Unit 11 *Homework Problems*

To get credit for the homework problems, you must include all of the following:

1. All equations must be solved in symbol form before substituting in any numbers.
2. All numbers substituted into the equations must have the correct units and number of significant figures, and the correct vector notation (where appropriate).
3. All final numerical answers must have the correct units, correct number of significant figures, and correct vector notation (where appropriate),
4. All problems should include a reference to the Activity Guide activity or activities that are related to the problem, a discussion of ***how*** the activity is related, and a discussion of the ***concepts*** that were learned in the activity.

UNIT 11 HOMEWORK AFTER SESSION ONE

11-1) We, and everything around us, are immersed in ceaseless processes of energy transformation. Look around the room or place in which you happen to be located. Identify and describe qualitatively at least three processes of transformation of energy that are going on right now in your vicinity. Do not ignore the fact that your own body may be involved in some of the processes.

11-2) A ball is thrown from ground level with initial horizontal velocity component v_{1x} and the initial vertical velocity component v_{1y} and returns to ground level. Neglecting friction and explaining your reasoning in each instance, write expressions **in terms of these two velocity components** for:

(a) The largest kinetic energy of the ball during its flight, in terms of v_{1x} and/or v_{1y}.

(b) The smallest kinetic energy of the ball during its flight, in terms of v_{1x} and/or v_{1y}.

(c) The maximum potential energy of the ball-earth system during the flight, in terms of v_{1x} and/or v_{1y}.

Hint: To remind you of the nature of a ball's path, you may want to view the movies entitled *pasco104.mov* or *pasco106.mov*.

11-3) The Red Cross has arranged to send a helicopter with supplies into a town in the Texas gulf that is isolated by floodwaters. The crates holding the supplies will burst if they hit the ground with a downward speed of more than 12 m/s. Suppose a crate of food, which has a mass of 125 kg, is released from the helicopter when the helicopter is rising at a rate of 5.3 m/s at an altitude of 11 m above the ground. Air resistance can be neglected. (*As with all the problems on this homework, you'll want to use energy methods to solve this problem; no kinematics, please.*)

(a) What is the total mechanical energy of the crate-earth system relative to the Earth's surface?

(b) What is the potential energy of the crate-earth system when the crate reaches its highest point?

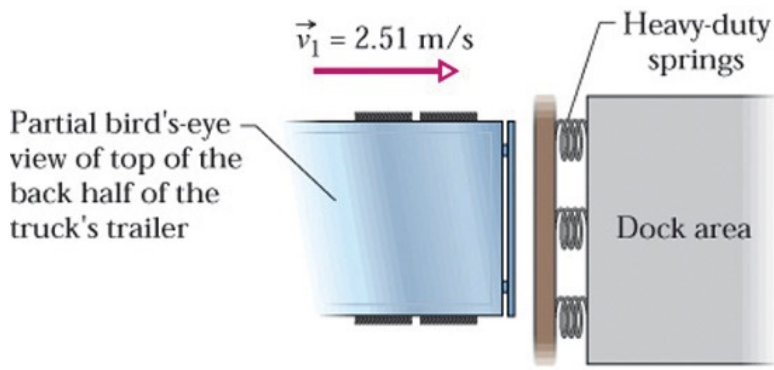
(c) How high is this point? (*Hint: It isn't* 11 m; *it's higher*)

(d) What is the kinetic energy of the crate when it hits the ground?

(e) How skilled is the copter pilot at making the drops. In other words, is the crate likely to break apart?

11-4) Show that the equations for gravitational potential energy and for the elastic (or spring) potential energy both have units of energy. **Hint**: You may want to look up the equation for elastic (or spring) potential energy in your textbook.

11-5) Loading docks often have spring loaded bumpers on them so the big rigs don't accidentally ruin the docks when backing up. Suppose a 6.45×10^3 kg truck backs into a spring-loaded dock at a speed of 2.51 m/s. If the truck compresses the dock bumper springs by 0.15 m when it slows down to zero speed, what is the effective spring constant of the bumper system? As always, use the correct number of significant figures.

