Physics 211 Final Exam

January 23, 2006

Your name:

ID number:

Time given: 120 minutes

Please provide your reasoning for each step of your solution (providing an answer without a solution is not enough)

Problem 1

A uniformly charged rod AB has a length L and an unknown negative charge density λ. Two given positive charges Q and 2Q are located at the points C and D, as shown on the Figure 1. Find the value of λ if $|AC| = |BD| = \frac{L}{2}$ and it is known that the total electrostatic force acting on the charge Q is zero.

Problem 2

A uniformly charged insulating spherical shell has the internal and external radii R and $2R$ and the *volume* charge density ρ, as shown on the Figure 2. Find the potential difference $\Delta V_{OA} = V_A - V_O$ between the points O and A if $|AO| = 3R$.

Problem 3

A spherical capacitor consists of two conducting spheres with the radii R and $3R$ The space between the spheres is partially filled with the dielectric having the form of the spherical shell with the internal and external radii R and $2R$, as shown on the Figure 3. The dielectric constant of the shell is $\kappa = 2$. Calculate the capacitance of this capacitor.

Problem 4

A circuit shown on the Figure 4 consists of a battery with the voltage ΔV, two resistors R and $2R$ and a capacitor C. A switch S is closed at the initial time moment $t = 0$. Find the voltage between the plates of the capacitor as a function of time.

Problem 5

A closed conducting loop carrying constant electric current I consists of the circular arc of radius R with the angle $\alpha = \frac{\pi}{3}$ and the straight piece AB (see the Figure 5). Find the magnitude and the direction of the magnetic field $\vec{B}$ at the center O of the circle.

Problem 6

A circuit shown on the Figure 6 consists of the battery ΔV, the inductor L and the resistor R. The switch S is connected at the initial moment $t = 0$ and then disconnected at the moment $t = T$ (T is given).

a)Find the energy stored by the magnetic field of the inductor as a function of time t (both for $t \leq T$ and for $t \geq T$)

b)Calculate the total energy dissipated in the resistor starting from $t = 0$.

Problem 7

The LC-contour shown on the Figure 7 consists of the solenoid L and the capacitor C. The solenoid L has n turns per unit length. Initially, the switch is disconnected and the charge between the capacitor's plate is equal to Q_0. Inside the solenoid there is a circular coil with the total number N of the turns. The center of the coil lies on the symmetry axis of the solenoid and the symmetry axis of the coil is at the angle $\alpha = \frac{\pi}{4}$ with the symmetry axis of the solenoid. The coil has the radius r and the total resistance R. The switch of the LC-contour is connected at the moment $t = 0$.

a)Find the induced emf and the induced current in the coil as the functions of time.

b)Find the torque acting on the coil in the magnetic field of the solenoid as the function of time.

Energy losses due to the coil's resistance can be neglected.