Lesson Topic: Relationship Between Energy and Forces

Objective:
Students will be able to:

1. Understand that forces including gravitational, magnetic, and electrical have potential energy.
2. Explain the effect of distance between objects on potential energy.
3. Recognize that changes in potential energy affect forces when moving objects in a system.

Time Required: 90 minutes

Materials Needed:

- Marble or metal ball
- Ring stand with clamp
- Sand
- Rectangular container to make a sand pit
- Ruler
- Meter stick
- Plastic straw
- Fake fur or wool (be careful of students with wool or fiber allergies)
- Balloon (be careful of students with latex allergies)
- Magnet
- Iron nail
- Teacher computer with internet access
- Projector/interactive whiteboard
- 1 computer/laptop/iPad per student with internet access
- Relationship Between Energy and Forces Worksheet (attached)
- Safety goggles (2 pairs)

Teacher Preparation:

- Assign a Legends of Learning Instructional Quick Play playlist for the day(s) you will be teaching the lesson.
    - Instructional - Middle School - Relationship Between Energy and Forces
- Assign a Legends of Learning Content Review Quick Play playlist for the day(s) you will be teaching the lesson.
    - Content Review - Middle School - Relationship Between Energy and Forces
- Make copies of Relationship Between Energy and Forces Worksheet (1 per student)
- Attach clamp to ring stand
- Fill container with sand

Engage (20 minutes):

1. Have students gather around the demonstration area.
2. Use the magnet and pick up the iron nail.
3. Ask students what is responsible for the attraction between the magnet and the nail.
    a. Answer: magnetic attraction

4. Ask for a student volunteer to hold up the meter stick, resting one end on the demonstration table.
5. Place the iron nail on the table near the meter stick.
6. Ask for a second student volunteer to operate the magnet.
7. Ask students how increasing the distance between the magnet and the nail will affect the attraction between the two objects.
    a. Answer: It will not be as strong.
8. Have the student volunteer increase the distance over a series of attempts until the magnet can no longer pick up the nail.
9. Explain to students that the nail and magnet system contains potential energy or stored energy, called magnetic potential energy, and as the distance in the system increases, the potential energy increases.
10. To further clarify the interaction in the system, explain that more energy is stored in the system, as work is no longer occurring. (The nail and magnet are no longer interacting as the distance increased.)
11. Ask for three student volunteers to help demonstrate electric potential energy. (Be sure that none of the volunteers has a latex or fiber allergy.)
12. Have Student One inflate and tie off the balloon.
13. Have Student Two hold the meter stick horizontally, and explain that they will measure distance in the system.
14. Have Student Three charge the plastic straw by rubbing the fabric on the straw, and then charge the balloon in the same manner.
15. Ask Student One to release the balloon while Student Two attempts to attract it with the charge straw.
16. Ask the class what causes the attraction between the straw and balloon.
    a. Answer: Static electricity
17. Recharge the objects if needed.
18. Ask Students One and Three to separate slowly and for Student One to release the balloon while Student Two measures the distance with the meter stick.
19. Have students repeat the interaction until no attraction occurs.
20. Explain to students that electric interactions also have potential energy, which also increases with distance.
21. Ask for two student volunteers, and issue each a pair of safety goggles.
22. Explain to students that they will observe how distance affects the gravitational potential energy in a system.
23. Show students the marble and sand-filled container, explain that this system is composed of the marble and the Earth, represented by the sand-filled container.
24. Instruct Student One to secure the marble in the ring stand clamp.
25. Instruct Student Two to measure the height of the marble.
26. Record the height in a table on the board, titled “Height vs. Impact Crater-Diameter.”
27. Ask Student One to release the marble.
28. Have Student Two measure the diameter of the impact crater.
29. Record the diameter on the table.
30. Increase the height of the marble and repeat the procedure.
31. Record the diameter on the table.
32. Increase the height of the marble and repeat the procedure.
33. Record the diameter on the table.

34. Ask students to describe how the diameter changed as the height of the marble increased.
    a. Answer: The diameter increased as the height of the marble increased.
35. Explain to students that the marble has gravitational potential energy, which increases with distance in the system.
36. Explain that as the marble landed, the gravitational potential energy converted to kinetic energy, and work was performed on the sand, creating the craters.
37. Summarize by reminding students that magnetic, electric, and gravitational interactions all have potential energy and are affected by distance, and they will learn more about these interactions during the lesson.

Explore (35 minutes):

1. Have your students sign in to Legends of Learning. Instruct students to complete the Instructional playlist.
2. As students complete the assigned games, students will complete the Relationship Between Energy and Forces Worksheet.
3. Circulate as students work through the playlist and complete the handout. Listen for evidence of understanding and use this opportunity to correct any misconceptions.

