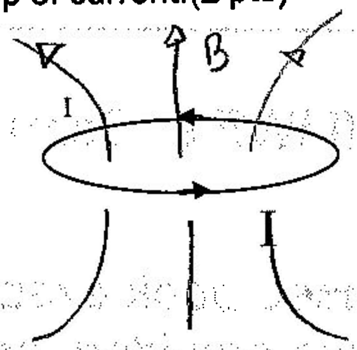
Multiple Choice (2 pts each, show work)

a) Sketch the magnetic field of a loop of current.(2 pts)



b) A magnetic field of 0.27 T makes an angle with respect to the velocity of a particle with charge 1.0x10^{-12} C traveling at 1000 m/s. If the magnitude of the force on the particle due to the magnetic field is 1.0x10^{-10} N, which of these angles best describes the angle of the magnetic field with respect to the particle velocity? (2 pts)

$\vec{F} = q\vec{v} \times \vec{B}$ $\quad |F| = |qvB||\sin\theta|$

$\theta = \sin^{-1}\left(\frac{F}{qvB}\right) = \sin^{-1}\left(\frac{10^{-10}}{10^{-12} \cdot 1000 \cdot (0.27)}\right)$

$= 22^0$

i) 1^0
ii) 5^0
iii) 11^0
[✓ iv) 22^0]
v) 34^0

c) An proton is in a circular orbit in a magnetic field of 1.0 milli-Tesla. What is the magnitude of the angular frequency with which this particle rotates(hint: ω=v/r)? 2 pts)

$\frac{mv^2}{r} = qvB \quad \frac{v}{r} = \frac{q}{m} B = \left(\frac{1.6\times10^{-19} C}{1.67\times10^{-27} Kg}\right) .001$

$= 95808$

i) 10 pico-rads/sec
ii) 0.11 rads/sec
iii) 8.8 rads/sec
iv) 1.0 milli-rads/sec
[✓ v) 96 kilo-rads/sec]

d) What is the magnetic field in the center of a 0.5 m long solenoid with 5000 turns that carries [illegible] A?(2pts)

4.0

$B = \mu_0 n I = 4\pi\times10^{-7} \frac{5000}{0.5m} 4.0A$

$= 0.05T$

i) 0.06 Tesla
[✓ ii) 0.05 Tesla]
iii) 130000 Tesla
iv) 5 micro-Tesla
v) 1.3 Tesla

Multiple Choice (contd.)

e) With an decrease in temperature inside a conductor like tungsten, should you expect the drift velocity to increase, decrease or remain the same? (Please give a ~ 5 word justification for your answer. You can use formulas in your explanation.)(2pts)

light bulb $R\uparrow T\uparrow$, less I

$R\downarrow T\downarrow$, more I, more v_D

(Stay the same.)

(Decrease.)

[✓ (Increase.)]

f) 2 wires carry identical current and are situated as shown in the figure below. Where must a 3rd wire, which carries an identical current, in an identical direction to the 1st 2 wires, be placed to eliminate the magnetic field at point P due to the original 2 wires? (Draw Magnetic field directions on figure)(2pts)

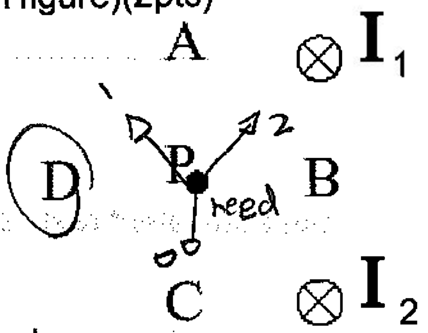
[✓ i) Point D]

ii) Point A

iii) Point B

iv) Point P

v) Point C



g) An capacitor in air is connected to a battery and has a stored energy of 1.0 nano-J. If we now insert a dielectric material of dielectric constant k=1.3 into the gap of the capacitor while it is still connected to the battery, what is the new stored energy of the capacitor?(2pts)

$U_0 = \frac{1}{2} C_0 V^2$ $\quad U_{new} = \frac{1}{2} k C_0 V^2$

$= 1.3 U_0$

[✓ i) 1.3 nano-J]

ii) 0.77 nano-J

iii) 1.7 nano-J

iv) 0.59 nano-J

v) 1.0 nano-J

h) What is the resistivity of a conducting wire of length 4.0 m, cross-sectional area of 1.0 mm^2, and resistance of 1.0 Ohm? (2 pts.)

