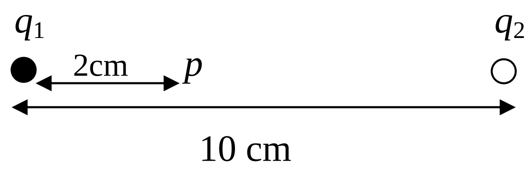
University of Bahrain **PHYCS 102** Date: 14/1/ 2002

Dept. of Physics **Final Exam**

Time: Two Hours

Use: $k = 9\times10^{+9}$ Nm^2/C^2, $\varepsilon_o = 8.85\times10^{-12}$ C^2/m^2.N, $\mu_o = 4\pi\times10^{-7}$ T.m/A

Q1- Two point charges; $q_1 = -20\ \mu$C and $q_2 = +40\ \mu$C are separated by a distance of 10 cm, as shown in the figure. What is the direction and magnitude of the electric field at point p?

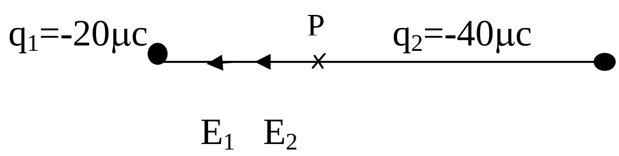


Solution:

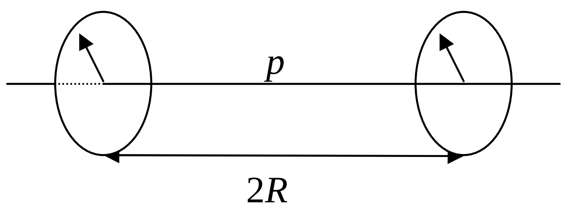
$$E_1 = \frac{kq_1}{r_1^2} = 4.5\text{x}10^8\ N/c$$

$$E_2 = \frac{kq_2}{r_2^2} = 5.6\text{x}10^7\ N/c$$

$$E = E_1 + E_2 = 5.06\text{x}10^8\ N/c$$



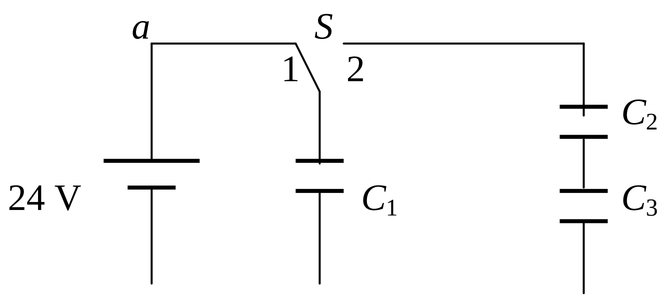
Q2- Two parallel circular rings of radius R=10 cm each. Their centers are separated by a distance 2R as shown in the figure. Each ring carries a uniformly distributed charge of Q=10 nC. Find the electric potential at the mid point p between them.



Solution:

$$\text{V}(x) = \frac{kQ}{\left(x^2 + R^2\right)^{1/2}},\ V = 2\left(\frac{kQ}{\sqrt{R^2 + R^2}}\right) = 1.27kV$$

Q3- In the circuit below C_1=1μF, C_2=2μF and C_3=3μF. A voltage V=24 V is applied across the points a and b with the switch S at position 1. When C_1 is fully charged S is thrown to position 2. What is the final charge on each capacitor?



b

Solution: $Q_T = C_1 V = 24\mu C$

$$C_{eq} = C_1 + \frac{C_2 C_3}{C_2 + C_3} = 2.2\mu F, Q_T = C_{eq} V_{new} \therefore V_{new} = 10.9V$$

$$Q_1 = C_1 V_{new} = 10.9\mu C$$

$$Q_2 = Q_3 = Q_T - Q_1 = 13.1\mu C$$

Q4- A wire is 20 m long and resistivity 1.6×10^{-8} Ω.m. (a) What is the diameter of the wire if its resistance is 0.1Ω? (b) If a current of 4 A passes through the wire, what is the voltage drop across it?

a. $R = \rho \frac{\ell}{A} \therefore A = 3.2 \; x \; 10^{-6} m^2, \; r = 1mm$

b. $V = Ir = 0.4V$

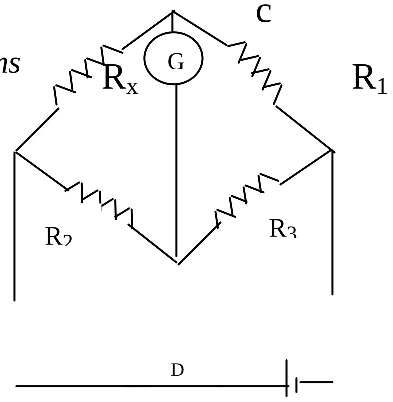
Q5- In a charging *RC* circuit; *C*=0.3 μF, *R*=20 kΩ and 12 V battery. Find (a) the time constant of the circuit, (b) the maximum charge on the capacitor (c) the time needed for the charge to reach 60% of its maximum value.

a. $\tau = RC = 6ms$

b. $Q_o = CV = 3.6\mu C$

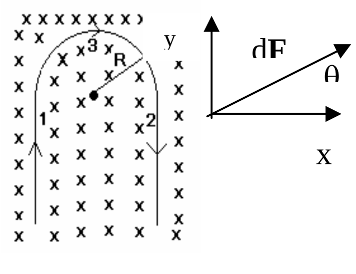
c. $0.6Q_o = Q_o\left(1 - e^{-t/\tau}\right) \therefore t = 5.5ms$

