PH45 230 MIDTERM 2 SOLUTIONS F04

A. MULTIPLE-CHOICE QUESTIONS. CIRCLE THE BEST ANSWER. (6 Pts. each):

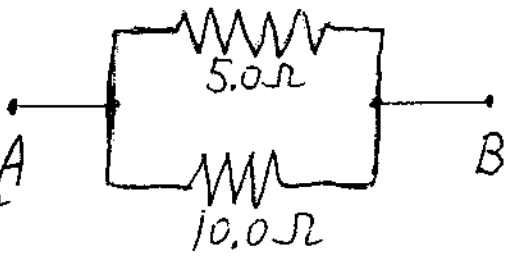
1. A 5.0 Ω resistor is in parallel with a 10.0 Ω resistor as shown. What is the equivalent resistance between points A and B?

a. 0.067 Ω
b. 0.30 Ω
c. 3.3 Ω
d. 7.5 Ω
e. 15 Ω

$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$

$= \frac{1}{5.0\Omega} + \frac{1}{10.0\Omega} = \frac{3}{10.0\Omega}$

$R_p = 10.0\Omega/3 = 3.3\Omega$



2. An 0.020 F parallel-plate capacitor with vacuum dielectric is attached to a 10V battery, allowed to fully charge, and then removed from the battery. A material with dielectric constant 4 is then placed between the plates. What is the stored energy in the capacitor with dielectric?

a) 0.06 J
b) 0.25 J
c) 1 J
d) 2.5 J
e) 4 J

$Q = CV = (.02F)(10V) = 0.2C$

$C' = \kappa C$

$U = \frac{Q^2}{2C'} = \frac{(0.2C)^2}{2(4)(0.02F)} = 0.25J$

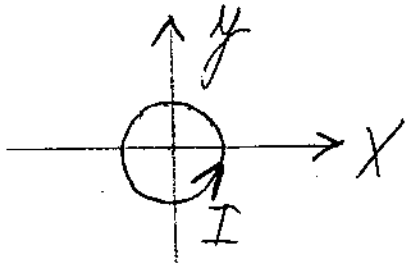
3. A 20 A current flows in a circular loop of radius 0.1 m as shown. What is the magnetic moment of the loop?

a. 2.0 A·m $\hat{i}$
b. 0.63 A·m^2 $\hat{k}$
c. -0.63 A·m^2 $\hat{k}$
d. -2.0 A·m $\hat{i}$
e. 0.2 A·m^2 $\hat{k}$
f. -0.2 A·m^2 $\hat{k}$

$\vec{m} = AI\hat{n}$

$= \pi(.1m)^2(20A)\hat{k}$

$= 0.63\ A\cdot m^2\hat{k}$



4. The magnetic field in a region is given by $\mathbf{B} = (3\text{ T})\cdot(\hat{i}+\hat{k})$. A particle of charge 0.1 C with velocity $\mathbf{v} = 50\text{ m/s}\,\hat{k}$ enters the region. What is the magnetic force on it?.

a) 15 N $\hat{j}$
b) -15 N $\hat{j}$
c) 15 N $\hat{k}$
d) -15 N $\hat{k}$
e) 7.5 N $\hat{j}$
f) -7.5 N $\hat{k}$

$\vec{F} = q\vec{v}\times\vec{B}$

$= (0.1C)(50\frac{m}{s})(3T)\,\hat{k}\times(\hat{i}+\hat{k})$

$= 15N\hat{j}$

5. A wire segment of length 0.20 m lies along the x-axis and is centered on the origin. It carries a current of 5.0A in the -x direction. What is the magnetic field B at the position (x=0, y=0.12m, z=0)?

a. 8.3 x 10^{-7} T $\hat{k}$
b. -8.3 x 10^{-7} T $\hat{k}$
c. 6.9 x 10^{-6} T $\hat{k}$
d. -6.9 x 10^{-6} T $\hat{k}$
e. 6.9 x 10^{-6} T (0.71$\hat{i}$ - 0.71$\hat{j}$)
f. -6.9 x 10^{-6} T (0.71$\hat{i}$ - 0.71$\hat{j}$)

