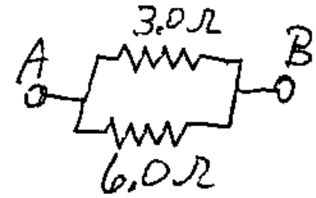
Phys 230, Fall 2004. **Practice Midterm 2.** SOLUTIONS

1. What is the equivalent resistance between points A and B in the circuit below?

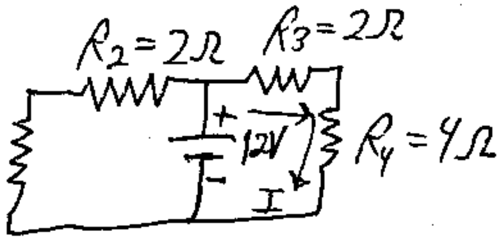


a) 0.5 Ω
b) 1.0 Ω
c) 2.0 Ω
d) 3.0 Ω
e) 9.0 Ω

$$\frac{1}{R_{\parallel}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$R_{\parallel} = \frac{1}{\frac{1}{3\Omega} + \frac{1}{6\Omega}} = \frac{1}{3/6\Omega} = 2\Omega$$

2. What is the current through resistor R_4 in the circuit below?



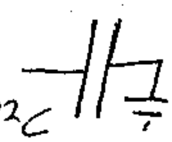
a) 1 A
b) 2 A
c) 3 A
d) 4 A
e) 6 A

Loop eqn. for right-hand loop

$$\mathcal{E} - IR_3 - IR_4 = 0$$

$$I = \frac{\mathcal{E}}{R_3 + R_4} = \frac{12V}{6\Omega} = 2A$$

3. The capacitor shown below has parallel plates, each of area 0.1 m^2, separated by a distance of 10^{-3} m, with vacuum between the plates. A charge of + 8.85 x 10^{-12} C is on the left-hand plate and a charge of - 8.85 x 10^{-12} C is on the right-hand plate. The right-hand plate has electric potential 0. What is the potential of the left-hand plate?



a) - 0.01 V
b) + 0.01 V
c) - 0.02 V
d) + 0.02 V
e) -100 V
f) +100 V

$$C = \frac{\varepsilon_0 A}{d}$$

$$Q = C\Delta V \Rightarrow \Delta V = \frac{Q}{C} = \frac{8.85\times10^{-12}C}{(8.85\times10^{-12}F/m)(0.1m^2)/10^{-3}m} = 10^{-2}V$$

4. A parallel plate capacitor with vacuum between the plates is charged by a battery and the battery is then removed. The capacitor has a stored energy of 5 J. A dielectric with κ = 5 is then put in to fill the space between the plates. What is the new stored energy?

a) 0.2 J
b) 1 J
c) 5 J
d) 25 J
e) 125 J

$$U = \frac{1}{2}\frac{Q^2}{C} = 5J$$

Charge is constant!

$$U' = \frac{1}{2}\frac{Q^2}{C'} = \frac{1}{2}\frac{Q^2}{5C} = 1J$$

5. A particle of charge -10^{-6}C has a velocity v = (100 m/s)($\hat{i} + \hat{j}$) in a region where the magnetic field B is 2T$\hat{k}$. What is the magnetic force on the particle?

a) -10^{-4} N$\hat{k}$
b) (2×10^{-4} N)($\hat{i} - \hat{j}$)
c) (-2×10^{-4} N)($\hat{i} - \hat{j}$)
d) (2×10^{-4} N)($\hat{i} + \hat{j}$)
e) (-2×10^{-4} N)($\hat{i} + \hat{j}$)
f) 0

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

$$= (-10^{-6}C)(100\,m/s)(\hat{i}+\hat{j})\times(2T\hat{k})$$

$$= -2\times10^{-4}N(-\hat{j}+\hat{i})$$

6. The magnetic field produced by a line element $\vec{dl}$ at a position $\vec{r}$ is found to be 0.1T $\hat{i}$. Which one of the following combinations of $\vec{dl}$ and $\vec{r}$ could produce this field?

