As usual, write your name here in the color you will use to write in!

Setup
1. Start by Googing "Phet collisions" and selecting the collision lab, starting it, and then selecting "Intro".
2. Click the "more data" box.
3. Slide the "elasticity" slider to 0.

1. Send the balls towards each other by changing the red ball's velocity to 0.50 m/s and the green ball's velocity to -0.50 m/s. (Don't forget the negative sign). When the balls collide, they will stick together. Predict which way they will move after the collision.

2.Now click "play" and observe what happens. Why do you suppose they move this way?

3. Click "restart" to reset the setup. Through trial and error, determine the initial velocity you need to give the red ball so that the balls do not move after they collide and record it below.

4. Consider the masses (0.50 kg and 1.50 kg) of the balls and the velocities needed so that when they collide the balls don't move. Can you formulate a general rule about when you expect any two masses m1 and m2 with velocities v1 and v2 to stop moving when they collide?

5. Use your theory from step 4 to predict the velocity the red ball will need to have if the red ball has mass 1 kg, the green ball has mass 4 kg, and the green ball has velocity -0.5 m/s. Test the validity of your theory. If it is invalid, try a new theory.

Conservation of Energy Problems Methods

The Model

For any system and any process where non-mechanical energy is not converted to mechanical energy

$$E_f = E_i + W_{other}$$

Where mechanical energy is defined as

$$E = U + K$$

And W_{other} is the work done by forces other than conservative forces on that system[1].

In this class we have two types of potential energy:

$$U_g = mgh \qquad \text{and} \qquad U_{el} = \frac{1}{2}kx^2$$

And of course we have kinetic energy:

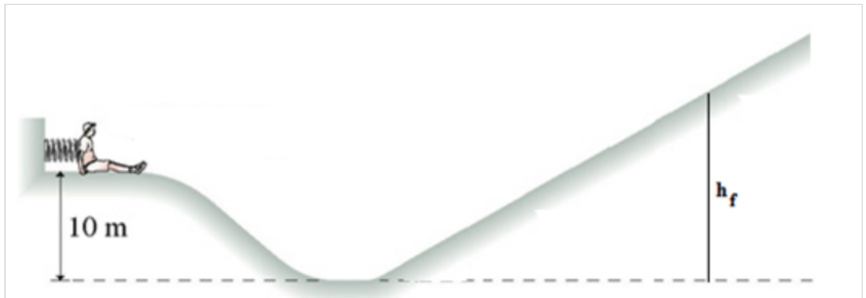
$$K = \frac{1}{2}mv^2$$

Problem Solving Steps

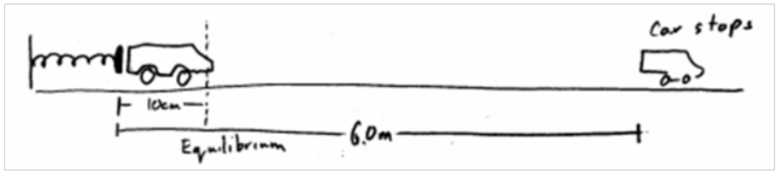
1) Organize and Plan
   a. Draw a clear diagram of the motion, labeling the key moments in time.
   b. Establish coordinate systems if using potential energies.
   c. Make and FBD for the object at a representative location in the middle of the motion.
   d. Determine which forces are conservative and which are non-conservative.
2) Solve
   a. Calculate the work done by each force, except for conservative forces. Usually, using these shortcuts is the way to go:
      i. If a force and the path are always perpendicular to each other, the work done by that force is zero.
      ii. If a force and the path are always in the same direction, and the magnitude of the force is constant, then the work is $F * d$.
      iii. If a force and the path are always in the opposite direction, and the magnitude of the force is constant, then the work is $-F * d$.
      iv. If a force is of constant magnitude and the angle between the force and the path is always θ, the work is $F * d * \cos(\theta)$.
      v. If a force is of varying magnitude, but the angle between the force and the path is always θ, then the work is $\cos(\theta)\int_A^B F(s) * ds$.
   b. Add up all of the "other" works from above to get the total "other" work.
   c. Break down each term for "E" in the energy conservation equation into kinetic and potential energies. (In some problems you may have both gravitational and elastic potential energy).
   d. Evaluate the initial and final energies using what you know, and add in the "other" work.
   e. Solve for what you don't know!
3) Reflect
   a. Does the answer make sense?
   b. Are the units correct?
   c. Did you use any new techniques?
   d. Any other insights?

1. Technical note: W_{other} really represents work done by two types of forces: forces of any type that are external to the system, and forces that are internal to the system but are dissipative. For our purposes, we will always consider conservative forces to be internal to our systems, with systems implicitly defined to include the bodies involved in creating the conservative forces. This means that we can treat W_{other} as representing the work done by non-conservative forces.

1. A daring 50 kg physics student designs a “person launcher” to get up a tall hill. The launcher is a spring with k = 20,000 N/m. The launcher itself sits 10 m above the floor of a ditch. The launching spring is compressed a distance of 0.75 m from its equilibrium position. The student then sits in front of the launcher, and the launcher is allowed to push him forwards. The student then slides with negligible friction down into the ditch and then up the hill. What height on the hill (above the bottom of the ditch) will the student reach?



2. A device shoots a toy car by compressing a spring a distance of 10 cm from its equilibrium point, and then allowing the spring to push the car as it returns to equilibrium (see figure). The car then continues to move forward unattached to the spring. As it moves, a constant 0.1 N force of kinetic friction acts on the car, eventually bringing the car to rest 6.0 meters from its initial position. (The friction acts even while the car is still in contact with the spring- so it acts over the entire 6.0 m distance the car travels). What is the spring constant of the spring?



5. A clever engineer designs a "sprong" that obeys the force law $\vec{F} = -bx^3\hat{\imath}$, where x = 0 must be the equilibrium position of the sprong. m is the sprong constant.

a) What are the units of b?

b) Find an expression for the potential energy of a stretched or compressed sprong at position d. Recall $\Delta U = -W_{Cons}$

c) A sprong-loaded toy gun shoots a 20g plastic ball. What is the launch speed if the sprong constant is 40,000, with the units you found in part a, and the sprong is compressed 10 cm? Assume the barrel is frictonless.