İzmir Kâtip Çelebi University
Department of Engineering Sciences
Phy102 Physics II
Final Examination
January 14, 2026 14:10 – 15:40
Good Luck!

NAME-SURNAME:

SIGNATURE:

◇ **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.**

ID:

DEPARTMENT:

INSTRUCTOR:

DURATION: 90 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.**

Question	Grade	Out of
1A		15
1B		15
2		20
3		15
4		15
5		20
TOTAL		100

This page is intentionally left blank. Use the space if needed.

1. A) A wire 4.00 m long and 6.00 mm in diameter has a resistance of 15.0 $m\Omega$. A potential difference of 23.0 V is applied between the ends.

   i What is the current in the wire?

   ii What is the magnitude of the current density?

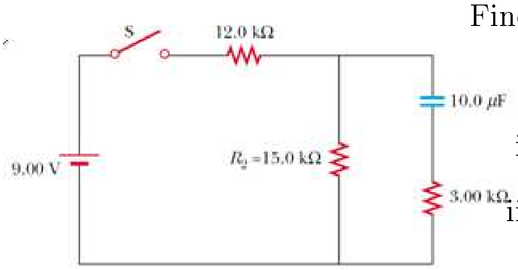
   iii Calculate the resistivity of the wire material.

i) $i = ?$ (3) $i = V/R = 23V / 15\times10^{-3}\,\Omega = \boxed{1.53\times10^{3} A}$ (1) (1)

ii) $J = ?$ (3) $J = i/A = 1.53\times10^{3} A / \pi(3\times10^{-2} m)^2 = \boxed{5.41\times10^{7} A/m^2}$ (1) (1)

iii) $\rho = ?$ (3) $R = \rho \frac{L}{A} \rightsquigarrow \rho = R\frac{A}{L} = \frac{15\times10^{-3}\,\Omega\ \pi(3\times10^{-3} m)^2}{4m} = \boxed{10.6\times10^{-8}\,\Omega m}$ (1) (1)

B) In figure, suppose the switch has been closed for a time interval sufficiently long for the capacitor to become fully charged.



Find

i the steady-state current in each resistor

ii the charge Q on the capacitor

iii The switch is now opened at t=0. Write an equation for the current in R_2 as a function of time.

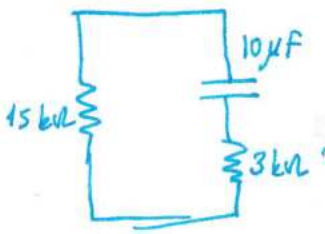
sufficiently long time interval ⇝ C becomes broken wire (2)
(steady-state)

i) $\boxed{I_{R_3}=0}$ since C is acting as broken wire

$I_{R_1} = I_{R_2} = I = \frac{\mathcal{E}}{(R_1+R_2)} = \frac{9V}{(12k\Omega + 15k\Omega)} = \boxed{333\,\mu A}$ (2) (1) (1)

ii) $C = \frac{Q}{V} \sim Q = CV = C(IR_2) = (10\mu F)(333\mu A)(15k\Omega) = \boxed{50\,\mu C}$ (2) (1) (1)

iii) switch is opened at $t=0$, C behaves as a battery; $(\Delta V)_C$

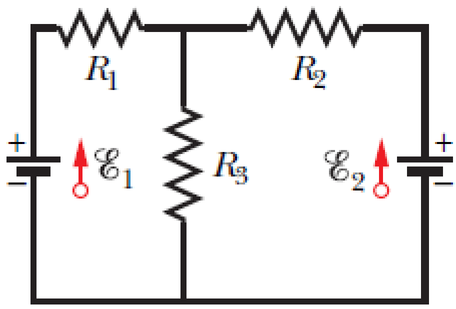


$I_{t=0} = \frac{(\Delta V)_C}{(R_2+R_3)} = \frac{IR_2}{R_2+R_3} = \frac{(333\mu A)(15k\Omega)}{(15k\Omega+3k\Omega)} = 278\mu A = I_i$ (2)

Time Constant: $\tau = (R_2+R_3)C = (18k\Omega)(10\mu F) = 0.180s$ (2)

$\Rightarrow \boxed{I_{R_2} = I_i e^{-t/\tau} = (278\mu A)\, e^{-t/0.180s}}$ for $t>0$ (1)

2. In figure given below, the ideal batteries have emfs $\varepsilon_1 = 10.0V$ and $\varepsilon_2 = 5.0V$, and the resistances are $R_1 = R_2 = R_3 = 4.00\ \Omega$.

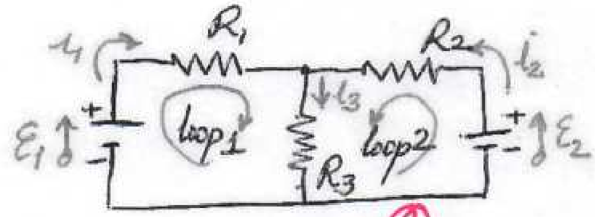


What are

i the direction and magnitude of the **current in resistor 3**?

ii the energy dissipated in **resistor 2**?

iii the power of **battery 1**?