a) $\vec{dl} = 10^{-3}m\hat{i}$; $\vec{r} = 1m\hat{k}$
b) $\vec{dl} = 10^{-3}m\hat{j}$; $\vec{r} = 1m\hat{k}$
c) $\vec{dl} = 10^{-3}m\hat{i}$; $\vec{r} = 1m\hat{j}$
d) $\vec{dl} = 10^{-3}m\hat{k}$; $\vec{r} = 1m\hat{j}$
e) $\vec{dl} = 10^{-3}m\hat{j}$; $\vec{r} = 1m\hat{j}$

$$d\vec{B} = \frac{\mu_0 I\, d\vec{l} \times \hat{r}}{r^2}$$

Need $d\vec{l} \times \hat{r} = c\hat{i}$

must have $\hat{dl} = \hat{j}$ and $\hat{r} = \hat{k}$

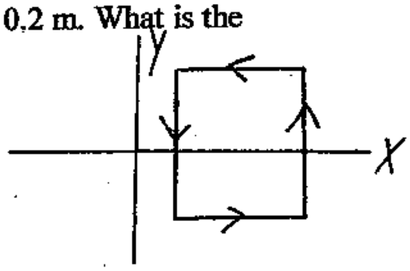
7. A wire of radius 0.1 m carries a current of 2A. What is the circulation $\mathcal{C}$ of magnetic field around the wire?

a) 2 T·m
b) 0.2 T·m
c) $2\pi \times 10^{-7}$ T·m
d) $8\pi \times 10^{-7}$ T·m
e) $0.8\pi \times 10^{-7}$ T·m

By Ampere's Law

$$\mathcal{C} = \mu_0 I_{through} = \left(4\pi \times 10^{-7} \frac{Tm}{A}\right)(2A)$$

8. A 5A current flow in the square loop shown; each side of the loop is of length 0.2 m. What is the magnetic moment of the loop?



a) 1 Am^2 **k**
b) ~~-1 Am^2 **k**~~
c) 0.2 Am^2 **k**
d) -0.2 Am^2 **k**
e) 0.2 Am^2 **i**

$$\vec{m} = IA\hat{k} = (5A)(0.2m)^2\hat{k} = 0.2\, Am^2\hat{k}$$

9. A current loop with magnetic moment 0.5 Am^2 is placed in a magnetic field of strength 3T. The normal to the loop makes a 60 degree angle with the field direction. What is the magnitude of the torque on the loop?

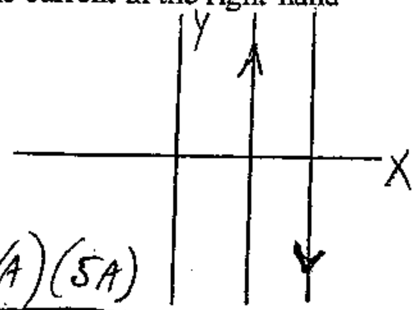
a) ~~1.5 Nm~~
b) 1.3 Nm
c) 0.75 Nm
d) 0.5 Nm
e) 0.25 Nm

$$\vec{\tau} \quad \vec{m} \times \vec{B} = mB\sin\theta = (0.5\,Am^2)(3T)(\sin 60°) = 1.3\ Nm$$

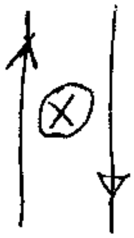
10. The magnetic field inside a solenoid in air is 0.1T. A material is placed in the solenoid and the magnetic field becomes 10T. The material is best described as

a) Diamagnetic
b) Dielectric
c) Paramagnetic
d) Ferromagnetic
e) Need more information to tell

1. Two long straight parallel wires located in the x-y plane are separated by 0.2 m. Each wire carries a current of 5A, with the current in the left-hand wire in the $+\hat{j}$ direction and the current in the right-hand wire in the $-\hat{j}$ direction.



a) What are the magnitude and direction of the magnetic field halfway between the wires?



Ampere's Law: $2\pi r B_1 = \mu_0 I$

$B_1 = \frac{\mu_0 I}{2\pi r}$; $B = 2B_1 = \frac{(4\pi \times 10^{-7}\ Tm/A)(5A)}{\pi\ (0.1\ m)}$

$= 2\times 10^{-5}\ T \longrightarrow \boxed{\vec{B} = -2\times 10^{-5}\ T\ \hat{k}}$

b) What are the magnitude and direction of the magnetic force per unit length on the right-hand wire?

