1103 Period 7: Work and Energy

7.1 How Do We Measure Work and Energy?

1) The units of work and energy: Work is done when a force moves an object. Energy is required to do work.

   a) Work and energy are measured in units of joules. 1 joule = 1 kg m^2/s^2
   Force is measured in units of newtons. 1 newton = 1 kg m/s^2
   Explain why a joule can also be called a newton meter.

   b) If you did one joule of work, how much energy did you exert to do this work? (Assume no energy was wasted.)

7.2 How Does the Work Done Compare to Potential Energy Gained?

2) A pile driver does work: Your instructor will demonstrate a model pile driver.

   a) The pile driver mass is 4 kilograms. What is its weight in newtons?

   b) How much force is needed to hold this mass stationary?

   c) How much force is needed to raise this mass at a constant velocity?

   d) To what height was the pile driver mass raised?

   e) How much work was done to raise the mass to this height?

3) Potential energy:

   a) How much potential energy did the mass have before it was raised?

   b) How much potential energy does the mass store when it is raised?

   c) The mass is now allowed to drop. What form of energy does the mass have just before it hits the metal stand at the bottom?
7.3 What Happens to Stored Potential Energy?

4) The nail: Your instructor will demonstrate the pile driver mass hitting a nail into a board.
   a) If this pile driver exerts a force of 500 N to drive a nail into a board a distance of 3 cm, how much work does has the pile driver done on the nail?

   b) If the 4 kg mass is raised to a height of 0.75 meters, how much potential energy does it store?

   c) Is the work done by the mass to pound the nail into the board the same, more, or less than the stored gravitational potential energy? ________________

   d) Explain what happens to the rest of the stored potential energy when the mass falls and hits the nail.

5) The can crush: Your instructor will crush cans with the pile driver mass.
   a) List the energy transformations that take place starting with the mass at rest at the top and ending with the mass at rest at the bottom.

   b) When the pile driver mass falls and hits the empty metal stand, what happens to the potential energy the mass had before it fell?
7.4 Kinetic Energy ↔ Potential Energy Conversions

6) The pendulum: Your instructor will demonstrate a pendulum, in which a ball swings freely.

a) On the sketch of below, fill in the blanks with "MOST" or "LEAST" to indicate the ball’s velocity, kinetic energy, and gravitational potential energy in each position.

b) Your instructor will discuss the gravitational potential energy of a swinging ball. If you release the ball from the height of your nose, why doesn’t it swing back and hit you in the nose?

c) The click-clack machine has 5 balls. What happens to the balls’ gravitational potential energy when 1, 2, 3, or 4 balls are raised and dropped? List the series of energy conversions that occur when one ball is raised and released.

d) Would the click-clack balls swing forever? Does a swinging click-clack ball reach the same height with each swing? What eventually happens to the gravitational potential energy the ball started with?
e) Use the curved plastic track to roll or slide the toy car, marble, ping pong ball, and a wooden block with smooth and rough sides. Make predictions first.

1) Which object wastes the most energy overcoming the force of friction?
   Prediction: _______________  Answer: _______________

2) Which object wastes the least energy overcoming the force of friction?
   Prediction: _______________  Answer: _______________

f) Group Discussion Question: Would it ever be possible for an object to roll higher than its original starting position? Explain why or why not.
Period 7 Exercises: Work and Energy

Write answers to the questions below. Show your mathematical steps and the units of the quantities. This sheet with your answers should be turned in at the beginning of Period 8.

1. **Doing work against gravity and friction:**
   How much work must be done to push a 25 pound box to the top of this ramp?

   ![Ramp Diagram]

   a) How much work against gravity is needed to raise the 25 pound box up 5 feet?
   
   b) How much work against friction is needed to push the box along the 13 foot ramp if the force of friction between the ramp and the box is 10 pounds?
   
   c) What is the total work needed to move the box up the ramp?

2. **EQUATING KINETIC AND GRAVITAL POTENTIAL ENERGY (English units):**
   A playground slide with a vertical height of 4 feet is totally frictionless. What speed would a child have at the bottom of the slide? (Hint: If we ignore friction, the gravitational potential energy at the top of the slide equals the kinetic energy at the bottom. The acceleration of gravity, $g$, in English units = 32 ft/s$^2$.)

3. **EQUATING KINETIC AND GRAVITAL POTENTIAL ENERGY (metric units):**
   A ball is thrown straight up with an initial velocity of 5.0 meters/sec. How high will the ball rise? (Ignore wasted energy.)