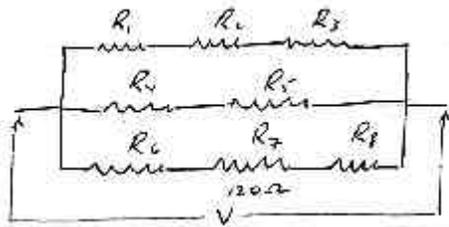


2<sup>nd</sup> Exam

1.



$$R_1 + R_2 + R_3 = 400 \Omega$$

$$R_4 + R_5 = 200 \Omega$$

$$R_5 = 120$$

$$R_6 + R_7 + R_8 = 250 \Omega$$

$$P_7 = I_1^2 R_7 = 300 \text{ mW}; R_7 = 120 \quad I_1 = \sqrt{\frac{0.300}{120}} = 0.05 \text{ A} \quad \therefore V = I_1 \times 250 = 12.5 \text{ V}$$

$$\therefore I_1 = \frac{V}{200} = 0.0625 \text{ A} \quad \therefore V_5 = I_1 R_5 = 7.5 \text{ V}$$

2.  $R_{1-3} = 400 \Omega$ ,  $R_{4-5} = 200 \Omega$ ,  $R_{6-8} = 250 \Omega$ ,  $R_7 = 140 \Omega$ ,  $R_5 = 90 \Omega$

$$P_7 = I_1^2 R_7 = 400 \text{ mW}; \therefore I_1 = \sqrt{\frac{0.400}{140}} = 0.0535 \text{ A} \quad \therefore V = 13.36 \text{ V}$$

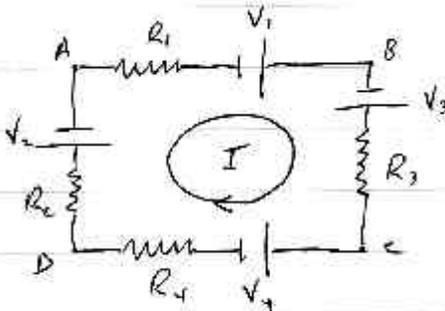
$$\therefore I_1 = \frac{V}{200} = 0.0668 \text{ A} \quad \therefore V_5 = I_1 R_5 = 6.01 \text{ V}$$

3.  $R_{1-3} = 400 \Omega$ ,  $R_{4-5} = 200 \Omega$ ,  $R_{6-8} = 250 \Omega$ ,  $R_7 = 130 \Omega$ ,  $R_5 = 65 \Omega$

$$P_7 = I_1^2 R_7 = 500 \text{ mW} \quad \therefore I_1 = \sqrt{\frac{0.500}{130}} = 0.0620 \text{ A} \quad \therefore V = I_1 \times R_{6-8} = 15.50 \text{ V}$$

$$\therefore I_1 = \frac{V}{200} = 0.0775 \text{ A} \quad \therefore V_5 = I_1 R_5 = 5.04 \text{ V}$$

4.



$$R_1 = \frac{125}{\cancel{100}} \Omega$$

$$V_1 = 3 \text{ V}$$

$$V_{DB} = -V_1 + (R_1 + R_2)I + V_2$$

$$R_2 = \frac{75}{\cancel{100}} \Omega$$

$$V_2 = 6 \text{ V}$$

$$V_{DB} = V_3 - (R_3 + R_4)I - V_4$$

$$R_3 = \frac{50}{\cancel{100}} \Omega$$

$$V_3 = 1.5 \text{ V}$$

$$\therefore (R_1 + R_2 + R_3 + R_4)I = V_1 - V_2 + V_3 - V_4$$

$$R_4 = \frac{125}{\cancel{100}} \Omega$$

$$V_4 = 3 \text{ V}$$

$$I = \frac{-4.5}{375} = -0.012 \text{ A}$$

$$V_{DB} = 0.6 \text{ V}$$

5.  $R_1 = 100 \Omega$

$$V_1 = 1.5 \text{ V}$$

$$I = \frac{V_1 - V_2 + V_3 - V_4}{R_1 + R_2 + R_3 + R_4} = \frac{-4.5}{325} = -0.01385 \text{ A}$$

