6^{th} HOMEWORK

Due April 29, 2009

1. Consider a very long selanoid that has a loop of conducting wire outside. We had discussed in the class that outside the selanoid, there is no magnetic field, and hence the outside loop doe not feel any magnetic field. But at the same time, we know that if the magnetic field inside selanoid changes, there should be an emf generated in the loop. How is this possible? What is wrong in our arguments?

2. Calculate the averages of the following functions over one full period.

   (a) $\sin^2 \omega t$

   (b) $\sin \omega t \cos \omega t$

   (c) $\sin \omega t \cos(\omega t + \phi)$

   (d) $\sin \omega t \sin(\omega t + \phi)$

   (e) $\sin 2\omega t \cos(3\omega t + \phi)$

   (f) $\sin 2\omega t \sin 3\omega t$

3. A parallel-plate capacitor with circular plates of area A separated by a distance d. A thin straight wire of length d lies along the axis of the capacitor and connects the two plates; this wire has a resistance R. The external terminals of the plates are connected to a source of alternating emf with a voltage $V = V_0 \sin \omega t$.

   (a) What is the current in the thin wire?

   (b) What is the displacement current through the capacitor?

   (c) What is the current arriving at the outside terminals of the capacitor?

   (d) What is the magnetic field between the capacitor plates at a distance r from the axis? Assume that r is less than the radius of the plates.

4. A parallel-plate capacitor has circular plates of radius 20 cm and a uniform electric field between the plates. The capacitor is being charged at a rate of 0.10 A.

(a) What is the net displacement current between the plates?

(b) What is the displacement current between the plates within the radial interval $0 \leq r \leq 5\ cm$

5. Suppose that the parallel-plate capacitor discussed in the class is filled with a slab of dielectric with a dielectric constant κ

   (a) By retracing the arguments we made in the class, show that the displacement current must be

   $$I_d = \kappa \epsilon_0 \frac{d\Phi}{dt} \tag{1}$$

   and Maxwell's modification of Ampere's Law must be

   $$\oint \vec{B} \cdot d\vec{l} = \mu_0 I + \kappa \mu_0 \epsilon_0 \frac{d\Phi}{dt} \tag{2}$$

   (b) What is the magnetic field inside the parallel plate capacitor?

6. Write Maxwell's equations for a medium of dielectric constant κ and relative permeability κ_m

7. A power station feeds $1.0 \times 10^8\ W$ of electric power at $760\ kV$ into a transmission line. Suppose that 10% of this power is lost in Joule heat in the transmission line. What percentage of the power would be lost if the power station were to feed $340\ kV$ into the transmission line instead of $760\ kV$, other things being equal?