Workshop Tutorials for Introductory Physics
MI7: **Conservation of Energy**

A. Review of Basic Ideas:

Use the following words to fill in the blanks:
potential energy, conserved, motion, conservation, energy, transformed, total energy, gravitational, kinetic energy

Energy

Energy is defined in physics as the ability to do work. This is sensible, because the more _____ you have, the more work you can do, so we hope you've had a good breakfast!

In physics there are fundamental laws called _____ laws, which state that a certain physical quantity is conserved. Examples are conservation of energy and conservation of mass. Energy can change forms, or be _____, but the _____ _____ is always conserved.

Two forms of energy we will be looking at are kinetic energy and potential energy. Kinetic energy is energy associated with _____, an object of mass m moving at velocity v, has kinetic energy $\frac{1}{2} mv^2$. The units of energy are *joules* (*J*).

Potential energy comes in several forms, for example gravitational potential energy. The _____ potential energy of an object of mass m at a height h is defined as mgh, where g is the acceleration due to gravity. There are other forms of potential energy also, such as elastic potential energy in a compressed spring and chemical potential energy in food.

Kinetic and potential energy can also be transformed into other forms of energy, such as heat and sound and light, but the total amount of energy is still always _____.

During the day you transform the chemical potential energy of your breakfast into other forms, such as _____ _____ when you move, and gravitational _____ _____ when you climb up stairs.

To represent the proportion of energy in different forms you can draw energy bar graphs like this:
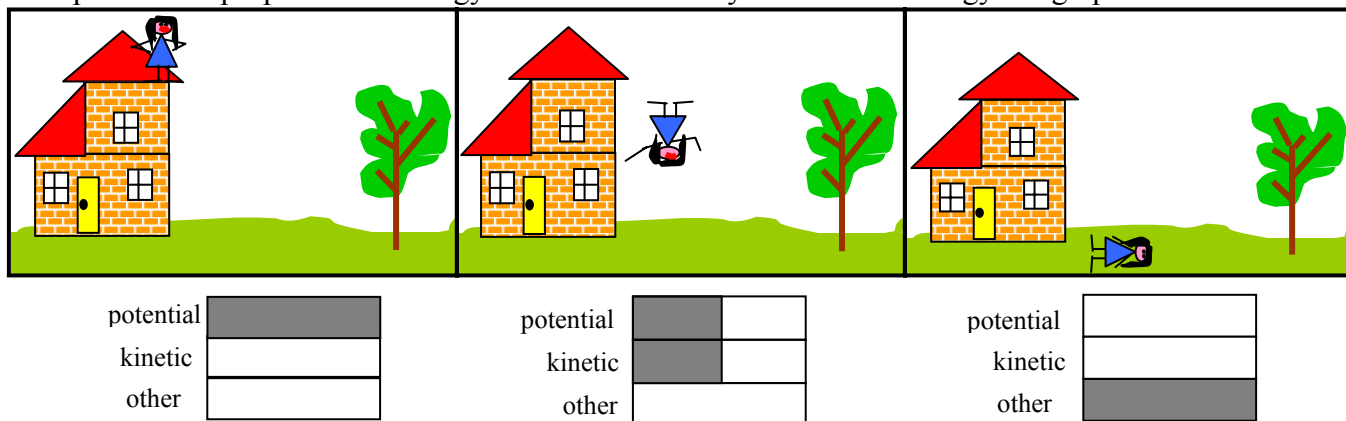
Remember that **the total energy is always conserved**!

Discussion questions
1. Can you think of what the "other" energy in the bar graph above might be?
2. When a child goes down a very slippery slide, such as a water slide, does their velocity at the bottom depend on the shape or angle of the slide?

B. Activity Questions:

1. Pendulum
At what position is the kinetic energy maximum, minimum? At what position is the potential energy maximum, minimum? Draw energy bar graphs for the pendulum at different points in its swing.

2. Solar panel and electric circuit
Trace the energy conversions using a flow chart and identify which ones are "useful" and which are not. Think of a case where this "not useful" energy may be useful.
Trace energy transformations from water stored in a dam, which supplies a hydro-electric power station, to turning on an appliance at home.

3. Bouncing balls I
Drop the balls from the same height. Why do some balls bounce higher than others?
Can you make any of the balls bounce higher than the original height? Does this contradict conservation laws? Explain your answer.

C. Qualitative Questions:

1. You throw a ball vertically into the air and catch it when it returns. Answer questions **a** and **b** first by ignoring air resistance, and then taking it into account.
a. What happens to the ball's kinetic energy during the flight?
b. What happens to the total energy of the ball?
c. What happens to the energy of the ball as you catch it and it comes to rest?
d. Why is it easier (and less painful) to catch a ball while moving your hands backwards?

2. Draw a set of diagrams for a situation which could be described by the following energy bar graphs **or** make up your own scenario and draw appropriate energy bar graphs (be creative!!)
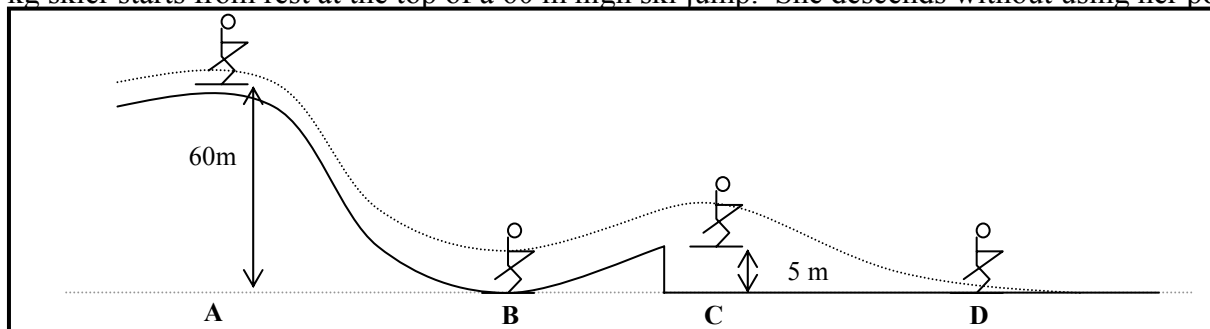

D. Quantitative Question:

A 60 kg skier starts from rest at the top of a 60 m high ski jump. She descends without using her poles.

a. What is her initial gravitational potential energy (at point A) with respect to the level ground at the bottom (point B or D)?
b. Assuming friction is negligible at what speed will she ideally arrive at the bottom?
c. The ramp at the bottom of the ski slope projects her to a height of 5 m (point C) before landing. Assuming negligible friction what speed will she ideally have at the bottom after using this ramp?
d. She reaches the bottom of the run (point D), travelling at 25m.s^{-1}. What is the net energy transferred via friction to her, the skis, the slope, and the air?