Q6- The Wheatstone bridge in the figure is balanced when R_1=6 Ω, R_2=9 Ω and R_3=4 Ω. What is the value of unknown resistance R_x?



$$Balance \left.\begin{matrix} I_3 R_3 = I_1 R_1 \\ I_3 R_2 = I_1 R_x \end{matrix}\right\} R_x = \frac{R_1}{R_3} R_2 = 13.5\Omega$$

Q7- A wire carrying a current *I* =10 A consists of semicircle of radius *R*=10 cm and two very long straight portions, as shown in the figure. The wire is placed in a plane perpendicular to a uniform magnetic field *B*= 0.4 T. Determine the net force on the wire.



$$\overrightarrow{F_1} + \overrightarrow{F_2} = 0$$

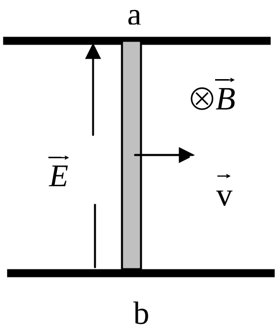
part:**3**

$$dF_y = dF \sin\theta, \; F_y = IBR \int_{-\pi/2}^{+\pi/2} \sin\theta \; d\theta = 2IBR \int_{o}^{\pi/2} \sin\theta \, d\theta$$

$$F_y = 2IBR = 0.8N$$

$\overrightarrow{F_{res}} = \overrightarrow{F_1} + \overrightarrow{F_2} + \overrightarrow{F_3} = 0.8\vec{j}$

Q8- A conductor 6 cm long moves with a constant velocity *v* through a magnetic field *B* =1.2 mT perpendicular to the conductor, as shown in the figure. A potential difference 4 μV is measured between points *a* and *b*. (a) Calculate the speed of the conductor. (b) Determine the magnitude and direction of the induced electric field.

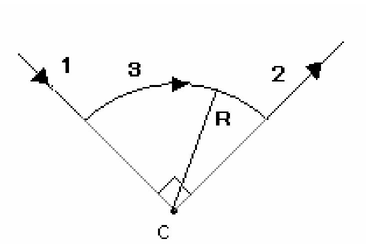


a. $\varepsilon = B\ell v,\ v = 0.06 m/s$

b. $V = E\ell,\ E = 66.6\,\mu v/m$

Q9- The wire in the figure carries a current *I*=10 A. The radius of the circular arc is *R*=10 cm. What is the magnitude and direction of the total magnetic field at point *c*?

Solution:



The arc:

$$dB = \frac{\mu o I}{4\pi R^2} d\ell,\ B = \frac{\mu_o I}{4\pi R}\int_o^{\pi/2} d\theta = \frac{\mu_o I}{8R} = 15.7\mu T$$

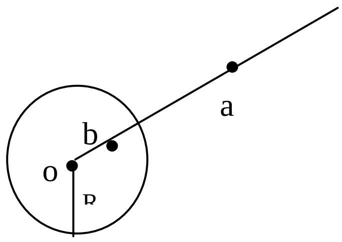
$$B_1 = B_2 = 0 \qquad B_3 = 15.7\mu T$$

Q10- A circular coil of wire has of radius 10 cm and 10 turns and carries a current 3A. The coil is placed in a magnetic field *B*=2 T. Determine the torque on the coil when the magnetic field is (a) parallel to the plane of the coil and (b) perpendicular to the plane of the coil.

a. $\tau = NIAB\sin\theta = 1.88 N.m, \qquad \theta = \pi/2$

b. $\tau = 0,\ \ \theta = 0$

Q11- A long straight wire of radius *R*=2mm carries a uniform current *I*=60A. Determine the magnetic field: (a) at a point 3 mm from the center of the wire. (b) at a point 1 mm from the center of the wire.

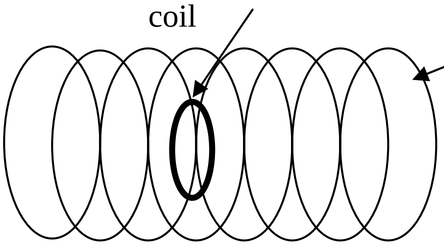


$\int B\,d\ell = \mu_o I$

a. $outside\ \ B(2\pi r) = \mu_o I,\ B = \frac{\mu_o I}{2\pi r} = 4mT$

b. $inside\ \ B(2\pi r) = \mu_o\left(I\frac{\pi r^2}{\pi R^2}\right), B = \frac{\mu_o I r}{2\pi R^2} = 3mT$

Q 12- A long solenoid of radius *R*=2.5 cm and 250 turns/m carries a current of *I*=1.5 A. Inside the solenoid and a coaxial with it is a coil that has radius *r*=1.20 cm and 50 turns. (a) Determine the magnetic field produced by solenoid. (b) Find the induced electromotive force in the coil when the current of solenoid is reduced uniformly to zero in 25 ms.



a. $B = \mu_o nI = 4.72\, x 10^{-4} T$

b. $\Phi = B\left(\pi r^2\right) = 2.135\ x\ 10^{-7} T.m^2$

$\Delta\phi = 2.135\ x\ 10^{-7}\ T.m^2$

$|\varepsilon_i| = N\frac{\Delta\phi}{\Delta t} = 50\ \frac{2.135\ x\ 10^{-7}}{25\ x\ 10^{-3}} = 0.427 mV$