Physics 101
Sample Midterm 2

1. (20 points) A mass 2 kg collides with a mass of 4 kg. The masses are both going at 3 m/s before they collide, and are moving at right angles to each other. They stick together after the collision, forming a single 6 kg mass. Draw a diagram showing the collision and the direction of the 6 kg mass after the collision. Calculate the final speed of the 6 kg mass after the collision.

2. (20 points) A particle of mass m has initial speed v and collides with a particle of mass $\frac{1}{2}m$ initially at rest. Is it possible for the particle of mass m to transfer all of its momentum to the particle of mass $\frac{1}{2}m$? Is it possible for the particle of mass m to transfer all of its energy to the particle of mass $\frac{1}{2}m$? *Hint:* Think about energy and momentum conservation. The collision may be either elastic or inelastic.

3. (20 points) Consider an electron of mass m and a proton of mass $M \gg m$ that are initially at rest a distance d apart. The electron has charge $-e$ and the proton has mass $+e$. Find a formula for the initial acceleration of the electron in terms of m, M, d, e, and k (the constant in Coulomb's law). Do the same for the proton. Which acceleration is greater?

4. (20 points) Give an example of an experimental result known in the early 1900's that could not be explained by classical physics and required quantum mechanics to account for it. Explain briefly why classical physics failed for this experiment and how quantum mechanics changes the classical picture for this experiment.

5. (20 points) Explain why the special theory of relativity predicts that moving clocks slow down.