Expectations for Work, Energy, Power, Efficiency, Thermo

1. Students should be familiar with the relation between work and the change in energy. They should be able to solve problems using this relation.
   Relationship: *Sample problem:*

2. Students should be familiar with the relationships (equations) that define kinetic energy, gravitational potential energy, and elastic potential energy. They should be able to solve problems involving these relationships.
   Relationships:

3. Students should understand the concept of efficiency and how it relates to energy and work.

4. Students should understand the usefulness of simple machines (lever, ramp, pulley) in accomplishing work. They should understand Mechanical Advantage and the tradeoffs that accompany using these machines.

5. Students understand the First Law of Thermodynamics in terms of the heat flowing into or out of a system and the work done on or by that system. They recognize that The 1^{st} Law is another way of stating the law of conservation of Energy.

6. Students understand the concept of heat capacity (both specific and molar) and the relationship that defines it.

7. Students understand the 2^{nd} Law of Thermodynamics in terms of heat flowing between a hot object and a cold object. They also understand the concept of thermal equilibrium.

8. Students understand that entropy is a measure of the order or disorder in a system that is related to the number of different arrangements of that system. They know that spontaneous processes tend toward states of greater disorder, and that in order to increase the order in one part of a system, they must increase the entropy more in another part of the system.

Practice Problems

1. A car with mass 2000kg accelerates from 0 to 60 mi/hr in 4sec. How much work was done? What is the power output of the car (ignoring air friction). How would our estimation of the power output change if we didn't ignore friction?
2. a kid lifts his puppy off the floor. The puppy weighs 15 pounds and is lifted to height of 2 feet. Find the work done in foot-lbs and N*m. If this takes 1 sec, what is the kid's power output in Horsepower and watts?
3. a force acts on a 5kg mass for a distance of 2 meters and increases its energy by 300 joules. How large was the force?
4. You need to lift 200 lbs of bricks to a height of 2 meters. you have 2 pulleys and a rope. Draw a diagram that would allow you to lift the bricks using the least force. Assuming an efficiency of 1 (ie. No friction), how much force would you need to pull with, and how far would you need to pull on the rope? Explain why.
5. you want to drop an egg from a height of 5m like in our eggstream challenge. Using the following numbers to calculate the length of rope needed:
    a. k=50N/m
    b. unstretched length = .5m
    c. mass = 1kg
    d. height = 5m
    e. safety margin = 0 (go for the gold baby!)
6. A cylinder contains 3 moles of gas. It has a volume of 6 liters, the pressure is 1 ATM, the temperature is 35 degrees Celsius.
    a. If the temperature is kept constant while a piston at one end of the container is pushed in so that the volume changes to 4.5 liters, does the pressure go up or down? What is the new pressure?
    b. If you push on the piston till the pressure inside is 3 ATM, what is the new volume?
    c. If you now let the piston move freely and heat the gas inside till it reaches 100 ^{o}C, what is the new volume?
    d. If 600J of heat were added to the gas, and it's internal energy raised by 500J, how much work did it do?
    e. What is the efficiency of this "engine"?
7. Imagine a great new car engine that is 40% efficient and has a maximum power output of 120hp. It is fueled by biodiesel which has an energy content of 35MJ/liter.
    a. If the engine is running at full power, how fast is it using up the fuel (in mL/minute and L/hour)
    b. The car has a top speed of 230 km/hr. What is the frictional force on the car when traveling at this speed?
8. A kid rides her bike up a long steep hill. She has a mass of 74kg and the bike has a mass of 10kg. The hill is 1 km long, and at an angle of 15 degrees. Assume the efficiency of her body is about 35%. It takes her 12 minutes to get up the hill.
    a. How much work did she do?
    b. What is her power output?
    c. How many calories did she burn?
    d. How many heat did she generate?
    e. Make a 1st law diagram of the situation.
    f. If she was carrying a 5kg backpack, how long would it have taken her to get up the hill?
9. What is entropy? Can entropy ever decrease? If so, under what conditions?
10. If you open the door to your refrigerator, will it cool down your kitchen? Why or why not?