Charlotte Teachers Institute
Collaborative Teacher Education

Conservation of Energy in Roller Coasters

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This curriculum unit is recommended for:
Physical Science and Honors Physics

Keywords: Work, Joule, Power, Energy, Mechanical Energy, Potential Energy, Kinetic Energy, Gravitational Potential Energy, Conservation of Energy

Teaching Standards: See Appendix 1 for teaching standards addressed in this unit.

Synopsis: This curriculum unit uses a thematic approach to teach Energy Unit. The students will perform a series of activities and experiments about Work/Power, Mechanical Energy, and Conservation of Energy. I included two activities/experiments in every major topic for the teacher to choose from depending on the materials available in your school. The students' understanding about these topics will prepare them in our Roller Coaster building Culmination activity. The students will be motivated to learn these topics because they know it will help them to design and build a working Roller Coaster. The students will try harder to master these Energy topics because they know they need to present and explain their Roller coaster to the judges when we compete in the Roller Coaster Building Contest at Carowinds.

I plan to teach this unit during the second semester this year to my Physical Science and Honors Physics Class. The Roller Coaster Building Contest at Carowinds is usually on the last weekend of May.

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Introduction

Harding University High School is a county-wide college-prep magnet and a Title I school. Harding serves students throughout Mecklenburg County who chose to participate in a college-preparatory curriculum. Our countywide magnet school offers the International Baccalaureate (IB) program. The IB program is a rigorous course of study designed to promote international understanding. At Harding, our IB program consists of the Middle Years Programme in grades 9 and 10 and the Diploma Programme for 11th- and 12th-grade students. Being a Title I school, previously known as No Child Left Behind (NCLB), the school's intent is to help ensure that all children have the opportunity to obtain a high quality education and reach proficiency on challenging State academic content and performance standards. I teach Physical Science, IBMYP (IB Middle Years Program) Honors Physics, AP Physics, and IB Physics II and III. In my Physical Science and IBMYP classes, I follow the Common Core Essential Standards. In my AP Physics class, I created a Course Syllabus that was audited and certified by the College Board. Included in this course outline are approved experiments for the entire year. I follow an entirely different curriculum for my IB classes. My students in these classes are required to accumulate 60 laboratory hours. My labs and activities are all inquiry based investigations. In my IBMYP Honors Physics, every year the culminating activity of our Energy unit is to compete in a Roller Coaster Building Contest at Carowinds (a local amusement park).

Rationale

Every teacher knows that Science has two main aspects namely theory and practical application. Theory is the understanding of why a certain mechanism or action is taking place. Practical application is how we can use scientific theory to drive improvements that will better our lives. Our students must be able to apply science concepts they learn inside the classroom to real life situations. Science activities and experiments definitely help them with this application. Hands on Activities help our students stay focused and motivated. My students are always excited about the Energy Unit because they know that at the end of the unit we have a Roller Coaster Building Culmination Activity. Every year we compete at the Roller Coaster Building Contest at Carowinds. They know they have to learn the concepts about energy so they can apply them to designing and building the Roller Coaster. They also need to master the concepts so they will be ready to answer questions from the judges when they are presenting their Roller Coaster. In this unit, I describe a series of experiments on Work/Power, Mechanical Energy and Conservation of Energy that will help students build an understanding of these topics. The culminating project of this unit is the Roller Coaster Design and Build project. This project demands that students apply the concepts that they have learned and re-enforces their understating of these key ideas. Also in this unit, I want my students to relate Conservation of Energy to engineering design. Mechanical engineers design a wide range of consumer and industry devices — transportation vehicles, home appliances, computer hardware, factory equipment — that use mechanical motion. The design of equipment for demolition purposes is one example. Like the movement of a pendulum, when an enormous wrecking ball is held at a height, it possesses potential energy, and as it falls, its potential energy is converted to kinetic energy. As the wrecking ball makes contact with the structure to be destroyed, it transfers that energy to take down the structure.

Objectives

During this unit I plan to address the following North Carolina Essential Science Standards in Physics

Phy.2.1 Understand the concepts of work, energy, and power, as well as the relationship among them.

Clarifying Objectives

Phy.2.1.1 Interpret data on work and energy presented graphically and numerically.

Phy.2.1.2 Compare the concepts of potential and kinetic energy and conservation of total mechanical energy in the description of the motion of objects.

Phy.2.1.3 Explain the relationship among work, power and energy

Scientific Content: Overview for Teachers

Vocabulary

Work - exerting a force on an object, causing it to move
Joule - A unit of work equal to one Newton-meter
Power - the rate at which work is done
Energy - The ability to do work or cause change
Mechanical Energy - Kinetic or potential energy associated with the motion or position of an object. It is the sum of potential energy and kinetic energy.
Potential Energy - stored energy that results from the position or shape of an object
Kinetic Energy - the energy an object has due to its motion
Gravitational Potential Energy - potential energy that depends on the height of an object
Conservation of Energy - The total energy of an isolated system cannot change. It is said to be conserved over time.

