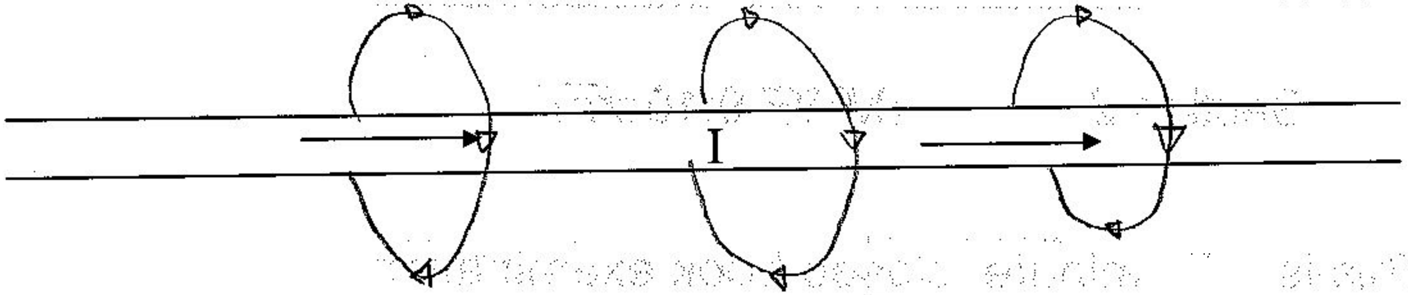
Multiple Choice (2 pts each, show work)

a) Sketch the magnetic field of a wire carrying a current I.(2 pts)



b) A magnetic field of 0.52 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)

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

$\theta = \sin^{-1}\frac{F}{qvB} = \sin^{-1}\left(\frac{10^{-10}N}{10^{-12}C\cdot 1000 m/s \cdot 0.52T}\right)$

- i) 1^{0}
- ii) 5^{0}
- [✓ iii) 11^{0}]
- iv) 20^{0}
- v) 340

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

- i) 60 giga-rads/sec
- ii) 0.11 rads/sec
- iii) 8.8 rads/sec
- iv) 1.0 micro-rads/sec
- [✓ v) 18 ~~micro-rads~~/sec] trouble

0.18 mega-rads

$\frac{mv^2}{r} = qvB$

$\frac{v}{r} = \omega = \frac{qB}{m} = \frac{1.602\times10^{-19}C}{9.11\times10^{-31}kg} 1\times10^{-6}T$

$=$

d) What is the magnetic field in the center of a 0.25 m long solenoid with 5000 turns that carries 2.0 A?(2pts)

$B = 4\pi\times10^{-7}\frac{Tm}{A}\frac{5000}{0.25m} 2.0A = B = \mu_0 n I$

$= 0.05 T$

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

Multiple Choice (contd.)

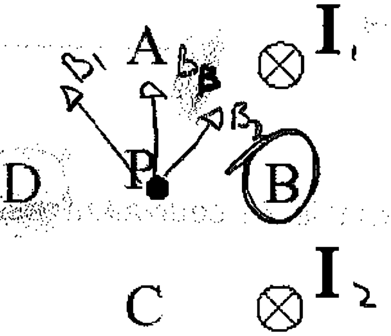
e) With an increase in temperature inside a conductor like tungsten, should you expect the drift velocity to increase, decrease or remain the same? (Please give a ~ 5 word justification for your answer. You can use formulas in your explanation.)(2pts) expect ρ to increase, I decreases, v_d decreases

or, less time bet collisions a τ smaller

(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 double the magnetic field at point P due to the original 2 wires? (Draw B directions on figure)(2pts)

i) Point D
ii) Point A
[✓ iii) Point B]
iv) Point P
v) Point C



g) An isolated capacitor in air 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, what is the new stored energy of the capacitor? (Hint: Use charge conservation.)(2pts)

same

$U_0 = \frac{1}{2}\frac{Q^2}{C} \Rightarrow kC \Rightarrow U_{new} = \frac{U_0}{1.3}$

$= 0.77 nJ$

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 2.0 m, cross-sectional area of 1.0 mm^2, and resistance of 1.0 Ohm? (2 pts.)

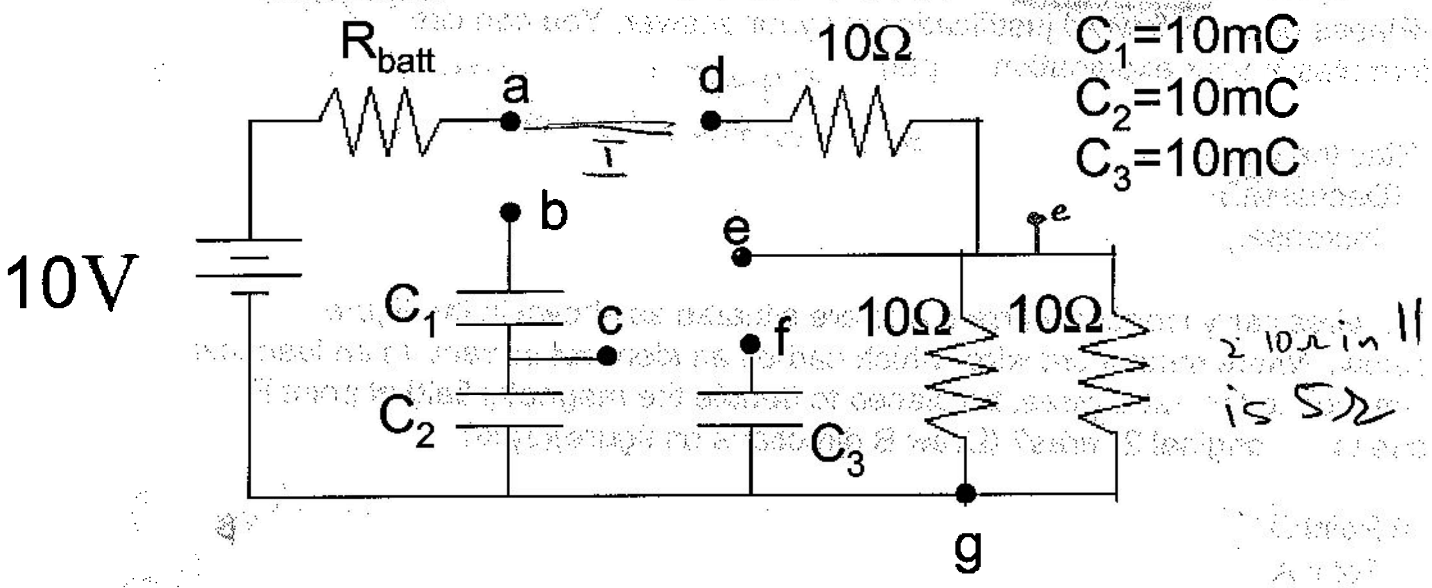
$R = \rho\frac{l}{A}$ $\rho = \frac{1mm^2 \cdot \left(\frac{1m}{1000mm}\right)^2 1.0\Omega}{2m}$

