PRINCE OF SONGKLA UNIVERSITY
FACULTY OF ENGINEERING

Final Examination: Semester II	Academic Year: 2009
Date: Feb 22, 2010	Time: 9.00-12.00
Subject: 210-251 Electromagnetic Field Theory	Room: หัวหุ่นยนต์
210-351 Electromagnetic Field Theory	Room: หัวหุ่นยนต์

Instructions:

a. Allow a student to open his/her own note (**one A4-size paper**) during the exam

b. Allow the student to use his/her own calculator and dictionary

Do all four problems

1. Faraday's law

1.1 The armature of a 60 Hz ac generator rotates in a 0.15 T magnetic field. If the area of the coil is $2x10^{-2}$ m^2, how many loops must the coil contain if the peak output is to be ε_{max} = 170 V?

1.2 The rectangular loop shown in Figure 1 has a constant width *l*, but its length *x* increases with time as a conducting bar slides at a uniform velocity *v* in a static magnetic field **B**. Find the motional emf.

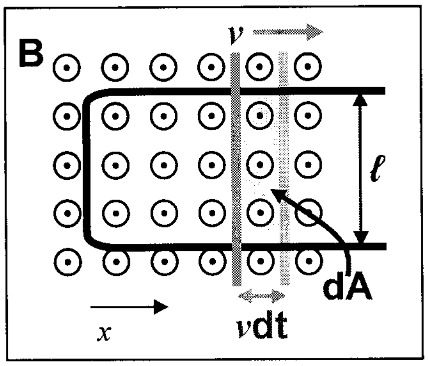

Figure 1 Sliding bar

(25 points)

2. The magnetic field intensity is given in the square region $x=0$, $0.5<y<1$, $1<z<1.5$ by $\mathbf{H} = z^2\mathbf{a}_x + x^3\mathbf{a}_y + y^4\mathbf{a}_z$ A/m.

a) Evaluate $\oint \mathbf{H}\cdot d\mathbf{L}$ about the perimeter of the square region

b) Find $\nabla \times \mathbf{H}$.

c) Calculate $(\nabla \times \mathbf{H})_x$ at the center of the region.

d) Does $(\nabla \times \mathbf{H})_x = \left(\oint \mathbf{H}\cdot d\mathbf{L}\right)/\text{Area enclosed}$?

(25 points)

3. In free space, where $\varepsilon = \varepsilon_0, \mu = \mu_0, \sigma = 0, \rho_v = 0$ and $\mathbf{J} = 0$, assume a Cartesian coordinate system in which **E** and **H** are both functions only of z and t.

a) If $\mathbf{E} = E_y\mathbf{a}_y$ and $\mathbf{H} = H_x\mathbf{a}_x$, begin with Maxwell's equations and determine the second-order partial differential equation that E_y must satisfy.

b) Let $E_y = 5(300t + bz)^2$ be a solution of the equation in a) for a particular value of b. Find the value of b.

(25 points)

4. Poynting vector

a) Find the Poynting vector, $P(\mathbf{r},t)$ if $E_s = 400e^{-j2x}\mathbf{a}_y$ V/m in free space

b) Find P at t=0 for $\mathbf{r}$=(a, 5, 10), where a = 0, 1, 2, and 3.

c) Find P at the origin for t = 0, 0.2T, 0.4T and 0.6T, where T is the oscillation period.

(25 points)

List of vector identities

$$(\mathbf{A}\times\mathbf{B})\cdot\mathbf{C}=(\mathbf{B}\times\mathbf{C})\cdot\mathbf{A}=(\mathbf{C}\times\mathbf{A})\cdot\mathbf{B} \tag{A.6}$$

$$\mathbf{A}\times(\mathbf{B}\times\mathbf{C})=(\mathbf{A}\cdot\mathbf{C})\mathbf{B}-(\mathbf{A}\cdot\mathbf{B})\mathbf{C} \tag{A.7}$$

$$\nabla\cdot(\mathbf{A}+\mathbf{B})=\nabla\cdot\mathbf{A}+\nabla\cdot\mathbf{B} \tag{A.8}$$

$$\nabla(V+W)=\nabla V+\nabla W \tag{A.9}$$

$$\nabla\times(\mathbf{A}+\mathbf{B})=\nabla\times\mathbf{A}+\nabla\times\mathbf{B} \tag{A.10}$$

$$\nabla\cdot(V\mathbf{A})=\mathbf{A}\cdot\nabla V+V\nabla\cdot\mathbf{A} \tag{A.11}$$

$$\nabla(VW)=V\nabla W+W\nabla V \tag{A.12}$$

$$\nabla\times(V\mathbf{A})=\nabla V\times\mathbf{A}+V\nabla\times\mathbf{A} \tag{A.13}$$

$$\nabla\cdot(\mathbf{A}\times\mathbf{B})=\mathbf{B}\cdot\nabla\times\mathbf{A}-\mathbf{A}\cdot\nabla\times\mathbf{B} \tag{A.14}$$

$$\nabla(\mathbf{A}\cdot\mathbf{B})=(\mathbf{A}\cdot\nabla)\mathbf{B}+(\mathbf{B}\cdot\nabla)\mathbf{A}+\mathbf{A}\times(\nabla\times\mathbf{B})+\mathbf{B}\times(\nabla\times\mathbf{A}) \tag{A.15}$$

$$\nabla\times(\mathbf{A}\times\mathbf{B})=\mathbf{A}\nabla\cdot\mathbf{B}-\mathbf{B}\nabla\cdot\mathbf{A}+(\mathbf{B}\cdot\nabla)\mathbf{A}-(\mathbf{A}\cdot\nabla)\mathbf{B} \tag{A.16}$$

$$\nabla\cdot\nabla V=\nabla^2 V \tag{A.17}$$

$$\nabla\cdot\nabla\times\mathbf{A}=0 \tag{A.18}$$

$$\nabla\times\nabla V=0 \tag{A.19}$$

$$\nabla\times\nabla\times\mathbf{A}=\nabla(\nabla\cdot\mathbf{A})-\nabla^2\mathbf{A} \tag{A.20}$$