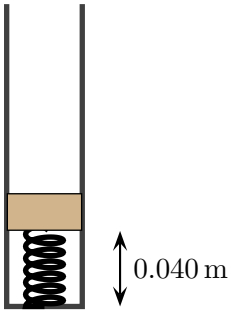
Concepts of Physics: Homework 6

Due: 11 October 2023

1 Spring gun

A spring gun consists of a vertical pipe with frictionless walls. A block is pushed against a spring, which is attached to the base of the pipe. The block is pushed against the spring and released from the indicated location while the pipe points vertically.



a) At the instant before the block is released, which types of energy are non-zero?

b) As the block moves up, which types of energy begin to decrease, which increase and which stay constant? Explain your answer.

2 Bungee jumper

A bungee jump involves jumping off a bridge while attached to a stretchy rope which is fixed to the bridge. The rope acts as a spring and aspects of this motion can be analyzed using energy conservation. Suppose that a person with mass 75 kg jumps from a bridge that is 100 m above a river. The person "jumps" by cautiously stepping off the bridge and, at this point, his speed is essentially 0 m/s and the rope is slack (no elastic energy).

a) Determine the total energy of the jumper as he falls.

b) When the jumper reaches his lowest point his speed is 0 m/s. What form(s) of energy could the jumper have at the lowest point, assuming that the lowest point is above the river?

c) Suppose that the jumper just touched the river at the lowest point. How much elastic energy would the rope have?

d) Suppose that, with this person jumping, the maximum stretch of the rope would result in elastic energy 65000 J. Determine the (gravitational) potential energy in this case. Would the jumper hit the river or not? Explain your answer.

e) Someone calculates that for this particular jumper, the elastic energy would actually be 85000 J. Would the jumper hit the river or not? Explain your answer.

3 Energy and a skater with friction

The following exercise will require the animation "Energy Skate Park" provided by the PhET group. The animation can be accessed at:

https://phet.colorado.edu/en/simulations/energy-skate-park

Click on the link and open the animation. Select the option "Intro." A track that runs down and up should appear. A skater will move on this track. The panel at the bottom controls the speed of the animation and you can freeze it by hitting "pause."

Open "Energy" in the panel on the top left. This will produce a bar graph which lists three types of energy plus a total energy. Release the skater from somewhere near the top of the track.

a) Set the friction to the midpoint between none and lots. Release the skater from somewhere near the top of the track. Describe what happens to the three types of energy as the skater descends. Into what forms is the potential energy converted on the way down? Describe what happens to the three types of energy as the skater ascends. Does the sum, $KE + PE$, remain constant during this motion?

The numbers for the energies can be extracted using the "Measure" window. Open this window and select the default track.

b) Set the friction to the midpoint between none and lots. Release the skater from somewhere near the top of the track. Record the potential energy (PE), kinetic energy (KE) and thermal energy at the moment closest to when the skater is released. Use these to determine the total energy.

c) Now consider a point when the skater is midway down the track. Record the PE, KE and thermal energy and use these to determine the total energy. How do these compare to the numbers at the highest point of the track?

d) Repeat the previous part for the first instant at which the skater reaches the bottom and also the midpoint on the way up.

e) Does the thermal energy ever decrease during the motion?

4 Ideal vs. real pendulum

The ideal pendulum that was described in class will swing forever but a real pendulum will eventually reach a stop. Has the initial potential energy of this real pendulum simply disappeared or was it converted into another form? If so, what form of energy?

5 Terminal velocity

A skydiver falls and after some point reaches terminal velocity, which means that subsequently his velocity does not change. As the skydiver falls with terminal velocity, what happens to his potential energy? Into which types of energy is it converted?

6 Skier efficiency

A skier with mass 70 kg starts move downhill from the top of a hill that is 10 m high. By the time she reaches the bottom of the hill she has lost 400 J of energy to thermal energy. Determine the efficiency of the process in terms of converting potential energy into kinetic energy.

7 Solar energy

The Sun provides energy via light to Earth. At some location on Earth the typical energy that arrives at the surface of Earth on a sunny day is 950 W per square meter of Earth's surface.

a) Suppose that you need to provide about 100 homes with energy by converting the solar energy into electrical energy. A typical household might demand about 3000 J of energy per second on average. Determine the total energy required per second for 100 such homes.

b) Assuming that the energy conversion from the energy provided by sunlight into electricity was perfect, determine the area from which the sunlight would have to be collected.

c) Assuming that the energy conversion from the energy provided by sunlight into electricity was only 20% efficient, determine the area from which the sunlight would have to be collected.

8 Reading Exercise

Read sections 8.1 to 8.3 (pages 164–173). The following exercises are intended to give you an understanding of the concepts presented in the text.

a) A neutral Sodium atom is held at rest near a neutral Chlorine atom. Do they exert an electric force on each other? If so, is the force attractive or repulsive?

b) A neutral Sodium atom donates an electron to a neutral Chlorine atom. Do the resulting ionized atoms subsequently exert an electric force on each other? If so, is the force attractive or repulsive?

c) Do Concept Check 1 without looking at the answer. Did your choice match the correct answer?