B at RH wire $= \frac{\mu_0 I}{2\pi (0.2m)} = 5\times 10^{-6}\ T$ ($-k$ direction)

$F = I\vec{l}\times\vec{B}$; $\frac{F}{l} = IB = 2.5\times 10^{-5} N$ (Direction $-\hat{j}\times -\hat{k} = \hat{i}$)

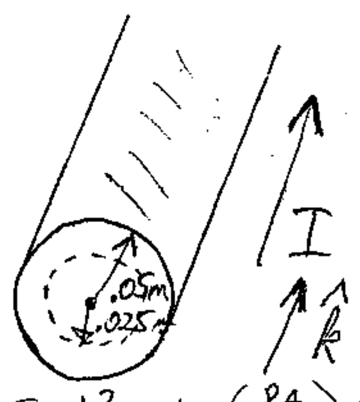
c) The current in the right-hand wire is changed to run in the $+\hat{j}$ direction. What are the magnitude and direction of the magnetic field halfway between the wires?

Fields from the two wires cancel; $B = 0$.

d) With the current in the right-hand wire in the $+\hat{j}$ direction, what are the magnitude and direction of the magnetic force on that wire?

$-2.5\times 10^{-5} N\ \hat{i}$

2. A current of 8A flows uniformly in a wire of radius 0.05 m as shown.



a) Draw in and give the dimensions of the Amperian curve you would use to find the magnetic field strength at radius 0.025 m.

Circle of radius 0.025 m

(b) Determine the strength of the magnetic field at radius 0.025 m.

Ampere's Law: $2\pi(.025m)B = \mu_0 (j\pi)(.025m)^2 = \mu_0 \left(\frac{8A}{(.5m)^2}\right)(.025m)$

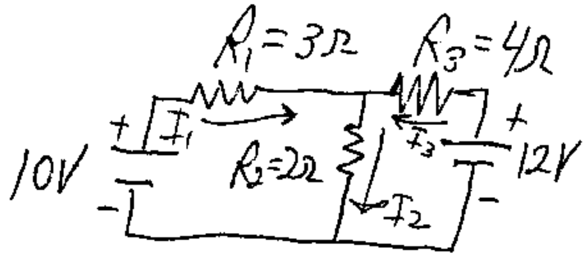
$B = \frac{(4\pi\times 10^{-7}\ Tm/A)(8A)(.025\ m)}{2\pi\ (0.5\ m)^2} = 1.6\times 10^{-7}\ T$

(c) Write the magnetic field at r = 0.025 m as a vector, in terms of the unit vectors r, θ, and k as needed.

$\vec{B} = -1.6\times 10^{-7}\ T\ \hat{\theta}$

3. For the circuit shown,

a) What is the current flowing in resistor R2?



$$I_1 + I_3 = I_2$$

$$10V - I_1(3\Omega) - I_2(2\Omega) = 0$$

$$12V - I_3(4\Omega) - I_2(2\Omega) = 0 \Rightarrow 12V - (I_2 - I_1)(4\Omega) - 2\Omega I_2 = 0$$

$$12V + 4\Omega I_1 - 6\Omega I_2 = 0$$

b) What is the voltage drop across resistor R2?

$$(4/3)10V - 4\Omega I_1 - \tfrac{8}{3}\Omega I_2 = 0$$

$$25.33V - 8.66\Omega I_2 = 0$$

$$I_2 = 2.9A$$

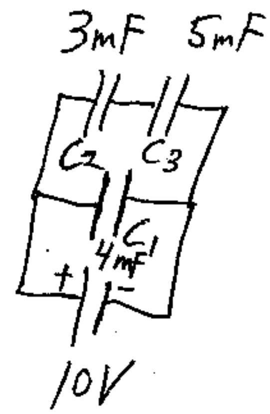
$$\Delta V_2 = I_2 R_2 = (2.9A)(2\Omega) = 5.8V$$

c) What power is dissipated in resistor R2?

$$P_2 = I_2 \Delta V_2 = (2.9A)(5.8V) = 17W$$

4. For the circuit shown,

a) Find the charge on capacitor C2



$$Q_2 = Q_3 = Q_5$$

$$C_5 = \frac{1}{\frac{1}{3mF} + \frac{1}{5mF}} = \frac{15}{8} mF$$

$$Q_2 = Q_5 = C_5 (10V) = 1.88 \times 10^{-2} C$$

b) Find the charge on capacitor C3

$$Q_3 = Q_2 = 1.88 \times 10^{-2} C$$

c) Find the potential difference across capacitor C2.

$$\Delta V_2 = \frac{Q_2}{C_2} = \frac{1.88 \times 10^{-2} C}{3 mF} = 6.25V$$