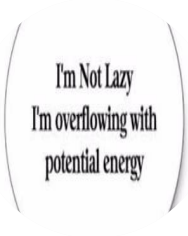

All Work and No Play

Work and Energy

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Grade Level	9th – 12th Grade	**Time Frame**	1-3 class period(s)
Course	Physical Science, Physics	**Duration**	150 minutes

Essential Question

What effect does increasing the potential energy of an object have on the work it does on another object during a collision?

Summary

In this lesson, students will explore conservation of mechanical energy and the relationship that it has with work.

Snapshot

Engage

Students are challenged to list as many things that they already know about potential energy, kinetic energy, and work.

Explore

Students make a hypothesis based on the essential question and devise a procedure to test the hypothesis.

Explain

Students state their hypothesis, explain their investigation, and state their conclusion.

Extend

Students calculate the amount of force applied to the car and create a graph that shows the affect of increasing potential energy on the force applied to the car and the distance it traveled.

Evaluate

Students are given a scenario of a car involved in a rear collision. Students will figure how far the car will travel and if a nearby pedestrian is in danger.

Standards

Next Generation Science Standards (Grades 9, 10, 11, 12)

HS-PS2-2: Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.
HS-PS3-1: Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

Oklahoma Academic Standards (Physical Science)

CH.PS4.3.1: Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other.

Oklahoma Academic Standards (Physical Science)

PS.PS1.2 : Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, knowledge of the patterns of chemical properties, and formation of compounds.
PS.PS2.2.1: Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object.

Oklahoma Academic Standards (Physical Science)

PH.PS2.3.DCI.2: Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.

Materials

- Toy cars (1 per group)
- Rulers (1 per group)
- Meter stick
- Marbles (a whole bag)
- Textbooks for stacking
- Electronic scale(s)
- Graph paper
- Scientific calculator
- Sticky notes

Engage

Pair students up. Write the terms "potential energy," "kinetic energy," and "work" on the board. Use the How I Know It strategy for students to write everything they know about these terms and how they know it. Challenge them to think back to previous science classes and experiments that they've done in the past.

The How I Know It strategy requires the students to think deeply about how they know the terms. If students can't really think how they know or remember these terms, lead a class discussion and start drawing those experiences and knowledge out as a group.

Make It A Challenge

You could make this fun by turning it in to a challenge for a prize for the pair that knows the most.

Allow pairs to share what they know and clarify any misconceptions. Review as needed so students are refreshed on the terms.

Before moving on to the Explore section of the lesson, have pairs join to make quads.

Explore

Post, either on the chalk board or SMART board, the essential question: *What effect does increasing the potential energy of an object have on the work that is done on another object during a collision?*

Instruct groups to collaborate for a few minutes and write a one-sentence hypothesis. Allow groups to share their hypotheses.

Show students the following materials: five marbles, a toy car, a ruler, a meter stick, marbles, books for stacking, and an electronic scale.

Challenge students to use any of the materials (they don't have to use everything) to design an investigation that will test their hypotheses and answer the essential question. Make sure the students know to gather quantitative data.

Teacher's Note

The idea is for students to roll the marbles down the ramp and collide with a waiting car at the bottom of the ramp, increasing the potential energy through several trials and measuring the distance that the car travels. Make sure the ruler has a groove for the marbles to roll down. Also, make sure the car is in good condition and will roll straight. To increase the potential energy, students may increase the height of the ramp or increase mass by using more marbles. The Marble Energy Lab from The Physics Classroom is a variation of this.

Before they begin, instruct groups to make a list of all the variables that can be measured when potential energy, kinetic energy, and work are involved. They will need a prior knowledge of the three equations. Also encourage them to make a list of variables they should keep constant.

Explain

Use the 3-2-1 strategy and have each group orally give an account of three things they learned from their investigation, two questions they have, and one thing they found interesting.

It would also be good for students to explain any sources of error for the experiment and address parts of the procedure that could be refined.

Pose the question: *In this investigation, how does potential energy eventually become the work that is applied to the second car?*

Allow students to answer and explain their reasoning to the question.

Possible Student Responses

Students should find something similar to the following: The potential energy at the top of the ramp becomes zero at the bottom of the ramp and the car (marbles) has full kinetic energy as it begins a horizontal roll. When the car collides with the other car at rest, it transfers its kinetic energy to the other car as work by applying a force to the car and moving it some distance. Not all of the kinetic energy becomes work (some transfers as heat and sound) on the second car, but for the purpose of this lesson, I would have the students assume that all the kinetic energy is transferred as work. Work is actually equal to the change in kinetic energy. Again, have the students assume that the final kinetic energy will be zero.

Extend

Instruct students to calculate the potential energy of each of their trials.

Say, assuming that all the potential energy is gone at the bottom of the ramp, what is the kinetic energy the car possesses? (The answer is equal to the initial potential energy.)

Say, assuming that all of the kinetic energy becomes work done on the second car, what force was placed on the second car?

Teacher's Note

Students will need to set KE = W so their equation will be: 1/2 mv2 = Fd (d is the distance the second car traveled after the collision).

Instruct the students to calculate the force of the car as the potential energy increases.

Now students are ready to create the graphs! Have them graph the increasing potential energy vs. the force applied on the car and the distance the car traveled. Students will need two y-axes (one on left and one on right, labeled force and distance) and the potential energy will be on the x-axis.

Discuss the trends they notice in the graph. Consider reviewing independent and dependent variables.

Ask students to separate from their groups so they can work individually for the Evaluate section of the lesson.

Additional Extension

The students may also calculate the velocity that the car has at the bottom of the ramp (at the point that potential is zero).

The equation is: v=v((2Fd)/m)

Evaluate

Give the students the following scenario: You are sitting at a stoplight at the bottom of a hill. A car at the top of the hill has brake failure. It is freely rolling down the hill and will collide with the rear of your car. The car is 1245 kg (similar to yours), the height of the hill is 155 m and it collides with your car applying 3255 N of force. A woman is pushing a stroller 600 m in front of you. When you car lurches forward, will you strike the woman and the stroller?

Teacher's Note

Students will calculate their distance traveled. Their answer should be 582 m. They will stop just shy of the woman.

Use the Exit Ticket strategy. Give students a sticky note and instruct them to write yes or no (indicating yes they will hit her or no they will not), followed by the distance their car will travel. Have them stick the note to your door on the way out. Make sure they put their name on the note.

Resources

- (2009). *Marble Energy Lab: Teacher's Guide*. The Physics Classroom. https://www.physicsclassroom.com/getattachment/lab/energy/e4tg.pdf
- K20 Center. (n.d.). 3-2-1. Strategies. https://learn.k20center.ou.edu/strategy/117
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