$$R_2 = 50 \Omega$$

$$V_2 = 3 \text{ V}$$

$$R_3 = 75 \Omega$$

$$V_3 = 3 \text{ V}$$

$$V_{DB} = -V_1 + (R_1 + R_2)I + V_2 = -0.177 \text{ V}$$

$$R_4 = 100 \Omega$$

$$V_4 = 6 \text{ V}$$

6.  $R_1 = 75 \Omega$

$$R_2 = 100 \Omega$$

$$V_1 = 1.5 \text{ V}$$

$$V_3 = 4.5 \text{ V}$$

$$I = \frac{V_1 - V_2 + V_3 - V_4}{R_1 + R_2 + R_3 + R_4} = \frac{-3.0}{375} = -0.008 \text{ A}$$

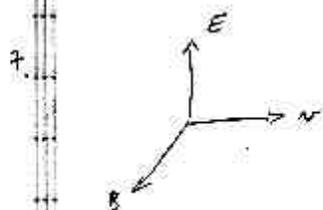
$$R_3 = 125 \Omega$$

$$R_4 = 75 \Omega$$

$$V_2 = 3 \text{ V}$$

$$V_4 = 6 \text{ V}$$

$$V_{DB} = -V_1 + (R_1 + R_2)I + V_2 = -0.1 \text{ V}$$



$$q = 2e$$

$$v = 2 \times 10^4 \text{ m/s}$$

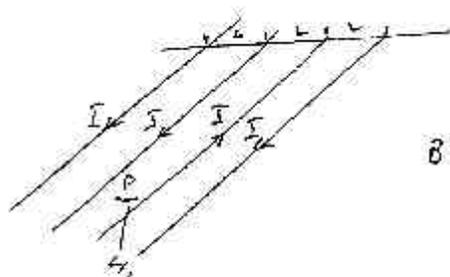
$$B = 5 \text{ T}$$

$$F = qvB \quad E = vB = 10^5 \text{ V/m}$$

8.  $q = 2e \quad v = 5 \times 10^3 \text{ m/s} \quad B = 8 \text{ T} \quad E = vB = 4 \times 10^4 \text{ V/m}$

9.  $q = 2e \quad v = 4 \times 10^4 \text{ m/s} \quad B = 7 \text{ T} \quad E = vB = 2.8 \times 10^5 \text{ V/m}$

10.



Take up (end of page) as true.

$$I = 40 \text{ A}$$

$$L = 3 \text{ mm}$$

$$B = \frac{\mu_0 I}{2\pi \cdot 1.5L} + \frac{\mu_0 I}{2\pi \cdot 0.5L} + \frac{\mu_0 I}{2\pi \cdot 0.5L} - \frac{\mu_0 I}{2\pi \cdot 1.5L} = \frac{2\mu_0 I}{2\pi \cdot 0.5L} = 0.0107 \text{ T}$$

11.

$$B = \frac{2\mu_0 I}{2\pi \cdot 0.5L} = 0.024 \text{ T} \quad (\text{using } I = 120 \text{ A}, L = 4 \text{ mm})$$

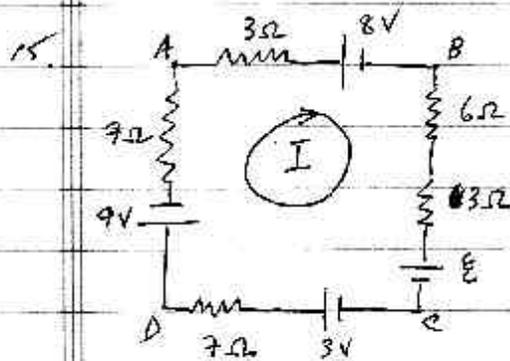
12.

$$B = \frac{2\mu_0 I}{2\pi \cdot 0.5L} = 0.052 \text{ T} \quad (\text{using } I = 80 \text{ A}, L = 2 \text{ mm})$$

13. Two capacitors in parallel have the same voltage across them.

14. At the instant the switch is closed, the voltage across the resistor is  $V_0$ . Thus, the initial current through the resistor will be  $V_0/R$ .