Work and Energy

In physics, work has its own special meaning, specifically: Work is done when a force causes an object to move. To be specific, work is the product of the component of a force in the direction of the displacement it causes and the magnitude of the displacement. For work to be accomplished, a force has to move an object and the force and displacement have to be in the same direction. If you lift a book a distance of one meter, you have done work on it. The book moved up and the force was directed up. If you hold a heavy book stationary at some height above the floor, you have done no work on it. The force was up, but there was no displacement, so there was no work.

A simple equation for work is: $W = F\Delta r$

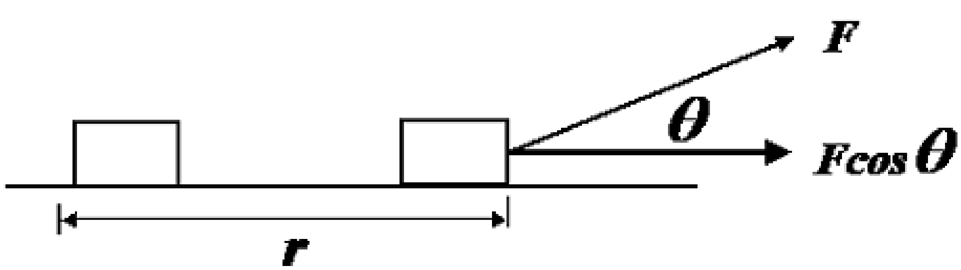
W is work, ***F*** is the applied force, and ***r*** is the change in displacement.

The unit we ended up with is a Newton meter. This is defined in physics as a joule. The symbol for the joule is *J*. (The joule is named after James Joule, a big name in the area of energy.)

$$1\,J = 1\,Nm$$

When the force and the displacement are not in the same direction, we use this general equation:

$$W = F \cdot \Delta r = F\Delta r\cos\theta$$



Here the '***F***' and '***cos***' part of the equation is the component of the applied force that is in the direction of the displacement.

The drawing above represents the motion of a crate being moved by an applied force. The crate is moved a distance r. The work done is

$$W = (F\cos\theta)r$$

We find this equation in its AP form as:

$$W = F \cdot \Delta r = F\Delta r\cos\theta$$

Here W is work, F is the net force, Δr is the distance the object is moved, and θ is the angle the net force makes with the direction of motion.

It is two equations in one. The first one is for when the angle is zero and the net force has the same direction as the motion. So we can say that
$W = F\,r$

The second one is used when there is an angle between the net force and the motion direction.

Energy

In physics we define energy as: ***the ability to do work.***

Work is done when something is displaced by a force. If work is done, it takes energy. If you lift a 1 N rock 1 m, you've done 1 J of work and expended 1 J of energy. Energy and work, intimately related as they are, use the same unit.

Energy comes in a vast array of types and all sorts of ways have been devised to classify the different types of energy. No doubt you can think of lots of them. There's electrical energy, solar energy, nuclear energy, thermal energy, chemical energy, etc.

There are two types of energy ***kinetic energy*** and ***potential energy***.

Kinetic Energy: This is the energy of motion. When a system is moving, it has kinetic energy. Thus the object's motion can be transformed into work. All this means is that a moving object can hit something and make it move, thus accomplishing work. The unit for kinetic energy is the joule. The equation for kinetic energy is:

$$K = \frac{1}{2}mv^2$$

K stands for kinetic energy, ***m*** is the mass of the object, and ***v*** is its velocity.

Potential Energy: Potential energy is stored energy. There are many ways that energy can be stored. For example, a battery represents stored chemical energy and water piled up behind a dam is stored gravitational potential energy. The type of potential energy that we will initially be interested in has to do with the energy of position brought about by gravity and by a spring being compressed or elongated.

When an object is lifted to a height above a reference frame, work is done and the object gains potential energy. The energy it gains is equal (ignoring friction) to the work done on it. The standard form that the equation for potential energy of position takes is:

$$U_g = mgy$$

Although it's usually written as simply: $U = mgy$

U is potential energy, ***m*** is the mass, ***g*** is the acceleration of gravity, and ***y*** is the vertical displacement.

It is also very common to write it in a slightly different form as:

$U = mgh$ Where h (standing for height) simply means the vertical displacement.

When solving potential energy problems, the reference frame should be chosen to simplify the solution. One sets the bottom position as zero and then all other displacements are measured in reference to the zero position.

Conservation of Energy: One of the most important laws in all of science is the ***law of conservation of energy***. In chemistry you probably looked at it in this form: energy cannot be created or destroyed. In physics, we say:

Energy is neither gained nor lost in any process.

