Work, Energy and Power

Summer Assignment

AP Physics

NAME ________________________________________________

Instructions: Use the following link to complete this assignment. The link can be found at the google classroom.

LINK:
https://www.physicsclassroom.com/class/energy/Lesson-1/Definition-and-Mathematics-of-Work

Work

1. In order for work to be done on an object, a __________ must be place on the object that causes ______________________________.

2. What are the three key ingredients for work? How are the three related to each other?

3. In the chart below, several situations are given. For each case, determine if work is being done and then explain how you know.

<table>
<thead>
<tr>
<th>Situation</th>
<th>Work Done? (Y or N)</th>
<th>Explain how you know</th>
</tr>
</thead>
<tbody>
<tr>
<td>A boy holds a heavy package for one hour.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A girl is coasting on a bicycle. She is not pedaling.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A rocket ship moves through space. There is no air resistance on the rocket and the rocket is moving at a constant speed.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>You push on an unlocked door and open the door.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>You push a shopping cart and cause the cart to move.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suppose you stop pushing the cart, but the cart keeps moving.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>John is thinking about his math test.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4. Below is the formula for calculating work. Explain what each variable means and what the units are for each variable.

\[ W = F \cdot d \cdot \cos \theta \]

- \( W \): Unit =
- \( F \): Unit =
- \( d \): Unit =
- \( \theta \): Unit =

5. In order for a force to do the maximum amount of work possible, the angle between the force and the distance should be _______. A force like this is able to maximum work because all of the force is causing the object to move.

6. A force does negative work when the angle between the force and the distance is _______. In this case, the force is working against the object, trying to slow the object down.

7. A force does no work on an object when the angle between the force and the distance is _______. In cases like this, the force does not cause the object to be displaced, so the force does no work.

**Calculating Work**

8. In each case shown below, determine how much work is being done by the force.

<table>
<thead>
<tr>
<th>Diagram A</th>
<th>Diagram B</th>
<th>Diagram C</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Diagram A" /></td>
<td><img src="image2.png" alt="Diagram B" /></td>
<td><img src="image3.png" alt="Diagram C" /></td>
</tr>
<tr>
<td>A 100 N force is applied to move a 15 kg object a horizontal distance of 5 meters at constant speed.</td>
<td>A 100 N force is applied at an angle of 30° to the horizontal to move a 15 kg object at a constant speed for a horizontal distance of 5 m.</td>
<td>An upward force is applied to lift a 15 kg object to a height of 5 meters at constant speed.</td>
</tr>
</tbody>
</table>
9. Draw a free body diagram for a box being pulled to the right by a 20 N force along a rope that is angled at 30 degrees above the horizontal. There is a 5 N frictional force on the box.

(b) Which forces on the free body diagram are doing work (positive or negative) and which forces are doing no work?

(c) Calculate how much work is being done by the pulling force.

(d) Calculate how much work is being done by the frictional force. Why is this work negative?

(e) Determine the total work (net work) done on the box by all the forces on it.

10. Find the work done by a 45 N force pulling a luggage carrier at an angle of 50 degrees above the horizontal, for a distance of 75 m.

11. A weightlifter is bench-pressing a 710 N barbell. He does this by placing an upward force of 710 N so that the barbell is lifted and lowered at a constant speed the entire time. The barbell is being lifted and lowered 0.65 m. (a) During the period where the barbell is being lifted upward, how much work does the lift force do?
(b) During the lowering of the barbell, how much work is the lifting force doing?

(c) Explain the difference between your answers for (a) and (b).

**Power**

For physics, power is defined as the rate at which you do work. More powerful devices can do work in a faster amount of time. Less powerful devices take more time to do work.

The formula for calculating power is

\[ P = \frac{W}{t} \]

The unit for Power is Watts. A Watt is a joule per second. This unit should be familiar to you as we learned about Power when we studied electricity. If you remember, the more powerful 100 W light bulb converted electricity at a faster rate, and was therefore brighter, than the less powerful 40 W light bulb.

Use this formula to answer the following questions:

12. Two physics students, Will and Ben, are in the weightlifting room. Will lifts the 100-pound barbell over his head 10 times in one minute; Ben lifts the 100-pound barbell over his head 10 times in 10 seconds. Which student does the most work? ______________ Which student delivers the most power? ______________ Explain your answers.

13. During a physics lab, Jack and Jill ran up a hill. Jack is twice as massive as Jill; yet Jill ascends the same distance in half the time. Who did the most work? ______________ Who delivered the most power? ______________ Explain your answers.
14. When doing a *chin-up*, a physics student lifts her 42.0-kg body a distance of 0.25 meters in 2 seconds. What is the power delivered by the student's biceps? Remember that to lift herself, she needs to lift with a force equal to her weight.

15. An escalator is used to move 20 passengers every minute from the first floor of a department store to the second. The second floor is located 5.20 meters above the first floor. The average passenger's mass is 54.9 kg. Determine the power requirement of the escalator in order to move this number of passengers in this amount of time.

**Running a Power Experiment--Determining your Power**

**Materials:** staircase, ruler, stopwatch

For this experiment, you will determine your power by ascending a staircase. Any staircase will work, but if you don’t have a staircase at your house, you will need to go find one somewhere.

Begin by measuring the vertical height of the staircase. This can be done by measuring the vertical height of a single step and then multiplying by the number of steps in your staircase.

Show your work in the space below for how you determined the vertical height of the staircase.

Next, you will need to know what you weigh (in Newtons) so that you will know how much force you are applying to lift yourself up the staircase. You can convert your weight in pounds to your weight in Newtons in the space below. (1 Newton = 0.225 pounds)
Calculate how much work you will do in lifting your weight up the staircase. Show this calculation below.

Finally, you will need to have someone time how long it takes you to ascend the steps from the bottom up to the top. Using the time, calculate how much power you have ascending the stairs. Show your power calculation below.

Another common unit for Power (beside the Watt) is a unit called horsepower (hp). Its a unit that was first used in the late 18th century by James Watt, a scottish engineer, who wanted to compare the power output of the newly invented steam engine, to that of the more conventional power of a draft horse. The horsepower is still used to today when giving the power output of engines. The horsepower is equal to 746 Watts. Use this conversion to determine your power rating in horsepower. Show the conversion in the space below.