(2)

$i_1 + i_2 = i_3$

loop 1: $\varepsilon_1 - i_1 R_1 - i_3 R_3 = 0$ (3)

loop2: $\varepsilon_2 - i_2 R_2 - i_3 R_3 = 0$ (3)

$10 = 4i_1 + 4i_3$

$5 = 4i_2 + 4i_3$

$10 = 4i_1 + 4i_1 + 4i_2$

$5 = 4i_2 + 4i_1 + 4i_2$

$10 = 8i_1 + 4i_2$

$-2/\ \ 5 = 4i_1 + 8i_2$

$0 = -12 i_2 \rightsquigarrow \boxed{i_2 = 0A}$

$\rightsquigarrow i_1 = 5/4\ A \rightsquigarrow \boxed{i_1 = 1.25A}$

(2) $\boxed{i_3 = 1.25A}$ (1)

i) $i_3 = 1.25A$ & downward (1)

ii) (2) $P = i_2^2 R_2 = \Delta U/\Delta t \rightsquigarrow U = i_2^2 R_2 t = \boxed{0}$ since $i_2 = 0$ (2)

iii) (2) $P = i_1 \varepsilon_1 = (1.25A)(10V) = \boxed{12.5\ W}$ (1)(1)

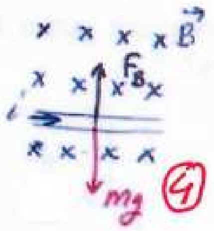
3. A 0.1 T uniform magnetic field is horizontal and parallel to the floor. A straight segment of 1.0 mm diameter copper wire,also parallel to the floor, is perpendicular to the magnetic field. What current through the wire, and in which direction, will allow the wire to float (not falling to the floor) in the magnetic field. Take $\rho = 8920\ kg/m^3$ as the density of copper and $\rho = mass/Volume$.

$B = 0.1T$ (uniform)

$d = 1 \times 10^{-3} m$

$\rho = 8920\ kg/m^3 = \frac{m}{V}$

$V = (\pi d^2 l)$



4

$|\vec{F}_B| = |\vec{F}_g|$ 5

$ilB \sin 90 = mg$

$il(0.1T) = (\rho V) g$

$i\cancel{l}(0.1T) = (8920 \frac{kg}{m^3})(\pi (\frac{d}{2})^2 \cancel{l})(9.8 m/s^2)$

$\rightsquigarrow i = \frac{\rho \pi (d/2)^2 g}{B}$

$\rightsquigarrow i = \frac{(8920\ kg/m^3)(\pi (1 \times 10^{-3} m/2)^2)(9.8 m/s^2)}{0.1T} = \underline{\underline{0.686A}}$ 1

4 1

4. A circular coil of 160 turns has a radius of 1.90 cm.

   i **Calculate the current** that results in a magnetic dipole moment of magnitude 2.30 $A.m^2$

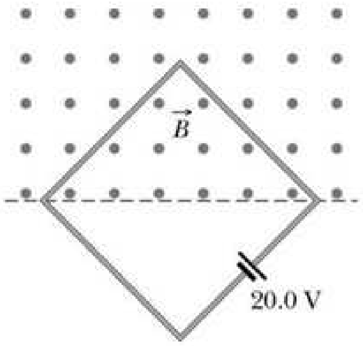
   ii Find the **maximum magnitude of the torque** that the coil, carrying this current, can experience in a uniform 35.0 T magnetic field.

i) $\mu = NiA$ (3) $\rightarrow i = \frac{\mu}{NA} = \frac{\mu}{N\pi R^2}$ (2) $= \frac{2.30\ A m^2}{(160)\pi(1.90\times10^{-2} m)^2} = \boxed{12.7 A}$ (1) (1)

ii) (3) $\vec{\tau} = \vec{\mu} \times \vec{B} \Rightarrow \tau = |\mu||B| \sin\theta$ (1) $\sim \tau_{max} = \mu B \sin 90^\circ$ (2)

$\rightarrow \tau_{max} = (2.30 A m^2)(35 T) = \boxed{80.5\ Nm}$ (1) (1)

5. A square wire loop with 3.00 m sides and resistance 3 Ω is perpendicular to a uniform magnetic field, with half the area of the loop in the field as shown in figure. The loop contains an ideal battery with emf (ε) 20.0 V. The magnitude of the field varies with time according to $B = 0.0420 - 0.3870t$, with B in teslas and t in second.



i Find the value and direction of the induced ε.

ii What is the net emf in the circuit?

iii Find the magnitude and the direction of the net current around the loop?

Hint: Magnetic field is decreasing.