Energy can be transformed from one type to another, but, in any closed system the amount of energy cannot change.

Using the Law of Conservation of Energy:

The energy in an isolated system cannot change.

Energy Before = ***Energy After*** or ***E*** = ***E'***

(The little apostrophe mark added to the *E* making it *E'* means the quantity after some event. We pronounce *E'* as "E prime".)

One example is a rock being held at some height ***y*** above the ground. The rock is dropped and falls. We examine the energy before and the energy after and determine that the two quantities must equal each other. Let us note that we are ignoring all other energy losses (such as air resistance), which is reasonable for this sort of event. Very little energy is lost by the rock as it falls a few meters.

The energy before (prior to being dropped) is: $U = mgy$

The energy after (just before the rock hits) is: $K = \frac{1}{2}mv^2$

Using these two relationships, we can write a general equation for the example.

$$mgy = \frac{1}{2}mv^2$$

In general, without knowing the specifics, we can write the following equation:

$$mgy_o + \frac{1}{2}mv_o{}^2 = mgy + \frac{1}{2}mv^2$$

This simply means that the energy before is the sum of its initial kinetic energy and potential energy. The energy after the event is the sum of its final kinetic and potential energy.

A roller coaster train is at rest at the top of a hill, the brakes are released and it rolls down some sort of a curved slope. What will be its speed at the bottom of the hill?

Conservation of energy! The energy at the top equals the energy at the bottom! (Ignoring friction of course.)

- A roller coaster pauses at the top of a 75 m hill. What will be its speed at the bottom of the hill?

$$mgy = \frac{1}{2}mv^2 \quad gy = \frac{1}{2}v^2 \quad v = \sqrt{2gy} = \sqrt{2\left(9.8\frac{m}{s^2}\right)75\,m} = \boxed{38\,\frac{m}{s}}$$

Strategies

This Curriculum Unit is designed for my IBMYP Honors Physics Class. I will teach this unit when we start the Energy Unit. This Curriculum Unit will be covered in two weeks. I will use the same lessons for my Physical Science Class except for the Roller Coaster Building. We will do a Roller Coaster Building Simulation instead. The two main teaching strategies I will use in this unit are Inquiry Based Approach and Simulations. I will begin the unit with the "Strength Competition". I will ask the class who they think is the strongest in the class. To determine who the strongest student is, the students will do the "Calculating Work and Power by Climbing Stairs" activity. In this activity, the students will find out if they are doing more work walking up a flight of stairs or running up the same flight of stairs. They will also learn what scientists mean by the words work and power. At the post activity session, the student's power will be compared to a horsepower. The activity will be followed by guided and individual practice problems and graphical analysis on Work and Power.

The second activity will start with a challenge. I will ask a volunteer to put his/her face on the line to prove the law of the conservation of energy.The student will release a 1.0 kg pendulum bob from their chin, and wait to see what happens when the ball swings back at their face! Will the ball smash their face in? Or will the laws of physics protect them? Post lab discussion will be about how the laws of physics protected the student.

The next activity is "Skate Park". This is a Simulation lab. In this activity Tony Hawk the skater will launch himself as high as possible off the half-pipe by applying the conservation of energy. In this lab, the students will look at the conversion of energy between gravitational-potential energy, work, and kinetic (or moving) energy.

To experience the law of conservation of energy, the student will perform the activity "Swinging Pendulum". This activity demonstrates how potential energy (PE) can be converted to kinetic energy (KE) and back again. Given a pendulum height, students calculate and predict how fast the pendulum will swing by understanding conservation of energy and using the equations for PE and KE. The equations are justified as students experimentally measure the speed of the pendulum and compare it to their predicted speed. The activity will be followed by guided and individual practice problems and graphical analysis on Kinetic, Potential Energy and Conservation of Energy.

Before the students design and build their roller coaster for the Carowinds contest, they will have to design their own roller coaster using the "Sum of All Thrills" website. This will give the students ideas and inspiration to build an actual roller coaster. This will also strengthen their concept of Conservation of Energy.

Assessment on the unit will include multiple choice, problem solving, and video analysis. The student will apply the concept of conservation of energy to a real life situation. They will learn to extract data from video to find quantitative information. They will use the quantitative information in combination with their concept of mechanical energy to determine quantitatively whether mechanical energy is conserved in a roller coaster ride.

