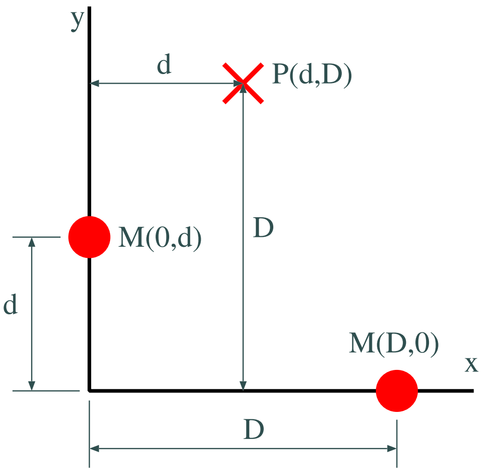
Physics 222 – Test 1 – Spring 2012

One-page reminder sheet allowed. *Show all work – no credit given if work not shown!*

1. Compute the gravitational field vector (in component form) at the point P due to the two equal masses M shown in the diagram below. Express your answer in terms of M, d, and D and the universal gravitational constant.



2. Imagine in an alternate universe that planets revolve around the sun in circular orbits with orbital speed v independent of orbital radius r.

   (a) Compute how the gravitational force F varies with radius, i.e., if $F = AmM/r^n$, find n. The quantities m and M are respectively the masses of the planet and the sun and A is a universal constant.

   (b) Does Gauss's law for gravity work in this alternate universe? Explain. Hint: Is the gravitational flux through a sphere due to a point mass at the center of the sphere independent of the sphere's radius?

3. Suppose that the potential momentum for a particle takes the form $\boldsymbol{Q} = (Cxt, 0, 0)$ where C is a constant.

   (a) Find a form for the potential energy of the particle U which together with $\boldsymbol{Q}$ satisfies the Lorenz condition.

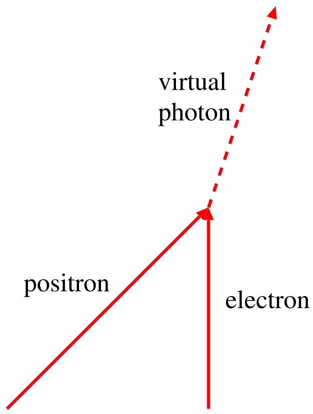
   (b) Given $\boldsymbol{Q}$ and your U, compute the force on the particle.

4. A positron and electron collide and annihilate to produce a virtual photon as shown below. The positron has momentum p and the electron is stationary. Both have mass m.

    (a) Compute the momentum and energy of the virtual photon.

    (b) Use the above results to compute the virtual mass of the virtual photon.

    (c) Compute the proper time that the virtual photon can exist.



5. An electron of mass m and charge e is moving non-relativistically in a circle in a uniform magnetic field of strength B. Derive an equation for the radius of the circle as a function of electron momentum and the magnetic field.

6. A permanent horseshoe magnet as shown below rotates at an angular rotation rate ω around a fixed, square loop of wire of area A as shown below. The magnet produces a magnetic field B inside the loop of wire, with the magnetic field vector rotating with the magnet. If the magnet is oriented with the magnetic field vertically upward at time $t = 0$ as shown, compute the EMF around the loop as a function of time.