$l = 2.00\,m$
$R = 3\,\Omega$
$\mathcal{E}_B = 20.0\,V$
$B = 0.0420 - 0.870t$
$A = L^2/2$ 1

i) $\mathcal{E}_i = -\frac{d\Phi_B}{dt}$ 2 $= -\frac{d(BA)}{dt}$ 1 $= -\frac{L^2}{2}\frac{dB}{dt} = -\frac{L^2}{2}\frac{d(0.0420 - 0.3870t)}{dt}$ 2

$= -\frac{L^2}{2}(-0.3870\,T/s) = \frac{(3.00\,m)^2}{2}(0.3870\,T/s)$

$\mathcal{E}_i = 1.74\,V$ 2 $\because$ B is out of page and DECREASING. 3

→ Induced emf should support the external magnetic field ⇒ ccc: direction of induced emf (current, ⇒ same direction with the battery

ii) → 3 $\mathcal{E}_{total} = \mathcal{E}_B + \mathcal{E}_i = 20.0V + 1.74V$
$= 21.74\,V$ 2

iii) Current is in the ccw. 2 $i = \frac{V}{R} = \frac{\mathcal{E}_{total}}{R} = \frac{21.74\,V}{3\,\Omega} = 7.23\,A$ 2

İzmir Kâtip Çelebi University
Department of Engineering Sciences
Phy102 Physics II
Final Examination
June 30, 2025 08:30 – 10:00
Good Luck!

NAME-SURNAME:

SIGNATURE:

◇ **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.**

ID:

DEPARTMENT:

INSTRUCTOR:

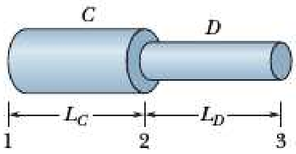
DURATION: 90 minutes

◇ **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.**

Question	Grade	Out of
1A		15
1B		15
2		20
3		15
4		20
5		15
TOTAL		100

This page is intentionally left blank. Use the space if needed.

1. A) Wire C and wire D are made from different materials and have length $L_C = L_D = 1.2\ m$. The resistivity and diameter of wire C are $2.6 \times 10^{-6}\ \Omega m$ and 1.40 mm, and those of wire D are $1.4 \times 10^{-6}\ \Omega m$ and 0.50 mm. The wires are joined as shown in Figure, and a current of 2.7 A is set up in them.



What is the electric potential difference between

i points 1 and 2,

ii points 2 and 3?

What is the rate at which energy is dissipated between

i points 1 and 2,

ii points 2 and 3?

$L_c = L_D = 1.2\,m$

$\rho_c = 2.6\times10^{-6}\ \Omega m$

$\rho_D = 1.4\times10^{-6}\ \Omega m$

$d_c = 1.4\times10^{-3}\ m$

$d_D = 0.5\times10^{-3}\ m$

same currents at both segments, $R = \rho \frac{l}{A} = \frac{V}{I}$

3

$R_C = \rho_C\, L_C / \pi\left(\frac{d_C}{2}\right)^2 = 2.6\times10^{-6}\ \Omega m \dfrac{1.2m}{\pi(0.7\times10^{-3}\ m)^2} = 2.03\Omega$ 3

$R_D = \rho_D\, L_D / \pi\left(\frac{d_D}{2}\right)^2 = 1.4\times10^{-6}\ \Omega m \dfrac{1.2m}{\pi(0.25\times10^{-3}\ m)^2} = 8.56\Omega$ 3

$(V_2 - V_1) = V_C = R_C i = 2.03\Omega \times 2.7A = \boxed{5.5V}$ 1.5

$(V_3 - V_2) = V_D = R_D i = 8.56\Omega \times 2.7A = \boxed{23.1V}$ 1.5

$P_C = i^2 R_C = (2.7A)^2\, 2.03\Omega = \boxed{14.8\ W}$ 1.5

$P_D = i^2 R_D = (2.7A)^2\, 8.56\Omega = \boxed{62.4\ W}$ 1.5

B) A 15.0 $k\Omega$ resistor and a capacitor are connected in series and then a 12.0 V potential difference is suddenly applied across them. The potential difference across the capacitor rises to 5.0 V in 1.30 μs.

a) Calculate the time constant of the circuit.

b) Find the capacitance of the capacitor.

Charging capacitor: $q = C\mathcal{E}(1-e^{-t/RC})$ & $\tau = RC$ (2)

$V(t) = \mathcal{E}(1-e^{-t/RC})$ (3)

i) $V(t) = \mathcal{E}(1-e^{-t/RC}) \Rightarrow 5V = 12V\left(1-e^{-\frac{1.3\times10^{-6}s}{\underbrace{15\times10^{3}\Omega C}_{\tau}}}\right)$

(3)

$e^{-1.3\times10^{-6}s/\tau} = 1-5/12 \rightsquigarrow \ln e^{-1.3\times10^{-6}/\tau} = \ln 7/12$

$\rightsquigarrow -1.3\times10^{-6}s/\tau = \ln 7/12 \rightsquigarrow \tau = \frac{-1.3\times10^{-6}s}{\ln 7/12} = \frac{-1.3\times10^{-6}s}{-0.54}$ (3)

$\Rightarrow \underline{\tau = 2.41\,\mu s}$ (2)

