2nd Midterm - November 25, 2010

Name and Surname:
Student ID:
Department:
Signature:

You should show your work. You will lose points if you do not show your work. The question might contain less or more than enough information. If the question does not contain all the necessary informations, you are supposed to make realistic assumptions. You will lose points if you make unnecessary assumptions.

Discussion

Answer the following question with words only. You do not need to give a quantitative answer, a qualitative answer is enough. You will lose points if you use equations.

1. Suppose you take very thin square sheets of a good conductor covered by infinitely thin insulators and pile them one on top of the other to make a large cube. Due to the insulator covering, current can not run from one sheet to the other one. If you send am EM wave into this pile

(a) If \( \vec{k} \) is perpendicular to the sheets, what can you say about the transmitted intensity? (10 points)

(b) If \( \vec{k} \) is perpendicular to the side of the cube that is not parallel to the surface of the sheets, what can you say about the polarization of the transmitted wave? (10 points)

2. Suppose you put a pencil inside a glass filled with water (only half is immersed under the water). What will be the shape of the pencil that you see? If, instead of water, you use a material that has a negative index of refraction, what will you see? (Materials that have a negative index of refraction are called meta materials.) (15 points)

Short Questions

You can give short answers in the following questions. You do not need to show your work in detail.

3. Consider an infinite wire that is has a uniform charge density. What is the electric field created by this wire? (10 points)

4. Consider an infinite surface that has a uniform surface current density. What is the magnetic field created? (10 points)
5. Suppose you put a infinite wire that carries a current $I$ into a uniform magnetic field such that the current is perpendicular to the magnetic field. Draw the magnetic field lines. (After you place the current the magnetic field is no longer uniform in the vicinity of the wire. (15 points)

**Explicit Calculations:**

6. Consider a resonant cavity that is in the shape of a cube of side length $L$. Derive an expression for the allowed frequencies in the cavity. (20 points)

7. Suppose you have a material whose conductivity tensor is given by

$$
\sigma = \sigma_0 \begin{pmatrix}
1 & 1 & 0 \\
1 & 1 & 0 \\
0 & 0 & 0
\end{pmatrix}
$$

, and it fills half of the space, i.e. $z > 0$ For simplicity, assume that $\mu = \epsilon = 1$.

(a) If you send a monochromatic EM wave of arbitrary polarization perpendicular to the interface $x = 0$, calculate the EM wave inside the material. What can you say about the polarization of the wave inside the material at a distance sufficiently far from the interface? (10 points)

(b) How can you physically construct such a material? (10 points)

(c) What changes if the conductivity tensor is

$$
\sigma = \sigma_0 \begin{pmatrix}
1 & -i & 0 \\
i & 1 & 0 \\
0 & 0 & 0
\end{pmatrix}
$$

(10 points)