The culmination activity on this unit is a Roller coaster building project. The students will apply the law of conservation of energy to design and build a Roller Coaster. We

Work and Power

I have two Work and Power lab activities. The title of the first one is "Horsepower Lab". In this lab, the students will determine their personal horsepower and compare it to the horsepower of lawnmower, light bulb or microwave oven. The title of the second one is "Calculating Work and Power by Climbing Stairs". In this lab, the students will be comparing their work and power while walking and running the stairs. What I usually do in my class is I have a weighing scale near the door. Before they go to their seat the students will weigh themselves. At the pre lab discussion, I discuss the procedure and how they will fill the data tables. I also go over the safety issues. Students who have health concerns don't have to do it. Also while walking or running the staircase, I tell the students that they should not skip a step. During post lab discussion, I have a class data table of Power walk and run and my students have to write their power walk and run data. A sample of this table is shown below.

Student Name	Power Walk	Power Run

From the table we will discuss the factors that affect work and power. We will also solve and compare their power to a single horse. The next day, the students will do guided and individual practice problems on work and power. The worksheets on work and power can be found in the appendix

Kinetic and Potential Energy

I have two Kinetic and Potential Energy lab activities. The tile of the first one is "Energy Skate Park". This is applicable if a teacher has access to a computer lab. In this activity, the students will be able to explore the concepts of kinetic and potential energy. The second activity is actually a challenge. The title of the activity is "Hot Wheels Challenge". I set up two meters of hot wheels track on my class floor. I have a starting line and finish line. The challenge is to set up their two pieces of hot wheels track so that their hot wheels car will stop as close as possible to the finish line two meters away. The groups are given two chances to do it. During the post lab discussion, I have a class data of how far their hot wheels car was from the finish line. An example of this table is shown below.

Group Name	1^{st} try	2^{nd} try	Average distance

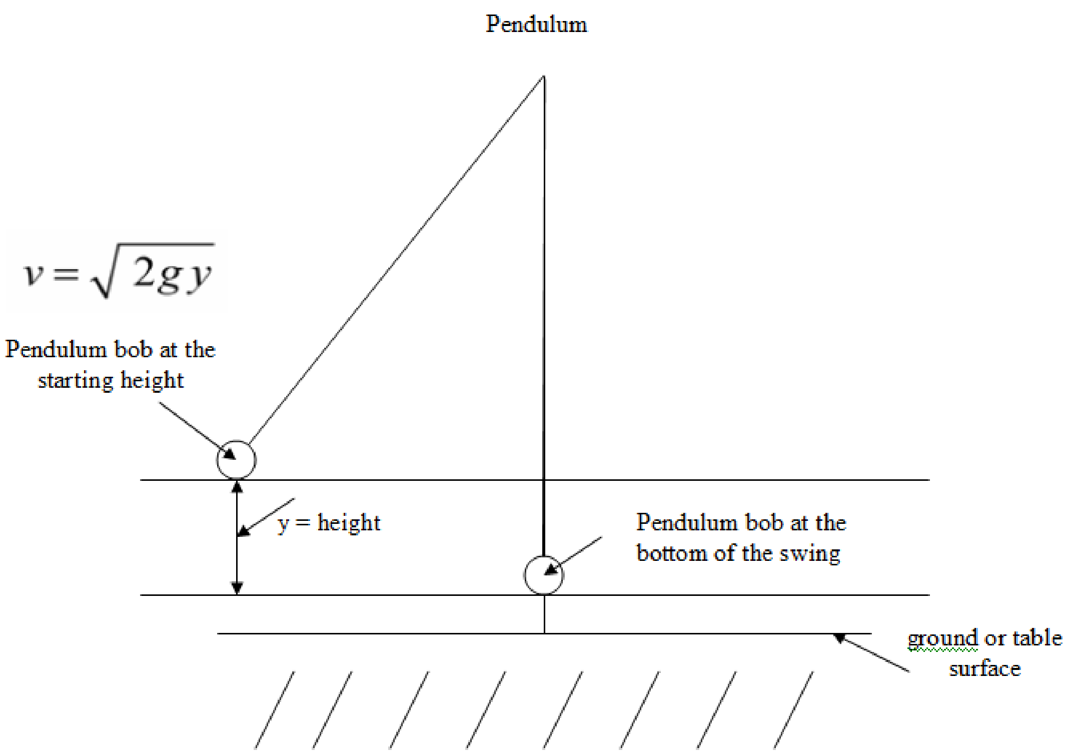
After declaring the winner, we will discuss how work is related in the activity. We will also discuss how work is related to kinetic and potential energy. We will also discuss the factors affecting kinetic and potential energy. At this point I will give them the equation of kinetic and potential energy. ($KE = 1/2mv^2$; $PE = mgh$) After the post lab discussion, the students will do guided and individual practice problems on kinetic and potential energy. The worksheets on Kinetic and Potential Energy can be found in the appendix

