Seat Number

King Mongkut's University of Technology Thonburi
Final Examination
Semester 1 -- Academic Year 2015

Subject: EIE 325 Electromagnetic fields and waves

For: Electronic and Telecommunication Engineering, 3rd Yr (Inter. Program)

Exam Date: Tuesday December 1, 2015 **Time:** 9.00am-12.00 pm.

Instructions:-

1. This exam consists of 5 problems with a total of 11 pages, including the cover.
2. This exam is closed books.
3. Answer each problem on the exam itself.
4. A calculator compiling with the university rule is allowed.
5. A dictionary is **not** allowed.
6. **Do not** bring any exam papers and answer sheets outside the exam room.
7. Open Minds ... No Cheating! GOOD LUCK!!!

Remarks:-

- **Raise your hand when you finish the exam to ask for a permission to leave the exam room.**
- **Students who fail to follow the exam instruction might eventually result in a failure of the class or may receive the highest punishment with university rules.**
- **Carefully read the entire exam before you start to solve problems. Before jumping into the mathematics, think about what the question is asking. Investing a few minutes of thought may allow you to avoid twenty minutes of needless calculation!**

Exam No.	1	2	3	4	5	TOTAL
Full Score	20	20	20	20	20	100
Graded Score						

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This examination is designed by
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This examination has been approved by the committees of the ENE department.

R. Silapunt

(Assoc. Prof. Rardchawadee Silapunt, Ph.D.)
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Formula sheet

1. Ampère's law

   1.1 Integral form $\oint \vec{H} \cdot d\vec{L} = I_{en}$

   1.2 Point form $\nabla \times \vec{H} = \vec{J}$

   where J = surface current density (A/m^2)

2. Magnetic flux density $B = \mu H$ Tesla

3. Magnetic field intensity of the surface current sheet $\vec{H} = \frac{1}{2}\vec{K} \times \hat{a}_n$

where K = current per cross-sectional width (A/m)

$\hat{a}_n$ = a unit vector from the current sheet to the observation point

4. Inductance:

   4.1 Self inductance $L = \frac{N\phi}{I}$ Henry

   where N = number of turns

   magnetic flux $\phi = \int_S \vec{B} \cdot d\vec{S}$ Wb

   4.2 Mutual inductance $M_{12} = \frac{N_2\phi_{12}}{I_1} = M_{21} = \frac{N_1\phi_{21}}{I_2}$ Henry

   where N_1 = number of turns of coil 1

   N_2 = number of turns of coil 2

   ϕ_{12} = the flux produced by coil 1 which links the path of the coil 2 (Wb)

   ϕ_{21} = the flux produced by coil 2 which links the path of the coil 1 (Wb)

   I_1 = current applied to coil 1 (A)

   I_2 = current applied to coil 2 (A)

5. Stationary electromotive force $emf = -N\frac{d\phi}{dt} = -N\frac{d\int_S \vec{B}\cdot d\vec{S}}{dt}$ Volt

6. Uniform plane wave

   6.1 EM wave properties in lossless media

   6.1.1 Phase constant $\beta = \omega\sqrt{\mu\varepsilon}$ rad/m

   6.1.2 Attenuation constant $\alpha = 0$ Np/m

   6.2 Magnetic field intensity $\vec{H} = \frac{1}{\eta}\hat{a}_\rho \times \vec{E}$ A/m

   where $\hat{a}_\rho$ = the direction of wave propagation

   6.3 Power transmission: $\vec{P}_{avg} = \frac{1}{2}Re\left[\vec{E} \times \vec{H}^*\right]$ W/m^2

   6.3.1 Incident power density: $\vec{P}_{avg}^{+} = \frac{1}{2}Re\left[\vec{E}^{+} \times \vec{H}^{+*}\right]$ W/m^2

   6.3.2 Reflected power density: $\vec{P}_{avg}^{-} = \frac{1}{2}Re\left[\vec{E}^{-} \times \vec{H}^{-*}\right]$ W/m^2

   6.4 Reflection coefficient: $\Gamma = \frac{\eta_2-\eta_1}{\eta_2+\eta_1}$

   6.5 Transmission coefficient: $\tau = \frac{2\eta_2}{\eta_2+\eta_1} = 1 + \Gamma$

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7. Free space permittivity ε_0 = 8.854x10^{-12} F/m
8. Free space permeability μ_0 = 4πx10^{-7} H/m

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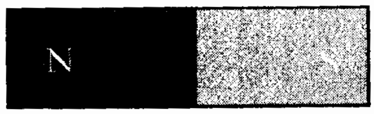
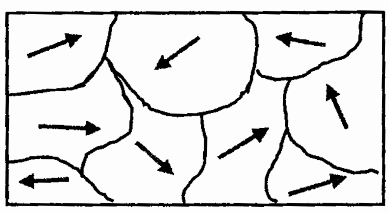
1. Theory and concepts: (20 pts)

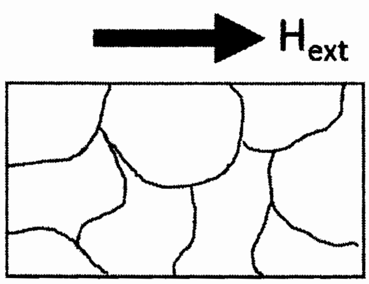
(a) A magnet bar shown below is cut in half. Draw flux lines inside and outside each magnet bar, and flux lines between them.



