seconds for 6 spaces and 0.20 seconds for 12 spaces. Repeat the procedure for the post-collision side of the tape and record. Velocities can be calculated for the cart (before collision) and for the cart and the brick (after the collision) as the distance/time ratio. The mass of the cart and of the brick (shown on the screen) can be used to determine the momentum of each object. The momentum of the individual objects can be *summed* to determine the system momentum. Because the distance values are the results of measurements, small amounts of error are inherent in the process of determining the momentum of the objects.

Data tables are provided for two trials. Additional tables can be made if necessary.

Data

Trial: ___________

		Before Collision				After Collision			
	Mass (kg)	Distance (cm)	Time (s)	v (cm/s)	p (kg•cm/s)	Distance (cm)	Time (s)	v (cm/s)	p (kg•cm/s)
Cart									
Brick									
System									

Trial: ___________

		Before Collision				After Collision			
	Mass (kg)	Distance (cm)	Time (s)	v (cm/s)	p (kg•cm/s)	Distance (cm)	Time (s)	v (cm/s)	p (kg•cm/s)
Cart									
Brick									
System									

Conclusion

Does the collision between the cart and the brick follow the law of momentum conservation? Make a claim (yes or no) and support the claim by describing the evidence and reasoning that that supports it. Use a separate page if necessary.

Energy Instructional Packet - Physics 37

Google and watch **Bill Nye The Science Guy Energy (29:51)**

Google "the physics classroom" to find the website (https://www.physicsclassroom.com). Select the "The Physics Classroom Tutorial" link.

On the website, select "Work and Energy"

Read and take notes on Lesson 1 Basic Terminology and Concepts. At the end of each section, try the Check Your Understanding questions and check your answers.

Complete the enclosed problem sheets.

- Work and Power Worksheet 1
- KE PE Worksheet 1

Read and take notes on Lesson 2 The Work-Energy Relationship. At the end of each section, try the Check Your Understanding questions and check your answers.

Complete the enclosed problem sheets.

- Conservation of Energy Worksheet 1
- Work Energy Theorem Worksheet 1

Complete the "Roller Coaster Energy" assignment. The interactive can be accessed on "The Physics Classroom" website. Select the "Physics Interactives" link, then the "Work and Energy" link.

Work / Power Worksheet 1 Name ________________

1. Two motorists together exert a 400 N force on a stalled car to move it a distance of 60 m. How much work do they do?

2. What work is done by a girl who pushes a box along a floor with a force of 80.0 N for a distance of 10.0 m?

3. A boy raises a 20.0 kg rock 1.50 m.
   a. What force does the boy use to raise the rock?
   b. What work does he do?

4. What work is done in pushing a cart 3.00 m with a force of 250 N?

5. How much work is done in lifting a 2.50 kg box a distance of 6.00 m?

6. How much work is done by a girl weighing 500 N in climbing 5.0 m up on a rope in the school gymnasium?

7. If a machine does 50 N-m of work in 10 seconds, what is its average power?

8. A student pushing a wagon with a force of 40 N moves it 12 m in 10 s.
   a. What is the work done?

   b. What is the power exerted?

9. How much work can a 250 W motor do in 12 s?

10. A student weighing 500 N raises his body 0.300 m on a chinning bar in 1.50s.
    a. What work was done?
    b. What was the student's power?

11. How much work can a 125 W motor do in 2.50 s?

Kinetic Energy / Potential Energy Work Sheet 1 Name________________

1. What is the kinetic energy of a mass of 5.0 kg moving at the speed of 4.0 m/s?

2. What is the potential energy of an elevator relative to the bottom of the shaft having a mass of 500 kg when it is 10 m above the bottom of its shaft?

3. What is the potential energy of the same elevator if it is 20 m above the bottom of its shaft?

4. What can you say about the potential energy of an object if you double its height?

5. A child on a sled is on top of a 15 m hill. What is the potential energy of the child and sled relative to the bottom of the hill if there combined mass is 50 kg?