Conservation of Mechanical Energy

The assumption at this part of the unit is the students have already mastered the concepts of kinetic and potential energy. I have two activities for the Conservation of Mechanical Energy lesson. The title of the first one is "Energy Skate Park Simulation – Conservation of Energy". The first one is applicable if a teacher has access to a computer lab. In this lab, the students will analyze energy transfer between gravitational potential energy, kinetic energy. The title of the second lab is "Conservation of Energy in a Pendulum". In this lab, the students will calculate and predict the speed of the pendulum bob. Also the students will verify their predicted speed by calculating the actual speed of the pendulum using a motion sensor. At the start of the lesson, I will give the class a challenge. The title of the challenge is "Will You Survive?" A student is going to put his face on the line. He will release a 1.0 kg pendulum bob close to his chin, and wait to see what happens when the ball swings back. The student will win the challenge if they did not move while the pendulum bob is swinging back to their face. At the pre lab discussion, we will discuss the kinetic and potential energy of the pendulum bob. We will also derive an equation to solve for the predicted speed of the pendulum bob at the bottom part of the swing. We will use the equation potential energy at the top of the swing is equal to the kinetic energy at the bottom of the swing. ($mgy_{top} = (mv^2)/2_{bottom}$) where m is the mass of the pendulum bob; g is acceleration due to gravity; y is height of the pendulum;v is the speed of the pendulum) and derive an equation for speed v. The equation will be $v = \sqrt{2gy}$. To be able to calculate the actual speed, the student will set up a photogate at the bottom of the swing so that the pendulum bob will pass through the motion sensor of the photogate.To solve the actual speed of the pendulum bob, the students will use the equation v_{actual} = diameter of the pendulum bob/photo gate time. The students will solve three different speeds at three different starting heights. During the post lab, I have a class data on predicted and actual speed of the pendulum bob at different heights. Example of this table is shown below.

Height meters	Predicted Speed				Actual Speed			
	Group 1	Group2	Group3	Group4	Group1	Group2	Group3	Group4
0.3								
0.4								
0.5								

Note: The height of the pendulum bob should be the final vertical height of the bob minus the initial vertical distance of the pendulum bob with respect to the surface of the table.



At the post lab discussion, we will compare the predicted speed and actual speed of the pendulum bob. The class data will verify the assumption of conservation of energy that we made at the beginning of the lesson when we equate the potential energy at the top and kinetic energy at the bottom. The next day, the students will do guided and individual practice problems on conservation of energy. The worksheets on conservation of energy are found in the appendix.

Culmination Activity

I will introduce the Roller Coaster Building Contest Rules and Regulations. The contest rules can be found in appendix. I will then assign leaders and the class will begin planning and designing their Roller coaster. In the next two days, the students will build their roller coaster.

Appendix 1

Implementing the Common Core Standards

I included two activities in every objective in this unit. One activity can be done if the teacher has access to a computer lab. The second activity is a practical lab. These labs will help the students develop understanding of Work, Power and Energy. The culminating activity will allow the students to apply their understanding on Work, Power and Energy to design and build an actual Roller Coaster. These activities will allow the students to demonstrate understanding of the following Common Core Standards

Phy.2.1 Understand the concepts of work, energy, and power, as well as the relationship among them

The sub-standards which fall under this are as follows

Phy.2.1.1 Interpret data on work and energy presented graphically and numerically.

Phy.2.1.2 Compare the concepts of potential and kinetic energy and conservation of total mechanical energy in the description of the motion of objects.

Phy.2.1.3 Explain the relationship among work, power and energy

Worksheets

There is a practice problem worksheet here on work/power, kinetic and potential energy, and conservation of energy. You can also sign up and register to problemattic.com to get more practice questions on these topics. It is a free test generating program.

Work and Power

1. A force of 5 newtons moves a 2-kilogram object a distance of 3 meters in 3 seconds. How much work is done on the object?

A. 1 Joules B. 10 Joules C. 15 Joules D. 30 Joules

2. A toaster uses 1500 watts of power in 90 seconds. The amount of electric energy used by the toaster is approximately

A. 140,000 J B. 17 J C. 520,000,000 J D. 0.060 J

3. About how much amount of electrical energy is needed to operate a 1600-watt toaster for 60 seconds?

A. 27 J B. 1500 J C. 1700 J D. 96000 J

4. A car jack exerts a force of 4,500 newtons to raise a car 0.25 meter. Approximately how much work is done by the car jack?

A. 0.00056 J B. 1,100 J C. 4,500 J D. 18,000J

5. A 600-newton man climbing a rope at a speed of 2 meters per second develops power at the rate of

A. 12 W B. 600 W C. 300 W D. 1,200 W

6. An electric iron has a power rating of 500 watts. The amount of energy used by the iron in 40 seconds is

A. 100 J B. 500 J C. 4,000 J D. 20,000 J

7. A constant force of 4.0 newtons moves a block 5 meters. How much work did the force do in moving the block?

A. 0 J B. 20 J C, 0.80 J D. 4 J

8. A motor has an output of 1,000 watts. When the motor is working at full capacity, how much time will it require to lift a 50-newton weight 100 meters?

