İzmir Kâtip Çelebi University
Department of Engineering Sciences
Phy102 Physics II
Final Examination
January 09, 2020 13:30 – 15:30
Good Luck!

NAME-SURNAME:

SIGNATURE:

ID:

DEPARTMENT:

INSTRUCTOR:

DURATION: 120 minutes

◇ **Answer all the questions.**
◇ **Write the solutions explicitly and clearly. Use the physical terminology.**
◇ **You are allowed to use Formulae Sheet.**
◇ **Calculator is allowed.**
◇ **You are not allowed to use any other electronic equipment in the exam.**
◇ **I declare hereby that I fulfilled the requirements for the attendance according to the University regulations and I accept that my examination will not be valid otherwise.**

Question	Grade	Out of
1A		15
1B		15
2		20
3		20
4		20
5		20
TOTAL		110

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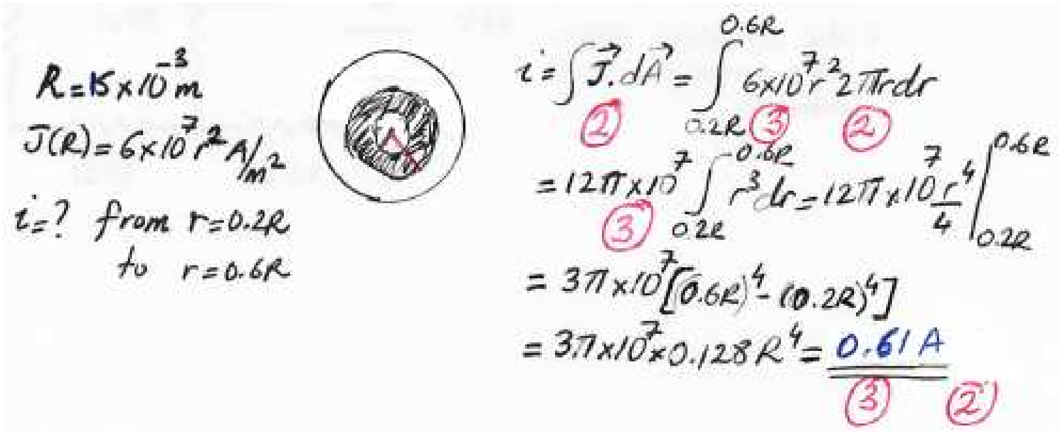
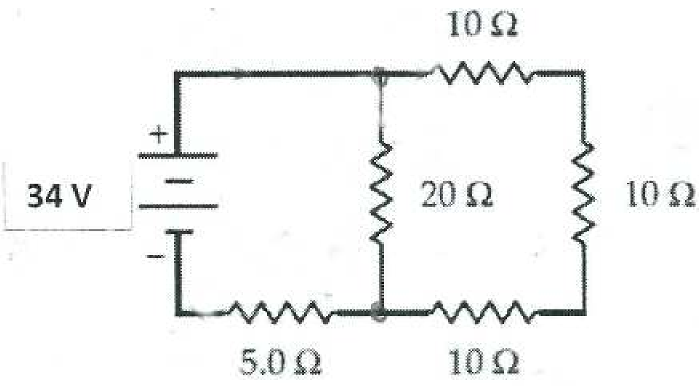
1. A) The magnitude J of the current density in a certain lab wire with a circular cross section of radius R=15.00 mm is given by $J = (6.00 \times 10^7)r^2$, with J in amperes per square meter and radial distance r in meters. What is the current through the outer section bounded by r=0.200R and r=0.600R?