15. See next page.



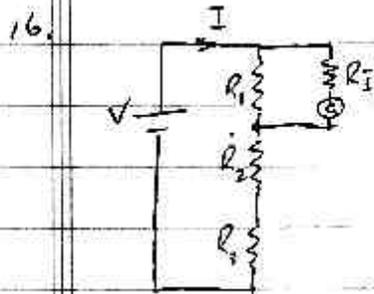
$$V_{BD} = -9 - 10I - 8 = 9.3$$

$$\therefore I = -2.63 \text{ A}$$

$$+7I - 3 + \varepsilon + 9I = 9.3$$

$$\varepsilon = 12.3 - 16I$$

$$= 54.38 \text{ V}$$



$$R_I = 8 \text{ k}\Omega$$

$$R_{II} = \frac{R_1 R_I}{R_1 + R_I} = 2.67 \text{ k}\Omega$$

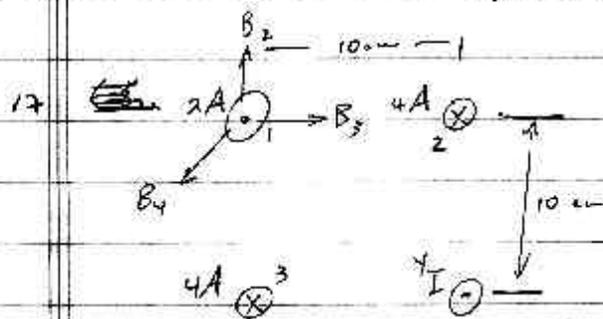
$$R_1 = 4 \text{ k}\Omega$$

$$R_2 = 2 \text{ k}\Omega$$

$$\therefore I = \frac{V_1}{R_{II}} = \frac{4.2}{2.67 \times 10^3} = 1.575 \text{ mA}$$

$$R_3 = 10 \text{ k}\Omega$$

$$V_{23} = I (R_3 + R_4) = 22.05 \text{ V} \quad \therefore V = 26.25 \text{ V}$$

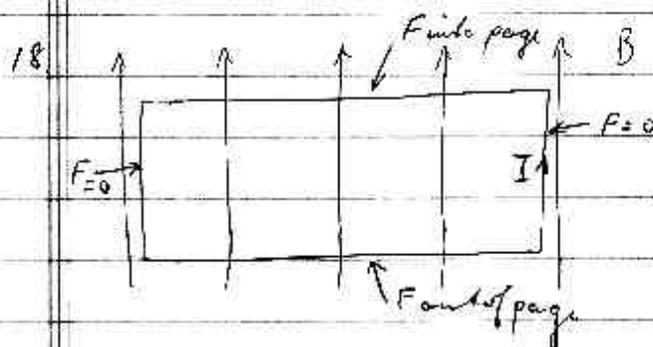


To cancel forces on wire 3, must cancel field

$$\therefore |B_4| = \sqrt{2} |B_2| = \frac{\mu_0 I_4}{2\pi \cdot \sqrt{2} \cdot 0.1} = \sqrt{2} \frac{\mu_0 I_2}{2\pi \cdot 0.1}$$

$$\therefore I_4 = 2 I_2 = 8 \text{ A}$$

$I_4$  out of page to give  $B_4$  in direction shown.

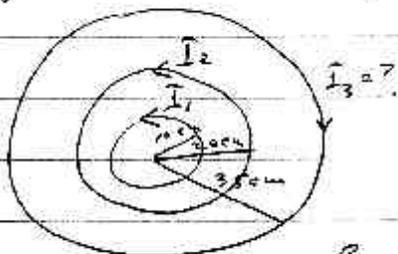


There is a net torque on the loop.