A. 5 s B. 10 s C. 50 s D. 100 s

9. Which is an example of work being done?

A. A force acts vertically on a cart that can only move horizontally.
B. A force is exerted by one team in a tug of war when there is no movement.

C. A force is exerted on a wagon while pulling it up a hill.
D. A force of gravitational attraction acts on a person standing on the surface of the Earth.

10. A 10-newton force is required to move a 3-kilogram box at a constant speed. How much power is required to move the box 8 meters in 2 seconds?

A. 40 W B. 20 W C. 15 W D. 12 W

11. A 45-kilogram bicyclist climbs a hill at a constant speed of 2.5 meters per second by applying an average force of 85 newtons. Approximately how much power does the bicyclist develop?

A. 110 W B. 210 W C. 1100 W D. 1400 W

12. Which action would require no work to be done on an object?

A. lifting the object from the floor to the ceiling
B. pushing the object along a horizontal floor against a frictional force
C. decreasing the speed of an object until it comes to rest
D. holding the object stationary above the ground

13. A student pulls a box across a flat floor at a constant speed of 4.0 meters per second with a constant horizontal force of 45 newtons. How much work does the student do in moving the box 5.5 meters across the floor?

A. 45 J B. 180 J C. 250 J D. 740 J

14. A student does 300 joules of work pushing a cart 3.0 meters due east and then does 400 joules of work pushing the cart 4.0 meters due north. The total amount of work done by the student is

A. 100 J B. 500 J C. 700 J D. 2500 J

15. A student applies a 20-newton force to move a crate at a constant speed of 4 meters per second across a rough floor. How much work is done by the student on the crate in 6 seconds?

A. 80 J B. 120 J C. 240 J D. 480 J

Answer Key

1. C 2. A 3. D 4. B 5. D 6. D 7. B 8. A 9. C 10. A 11. B 12. D

13. C 14. C 15. D

Kinetic and Potential Energy

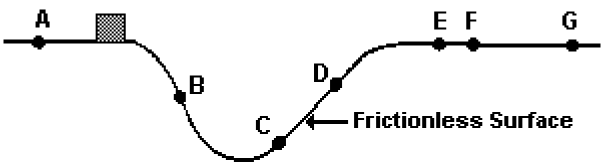
1. As an object falls freely near the Earth's surface, the loss in gravitational potential energy of the object is equal to its

A. loss of height
B. loss of mass
C. gain in velocity
D. gain in kinetic energy

2. When a 5-kilogram mass is lifted from the ground to a height of 10 meters, the gravitational potential energy of the mass is increased by approximately

A. 0.5 J B. 2 J C. 50 J D. 500 J

3. The diagram represents a block sliding along a frictionless surface between points *A* and *G*.



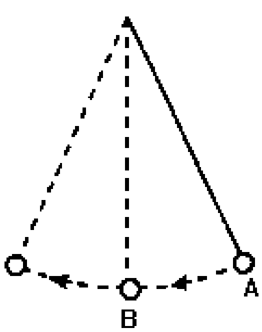
As the block moves from point *A* to point *B*, the speed of the block will be

A. decreasing
B. increasing
C. constant, but not zero
D. zero

4. A basketball player who weighs 600 newtons jumps 0.5 meter off the floor. What is her kinetic energy just before hitting the floor?

A. 30 J B. 60 J C. 300 J D. 600 J

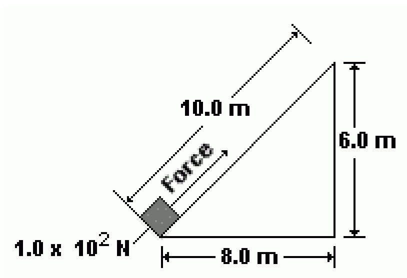
In the diagram, an ideal pendulum released from point *A* swings freely through point *B* .



5. Compared to the pendulum's kinetic energy at *A*, its potential energy at *B* is

A. half as great B. twice as great C. the same D. four times as great

6. A box weighing 1.0×10^2 newtons is dragged to the top of an incline, as shown in the diagram.



The gravitational potential energy of the box at the top of the incline is approximately

A. 1.0×10^2 J B. 6.0×10^2 J C. 8.0×10^2 J D. 1.0×10^3 J

7. A cart of mass *m* traveling at a speed *v* has kinetic energy KE. If the mass of the cart is doubled and its speed is halved, the kinetic energy of the cart will be

A. half as great
B. twice as great
C. one-fourth as great
D. four times as great

8. What is the gravitational potential energy with respect to the surface of the water of a 75.0- kilogram diver located 3.00 meters above the water?