6. What is the kinetic energy of a 4.0 kg mass moving at the speed of 5.0 m/s?

7. What is the kinetic energy of a 4.0 kg mass moving at twice the speed of the above problem?

8. What happens to the kinetic energy of an object if you double the speed?

9. The speed of an automobile of mass 1600 kg increases uniformly from 20 m/s to 30 m/s. What is the increase in its kinetic energy?

10. A 2.0 kg rock falls from a height of 25 m to a point 20 m above the ground. How much potential energy does it lose?

Name ________________

Conservation of Energy Worksheet 1

1. A mass of 2.0 kg is dropped from a height of 5.0 m. Make a table showing its potential and kinetic energies when it is at each of these distances from the ground. (use PE = mgh for each, at 5.0m TE = PE + KE where KE is 0 J, so TE = PE) (Use TE = PE + KE to solve for each KE)

Height	PE	KE
5.0 m		
4.0 m		
2.0 m		
.0 m		

2. A projectile weighing 2.5 kg is fired directly upward from a cannon and rises to a height of 400 m.
   a. What is it potential energy at the top of its flight?

   b. With what kinetic energy does it leave the cannon?

   c. What is its kinetic energy and potential energy at a height of 300 m? (use PE = mgh , then Use TE = PE + KE to solve for KE)

3. A cart of mass 500 kg starts from rest at the top of one hill, rolls to the bottom, and then ascends a second hill. The height of the first hill is 30 m and that of the second hill is 10 m. What is the kinetic energy of the cart when it reaches the top of the second hill? (use PE = mgh , then Use TE = PE + KE to solve for KE)

4. A large chunk of ice with a mass of 15 kg falls from a roof that is 8.0 m above the ground.
   a. What is the potential energy of the ice before it falls? PE = mgh

   b. What is the kinetic energy of the ice right before it hits the ground?
   PE + KE = TE

   c. What is the speed just as it reaches the ground? $KE = \frac{1}{2} mv^2$
   Or $v = \sqrt{2\ KE / m}$

5. An 8.0 kg flower pot falls from a window ledge 12.0 m above the sidewalk.
   a. What is the potential energy of the pot before it falls? PE = mgh

   b. What is the kinetic energy of the pot just before it reaches the sidewalk?
   PE + KE = TE

   c. Determine the speed of the pot just before it strikes the sidewalk.
   $KE = \frac{1}{2} mv^2$ Or $v = \sqrt{2\ KE / m}$

6. A 5.0 kg mass is projected straight up with a speed of 15 m/s.
   a. What is the kinetic energy of the mass when it is launched? $KE = \frac{1}{2} mv^2$

   b. What is the potential energy at the top of the path? PE + KE = TE

   c. What is the height the mass reaches? h = PE/mg

Work = ΔE Name ____________________

$F \times d = \frac{1}{2} m v_2^2 - \frac{1}{2} m v_1^2$

Work Energy Theorem Worksheet 1

1. When the brake is applied to a car having a mass of 1000 kg, its speed is reduced from 25 m/s to 15 m/s. How much work does the brake do?

2. If the brake in the car from the above problem is applied for a distance of 20 m, what force does it exert on the car?

3. A boy rides his bike at 10 m/s and the mass of the boy and the bike are 75 kg. What force is applied to the brakes in order for the boy to slow down to 5 m/s in 2 m?

4. Two men apply a force of 5000 N for a distance of 5m on an automobile has a mass of 1000 kg that is initially at rest. What is the final kinetic energy of the automobile?

5. When the brake is applied to a car having a mass of 1000 kg, its speed is reduced from 20 m/s to 10 m/s.
    a. What is the change in kinetic energy?
    b. If the change in kinetic energy equals the work done on the car, if a force is applied for 20 m, what is the force being applied to the car?

2. A 75 kg bobsled is pushed along a horizontal surface by two athletes. After the bobsled is pushed a distance of 5 m starting from rest, its speed is 6.0 m/s. What is the magnitude of the force on the bobsled?

Roller Coasters and Energy

Purpose: To investigate energy relationships for a roller coaster car.