19. (The field of a loop is given in the solution for Q1, Exam 3, April 14, 1998)

$$B_{loop} = \frac{\mu_0 I}{2r}$$

Take out of page  
as +ve.



$$B_1 = \frac{10 \mu_0 \cdot 2}{2 \cdot 0.1}$$

$$= 4\pi \times 10^{-5} \text{ T out of page}$$

$$B_2 = \frac{10 \mu_0 \cdot 4}{2 \cdot 0.2} = 4\pi \times 10^{-5} \text{ T out of page}$$

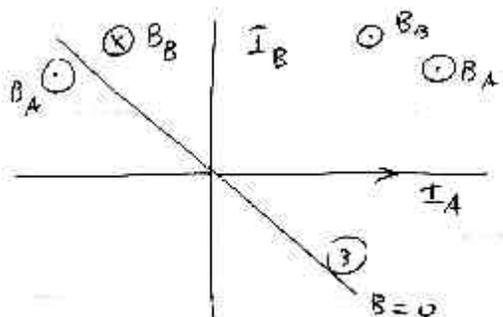
$$B_1 + B_2 + B_3 = -1.8 \times 10^{-4} \text{ T (i into page)} \quad 2 \times 0.2$$

$$\therefore B_3 = -1.8 \times 10^{-4} - 2.513 \times 10^{-4} = -4.313 \times 10^{-4} \text{ T (i into page)}$$

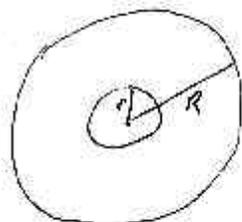
$$\therefore I_3 = \frac{2 \times 0.35 \times |B_3|}{10 \mu_0} = 24.03 \text{ A in a clockwise direction}$$

20. The separation distance between the particles will be identically zero, independent of the value of the potential (and magnetic field)

21



22



$$R = 1.5 \times 10^{-3} \text{ m}$$

$$r = 0.5 \times 10^{-3} \text{ m}$$

$$I = 10 \text{ A}$$

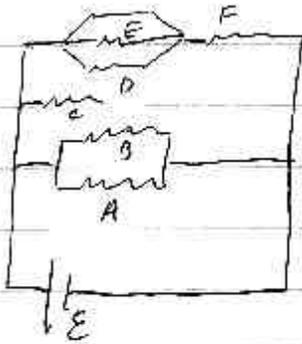
$$S = \frac{I}{\pi R^2}$$

$$B = \frac{\mu_0 \cdot S \cdot \pi r^2}{2\pi r}$$

$$= \frac{\mu_0 S \cdot r}{2}$$

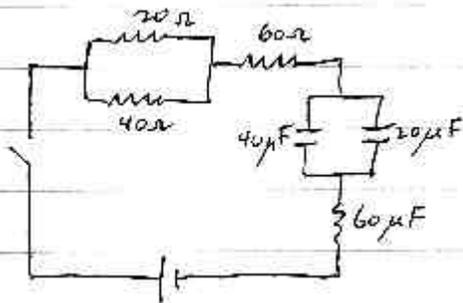
$$= 4.4 \times 10^{-4} \text{ A}$$

23.



$$R_{\text{off}} = \left( \frac{1}{R_A} + \frac{1}{R_B} + \frac{1}{R_C} \right)^{-1} = 1.67 \Omega$$

24.



$$R_{\text{off}} = \left( \frac{1}{20} + \frac{1}{40} \right)^{-1} + 60 = 73.33 \Omega$$

$$C_{\text{eff}} = \left( \frac{1}{40+20} + \frac{1}{60} \right)^{-1} = 30 \mu\text{F}$$

$$\tau = RC = 2.2 \text{ ms}$$

$$Q_c = CV(1 - e^{-t/\tau})$$

$$\frac{Q_c}{CV} = 0.632 \text{ at } t = \tau (= 2.2 \text{ ms})$$

25.

$$E_k = qV = \frac{1}{2} m v^2$$

$$q v B = \frac{m v^2}{r} \Rightarrow r = \frac{m v}{q B} = \frac{\sqrt{2 m E_k}}{q B} = \sqrt{\frac{2 m V}{9 B^2}}$$

$$r_{\text{max}} = \sqrt{\frac{2V}{9}} \cdot \frac{\sqrt{m_{\text{max}}}}{B} = 1.08696 \times 10^{-4} \sqrt{m_{\text{max}}}$$