A. 2.17×10^4 J
B. 2.21×10^3 J
C. 2.25×10^2 J
D. 2.29×10^1 J

9. A 60.0-kilogram runner has 1920 joules of kinetic energy. At what speed is she running?

A. 5.66 m/s B. 8.00 m/s C. 32.0 m/s D. 64.0 m/s

10. Which situation describes a system with *decreasing* gravitational potential energy?

A. a girl stretching a horizontal spring
B. a bicyclist riding up a steep hill
C. a rocket rising vertically from Earth
D. a boy jumping down from a tree limb

Answer Key

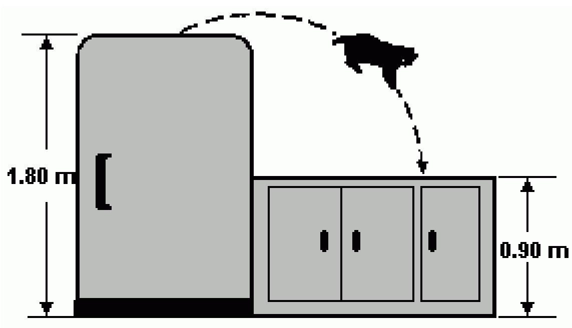
1. D 2. D 3. B 4. C 5. C 6. B 7. A 8. B 9. B 10. D

Conservation of Energy

1. A person does 100 joules of work in pulling back the string of a bow. What will be the initial speed of a 0.5-kilogram arrow when it is fired from the bow?

A. 20 m/s B. 50 m/s C. 200 m/s D. 400 m/s

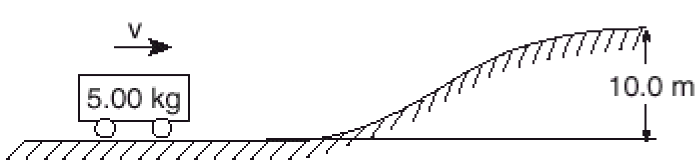
2. The diagram below shows a 1.5-kilogram kitten jumping from the top of a 1.80-meter-high refrigerator to a 0.90-meter-high counter.



Compared to the kitten's gravitational potential energy on top of the refrigerator, the kitten's gravitational potential energy on top of the counter is

A. half as great
B. twice as great
C. one-fourth as great
D. four times as great

3. The diagram below shows a moving, 5.00-kilogram cart at the foot of a hill 10.0 meters high. For the cart to reach the top of the hill, what is the minimum kinetic energy of the cart in the position shown? [Neglect energy loss due to friction.]

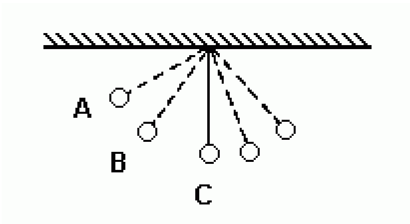


A. 4.91 J B. 50.0 J C. 250. J D. 491 J

4. A 0.50-kilogram ball is thrown vertically upward with an initial kinetic energy of 25 joules. Approximately how high will the ball rise? [Neglect air resistance.]

A. 2.6 m B. 5.1 m C. 13 m D. 25 m

5. The diagram shows the motion of a pendulum.



What happens as the pendulum swings from position *A* to position *C*? [Neglect friction.]

A. Its kinetic energy decreases more than its potential energy increases.
B. Its kinetic energy increases more than its potential energy decreases.
C. Its kinetic energy decrease is equal to its potential energy increase.
D. Its kinetic energy increase is equal to its potential energy decrease.

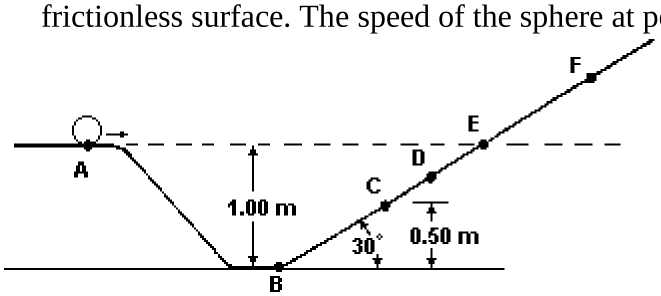
6. A 0.10-kilogram ball dropped vertically from a height of 1.0 meter above the floor bounces back to a height of 0.80 meter. The mechanical energy lost by the ball as it bounces is approximately

A. 0.080 J B. 0.20 J C. 0.30 J D. 0.78 J

7. A 20.-kilogram object strikes the ground with 1960 joules of kinetic energy after falling freely from rest. How far above the ground was the object when it was released?

