KING FAHD UNIVERSITY OF PETROLEUM AND MINERALS

ELECTRICAL ENGINEERING DEPARTMENT

SECOND SEMESTER 2007/2008

EE 340 (04) MAJOR EXAM II

TIME: 11:00 -11:50 A.M.

DATE: MONDAY 19-MAY-2008

LOCATION: IN CLASS

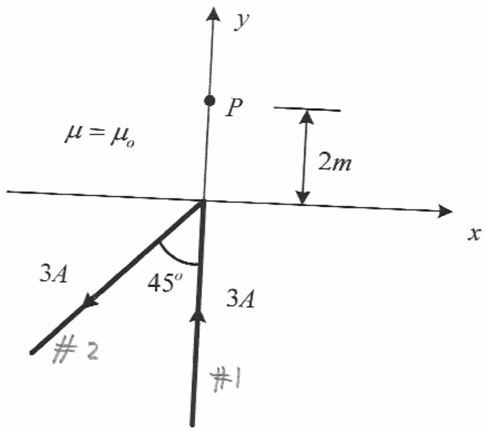
Student's Name:..

Student's I.D. Number: ....

	Maximum Score	**Score**
Problem 1	**25**	
Problem 2	**25**	
Problem 3	**25**	
Problem 4	**25**	
Total	**100**	

Problem 1 [25 points]

Consider the infinitely long filamentary conductor shown in the given figure. The conductor is located entirely in the $x-y$ plane and carries $3A$ of D.C. current. As shown in the figure, the conductor makes a sharp turn at the origin. Calculate the resulting magnetic flux density *vector* at point P located on the y axis, 2m from the origin.



$\vec{H}_1 = \vec{0}$, because $\vec{dl} \times \vec{R} = \vec{0}$ $(\vec{dl} \parallel \vec{R})$

$$\vec{H}_2 = -\vec{a}_z \frac{3}{4\pi\sqrt{2}}\left[\cos 0^\circ - \cos 45^\circ\right]$$

$$= -\vec{a}_z \; 0.04944 \; A/m$$

$$\therefore \vec{B} = \mu_o \vec{H} = -62.13 \times 10^{-9} \vec{a}_z \; (T)$$

Problem 2 [25 points]

Consider two semi-infinite media. Medium 1 ($x > 0$) is free space and medium 2 ($x < 0$) is a magnetic medium with a relative permeability of 100. The boundary $x = 0$ has no surface current. The magnetostatic field $\vec{B}_1 = 2\vec{a}_x - 5\vec{a}_y + 6\vec{a}_z$ $[Wb/m^2]$ exists in air. Calculate the magnetostatic field $\vec{B}_2$ in medium 2, at the boundary.

$$\vec{B}_{2n} = \vec{B}_{1n} = 2\vec{a}_x$$

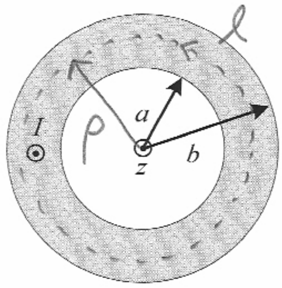
$$\vec{H}_{1t} = \vec{H}_{2t} \Rightarrow \frac{\vec{B}_{1t}}{\mu_1} = \frac{\vec{B}_{2t}}{\mu_2}$$

$$\therefore \vec{B}_{2t} = \frac{\mu_2}{\mu_1}\vec{B}_{1t} = 100\left(-5\vec{a}_y + 6\vec{a}_z\right)$$

$$\therefore \vec{B}_2 = 2\vec{a}_x - 500\vec{a}_y + 600\vec{a}_z \quad (T).$$

Problem 3 [25 points]

Consider an infinitely long, hollow cylindrical conductor with an inner radius a and outer radius b. As shown in the figure, the conductor carries D.C. current I in the z direction. *Derive* an expression for the magnetic field $\vec{H}$ *inside* the conductor (i.e. in the region $a < \rho < b$).



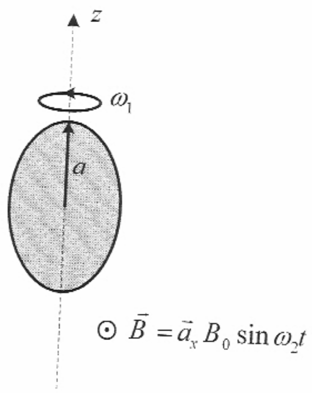
$$\oint \vec{H} \cdot \vec{d\ell} = I$$

$$H\, 2\pi\rho = JS = \frac{I}{\pi(b^2-a^2)} \cdot \pi(\rho^2-a^2)$$

$$\therefore \quad \vec{H} = \frac{I(\rho^2-a^2)}{2\pi\rho(b^2-a^2)} \vec{a}_\phi \qquad (a < \rho < b)$$

Problem 4 [25 points]

Consider a circular conducting loop of radius a. As shown in the figure, the loop rotates around the z – axis with angular frequency ω_1. At $t = 0$, the entire area of the loop lies in the $x - y$ plane. The rotating loop is placed in the uniform time-varying magnetic field $\vec{B} = \vec{a}_x B_0 \sin \omega_2 t$, where B_0 is the amplitude and ω_2 is the angular frequency of the magnetic field. Develop an expression for the emf induced in the loop.



$$\Psi = BS \cos \alpha \quad , \quad \alpha = \omega_1 t$$

$$= (B_0 \sin \omega_2 t)(\pi a^2)(\cos \omega_1 t)$$

$$\therefore \quad emf = -\frac{d\Psi}{dt}$$

$$= B_0 \pi a^2 \left[\omega_1 \sin \omega_2 t \sin \omega_1 t - \omega_2 \cos \omega_2 t \cos \omega_1 t \right] \quad [V]$$