PHYSICS WORKSHEET 5: CONSERVATION OF ENERGY

For any system with no time-dependent external influences (e.g. an isolated system, or a system in a constant gravitational field), the total ENERGY of the system is unchanging in time.

Like conservation of momentum, this CONSERVATION OF ENERGY principle can be extremely useful for solving problems that would be very difficult using Newton's Laws. For almost any mechanics problem you encounter, it's a good idea to first ask yourself whether you can learn anything by using these conservation laws, even before you write down the equations of motion from Newton's Second Law.

Here are the basic steps:

1. Identify the system you are talking about. Decide which quantities (E, p_x, p_y, p_z) are conserved for this system (see below).
2. Draw a "before" diagram and an "after" diagram.
3. For the initial configuration, write an expression for each conserved quantity in terms the information given and/or any unknowns.
4. Do the same for the final configuration.
5. Equate the conserved quantities before and after and use these equations to solve for the unknowns.

It's important to remember that MECHANICAL ENERGY (kinetic plus potential energy) is only conserved if there is no energy being converted to or from thermal energy (e.g. by friction, chemical reactions, an inelastic collision, or air drag) and if no energy is being transferred to or from the environment. Similarly, momentum is only conserved if there are no external forces acting.

QUESTION 1

A 10.2kg block is dropped from a height of 15cm above the top of a spring with normal length 20cm. If the spring constant is 5000N/m, what is the length of the spring when it is most compressed?

System:

(Useful) conserved quantity/quantities:

Before diagram:

After diagram:

Conservation equations:

QUESTION 2:

A billiard ball of mass m sits on a billiards table near the edge. Another ball of mass M is shot towards the first ball with speed v. Assuming that the collision is elastic and head-on, find a set of equations that determine the velocities of the two balls after the collision.

Challenge question for bonus marks: if M is larger than m, the smaller ball will bounce back and forth between the larger ball and the wall a number of times before the larger ball eventually moves off with a larger speed than the smaller one. If all collisions are elastic, determine the total number of collisions (ball-ball and ball-wall) if $M = m$, $M=100m$, and $M=10000m$ (you will probably need to use Excel). Can you guess the result for $M = 100^N m$?

QUESTION 3:

A bullet with mass 10g is fired into a 2kg weight hanging from a string of length 5m. If the string swings to a 30 degree angle, how fast was the bullet travelling? (*Hint: you need to analyze this problem in two stages)*