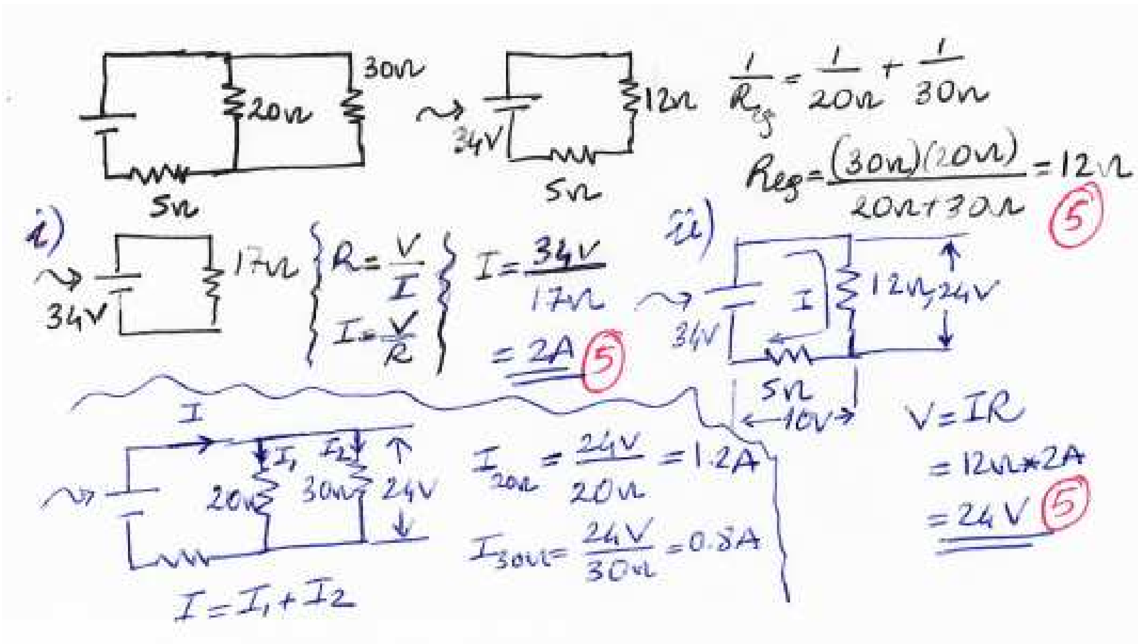


B) For the circuit shown find

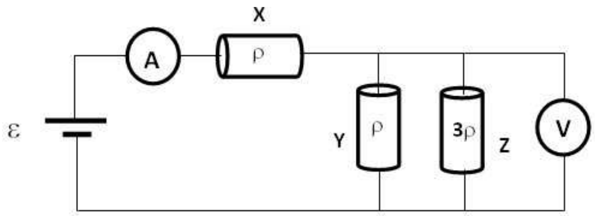
i the current delivered by the battery,

ii the potential difference across the 20 Ω resistor.





2. The circuit containing three cylindrical resistors, namely X, Y and Z, which obey Ohm's Law is shown in the figure below. The resistors which have length of L and cross-sectional area of A are connected to an ideal battery of emf ε. As shown an ammeter is connected in series while voltmeter is connected to ends of resistor Z. The resistors X and Y have a resistivity ρ and the resistor Z has a resistivity 3ρ.



i Find the current i through the ammeter.

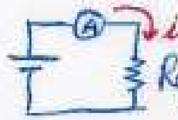
ii Find the reading of voltmeter. (Hint: Multi-loop circuit. Apply junction and loop rules.)

Express your result in terms of given quantities and constants $(\rho, \varepsilon, A, L)$.
(Hint: Resistance is related to resistivity.)

i) $\frac{1}{R_{yz}} = \frac{1}{R_y} + \frac{1}{R_z} \rightarrow R_{yz} = \frac{R_y R_z}{R_y + R_z}$ (3) $\Rightarrow R_{eq} = R_x + R_{yz} = R_x + \frac{R_y R_z}{R_y + R_z}$ (2)

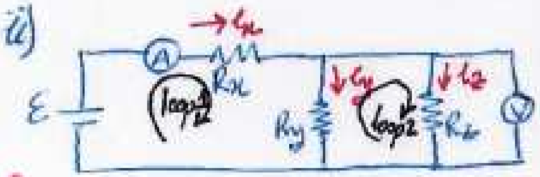
where $R_x = R_y = \rho \frac{L}{A}$ & $R_z = 3\rho \frac{L}{A} \Rightarrow R_{eq} = \rho \frac{L}{A} + \frac{\rho \frac{L}{A} \cdot 3\rho \frac{L}{A}}{\rho \frac{L}{A} + 3\rho \frac{L}{A}}$

$\Rightarrow R_{eq} = \frac{7\rho L}{4A}$ (3)



$i = \frac{\varepsilon}{R_{eq}} = \boxed{\frac{4\varepsilon A}{7\rho L}} = i_x$ (2)

ii)



$i_x = i_y + i_z$ (2)

(2) loop1: $\varepsilon - i_x R_x - i_y R_y = 0 \rightarrow i_y = \frac{\varepsilon - i_x R_x}{R_y}$

(2) loop2: $+i_y R_y - i_z R_z = 0 \rightarrow i_z = i_y \frac{R_y}{R_z} = \left(\frac{\varepsilon - i_x R_x}{R_y}\right)\frac{R_y}{R_z} = \frac{\varepsilon - i_x R_x}{R_z}$ (2)

$V = i_z R_z = \frac{\varepsilon - i_x R_x}{R_z} R_z = \varepsilon - i_x R_x$

$= \varepsilon - \left(\frac{4\varepsilon A}{7\rho L}\right)\rho \frac{L}{A} = \varepsilon - \frac{4\varepsilon}{7} = \boxed{\frac{3\varepsilon}{7}}$ (2)

3. A proton of kinetic energy 2.10 keV circles in a plane perpendicular to a uniform magnetic field.The orbit radius is 25.0 cm. Find

   i the proton's speed,

   ii the magnetic field magnitude,

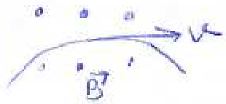
   iii the circling frequency,

   iv the period of the motion.