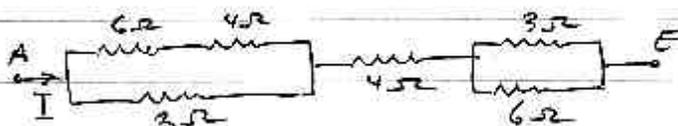
$$\Delta r = 1.08696 \times 10^{-4} (\sqrt{m_{\text{max}}} - \sqrt{m_{\text{min}}})$$

$$r_{\text{min}} = \sqrt{\frac{2V}{9}} \cdot \frac{\sqrt{m_{\text{min}}}}{B} = 1.08696 \times 10^{-4} \sqrt{m_{\text{min}}}$$

$$\approx 1 \times 10^{-4} \text{ m}$$

$$\text{slit width} = 2 \Delta r = 0.1 \text{ mm}$$

26.



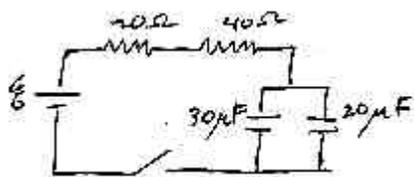
$$R_{\text{off}} = \left( \frac{1}{2} + \frac{1}{10} \right)^{-1} + 4 + \left( \frac{1}{3} + \frac{1}{6} \right)^{-1} \\ = 1.67 + 4 + 2 = 7.67 \Omega$$

$$V = 12 \text{ V}$$

$$\therefore I = \frac{V}{R_{\text{off}}} = 1.565 \text{ A}$$

$$I_3 = \frac{2}{3} I = 1.04 \text{ A}$$

27



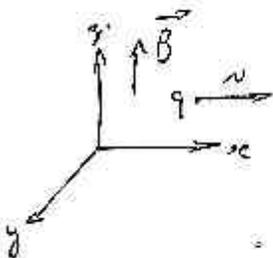
$$\tau = R_{\text{eff}} \cdot C_{\text{eff}} = (20+40) \cdot (30+20) \mu\text{F} \times 10^{-6}$$

$$= 3 \text{ ms.}$$

$$I_2 = \frac{\varepsilon}{R_{\text{eff}}} \cdot (\exp(-t/\tau)) \quad \text{exp}(-t/\tau) = 1/2$$

at  $t = \tau = 3 \text{ ms.}$

28



$$F = q\vec{E} = q\vec{v} \times \vec{B} \quad E = vB = 8 \times 10^4 \text{ V/m.}$$

$E$  must be in the  $-y$  direction to cancel out the effects of the magnetic force.

29

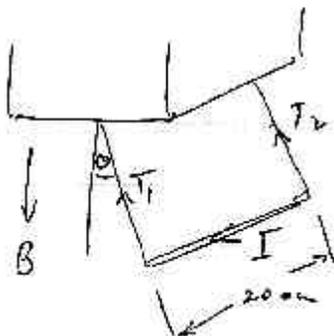
$$\tau = B \cdot I \cdot A \cdot \sin \theta.$$

$$A_{\text{sq}} = \left(\frac{L}{4}\right)^2 = \frac{L^2}{16}$$

$$A_{\text{coil}} = \pi \left(\frac{L}{2\pi}\right)^2 = \frac{L^2}{4\pi}$$

$$\frac{\tau_{\text{sq}}}{\tau_{\text{coil}}} = \frac{A_{\text{sq}}}{A_{\text{coil}}} = \frac{\pi}{4} = 0.785$$

30



Look end on



$$F_B = I l B.$$

$$M = 0.2 \text{ kg}$$

$$l = 0.20 \text{ m}$$

$$I = 3 \text{ A}$$

$$B = 2 \text{ T}$$

$$T \cos \theta = Mg.$$

$$T \sin \theta = I l B$$

$$\tan \theta = \frac{I l B}{Mg}$$

$$T = \sqrt{(Mg)^2 + (I l B)^2}$$

$$= 2.83 \text{ N.}$$

But  $T = T_1 + T_2 \quad \therefore T_1 (=T_2) = T/2 = 1.415 \text{ N.}$