HW: Work and Energy Intuition

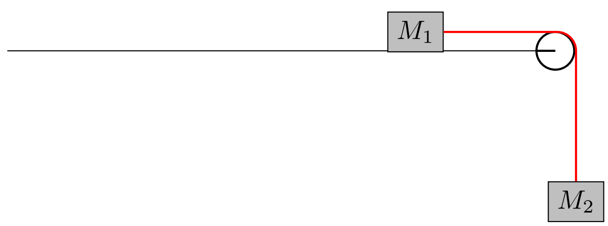
Full Name, Period, AP/Honors: **due: 9/9**

Instructions: For short answer questions, work must be shown to receive credit.

1 Energy... and you're done!

1. Two objects with the same densities, but different volumes are dropped from the same height at the same time. Which of these statements will be true? Do not take the Earth as part of the system, and take gravity as an external force. Air resistance is negligible. **Select all that apply!**
   A. The work done on the objects is the same.
   B. The final velocity of the objects is the same.
   C. The time required to hit the ground is the same.
   D. The force of gravity on the objects is the same.

2. (**All**) You create the pulley system shown and release the masses and observe that they begin to move. Mass M_1 has friction with the surface, but there is no air resistance. Note: in both problems below, I am asking for the work done **on** the system, not **by** the system.



   (a) (3 pt) W_1 refers to the work done on the system consisting of M_1 and Earth. W_2 refers to the work done on the system consisting of M_2 and Earth. W_{tot} refers to the change in energy of the system consisting of both masses and Earth. What will be true about each work done?
   A. $W_1 > 0$, $W_2 < 0$, $W_{tot} = 0$
   B. $W_1 > 0$, $W_2 > 0$, $W_{tot} > 0$
   C. $W_1 < 0$, $W_2 > 0$, $W_{tot} = 0$
   D. $W_1 > 0$, $W_2 < 0$, $W_{tot} < 0$

   (b) (4 pt) If the coefficient of friction with the surface is μ_k, calculate the work done on each mass in the case where the earth is NOT included in any of the systems. Answers may include (no variables except) any combination of M_1, M_2, μ_k, v_f and g.

3. An object with mass 10 kg is lowered at constant velocity from a height of 10^4 m to a height of 9×10^3 m in a time of 10 seconds at a constant velocity. What was the rate of power input into the system.

   A. -10^3 W

   B. 10^3 W

   C. -10^4 W

   D. 10^4 W

4. In which of these scenarios is net work (positive or negative) done on the object? Assume that the Earth is part of the system and that potential energy is defined.

   A. A train turns a corner at constant speed.

   B. A bicycle accelerates down a frictionless hill (without pedaling).

   C. A stroller is pushed at constant speed up a frictionless hill.

   D. A book is carried at a constant speed down a long hallway.

2 Some Realistic Problems

Numerical answers here are not expected to be exact, but you should easily be able to get within a factor of a few of the correct answer. In physics we refer to this as "order of magnitude." You are free to use a calculator, but since this is approximation, you shouldn't really need one.

1. Elevators consist of an electric motor that grips a cable. On one end of the cable is the carriage that people ride in, on the other end is a large weight. The motor can exert a force in either direction on the cable to move the elevator.

   (a) How does the weight aid in the operation of the elevator?

   (b) If the mass of the elevator when empty is M_e, and the maximum mass that the elevator is rated for is M_m about how much mass should the weight have? Explain your answer.

   (c) The tallest buildings are about 0.8 km tall. Elevators in these buildings need to make it to the top in a bit under 2 minutes. If the elevators can hold 25 people weighs 1000 kg empty, estimate the minimum horsepower that the elevator motor must be capable of providing. (1 HP = 745.7 W)

2. I drive a Subaru WRX, which weighs about 1000 kg has about 270 HP. Estimate the time required to go from 0-60 mph. Your estimate will likely be a bit low. Speculate about why.

3 Energy Conservation Conceptually

Determine whether each of the scenarios below violates energy conservation. **Explain your answers.** Also, note that some of these might be impossible for reasons other than energy conservation.

1. On a perfectly flat surface (with friction so he can move, but no air resistance), a runner "burns calories" by running in a perfectly straight line with a perfectly constant speed.

2. 2 perfectly rigid objects traveling in opposite directions crash into each other. The collision produces no sound, heat, or permanent changes to the objects. As a result of the collision, both objects come to a stop.

4 Rotation

1. Some experimental types of hybrid cars use a mechanical flywheel to store energy that is then given back to the car. Flywheels are typically made of steel disks that have a radius of about $\frac{1}{2}$ m and mass of about 30 kg. How fast would the disk need to spin to be able to accelerate a 1000 kg car to 5 $\frac{\mathrm{m}}{\mathrm{s}}$

2. A car with mass M (not including the wheels), has 4 wheels of mass $\frac{M}{4}$ that are solid cylinders. If the car is released from a height h on a ramp, what will be the speed of the car when it reaches the bottom?

5 And Now for Some Biology

1. My mass is about 80 kg. In a reasonable day of mountain climbing I typically will have a total elevation gain (ie all gains summed together without subtracting downhill) of around 2 miles (1 mile is about 1600 m). If my body was perfectly efficient, how many Calories would I need to consume in order to do this?
   (1 Calorie = 1000 calories = 4180 J)

2. I find that on these days I typically need to eat at least 6000 Calories (including the 2500 I eat daily). Use this to estimate the efficiency of the human body at climbing. (Efficiency is defined as $\frac{E_{out}}{E_{in}}$

3. Where does the rest of the energy go?