(b) The ferromagnetic bar has random dipole moments as shown below.



Draw the directions of dipole moments if the bar is placed in a magnetic field that has a direction shown below.



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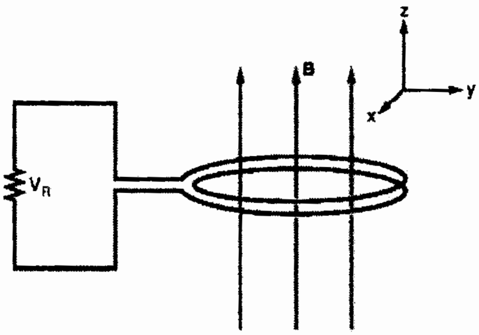
(c) A conducting loop is placed in a magnetic field whose flux density is $\vec{B} = 10^5\cos(100\pi t)\,\hat{a}_z$ T. Draw the voltage polarity across the resistor at t = 5 ms.



d) There are a few methods to make a temporary magnet from an iron nail. Name 1 method and explain how it works, briefly.

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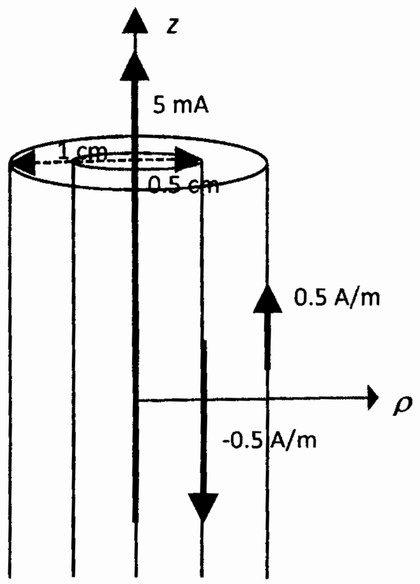
2. A current filament on the z axis carries a current of 5 mA in the $\hat{\boldsymbol{a}}_{\boldsymbol{z}}$ direction and current sheets of $-0.5\hat{\boldsymbol{a}}_{\boldsymbol{z}}$ A/m and $0.5\hat{\boldsymbol{a}}_{\boldsymbol{z}}$ A/m are located at ρ = 0.5 cm and ρ = 1 cm, respectively. Calculate $\vec{H}$ at (20 pts)



(a) ρ = 0.5 cm (5 pts)

(b) ρ = 2 cm (5 pts)

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(c) ρ = 4 cm (5 pts)

(d) What current sheet located at ρ = 4 cm should be so that $\vec{H}$ = 0 for all ρ > 4 cm? (5 pts)

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3. A solenoid is 20 cm long with 2 cm diameter contains 1,000 turns. The cylindrical core has a diameter of 2 cm and a relative permeability μ_r = 50. This coil is coaxial with a second solenoid, also 20 cm long, but with a 3 cm diameter and 1,200 turns. Calculate (20 pts)

(a) Inductance *L* for the inner solenoid (7.5 pts)

(b) Inductance *L* for the outer solenoid (7.5 pts)

c) Mutual inductance *M* between two solenoids. (5 pts)

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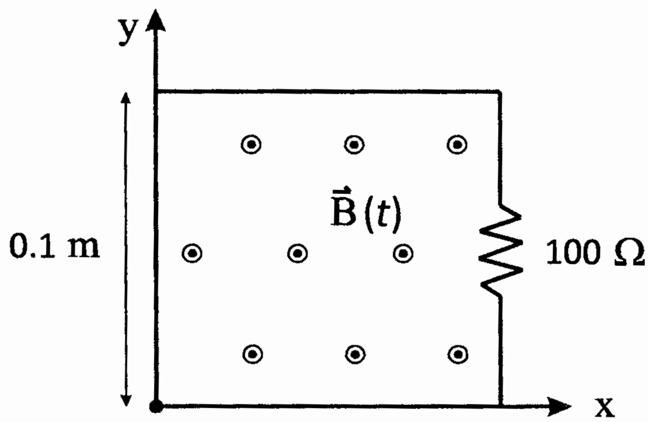
4. A perfectly conducting filament containing a small 100 Ω resistor is formed into a square of 0.1 m x 0.1 m as shown below. Find $I(t)$ if (20 pts)



(a) $\vec{B} = \cos(10\pi t - 60^\circ)\, \hat{a}_z$ μT (10 pts)

(b) $\vec{B} = \cos(10\pi t - 2.5x)\, \hat{a}_z$ μT (10 pts)

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5. Uniform plane wave (UPW): The plane y = 0 defines the boundary between two lossless dielectrics. For y < 0, ε_{r1} = 1 and $\mu_1 = \mu_0$. For y > 0, ε_{r2} = 5 and $\mu_2 = \mu_0$. Let $E_{z1}^{+} = 150cos(\omega t - 8y)$ V/m and find (20 pts)

(a) ω (5 pts)

(b) $\vec{P}_{avg,1}^{+}$ (5 pts)

(c) $\vec{P}_{avg,1}^{-}$ (5 pts)

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(d) $\vec{P}^{+}_{avg,2}$ (5 pts)