$= \frac{1}{2}\mu\Omega$

i) 20 Ohm-m
ii) 2.0 micro-Ohm-m
[✓ iii) 1/2 micro-Ohm-m]
iv) 20 Mega-Ohm-m
v) 2.0 Ohm-m

2) Circuit (16 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)

$$\frac{1}{R_{eg}} = \frac{1}{10\Omega} + \frac{1}{10\Omega}$$

$$R_{eg} = 5\Omega$$

R_{eg} = 5Ω

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

10Ω in series w/ R_{eg}

$10\Omega + 5\Omega = 15\Omega$

R_{dg} = 15Ω

iii) If point "a" is connected to point "d" with a wire and 0.57 Amps of current flow through R_{batt}, what is R_{batt}?(3pts)

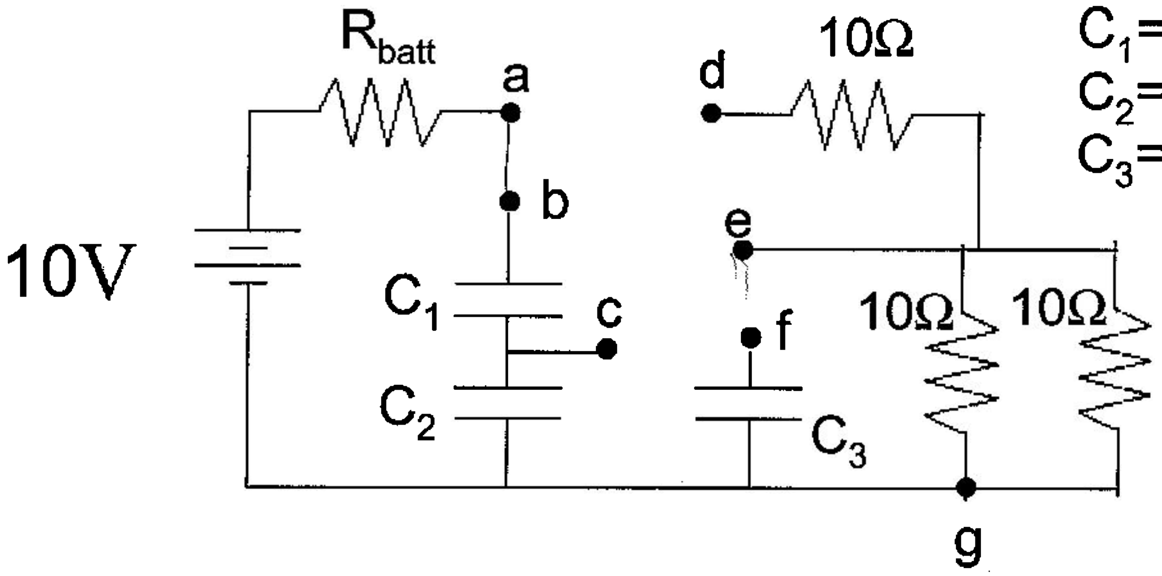
R_{eg} of whole $= \frac{10V}{0.57A} = 17.54\Omega$

R_{batt} = 2.54Ω

$17.54\Omega = R_{batt} + R_{dg} = R_{batt} + 15\Omega$

$R_{batt} = 2.54\Omega$

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



C_1=10m~~C~~ F

C_2=10m~~C~~ F

C_3=~~10m~~~~C~~ F 20m F

iv) If point "a" is connected to point "b" 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_2? (3pts)

Since $C_1 = C_2$, 5V across C_2

$Q = CV = (10mF)(5V) = 50mC$

Q= 50mC

v) Now, the wire between points "a" and "b" is removed without changing the charges (from "after a very long time" in part iv)) on C_1 or C_2. Then point "c" is connected to point "f" with a wire. What is the charge on C_3 after the charges have stopped moving? (4pts)

connected, V same

$\frac{Q_2}{C_2} = \frac{Q_3}{C_3}$ $\quad Q_2 + Q_3 = 50mC$

$Q_2 = \frac{C_2}{C_3} Q_3 = \frac{1}{2} Q_3$ $\quad \frac{3}{2} Q_3 = 50mC$

Q=33.3mC

vi) Now, the wire between points "c" 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 "f" is connected to point "e" with a wire. How long will it take the charge on C_3 to go to 10% of it's initial value? (3pts)

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

$RC = C_3 R_{eq}$
$= 20mF \; 5\Omega = 0.1s$

t= 0.23s

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

$\ln(0.1) = -t/0.1s$

$t = .23s$