Name: SOLUTION

Student ID: ....

Problem	points	max
1		12
2		4
3		8
4		4
Total		28

EE1 - Winter 11: QUIZ 2

Thursday, February 17, 2011

Answer ALL 4 questions. Write your answers directly onto this handout. Show all your work. You are allowed to use your 3"x5" index card as cheat-sheet and a calculator.

Problem 1 (Concepts)

(12/28)

[1] You place a negative charge a distance ρ from a wire carrying a current I. What will happen to the charge ?

(a) it will circle the wire clockwise

(b) it will circle the wire counter-clockwise

(c) it will move parallel to the wire

(d) it will move radially outwards away from the wire

(e) it will stay where it is

[2] Mark all materials that will be repelled by a bar-magnet

(a) aluminum ($\mu_r = 1.000022$)

(b) water ($\mu_r = 0.999992$)

(c) super-conductors ($\mu_r = 0$)

(d) bismuth ($\mu_r = 0.999834$)

(e) iron ($\mu_r = 3000$)

[3] Two current carrying wires are crossed and exactly perpendicular to each other. What will happen ?

(a) Since the wires are not parallel nothing will happen

(b) The wires will repel each other

(c) The wires will torque to align to each other, then repel each other

(d) can't tell

[4] Electrons in a conductor move at a velocity that

(a) is proportional to the electric field

(b) is independent of the electric field since there is no E inside a conductor

(c) only depends on the material (i.e. mobility)

(d) depends on the charge density

[5] Which of the following will create a homogeneous magnetic field ?

(a) a straight bar magnet

(b) an infinitely long perfectly cylindrical wire

(c) a current carrying circular loop

(d) An infinite current sheet

(e) two aligned bar-magnets in a small gap between the magnets

[6] A magnetic dipole in an inhomogeneous magnetic field with an angle of 45^o between dipole axis and field direction experiences

(a) A net torque but no net force

(b) both a net torque and a net-force

(c) neither a net torque nor a net-force

(d) Need to know both angles to answer this question

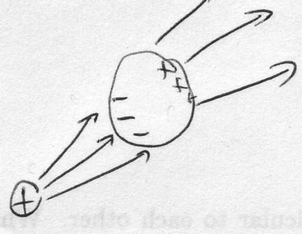
[7]A magnetic dipole in the field of a second magnetic dipole experiences

(a) both a net torque and a net force

(b) only a net torque

(c) no force at all since it is at rest

[8] You place a conducting sphere inside an existing electric field from a point-charge. Draw a sketch of the field lines and describe in words what happens to the electric field inside and outside of the conductor.



- charge separation

=> no charge inside conductor

- field lines end and start on surface charges

- field outside conductor does not change

[9] If you fill an initially empty space that is immersed in an electric field with water, what will happen to the electric field in this space ?

(a) It will refract

(b) It will decrease

(c) It will increase

(d) It will be expelled completely

(e) It will stay the same

[10] A plate capacitor is charged to 2 kV and then disconnected from the power-supply. Which of the following will lead to an increase in voltage across the plates ?

(a) Moving the plates further apart

(b) Filling the space between the plates with a dielectric

(c) Filling the space between the plates with a conductor

(d) Filling half of the space between plates with a conductor so there is no electric contact with the plates

(e) None of the above. The only way to change the voltage is by reconnecting to the power-source and changing the charging voltage.

[11] Which of the following current carrying systems creates the largest magnetic field at a fixed distance ρ from the center, assuming the total current through all systems is the same:

(a) an infinitely long and infinitely thin wire

(b) a solid cylindrical conductor with radius ρ

(c) a hollow cylindrical conductor shell with infinitely thin shell thickness and radius ρ

(d) three hollow shells with radius $\rho/3$, $\rho/2$, and ρ, each carrying $I/3$

(e) they all create the same magnetic field

[12] Explain in your own words what happens when a strong magnet is brought near a piece of iron and why.

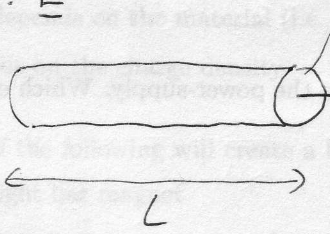
- magnetic dipols align, creating a magn. field in the same direction as the external field.

