Concepts of Physics: Homework 5

Due: 5 October 2022

1 Kinetic energies

Various cars move with the indicated speeds.

Car	**Mass**	**Speed**
White	2000 kg	3.0 m/s
Red	2000 kg	6.0 m/s
Black	4000 kg	3.0 m/s

a) Determine the kinetic energy of each car.

b) How many *times larger* is the kinetic energy of the red car than the white car?

c) How many *times larger* is the kinetic energy of the red car than the black car?

d) Consider two identical objects, A and B. A moves twice as fast as B. How many *times larger* is the kinetic energy of A than B?

e) Consider two identical objects, A and B. A moves three times as fast as B. How many *times larger* is the kinetic energy of A than B?

2 Kinetic and potential energy

A skater (and skateboard) have total mass 80 kg.

a) The skater starts moving from the top of two ramps ("big" and "small"). The height of the big ramp is 4 m and the height of the small ramp is 1 m. How many *times larger* is the potential energy at the top of the big ramp compared to at the top of the small ramp? Explain your answer.

b) The speed is observed at two instants. Earlier it is 1.0 m/s and later it is twice this. How many *times larger* is the kinetic energy later compared to earlier? Explain your answer.

3 Energy and a skater

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

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

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."

Click “Bar Graph” in the panel on the right. This will produce a separate window which lists three types of energy plus a total energy. Release the skater from somewhere near the top of the track.

a) As the skater descends, does the kinetic energy increase, decrease or stay the same? As the skater ascends does the kinetic energy increase, decrease or stay the same? When is the kinetic energy largest?

b) As the skater descends, does the potential energy increase, decrease or stay the same? As the skater ascends does the potential energy increase, decrease or stay the same? When is the potential energy largest?

c) As the skater descends, does the total energy increase, decrease or stay the same? As the skater ascends does the total energy increase, decrease or stay the same?

A more sophisticated version of this animation is called “Energy Skate Park” and is at

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

Run this animation and select the option “Measure.” A track that runs down and up should appear. There are a number of adjustable controls in the panel on the right. Ensure that the location is “Earth” and that the gravity is $9.8\,\mathrm{m/s}^2$. There should be no friction.

d) Release the skater at the left side from somewhere near the top of the track. Allow the skater to move down and up once. A series of dots will appear on the track.

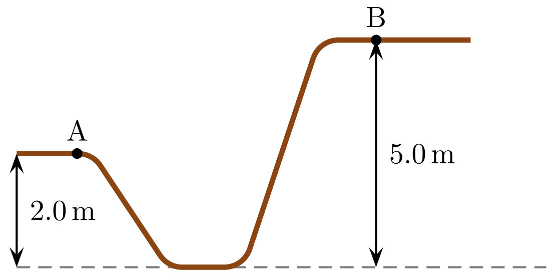
e) Observe the highest recorded point on the left. Record the potential energy (PE) and kinetic energy (KE) and use these to determine the total energy.

f) Record the potential energy (PE) and kinetic energy (KE) for an instant when the skater is roughly halfway down the ramp. Use these to determine the total energy. How do these compare to the numbers at the highest point of the track? Repeat this for the bottom and the midpoint on the way up on the right.

g) Based on these observations, what can you conclude about the total energy of the skater at all times?

h) Suppose that the skater is released from a known height on the left. Consider the highest point the skater reaches on the right. How high is this compared to the release point on the left? Explain your answer.

4 Skate park



A skater, with mass 60 kg, moves left to right on the illustrated track. She reaches point A with speed 10 m/s. Ignore friction and air resistance.

a) Calculate the kinetic energy and potential of the skater at point A.

b) Calculate the total energy of the skater.

c) Does the skater reach point B? To answer this determine the potential energy that the skater would have at point B. Is this available to the skater in this situation?

d) Describe *how* you might use energy to determine the slowest speed that the skater could have at point A so that she reaches point B.

5 Tarzan

Tarzan, with mass 80 kg, grabs a 5.0 m rope and swings, starting from rest, in a circular arc. At the lowest point Tarzan is just above Earth's surface (height is 0 m). At the moment that he starts to swing he is 10 m above the ground. Ignore air resistance. In the following, explain your answers.

a) Which types of energy are non-zero at the moment when he starts to swing?

b) Which types of energy are non-zero at the moment when he reaches his lowest point?

c) What is the total energy that Tarzan has throughout the swing?

d) How fast is Tarzan moving at the lowest point of the swing?

6 Large pendulum

There is an interesting demonstration of a pendulum provided by the Department of Physics at the University of Iowa. Videos are available at:

https://instructional-resources.physics.uiowa.edu/demos/1m4010-large-classroom-pendulum

Explain, using energies, why the person in this video does not need to be scared about the pendulum hitting him.

7 Reading exercise: energy transformations

Read sections 6.4 to 6.6 (pages 122-129). The following exercises are intended to give you an understanding of the concepts presented in the text.

a) We will consider a block, sitting on a table and that is compressed against a spring. Initially the block is held at rest and the spring is compressed. What form of energy, described on page 123, most accurately describes the energy of the block and spring?

b) The block is released and the spring uncompresses, sending the block into motion. At this point what form of energy, described on page 123, most accurately describes the energy of the block and spring?

c) The block eventually slows to a stop. At this point what form of energy, described on page 123, most accurately describes the energy of the block and spring?

d) Suppose that the spring loses some energy as it uncompresses and that measurements reveal the following. Prior to release, the spring has energy 80 J and it delivers 60 J to the block. What is the energy efficiency in this case?