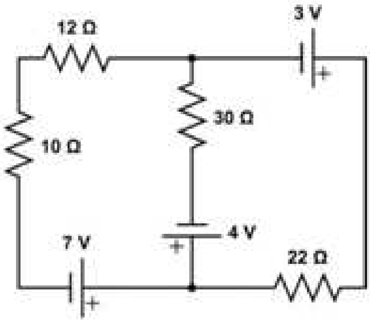
ii) $\tau = RC \rightsquigarrow C = \frac{\tau}{R} = \frac{2.41\times10^{-6}s}{15\times10^{3}\Omega} = 1.61\times10^{-10}F$

$= 0.161\,nF$

$\underline{= 162\,pF}$

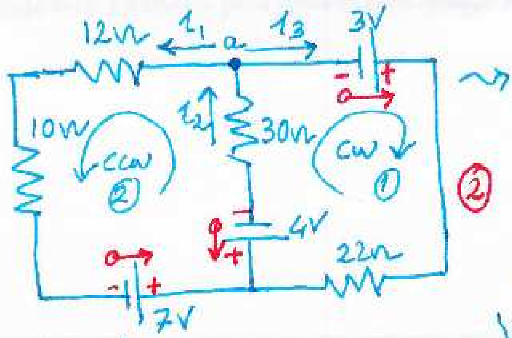
(2)

2. A circuit is assembled as shown at the figure. If $R_1 = 10\ \Omega$, $R_2 = 12\ \Omega$, $R_3 = 30\ \Omega$, $R_4 = 22\ \Omega$, $\xi_1 = 7\ V$, $\xi_2 = 4\ V$, and $\xi_3 = 3\ V$;



i What is the magnitude of the current through the 30 Ω resistor?

ii How much power is drawn by the 7 V battery?



Junction rule: $I_1 + I_3 = I_2$ (3)

loop1: $-12I_1 - 10I_1 + 7 - 4 - 30I_2 = 0$ (3)

loop2: $3 - 22I_3 - 4 - 30I_2 = 0$ (3)

$$22I_1 + 30I_2 = 3$$
$$-30I_2 - 22I_3 = 1$$

$$22I_1 + 30(I_1 + I_3) = 3$$
$$-30(I_1 + I_3) - 22I_3 = 1$$

$$52I_1 + 30I_3 = 3$$
$$-30I_1 - 52I_3 = 1$$

$$52I_1 + 30\left(\frac{-1 - 30I_1}{52}\right) = 3$$

$\rightsquigarrow I_1 = 0.103\,A$ (1)

$I_3 = -\frac{1}{52} - \frac{30}{52} I_1 = -0.078\,A$ (1) (1)

$\boxed{I_2 = 0.0244\,A}$ (1) (1) i)

ii) $P = iV = I_1\,7V$ (1)

$= (0.103A)(7V) = \boxed{0.72W}$ (1) (1)

3. A 0.1 T uniform magnetic field is horizontal and parallel to the floor. A straight segment of 1.0 mm diameter copper wire,also parallel to the floor, is perpendicular to the magnetic field. What current through the wire, and in which direction, will allow the wire to float (not falling to the floor) in the magnetic field. Take $\rho = 8920\ kg/m^3$ as the density of copper and $\rho = mass/Volume$.

$B = 0.1T$ (uniform)
$d = 1\times10^{-3} m$
$\rho = 8920\ kg/m^3 = \frac{m}{V}$
$V = (\pi d^2 l)$

4

$|\vec{F_B}| = |\vec{F_g}|$ 5

$ilB\sin 90 = mg$

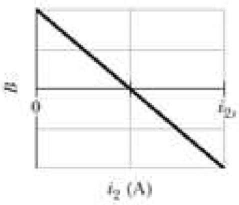
$il(0.1T) = (\rho V)g$

$\cancel{i}\cancel{l}(0.1T) = (8920 \frac{kg}{m^3})(\pi (\frac{d}{2})^2 \cancel{l})(9.8 m/s^2)$

$\rightsquigarrow i = \frac{\rho \pi (d/2)^2 g}{B}$ $\rightsquigarrow i = \frac{(8920\ kg/m^3)(\pi (1\times10^{-3} m/2)^2)(9.8 m/s^2)}{0.1T} = \underline{\underline{0.686A}}$ 4 1 1

4. Figure(a) shows two wires, each carrying a current. Wire 1 consists of a circular arc of radius R and two radial lengths; it carries current $i_1 = 3.0\ A$ in the direction indicated. Wire 2 is long and straight; it carries a current i_2 that can be varied; and it is at distance R/2 from the center of the arc. The net magnetic field B due to the two currents is measured at the center of curvature of the arc.