$$R = \rho l / A \qquad \rho = \frac{RA}{l} = \frac{1.0\,(1.0\,mm^2)\cdot\left(\frac{1\,m}{1000\,m}\right)^2}{4.0\,m}$$

$$= \frac{1}{4} \times 10^{-6}$$

i) 40 Ohm-m

ii) 4.0 micro-Ohm-m

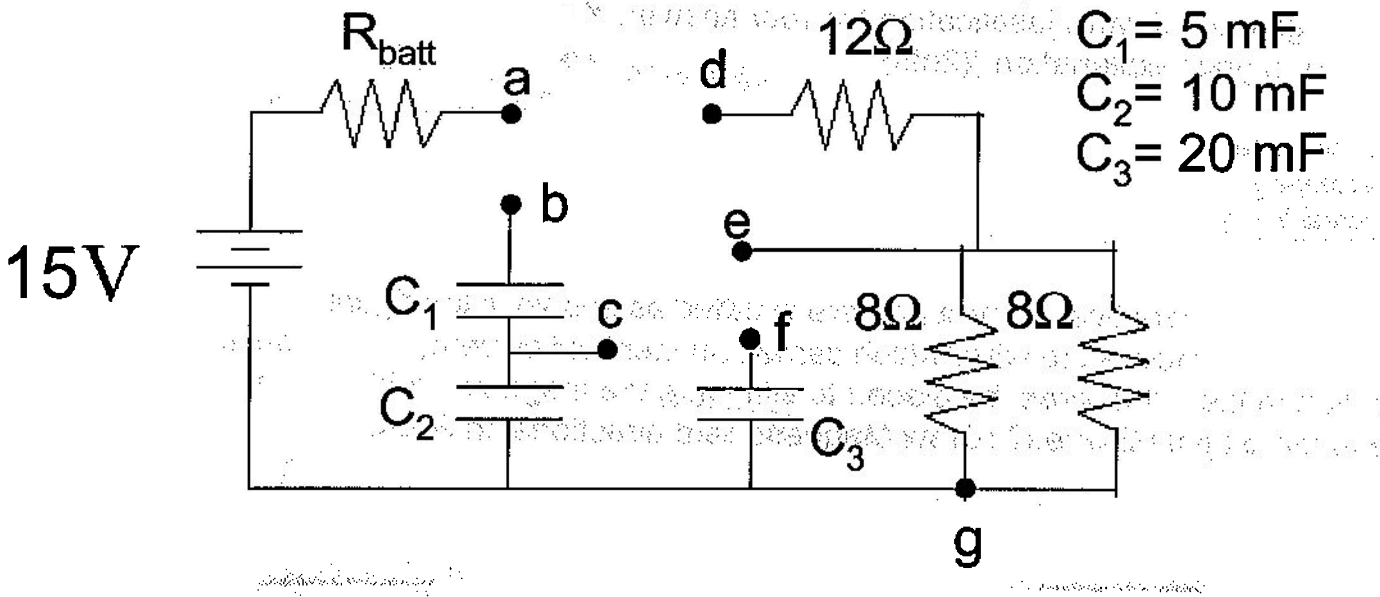
[✓ iii) 1/4 micro-Ohm-m]

iv) 40 Mega-Ohm-m

v) 4.0 Ohm-m

2) Circuit pts)

(In the diagram below, all capacitors are initially uncharged. All wires used are conducting wires.)



i) What is the equivalent resistance between points e) and g)?(1pts)

$$\frac{1}{R_i} = \frac{1}{8} + \frac{1}{8} = \frac{1}{4}$$

$R_i = 4\Omega$

$\boxed{R_{eg} = 4\Omega}$

ii) What is the equivalent resistance between points d) and g)?(2pts)