Problem 2

(4/28)

Use Ohm's law in its general (vector) form to find the well-known relation between voltage and current in a conductor.

$\underset{\sim}{J} = \sigma \cdot E$



$V = -\int E \, dl = E \cdot L$

$I = J \cdot S \quad , \quad J = \frac{I}{S}$ (1)

$\Rightarrow J = \sigma \cdot E \quad \text{or} \quad \frac{I}{S} = \sigma \cdot \frac{V}{L}$ (1)

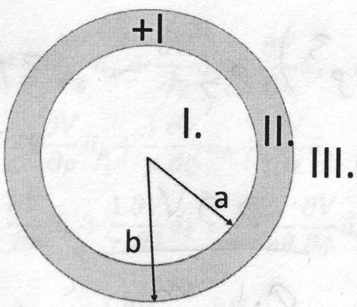
$I = \frac{S \cdot \sigma}{L} V \Rightarrow I = \frac{V}{R}$ (1)

$\frac{S \cdot \sigma}{L} =: \frac{1}{R}$

Problem 3

(8/28)

A current I is sent through a hollow cylindrical conducting shell with inner radius a and outer radius b. (a) Find the vector magnetic field in all three regions:
(I) inside the shell ($\rho < a$)
(II) within the conducting shell ($a < \rho < b$), and
(III) outside the shell ($\rho > b$).
(b) Draw a sketch of H as a function of ρ.



$\oint \underline{H}\, d\underline{l} = I_{end}$

$\underline{H} = H_\phi \cdot \underline{a}_\phi$ ①

$d\underline{l} = \rho\, d\phi\, \underline{a}_\phi$ ①

$\oint \underline{H}\, d\underline{l} = \oint H_\phi \rho\, d\phi = H_\phi \rho \oint d\phi = 2\pi\rho H_\phi$ (with $\oint d\phi = 2\pi$)

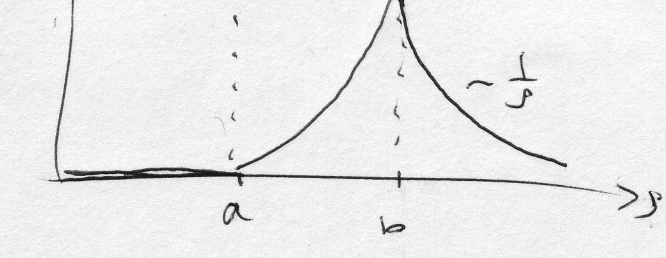
↑ because $H_\phi = H_\phi(\rho)$

$H_\phi = \frac{I_{end}}{2\pi\rho}$ everywhere, $\underline{H} = \frac{I_{end}}{2\pi\rho}\, \underline{a}_\phi$ ①

I: $I_{end} = 0 \Rightarrow \underline{H} = 0$ ①

II: $I_{end} = I \cdot \frac{(\pi\rho^2 - \pi a^2)}{(\pi b^2 - \pi a^2)}$ ① $\Rightarrow \underline{H} = \frac{I}{2\pi(b^2 - a^2)} \frac{(\rho^2 - a^2)}{\rho}\, \underline{a}_\phi$ ①

III: $I_{end} = I \Rightarrow \underline{H} = \frac{I}{2\pi\rho}\, \underline{a}_\phi$ ①



Problem 4

(4/28)

A solid, cylindrical conductor has a conductivity σ that varies with radius. The magnetic field within the conductor is $\vec{H} = \pi\rho^2 \vec{a_\phi}$ A/m, when a voltage of 9 V is applied across the 10 cm long conductor. Find σ as a function of ρ.

$$\underline{J} = \underline{\nabla} \times \underline{H} = \frac{1}{\rho}\frac{d}{d\rho}(\rho H_\phi)\, \underline{a}_z \quad (1)$$

$$= \frac{1}{\rho}\frac{d}{d\rho}(\pi\rho^3)\, \underline{a}_z = 3\pi\rho\, \underline{a}_z \ \frac{A}{m^2} \quad (1)$$

with $$E = \frac{V}{L} = \frac{0.9\,V}{0.1\ m} = 90\ \frac{V}{m} \quad (1)$$

we get

$$\sigma = \frac{J}{E} = \frac{3\pi\rho}{90}\ \frac{S}{m} = \frac{\pi\rho}{30}\ \frac{S}{m} \quad (1)$$