(a)



(b)

Figure(b) is a plot of B in the direction perpendicular to the figure as a function of current i_2. The horizontal scale is set by $i_{2s} = 2.00\ A$. **What is the angle subtended by the arc?**

$i_1 = 3A$, R
i_2: variable, R/2

net magnetic field at point P

$$B_P = \underbrace{\frac{\mu_0 i_1}{4\pi R}}_{\text{circular arc (out of page)}} \phi - \underbrace{\frac{\mu_0 i_2}{2\pi R/2}}_{\text{straight wire (into page)}}$$

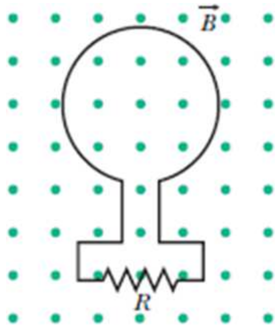
5 5

at $i_2 = 1\,A \rightsquigarrow B_P = 0 \rightsquigarrow \frac{\mu_0 3A}{4\pi R}\phi = \frac{\mu_0 1A}{\pi R}$ 5

$\rightsquigarrow \phi = \frac{4}{3}$ radians $= \underline{\underline{76.4^\circ}}$ 3 2

(3.14 rad $\rightsquigarrow$ 180°)

5. In Figure given below, the magnetic flux through the loop increases according to the relation $\Phi_B = 6.0t^2 + 7.0t$, where Φ_B is in miliwebers and t is in seconds.



i What is the magnitude of the emf (ϵ) induced in the loop when $t = 2.0\ s$?

ii Is the direction of the current through R to the right or left? Explain.

Increasing magnetic flux $\xrightarrow{1}$ induced emf in the loop

i) $|\mathcal{E}| = \left|\frac{d\Phi_B}{dt}\right|$ 3 $\rightarrow \mathcal{E} = \frac{d}{dt}(6.0t^2+7.0t)\Big|_{t=2s}$ 2 $= 12t+7\Big|_{t=2s}$ 2

$\rightarrow \boxed{\mathcal{E} = 31\ mV}$ 2

ii) Increasing flux $\leftrightarrow$ induced emf should create a magnetic flux to <u>oppose</u> (to decrease external field)

To have an inward (induced) B, we should have a clockwise current at the loop. 3

$\rightarrow$ $\boxed{\text{Left through R}}$ 2

İzmir Kâtip Çelebi University
Department of Engineering Sciences
Phy102 Physics II
Final Examination
June 07, 2024 10:20 – 11:50
Good Luck!

NAME-SURNAME:

SIGNATURE:

◇ **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.**
ID:

DEPARTMENT:

INSTRUCTOR:

DURATION: 90 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.**

Question	Grade	Out of
1A		10
1B		15
2		20
3		15
4		20
5		20
TOTAL		100

This page is intentionally left blank. Use the space if needed.

1. A) A 24.0 m length of 2.0 mm diameter cylindrical conducting wire carries a 140 A current when 28.0 V is applied to its ends.

   i Calculate the resistance R and resistivity ρ of the conducting wire.

   ii Find the current density J and electric field E inside the conducting wire.

   iii If the current is maintained in the conductor for 3 hours, calculate the dissipated energy in the conducting wire.

i) $R = \frac{V}{I}$ & $R = \rho \frac{L}{A} \rightsquigarrow \rho = \frac{A}{L} R$, $A = \pi r^2$

$R = \frac{28V}{140A} = \underline{0.2\,\Omega}$ (1) (1)

$= \frac{\pi (2\times10^{-3} m/2)^2}{24m} 0.2\,\Omega$ (1)

$= \underline{2.6\times10^{-8}\,\Omega m}$ (1)

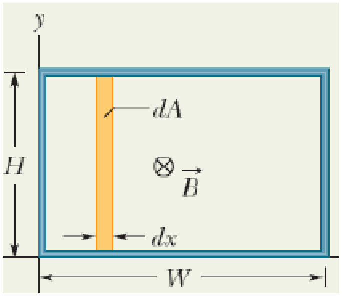
ii) $J = \frac{I}{A} = \frac{140A}{\pi(10^{-3}m)^2} = \underline{4.5\times10^{7}\ A/m^2}$ (1) (1)

$E = \rho J = (2.6\times10^{-8}\,\Omega m)(4.5\times10^{7} A/m^2) = \underline{1.2\ V/m}$ (1) (1)

iii) $\frac{\Delta U}{\Delta t} = P = i^2 R \rightsquigarrow \Delta U = i^2 R \Delta t$

$\rightsquigarrow \Delta U = (140A)^2 (0.2\Omega)(3\times60\times60s) = \underline{4.2\times10^{7}\ J}$ (1) (1)

B) Figure shows a rectangular loop of wire immersed in a nonuniform and varying magnetic field $\vec{B}$ that is perpendicular to and directed into the page. The field's magnitude is given by $B = 4t^2x^2$, with B in teslas, t in seconds, and x in meters.



The loop has width $W = 3.0\ m$ and height $H = 2.0\ m$. What are the magnitude and direction of the induced emf ξ around the loop at $t = 0.10\ s$?

