Final Make-up Exam - June 13, 2008

Name and Surname:
Student ID:
Department:
Signature:

You should show your work. You will lose points if you do not put the right units and put the vector signs for vectors. For vector quantities, you have to express both the magnitude and the direction.

1. Express each of the units $Volt$, $Farad$, $Ampere$, Ohm in terms of kg (for mass), m(for length), sec(for time) and C (for coulomb). (10 points)

2. The classical radius of the electron is defined as follows: Assume that the electron is a sphere of radius r_e that has its charge uniformly distributed over its surface. Consider the electric field created by this electron (take it to be stationary). This electric field has an energy density. Integrating it over all space gives the total energy of the electric field created by the electron. If one assumes that the mass of the electron is due to only to the energy of the electric field, (i.e. $m_e c^2$ = energy of the electric field), this gives you a radius of the electron. Find this radius. Show explicitly that the final expression of the radius has the correct units. (20 points)

3. Consider a circuit consisting of an inductor with inductance L and a capacitor with capacitance C connected in parallel and then a resistor with resistance R is attached in series. If this circuit is driven by an emf source $\mathcal{E} = \mathcal{E}_0 \sin \omega t$, calculate the currents passing through the capacitor and the inductor separately. Show that the final expression have the correct units. (20 points)

4. Consider a hemispherical shell that has a uniform charge density σ distributed over its axis. Calculate the electric field at any point on the symmetry access. (the symmetry access is the line that passes through the center of the sphere and is perpendicular to the plane whose boundary is the rim of the shell). Show that the final expression have the correct units. (20 points)

5. Consider a U shaped wire and a conducting rod of mass m. The rod is placed on the wire such that the rod and the wire form a rectangle. Assume that this system is placed in a uniform gravitational field such that the rod is parallel to the ground and the rectangle makes an angle θ with the ground. The rod is free to slide on the wire. We have seen in the first term the rod would slide down with an acceleration whose magnitude is given by $a = g \sin \theta$. Assume that this system is put in a uniform magnetic field that is given by $\vec{B} = B_0 \hat{z}$. ($\hat{z}$ points upwards, in the opposite direction of the gravitational acceleration). If the rod is initially moving with a velocity v, write down an equation that will govern

its subsequent motion(15 points). What is the angle θ for which the rod will slide down with constant acceleration?(10 points) (Assume that the total resistance of the rectangle formed by the U shaped wire and the rod is R and is constant.) Show that the expression for the angle θ has the correct units. (5 points) (30 points total)

6. Consider two dipoles $\vec{p}_1$ and $\vec{p}_2$ that are separated by $\vec{r}$, Calculate the electrostatic energy of this system. (Note that $\vec{p}_i$ and $\vec{r}$ need not have any simple orientations) (20 points)