proton
$KE = 2.1\times10^{3}\,eV$
$R = 2.5\times10^{-2}\,m$

$$m\frac{v^2}{R} = qvB\sin 90$$

$$v = \frac{qRB}{m} \rightsquigarrow R = \frac{mv}{qB}$$



i) $\frac{1}{2}m_p v^2 = 2.1\times10^{3}\,eV \rightsquigarrow v^2 = \frac{2(2.1\times10^{3}\,eV)(1.6\times10^{-19}\,J/eV)}{1.67\times10^{-27}\,kg} = 4.02\times10^{11}\,m^2/s^2$ (4)

$\rightsquigarrow v = \boxed{0.634\times10^{6}\,m/s}$ (3)

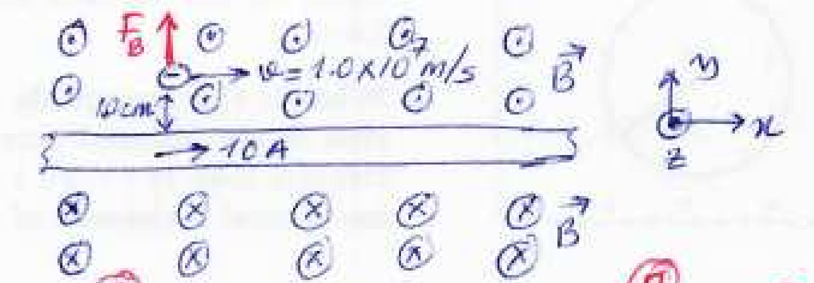
ii) $B = \frac{m_p v}{qR} = \frac{(1.67\times10^{-27}\,kg)(0.634\times10^{6}\,m/s)}{(1.6\times10^{-19}\,C)(25\times10^{-2}\,m)} = \boxed{0.027\,T}$ (3)

(4)

iii) $T = \frac{1}{f} = \frac{2\pi R}{v} \rightsquigarrow f = \frac{v}{2\pi R} = \frac{0.634\times10^{6}\,m/s}{2\pi(25\times10^{-2}\,m)} = \boxed{0.404\times10^{6}\,Hz}$ (2) (2)

iv) $T = \frac{1}{f} = \boxed{2.48\times10^{-6}\,s}$ (2)

4. A long wire carries a 10 A current from left to right. An electron 1.0 cm above the wire is traveling to the right at a speed of 1.0×10^7 m/s. What are the magnitude and the direction of the magnetic force on the electrons?



$$B = \frac{\mu_0 I}{2\pi d} = \frac{(4\pi\times10^{-7}\ TM/A)\ 10A}{2\pi\ 1.0\times10^{-2}\ m} = 2\times10^{-4}\ T$$

(3) (3) (2)

$$\vec{F}_B = q\,\vec{v}\times\vec{B} \Rightarrow |\vec{F}_B| = (1.602\times10^{-19}\ C)(1.0\times10^{7}\ m/s)(2\times10^{-4}\ T)$$

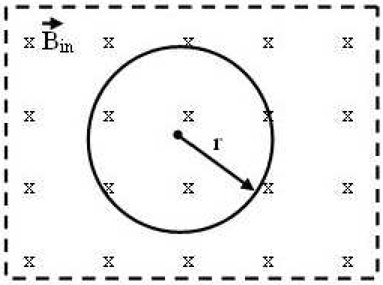
$$= 3.2\times10^{-16}\ N$$

(3) (3) (2)

$$\vec{F}_B = 3.2\times10^{-16}\ N\ \hat{j}$$

(4)

5. In figure below, the magnetic flux through the circular loop of radius $r = 2.0\ m$ increases according to the relation $\Phi_B = 6t^2 + 6t$, where Φ_B is in Webers and t is in seconds.



i Find the magnitude of the induced emf, ξ in the circular loop at $t = 2.0\ s$.

ii What is the magnitude and direction of the induced current in the circular loop at $t = 2.0\ s$ if the loop has a total resistance of $R = 60\ \Omega$?

i) $\phi_B(t) = 6t^2 + 6t$; increasing flux $\Rightarrow$ induced $\mathcal{E}, i$ should oppose

$\mathcal{E} = -N \frac{d\phi_B}{dt} \Rightarrow |\mathcal{E}| = \frac{d}{dt}(6t^2 + 6t)\Big|_{t=2s} = 12t + 6\Big|_{t=2s}$ (5) (3)

$\rightsquigarrow \mathcal{E}\Big|_{t=2s} = 30\ \text{Volt}$ (5)

ii) $i_{induced} = \frac{\mathcal{E}}{R} = \frac{30\ \text{Volt}}{60\ \Omega} = 0.5\ A.$ (2) (2)

direction $\rightsquigarrow$ ccw (3)