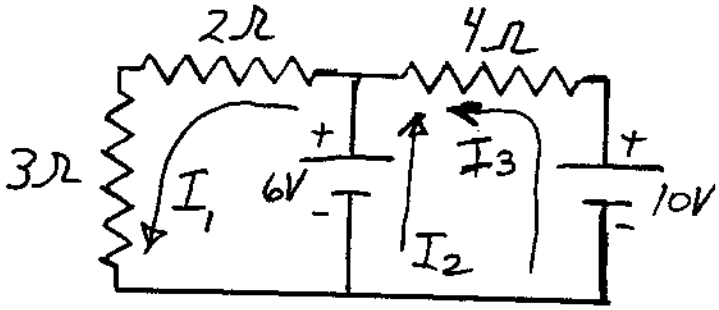
$d\vec{B} = \left(\frac{\mu_0}{4\pi}\right) I \frac{d\vec{l}\times\hat{r}}{r^2}$

$= \left(10^{-7}\frac{T\cdot m}{A}\right)(5.0A)\frac{0.20m}{(.12m)^2}\left[-\hat{i}\times\hat{j}\right]$

$= -6.9\times10^{-6}\,T\,\hat{k}$

cbbad

B. PROBLEMS. BE SURE TO SHOW YOUR METHOD CLEARLY. BE SURE THAT ANSWERS ARE WRITTEN IN TERMS OF ONLY ***GIVEN*** QUANTITIES.



1. Consider the circuit shown.

a) Find the current I_1; be sure to indicate whether your value is positive or negative.

$$6V - I_1(2\Omega + 3\Omega) = 0$$

$$I_1 = \frac{6V}{5\Omega} = 1.2A$$

b. Find the value and sign of the current I_3.

$$10V - I_3(4\Omega) - 6V = 0$$

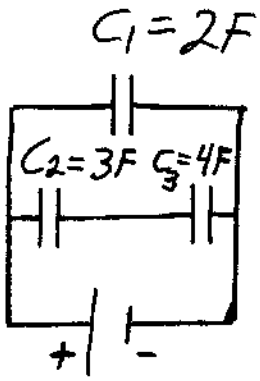
$$I_3 = \frac{4V}{4\Omega} = 1A$$

c. How much power is dissipated in the 2 Ω resistor?

$$P = I_1 \Delta V \qquad \Delta V = I_1(2\Omega)$$

$$P = I_1^2(2\Omega) = (1.2A)^2(2\Omega) = 2.9W$$

2. Consider the capacitor circuit shown.



a) What will be the charge on C_1?

$$Q_1 = C_1 \Delta V_1$$
$$= (2F)(10V) = 20C$$

b) What will be the charge on C_2?

$$Q_2 = Q_3 = Q_S = \mathcal{E} C_S$$

$$\frac{1}{C_S} = \frac{1}{C_2} + \frac{1}{C_3} = \frac{1}{3F} + \frac{1}{4F} = \frac{7}{12F}$$

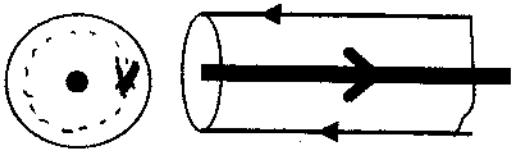
$$C_S = \frac{12}{7} F$$

$$Q_2 = (10V)\left(\frac{12}{7}F\right) = 17C$$

What will be the **potential difference** across C_3?

$$\Delta V_3 = \frac{Q_3}{C_3} = \frac{17C}{4F} = 4.25V$$

3. Consider a long coaxial cable made with a central wire of radius 0.05m carrying a current of 5A surrounded by a cylindrical shell of radius 0.20 m. carrying current 5A in the opposite direction.



Cross-section

a) Draw in on the figure and describe the Amperian curve you would use to find the magnitude of the magnetic field at a radial distance of 0.15 m from the axis of the wire.

Circle of radius 0.15m around the wire axis

b) What is the magnitude of the magnetic field at a radial distance of 0.15 m from the axis of the wire? Be sure to show your method!

$$\mathcal{C} = 2\pi r B = \mu_0 I_{through}$$

$$B = \frac{\mu_0 I_{through}}{2\pi(.15m)} = \frac{(4\pi \times 10^{-7} T\cdot m/A)(5A)}{2\pi(.15m)}$$

$$= 6.67 \times 10^{-6} T$$

c) What is the magnetic field magnitude outside the cable at a radial distance 0.30m from the axis? Be sure to show your method!

$$2\pi r = \mu_0 I_{through} = \mu_0(+5A - 5A) = 0$$

$$B = 0$$