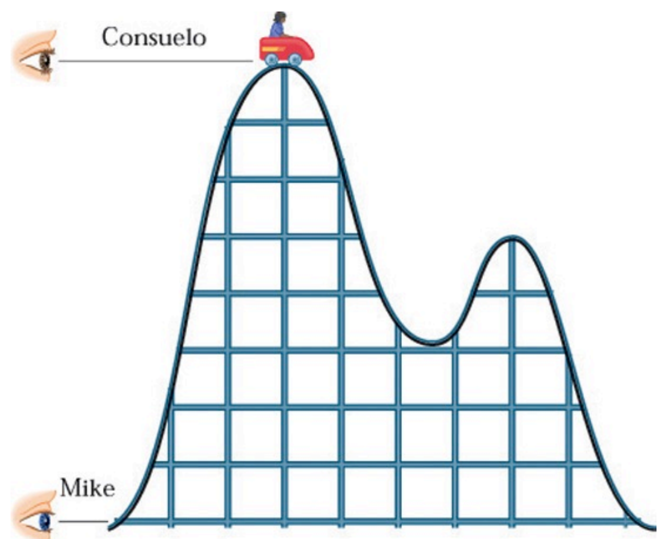


11-6) *Frames of Reference:* Different observers can choose to use different coordinate systems. A frictionless roller coaster has been invented in which a single rider in a little cart can roll from the highest point to the lowest point picking up kinetic energy as it goes downhill. In the schematic of the roller coaster shown below, the struts are 4.00 meters apart and the cart and rider have a combined mass of 195 kg. **Hint**: You may want to look at some of the roller coaster movies in the Hershey Park collection. For example, *hrsy018.mov* and *hrsy019.mov* provide similar scenarios. Although real roller coasters are not frictionless, using the Logger Pro software to find the location of a car at the top of a hill from the perspectives of two coordinate systems might be helpful.

(a) What is the total mechanical energy of the cart-rider/Earth system according to Consuelo (an observer at the highest point on the track)?

(b) What is the total mechanical energy of the cart-rider/Earth system according to Mike (an observer at the ground level)?

(c) Do Consuelo and Mike agree on the *value* of the total mechanical energy? Why or why not?



(d) Do Consuelo and Mike agree that mechanical energy is conserved? Explain.

(e) Assuming that mechanical energy is conserved, what is the kinetic energy of the cart and rider when it rolls over the top of the second smaller hill?

UNIT 11 HOMEWORK AFTER SESSION TWO

11-7) Suppose a person wants to slide a trash barrel across the floor to a large trash bin. If the coefficient of kinetic friction is 0.123, determine the work done by the kinetic friction force on a 25 kg trash barrel that is pushed horizontally at a constant speed:

(a) Around a semicircle of diameter 2.3 m

(b) Straight across the diameter.

11-8) A 5.0-kg block travels to the right on a rough, horizontal surface and collides with a spring. The speed of the block *just before* the collision is 3.0 m/s. As the block rebounds to the left with the spring uncompressed, its speed as it leaves the spring is 2.2 m/s. If the coefficient of kinetic friction between the block and surface is 0.3, determine:

(a) The work done by friction while the block is in contact with the spring.

(b) The maximum distance the spring is compressed.

11-9) *Air drag and coffee filters:* If a flat-bottomed coffee filter is dropped from rest near the surface of the Earth, it will appear to fall more slowly than a small dense object of the same mass. You are to investigate whether or not mechanical energy is conserved during the fall of two stacked coffee filters by using the Logger Pro analysis software along with the movie entitled *pasco121.mov* for this analysis. (It might be easiest to collect data for the bottom edge of the coffee filter.)

(a) If the coffee filter stack is dropping from rest, what is its initial velocity and kinetic energy?

(b) What is the final velocity and kinetic energy of the coffee filter stack (at the time of the last frame?) Explain how you arrived at the final velocity.

(c) What are the initial and final potential energies of the earth-coffee filter stack system?

(d) Is mechanical energy conserved as the coffee filter stack falls? Cite the evidence based on your measurements and calculations?

(e) How much mechanical energy, if any, is transferred to other types of energy?

(f) What is the most likely source of a non-conservative force on the coffee filter stack? Where would missing mechanical energy probably go?

11-10) Consider the cart rolling up a short stretch of an inclined ramp that is shown in the *pasco054.mov* movie.

(a) Use the Logger Pro software to find and collect the data needed to calculate the total mechanical energy of the earth-cart system before and after the cart travels up the incline. Of course, this mechanical energy is relative to the coordinate system you choose to use. Start with a coordinate system that has an x-axis that is even with the middle of the cart along the lower ramp of the top track.

(b) Calculate the total mechanical energy of the earth-cart system before and after the cart travels up the incline. Show the data, equations, and calculations to find theses values of mechanical energy. **Hints:** The data in frames 0-11 can be used to determine the initial velocity of the cart and the average height relative to the x-axis. The data in frames 31-51 can be used to determine the final velocity of the cart and the average height relative to the x-axis.

(c) Show that if the cart mass is 0.510 kg, then approximately 0.020 J of mechanical energy is lost as the cart travels up the incline. If we still believe energy is conserved how might we account for the missing energy?

(d) Would the part (b) answer be different for an observer on the upper ramp of the top track? Why or why not?

(e) Would the part (c) answer be different for an observer on the upper ramp of the top track? Why or why not?