series

$R_i + 12\Omega = 16\Omega$

$\boxed{R_{dg} = 16\Omega}$

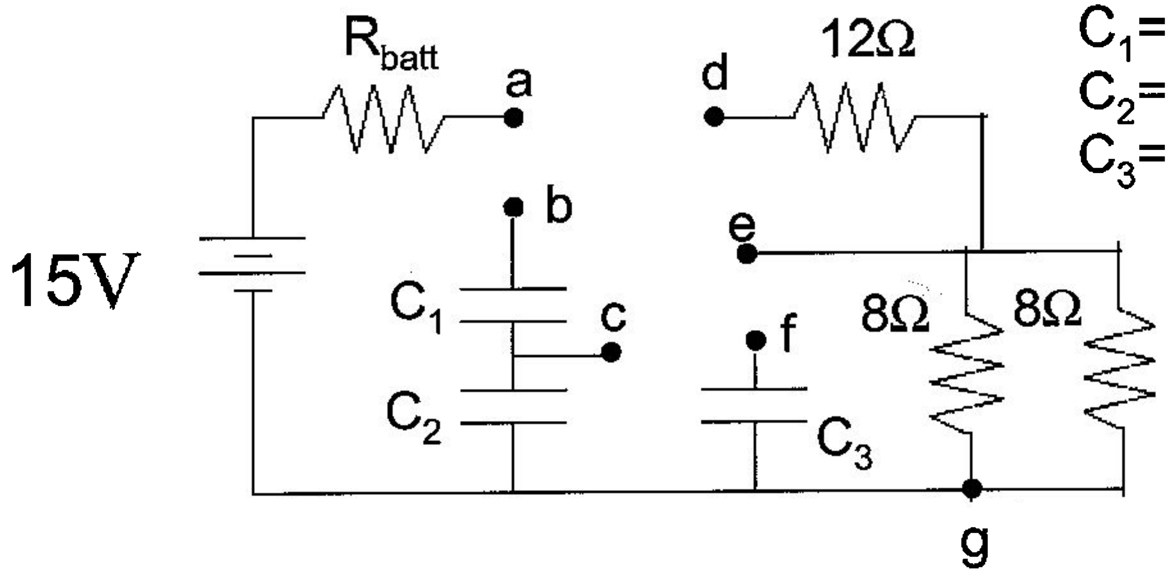
iii) If point "a" is connected to point "d" with a wire and 0.88 Amps of current flow through R_{batt}, what is R_{batt}?(3pts)

$$\frac{15V}{.88A} = R_{batt} + 16\Omega = 17\Omega$$

$R_{batt} = 1\Omega$

$\boxed{R_{batt} = 1\Omega}$

2) Circuit (contd.) (In the diagram below, all capacitors are initially uncharged, and all wires used are conducting wires.)



C_1= 5 mF
C_2= 10 mF
C_3= 20 mF

iv) Now, the wire between points “a” and “d” is removed. Then point “a” is connected to point “f” with a wire, and we wait for the current to stop flowing (i.e. after a very long time). What will be the charge on capacitor C_3 after a very long time? (3pts)

V same as batt after long time

$Q = CV = (20mF)15V$

$= 0.3C$

$\boxed{Q= 0.3C}$

v) Now, the wire between points “a” and “f” is removed without changing the charge (from “after a very long time” in part iv)) on C_3. Then point “b” is connected to point “f” with a wire. What is the charge on C_2 after the charges have stopped moving? (4pts)

C_3 in para w/ C_1 & C_2 in series $Q_1 = Q_2$

$Q_{iv} = Q_3 + Q_{12}$

Q_{iv} is total charge

$Q_{iv} = Q_{12}\left(\frac{C_3}{C_{12}} + 1\right)$

$Q_3 = \frac{Q_{12}}{C_{12}} C_3$, $\frac{Q_3}{C_3} = \frac{Q_{12}}{C_{12}}$, $Q_{12} = \frac{0.3C}{\left(\frac{20}{3.33}+1\right)}$

$\frac{1}{C_{12}} = \frac{1}{C_1} + \frac{1}{C_2}$

$= \frac{1}{5mF} + \frac{1}{10mF}$

$= \frac{3}{10mF}$

$C_{12} = 3.333mF$

$Q_{12} = \frac{.3C}{7} = 0.043C$

$\boxed{Q=0.043C}$

vi) Now, the wire between points “b” and “f” is removed without changing the charges (from “after the charges have stopped moving” in part v)) on C_1, C_2, or C_3. Then, point “c” is connected to point “e” with a wire. How long will it take the charge on C_2 to go to 10% of it’s initial value? (3pts)

$Q(t) = Q_0 e^{-t/RC}$

$RC = (4\Omega)(10mF)$

$= 0.04s$

$0.1Q_0 = Q_0 e^{-t/RC}$

$0.1 = e^{-t/RC}$

$-\ln(0.1)(0.04s) = t = 0.092s$

$\boxed{t= 0.092s}$