A. 10. m B. 14 m C. 98 m D. 200 m

8. The diagram represents a 0.20-kilogram sphere moving to the right along a section of a frictionless surface. The speed of the sphere at point *A* is 3.0 meters per second.



Approximately how much kinetic energy does the sphere gain as it goes from point *A* to point *B*?

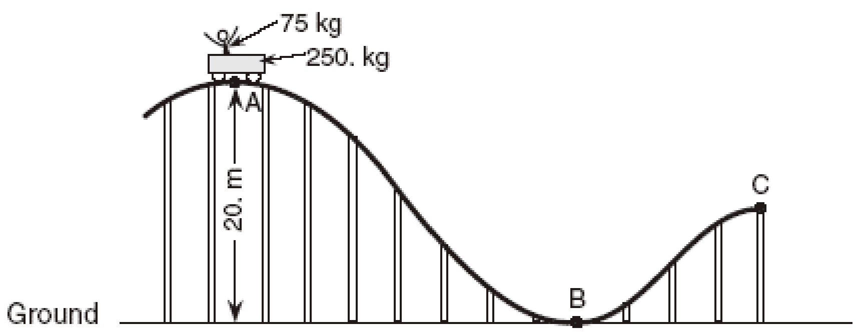
A. 1.0 J B. 2.0 J C. 3.9 J D. 0.98 J

9. A basketball player who weighs 600 newtons jumps 0.5 meter off the floor. What is her kinetic energy just before hitting the floor?

A. 30 J B. 60 J C. 300 J D. 600 J

Base your answer to the question on the information and diagram.

10. A 250.-kilogram car is initially at rest at point *A* on a roller coaster track. The car carries a 75-kilogram passenger and is 20. meters above the ground at point *A*. [Neglect friction.]



Compare the total mechanical energy of the car and passenger at points *A*, *B*, and *C*.

A. The total mechanical energy is less at point *C* than it is at points *A* or *B*.
B. The total mechanical energy is greatest at point *A*.
C. The total mechanical energy is the same at all three points.
D. The total mechanical energy is greatest at point *B*.

Answer Key

1. A 2. A 3. D 4. B 5. D 6. B 7. A 8. B 9. C 10. C

Carowinds Roller Coaster Building Contest

Students display their previously constructed themed roller coasters following the rules outlined here. Encourage your students to let their imaginations "run wild" as they create loops, turns, and lifts by using simple principles of gravity, physics, and engineering.

1. Please limit model base and dimensions to total of (9) square feet.
2. Primary construction materials should be wood (popsicle sticks, balsa wood, etc.) Other suggested materials include string, twine, wire, plastic straws, tooth picks, wood shavings, wooded dowels, cardboard, construction paper, wood glue/hot gun glue and plastic tubing.
3. The name of the coaster must be clearly visible on the model
4. Teams may consist of no more that six (6) students per coaster model entry.
5. One 3x5 inch index card attached to the model base clearly displaying the following must accompany each coaster entry. Team Member Names and Grade level.
6. Students are responsible for getting their coasters into the Park and taken back out after the contest is over as Carowinds is not responsible for any coasters left after the contest is over and there is no special entrance for the entries, take in mind that they must fit through the turnstiles at the front gate.

All coaster models will be judged on dynamics of the coaster ("G" forces, etc. and functionality of the model), creativity, use of materials and coaster name/theme. Pre-packaged electrical coasters, pre-packaged Lego coaster models or any type of pre-packaged coaster model will not be permitted. Lego pieces here and there in the model are permitted but no over-used…..the judges prefer your own creativity. They like to see working coasters or if a non-working coaster could in all reality be a working coaster.

**** ENGINEERING DAY COASTER MODELS ARE NOT ELIGIBLE FOR THE COASTER MANIA COMPETITION!!

Annotated Resources

Bohacek, Peter. "Conservation of Energy of a Rollercoaster Using High Speed Video." Conservation of Energy of a Rollercoaster Using High Speed Video. N.p., n.d. Web. 24 Nov. 2013.

"Horse Power Lab." N.p., n.d. Web. 24 Nov. 2013.

"Calculating Work and Power By Climbing Stairs." N.p., n.d. Web. 24 Nov. 2013.
Ross, Cameron. "For Teachers." Kinetic and Potential Energy. N.p., n.d. Web. 01 Nov. 2013.

Broberg, Paul . "For Teachers." *Conservation of Energy*. N.p.,n.d. Web.24.2013
"Quizlet." Work and Energy Vocabulary Flashcards. N.p., n.d. Web. 01 Nov. 2013.

Gende, Dolores. "DOLORES GENDE: AP PHYSICS B HOME." DOLORES GENDE: AP PHYSICS B HOME. N.p., n.d. Web. 01 Nov. 2013.
Schnell, Anthony. N.p., n.d. Web.