

### Make-up Exam - June 16, 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. Explain the processes that lead to paramagnetism, diamagnetism and ferromagnetism in a magnetic material. (20 points)
2. Consider a sphere that carries a uniform charge distribution over all its volume  $V$ . Assume that the charge density of the sphere is given by  $\sigma$ . Starting from the Gauss law for electrostatics, calculate the electric field at an arbitrary point in space. (The point can be inside or outside the sphere. Obtain an expression for both cases. Note also that to calculate the electric field, which is a vector, means to obtain the magnitude *and* the direction). (20 points)
3. Consider a driven RLC circuit that contains a resistor with resistance  $R$ , a capacitor with capacitance  $C$  and an inductor with inductance  $L$  all connected in parallel. Assume that the driving emf is given by  $\mathcal{E} = \mathcal{E}_{max} \sin \omega t$ . (30 points total)
  - (a) Calculate the current passing through each of the circuit elements (15 points).
  - (b) What is the maximum current that flows through the circuit? (10 points)
  - (c) Does there exist a value of  $\omega$  such that the maximum current that flows in the circuit obtains the maximum value, i.e. does there exist a value of  $\omega$  for which there is a resonance? (5 points)
4. Consider a wire that carries a current  $I$  running from  $x = +\infty$  to the origin along the  $x$ -axis and then from the origin, the current goes to  $y = +\infty$  along the  $y$ -axis. Calculate the magnetic field at the point  $(x_0, y_0)$  on the  $xy$ -plane. Assume  $x_0 > 0$  and  $y_0 > 0$  (20 points)
5. Consider a circular wire of radius  $R$ . Calculate the self inductance of the wire. (20 points)