Explain (20 minutes):

1. Review answers to the Relationship Between Energy and Forces Worksheet by drawing the diagrams of each situation on the whiteboard or using Smartboard. Ask for student volunteers to identify the interaction and change in potential energy in each situation. Review part 2 of the worksheet, by asking students to stand to acknowledge agreement as each statement is read to the class.
1. Relate student knowledge to the demonstration at the beginning of the lesson.
    a. What is meant by a system? (interaction between two objects)
    b. What is the relationship between potential energy and distance? (as distance increases, potential energy increases; as distance decreases, potential energy decreases)
    c. Who can give a demonstration of the relationship of gravitational potential energy and potential energy using the sand container and marble? (student performs tests changing the height of the marble and measure the diameter of the impact crater)
    d. Why is the diameter increasing? (more work is done on the sand as the potential energy converts to other forms of energy – kinetic energy and thermal energy)
    e. Who can describe another relationship between forces and energy? (magnet and a piece of iron, when the distance increases the potential energy increases)
    f. Can anyone name a third interaction between forces and energy? (electric, such as the balloon and the straw, two oppositely charged particles attract each other and create a field. As the distance between the two objects changes, the potential energy will change. It increases as the distance increases.)

Elaborate (5 minutes):

1. Explain to students that they experience examples of interaction of forces and energy all the time, from electric forces interacting between your hair and a wool sweater, a magnet holding to a metal locker, and even the Moon orbiting Earth. The distance between the objects in these systems also means that a certain amount of potential energy exists based on that distance. When the distance increases, the potential energy increases, which means the system has more stored energy. Now imagine that the system is a massive meteor or asteroid and the Earth.
2. Show this video of a meteor crater in Arizona: Meteor Crater in Arizona
3. Ask students what the potential energy is like between a distant space object and Earth and why the impact crater is so massive in the video.
    a. Answer: The potential energy would be large, and the energy transferred to the surface would be immense, which means the ability to perform work on the Earth surface by creating the crater would also be considerable.

Evaluate (10 minutes):

1. Have your students sign in to Legends of Learning. Instruct students to complete the Content Review playlist.
2. Analyze student results to determine what concepts need to be a focus for reteaching.

Additional Lesson Strategies:

- To use Legends for additional instruction, create a custom playlist with an instructional game and pre and post assessment.
- To use Legends for a quick formative assessment, create a 5-question assessment in a playlist.
- To use Legends for a student-directed experience, create a targeted freeplay playlist.
- Encourage students to play on their own at home in Legends of Learning: Awakening for a student-driven experience including avatars, battling, and quests all centered around topics they are covering in class.

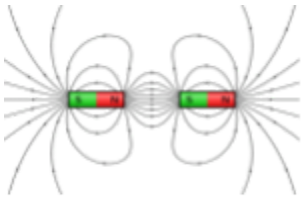
Relationship Between Energy and Force

Name:_____

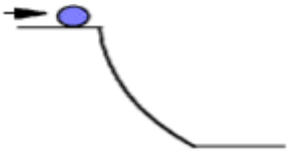
Directions: While playing the games in Legends of Learning, use what you learn to answer the following questions.

Part 1. Identify the type of interaction in each system **(gravitational, magnetic, or electric)**, and describe the change in potential energy if the distance between the object changes. Write your answer in the boxes provided.

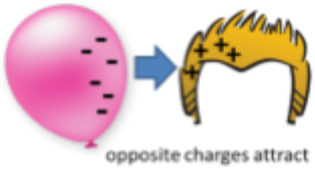
Situation #1 Distance increases.



Situation #2 Distance decreases.



Situation #3 Distance increases.



Part 2. Agree or Disagree. Next to each of the statements below, write **A** if you agree with the statement or **D** if you disagree with the statement.

_____1. When two objects interact, they exert a force on each other.

_____2. During collisions between objects, energy is gained by the system.

_____3. Gravitational potential energy decreases as the height of an object increases.

_____4. Energy is the ability to do work on an object.

Relationship Between Energy and Force

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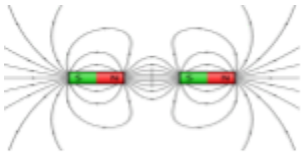
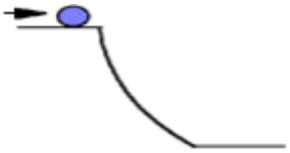


Magnetic

Potential energy increases as distance increases.

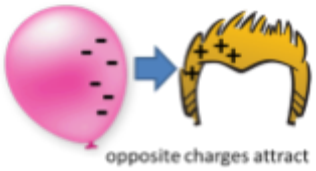
Situation #2 Distance decreases.



Gravitational

Potential energy decreases as distance decreases.

Situation #3 Distance increases.



Electrical

Potential energy increases as distance increases.

Part 2. Agree or Disagree. Next to each of the statements below, write **A** if you agree with the state or **D** if you disagree with the statement.

___A__1. When two objects interact, they exert a force on each other.

___D__2. During collisions between objects, energy is gained by the system.

___D__3. Gravitational potential energy decreases as the height of an object increases.

___A__4. Energy is the ability to do work on an object.