$\Phi_B = \int \vec{B} \cdot d\vec{A}$, $B // A$, $\Phi_B = \int B\,dA = \int 4t^2x^2 H\,dx$ (3)

$B(x,t) = 4t^2x^2$

$A = Hx$, $dA = H\,dx$

$W = 3m$ & $H = 2m$

$\Delta t = 0.10 s$

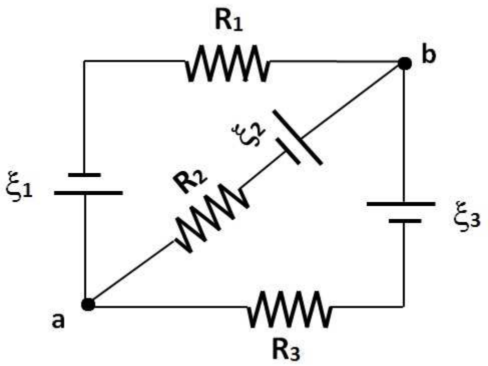
$= 4t^2 H \int_0^3 x^2 dx = 4t^2 H \frac{x^3}{3}\Big|_0^3$

$= 72t^2 = \Phi_B$ (3)

$|\mathcal{E}| = +\frac{d\Phi_B}{dt} = +144t\Big|_{t=0.1s} = 14.4 V$ (3) magnitude (3)

Increasing B ⊗ → induced current should oppose (3) ⊙ ⇒ CCW

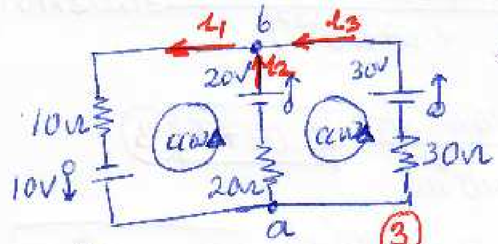
2. The circuit containing three ideal batteries and resistors is shown in figure. If $R_1 = 10\ \Omega$, $R_2 = 20\ \Omega$, $R_3 = 30\ \Omega$, $\xi_1 = 10\ V$, and $\xi_2 = 20\ V$, $\xi_3 = 30\ V$;



i Calculate the current through each battery.

ii Calculate $V_b - V_a$, the potential difference between the points b and a.

iii Find the total thermal energy dissipation rate in the circuit.



3

i) $i_1 = i_2 + i_3$ 1

$-20\Omega\, i_2 + 20V - 10\Omega\, i_1 + 10V = 0$ 2

$-30\Omega\, i_3 + 30V - 20V + 20\Omega\, i_2 = 0$ 2

$-20 i_2 + 30 - 10 i_1 = 0$

$-30 i_3 + 10 + 20 i_2 = 0$

$\rightarrow 10 i_1 + 20 i_2 = 30$

$20 i_2 - 30 i_3 = -10$

$10(i_2 + i_3) + 20 i_2 = 30$

$20 i_2 - 30 i_3 = -10$

3/ $30 i_2 + 10 i_3 = 30$

$20 i_2 - 30 i_3 = -10$

$110 i_2 = 80 \rightsquigarrow$ $\boxed{i_2 = 0.73A}$ 2, $\boxed{i_3 = 0.82A}$ 2, $\boxed{i_1 = 1.55A}$ 2

ii) $V_b - 20V + (20\Omega)(0.73A) = V_a$

$V_b - (1.55A)(10\Omega) + 10V = V_a$

$V_b - 30V + (30\Omega)(0.82A) = V_a$

$\Rightarrow V_b - V_a = \boxed{5.5V}$ 3

iii) $P_{tot} = i_1^2 R_1 + i_2^2 R_2 + i_3^2 R_3$

$= (1.55A)^2\, 10\Omega + (0.73A)^2\, 20\Omega + (0.82A)^2\, 30\Omega$

$= \boxed{54.9\ W}$ 3

3. **What uniform magnetic field**, applied **perpendicular** to a beam of electrons moving at $1.30 \times 10^6\ m/s$, is required to make the electrons travel **in a circular arc** of radius of 0.35 m? **(Hint:** Centripetal Force; $F_c = m\frac{v^2}{R}$)

$v = 1.3 \times 10^6\ m/s$

$R = 0.35\,m$

$e = 1.602 \times 10^{-19}\ C\ (\equiv |q|)$

$m_e = 9.109 \times 10^{-31}\ kg$

$B = ?$

$F_c = m\frac{v^2}{R}$ & $F_B = |q| v B \sin\theta$

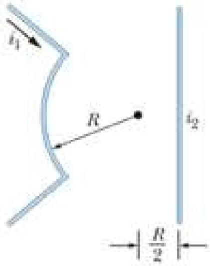
$|q| v B \sin 90^\circ = m_e v^2/R$ 5

$\Rightarrow B = \frac{m_e v}{e R}$ 5

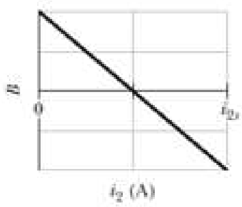
$= \frac{(9.109 \times 10^{-31}\ kg)(1.3 \times 10^6\ m/s)}{(1.602 \times 10^{-19}\ C)(0.35\,m)}$

$= \boxed{2.11 \times 10^{-5}\ T}$ 5

4. Figure(a) shows two wires, each carrying a current. Wire 1 consists of a circular arc of radius R and two radial lengths; it carries current $i_1 = 3.0\ A$ in the direction indicated. Wire 2 is long and straight; it carries a current i_2 that can be varied; and it is at distance R/2 from the center of the arc. The net magnetic field B due to the two currents is measured at the center of curvature of the arc.



