Name: _______________

Learning Intention

- Understanding the definitions of work, energy, and power
- Learn how to calculate the gravitational potential energy of an object.

Definitions and Formulas

1. Work, power, and energy give us a new framework to use to solve all sorts of physics problems.
2. Work was originally defined by Gaspard-Gustave Coriolis as a ________________ lifted through a ________________.
3. The definition of work we will use is

    a. Work is a (scalar / vector).

    b. If you push on an object and it does not move, you have done ________________ Joules of work on the object. However, your muscles get tired because they do work on _________________________.
4. The ________________ work is the sum of all the work done on and by an object.
5. In physics, energy is the ability to do ________________.
6. The Theory of Conservation of ________________ states that ________________ cannot be created or destroyed, but can only change ________________.

    a. This is often written as:

7. In physics, power is the rate of doing ________________. It is defined by the equation:

8. Coriolis was interested in raising heavy loads out of mines. He wanted to know how much energy it would take to lift a load from the bottom of a mine up to the surface. We will assume that the load has a mass of m kilograms and the mine has a depth of h meters.
    a. Draw a free body diagram of the mass, as it is moving upwards at a constant velocity. What is the upwards force?

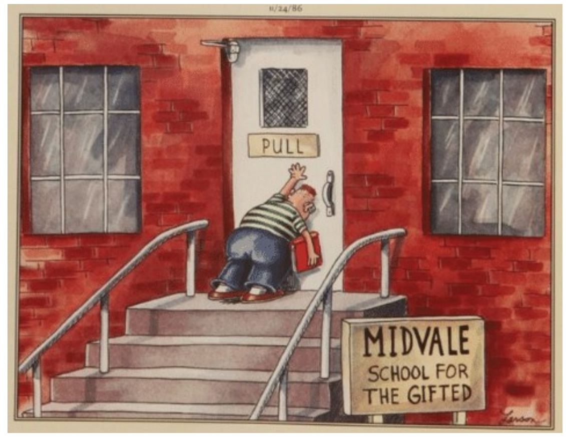
    b. How much work is done on the mass as it is raised by a height h?

    c. When the mass is lifted, ________________ is performed, and the ________________ is transformed into ________________ ________________ ________________.

9. Near the surface of the Earth, gravitational potential energy is calculated as

Questions

1. A student pushes a box forwards with a force of 56 N for a distance of 13 m.
    a. How much work does the student do?
    b. If there was a force of friction of 32 N opposing the motion of the box, how much work was done by the force of friction?
    c. What is the net work done on the box?



2. A student pushes forwards with a force of 220 N on a door labeled "Pull". The door does not move. How much work was done by the student on the door?
3. The express elevators in the Taipei 101 tower can lift a 1,200 kg mass to a height of 382 m in 37 seconds.
    a. How much gravitational potential energy does the mass have at the top?
    b. How powerful must the elevator motor be?
4. A year has 3.15 x 10^7 seconds.
    a. How much energy does a 60 Watt incandescent bulb use in a year?
    b. How much energy does the equivalent 13 W CFL (compact fluorescent light) bulb use in a year?
5. How many Joules of energy are in a kilowatt hour (kWh)?

6. The picture to the right shows an exercise called the "clean and jerk". If you look at the start and end positions of the mass, you will notice that the mass is lifted almost exactly to the height of the athlete. Professional weightlifter Leonid Taranenko of the Soviet Union set an all-time record when he lifted a 266 kg barbell above his head in the clean and jerk. If Taranenko is 183 cm tall, how much gravitational potential energy does the barbell have when it is at its highest point?
7. A 52 kg person has 4800 J of gravitational potential energy. How high above the Earth's surface are they?
8. Mr. Renwick has a mass of 90 kg. He eats a can of spinach (75 Calories), and attempts to use the energy to climb to the top of the CN Tower in Toronto. Assume that all of the

chemical potential energy in the spinach gets turned into gravitational potential energy, and Mr. Renwick can only use the energy from the spinach to climb.

   a. Will Mr. Renwick have enough energy to reach the top of the stairs, 315 meters above the Earth?
   b. How high is the highest that he could climb?

9. In 2017, 12-year-old Aysia Maurice (mass: 35 kg) climbed 315 meters up the CN Tower in Toronto in 9 minutes and 55 seconds. What was her power output?

Answers

1. a. W_A = 730 J
   b. W_f = -420 J
   c. W_{net} = 310 J
2. W = 0 J
3. a. $E_P = 4.5 \times 10^6$ J = 4.5 MJ
   b. $P = 1.2 \times 10^5$ W = 120 kW
4. a. $W = 1.9 \times 10^9$ J = 1.9 GW = 1,900 MJ
   b. $W = 4.1 \times 10^8$ J = 410 MJ
5. $W = 3.6 \times 10^6$ J = 3.6 MJ
6. E_p = 4,780 J
7. h = 9.4 m
8. a. Yes
   b. 360 m
9. P = 180 W