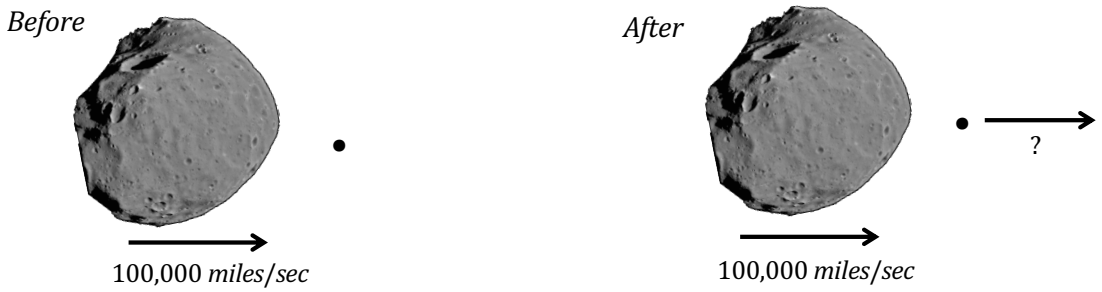
Assignment #5: Mass and Energy

1. A very massive meteor flies past a planet at 100,000 *miles/sec*. In its path lie particles of dust which bounce off of it elastically. Determine the speed of the dust particles with respect to the planet after they are struck by the meteor. (*Hint*: What does an observer on the meteor see?) Consider:
   (a) The case in classical physics;
   (b) The case in relativistic physics.

   Assume the dust particles are hit squarely so that they move in the direction of motion of the meteor.



2. (a) What happens to the mass of a spaceship as the spaceship gets closer and closer to the speed of light?
   (b) How does this prevent any possible rocket motor accelerating the spaceship to the speed of light?
   (c) What does an observer on the spaceship see for the mass of the spaceship when it is traveling at constant speed very close to the speed of light? (It is possible for the spaceship observer to determine this mass by experiment with some simple but delicate measurements.)
   (d) Justify your answer to (c) by appealing to the Principle of Relativity.

3. Consider a completely isolated chamber which contains a gas and a battery-operated electric heater. The electric heater is turned on and energy is transferred as heat to the gas. The gas becomes hotter, which means that its individual molecules move faster. At the same time, the energy of the battery is depleted. During this process:
   (a) What happens to the total energy of the chamber and its contents?
   (b) What happens to the mass of each gas molecule?
   (c) What happens to the mass of the gas?
   (d) What happens to the mass of the battery?
   (e) What happens to the total mass of the chamber and its contents?

   Be sure to explain how you arrived at your answers to (a), (b), (c), (d) and (e).