Getting Ready: Navigate to the Roller Coaster Model in the Physics Interactives section of The Physics Classroom website:

http://www.physicsclassroom.com/Physics-Interactives/Work-and-Energy/Roller-Coaster-Model

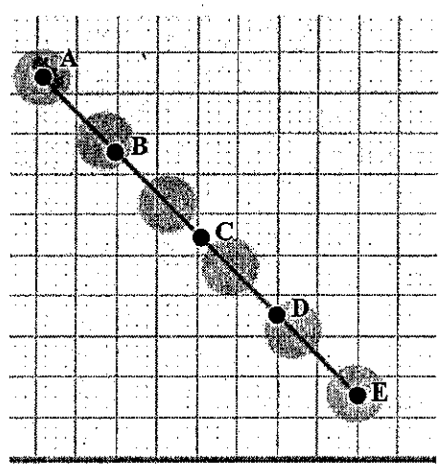
Path:
physicsclassroom.com => Physics Interactives => Work and Energy => Roller Coaster Model

Once the Interactive opens, get acquainted with how it functions. Know how to **Start**, **Pause**, **Step**, and **Reset** the simulation. Observe the three different tabs at the top of the simulation for toggling between **Ramp**, **Loop**, and **Bumps**. Observe that each track design can be further modified by dragging a grey circle to a different position. Experiment with the three controls for showing the **Velocity** vector and **Force** vectors and toggling **Track Drag** on and off. Once acquainted with the program, select the **Ramp** button to reset the simulation to default settings and then perform the following studies:

Section 1: Basic Energy Relationships

1. Click/tap the **Start** button and observe the motion. View the bar charts and the velocity value as the coaster car moves. Complete the following paragraph by entering total mechanical energy (**ME**), kinetic energy (**KE**), and potential energy (**PE**). The labeled locations refer to the graphic at the right.

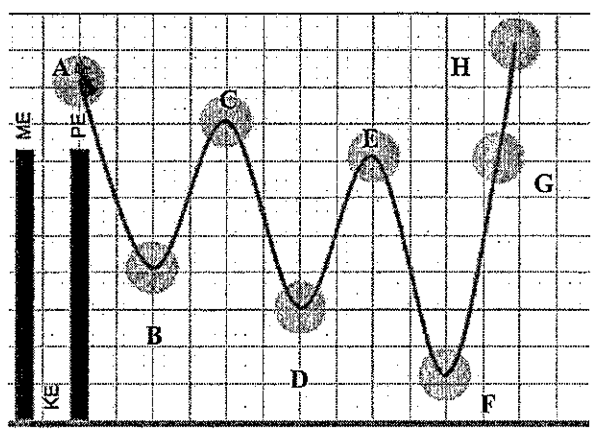
   As the coaster car rolls down the track from A to E, the ________ values decrease and the _______ value increase and the ________ values remain constant. The _______ is greatest at point A and smallest at point E. However, the _______ is smallest at point A and largest at point E.



Section 2: Hill Design

2. Click/tap on the **Bumps** tab at the top of the Interactive. Then drag the grey circles to modify the track so that it looks like the track design at the right. Pay attention to the background grid to help with the design. Note that Dot G is at the same height as Dot E; make sure that the same is true of your final design.

3. Run the simulation. Does the coaster car travel as high as point H? ___________ Give an explanation for why it does or doesn't reach point H.



4. How does the speed at point E compare to the speed at point G? ______________________
   Explain why this is true.

5. Rank the PE for the eight locations, from the lowest PE to the highest PE. Write letters in the blanks and place < or = symbols between the letters.

   _____ _____ _____ _____ _____ _____ _____ _____

6. Rank the KE for the eight locations, from the lowest KE to the highest KE. Write letters in the blanks and place < or = symbols between the letters.

   _____ _____ _____ _____ _____ _____ _____ _____

7. Mac and Tosh are arguing about the track design. Mac claims that the car is moving fastest at point F because it is furthest along the track. Tosh disagrees, claiming that the car moves fastest at point F because point F is at the lowest height. Who do you agree with? __________ Make a modification of the track design for point F and gather some evidence to support one claim or the other. Then discuss what changes you made, what observations were made, and the reasoning that supports one of the claim of either Mac or Tosh.

8. Does changing the height of point C affect the speed of the coaster car at point D? Try it and find out. Once certain of the answer, make a claim and support it with evidence (data) and reasoning.