(a)



(b)

Figure(b) is a plot of B in the direction perpendicular to the figure as a function of current i_2. The horizontal scale is set by $i_{2s} = 2.00\ A$. What is the angle subtended by the arc?

$i_1 = 3A$, R
i_2 = variable, R/2

net magnetic field at point P

$$B_P = \underbrace{\frac{\mu_0 i_1}{4\pi R}}_{\substack{\text{circular arc} \\ \text{(out of page)}}} \phi - \underbrace{\frac{\mu_0 i_2}{2\pi R/2}}_{\substack{\text{straight wire} \\ \text{(into page)}}}$$

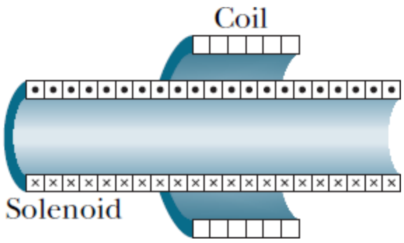
5 5

at $i_2 = 1\,A \rightsquigarrow B_P = 0 \rightsquigarrow \frac{\mu_0\, 3A}{4\pi R}\phi = \frac{\mu_0\, 1A}{\pi R}$ 5

$\rightsquigarrow \phi = \frac{4}{3}$ radians $= \underline{\underline{76.4^\circ}}$ 3 2

(3.14 rad $\rightsquigarrow$ 180°)

5. In Figure below, a 120-turn coil of radius 1.8 cm and resistance 5.3 Ω is coaxial with a solenoid of 220 turns/cm and diameter 3.2 cm. The solenoid current drops from 1.5 A to zero in time interval $\Delta t = 25\ ms$.



What current is induced in the coil during Δt?

We need the induced emf, $\mathcal{E}$ on the coil by changing current in the solenoid.

Changing current → changing magnetic flux ⇒ induced emf

Lenz's law (3) $\mathcal{E} = -N\frac{d\Phi_B}{dt} = -NA\frac{dB}{dt}$ (3) Magnetic Field of a solenoid $B = \mu_0 n i$

$\Rightarrow \mathcal{E} = -NA\frac{d}{dt}(\mu_0 i n) = -NA\mu_0 n\frac{di}{dt}$ (3) $\frac{di}{dt} \sim \frac{\Delta i}{\Delta t}$

(3) $\frac{\Delta i}{\Delta t} = \frac{0-1.5A}{25\times10^{-3}s - 0}$

$\Rightarrow \mathcal{E} = -(120)(\pi \times (1.6\times10^{-2}\,m)^2)(4\pi\times10^{-7}\,Tm/A)(22000\,\frac{turns}{m})\left(\frac{-1.5A}{25\times10^{-3}s}\right)$ (1) (1) (1)

(1) $\boxed{=0.16\,V}$ (1)

→ Then, Ohm's law (1) $i = \frac{\mathcal{E}}{R} = \frac{0.16V}{5.3\Omega}$ $\boxed{=0.030\,A}$ (1) (1)

İzmir Kâtip Çelebi University
Department of Engineering Sciences
Phy102 Physics II
Final Examination
January 09, 2023 17:00 – 18:30
Good Luck!

NAME-SURNAME:

SIGNATURE:

ID:

DEPARTMENT:

INSTRUCTOR:

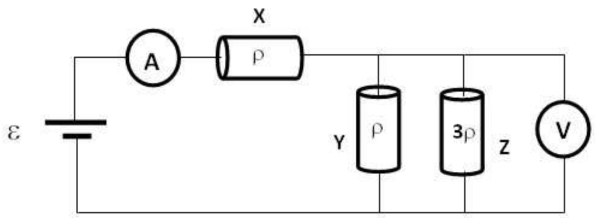
DURATION: 90 minutes

◇ **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

This page is intentionally left blank. Use the space if needed.

1. A) 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.



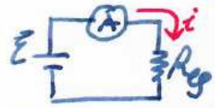
i Find the current i through the ammeter.

ii Find the reading of voltmeter.

Express your result in terms of given quantities and constants (ε, A, ρ, L). **(Hint:** Resistance is related to resistivity; $R = \rho\frac{L}{A}$)

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

where $R_x = R_y = \rho\frac{L}{A}$ & $R_z = 3\rho\frac{L}{A} \Rightarrow R_{eq} = \rho\frac{L}{A} + \frac{\rho\frac{L}{A}\cdot 3\rho\frac{L}{A}}{\rho\frac{L}{A} + 3\rho\frac{L}{A}} = \frac{7}{4}\rho\frac{L}{A}$ 2



$\rightarrow i = \frac{\varepsilon}{R_{eq}} = \boxed{\frac{4}{7}\frac{\varepsilon A}{\rho L}} = i_x \rightarrow i_x = i_y + i_z$ 1

ii)

