NATIONAL UNIVERSITY OF SINGAPORE

PC2131, Electricity and Magnetism I

(Semester II: AY 2012-13)

Time Allowed: 2 Hours

INSTRUCTIONS TO CANDIDATES

1. This examination paper contains **4** questions. It comprises **2** printed pages (including this).
2. Answer all the questions.
3. Use separate pages for separate questions.
4. Present your solutions in a clear and comprehensible manner.
5. Each question is worth 10 points.
6. This is a CLOSED BOOK examination. Students are allowed to bring in an A4-sized (both sides) sheet of notes.
7. A non-programmable calculator is allowed.

QUESTIONS:

1. Consider a cylinder of length L and radius R carrying a uniform and constant current I.

a) Determine the electric and magnetic fields on the surface of the cylinder.

b) Show that the integral $\int_A \vec{S} \cdot d\vec{A}$, where $\vec{S}$ is the Poynting vector, is equal to the thermally dissipated power ($P = VI$) in the wire.

2. Consider a ball with radius R carrying a uniform charge density ρ inside the ball. The ball is made from a material with dielectric constant ϵ_r (i.e. the material is linear $\vec{D} = \epsilon_0 \epsilon_r \vec{E}$).

a) Determine the potential difference ΔV between the centre and surface of the sphere.

b) Calculate the energy stored in the electric field.

3. Consider a long wire with radius R carrying a uniformly distributed current I. The relative permeability of the wire material is μ (i.e. the material is linear $\vec{B} = \mu_0 \mu \vec{H}$).

a) Calculate $\vec{H}$ and $\vec{B}$-fields inside and outside the wire.

b) Determine the bound currents inside the wire and at the surface.

c) What is the total bound current along the wire?

4. Consider a capacitor made from two circular disks with radius R separated a distance d from each other. The capacitance of this capacitor is $C = \frac{\epsilon_0 \pi R^2}{d}$. The capacitor is charged to a voltage V_0 and connected to a resistor with resistance R and discharged. This gives a time-dependent electric field $\vec{E}(t) = \frac{V_0}{d} e^{-\frac{t}{RC}} \hat{z}$ between the disks.

a) Determine the displacement current and the magnetic field $\vec{B}(r)$ between the disks.

b) Determine the Poynting vector at the rim ($r = R$). What does it represent?

c) Calculate how much energy is removed from the region between the disks during the discharge?

END OF PAPER

BH