Loop1: 2 $\varepsilon - i_x R_x - i_y R_y = 0 \rightarrow i_y = \frac{\varepsilon - i_x R_x}{R_y}$

loop2: 2 $i_y R_y - i_z R_z = 0 \rightarrow i_z = i_y \frac{R_y}{R_z}$

$\Rightarrow i_y = \frac{\varepsilon - i_x R_x}{R_y}$ & $i_z = \left(\frac{\varepsilon - i_x R_x}{R_y}\right)\frac{R_y}{R_z} = \frac{\varepsilon - i_x R_x}{R_z}$ 1

$\Rightarrow V = i_z R_z = \left(\frac{\varepsilon - i_x R_x}{R_z}\right) R_z = \varepsilon - i_x R_x = \varepsilon - \left(\frac{4}{7}\frac{\varepsilon A}{\rho L}\right)\rho\frac{L}{A} = \varepsilon - \frac{4\varepsilon}{7}$

$\boxed{V = \frac{3\varepsilon}{7}}$ 1

B) **What uniform magnetic field**, applied **perpendicular** to a beam of electrons moving at 1.30×10^6 m/s, is required to make the electrons travel **in a circular arc** of radius of 0.35 m? **(Hint:** Centripetal Force; $F_c = m\frac{v^2}{R}$)

$v = 1.3 \times 10^6 \, m/s$

$R = 0.35 m$

$e = 1.602 \times 10^{-19} C \; (\equiv |q|)$

$m_e = 9.109 \times 10^{-31} kg$

$B = ?$

$F_c = m\frac{v^2}{R}$ & $F_B = |q| v B \sin\theta$

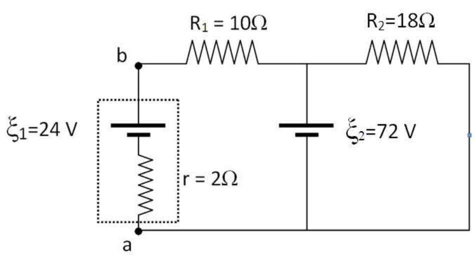
$|q| v B \sin 90^\circ = m_e v^2/R$ 5

$\Rightarrow B = \frac{m_e v}{e R}$ 5

$= \frac{(9.109 \times 10^{-31} kg)(1.3 \times 10^6 m/s)}{(1.602 \times 10^{-19} C)(0.35 m)}$

$= \boxed{2.11 \times 10^{-5} T}$ 5

2. Consider circuit as shown in figure which consists of two batteries. One of the following batteries has an internal resistance r, while the other battery is an ideal battery.

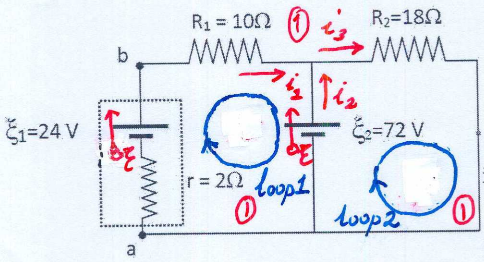


Calculate;

i Currents through each battery,

ii Total power dissipated by resistors.

iii Potential difference between points a and b, V_{ab},



i Currents through each battery,

ii Potential difference between points a and b, V_{ab},

iii Total power supplied by batteries,

iv Total power dissipated by resistors.

i) 1 loop 1: $-i_1 r + \mathcal{E}_1 - i_1 R_1 - \mathcal{E}_2 = 0 \Rightarrow -2i_1 + 24 - 10i_1 - 72 = 0$ 2

2 loop2: $\mathcal{E}_2 - i_3 R_2 = 0 \Rightarrow 72 - 18 i_3 = 0$ 2 $\quad -12 i_1 = 48$

3 $i_1 + i_2 = i_3$ 1 $\Rightarrow -4A + i_2 = 4A \rightarrow \boxed{i_2 = 8A}$ 1 $\boxed{i_3 = 4A}$ 1 $\quad \boxed{i_1 = -4A}$ 1

opposite direction

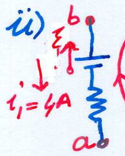
Three unknowns ($i_{1,2,3}$), three equations

$i_1 = -4A$: Through battery 1

$i_2 = 8A$: Through battery 2

$i_3 = 4A$: Through Resistor 3

ii)



$V_{ab} = V_b - V_a$ 2

$V_a + i_1 r + \xi_1 = V_b$

$V_b - V_a = 4A\,2\Omega + 24V$

$\boxed{= 32V}$ 1

iii) $P = i\mathcal{E}$

Battery 1: $P_1 = i_1 \xi_1 = (4A)(24V)$ $\boxed{= -96W}$ 1.5

Battery2: $P_2 = i_2 \xi_2 = (8A)(72V)$ $\boxed{= 576W}$ 1.5

$P_1 + P_2 \boxed{= 480W}$

iv) $P = i^2 R$

Resistor 1: $P'_1 = i_1^2 R_1 = (4A)^2 (10\Omega) = 160W$ — R_1 1

Resistor 2: $P'_2 = i_3^2 R_2 = (4A)^2 (18\Omega) = 288W$ — R_2 1

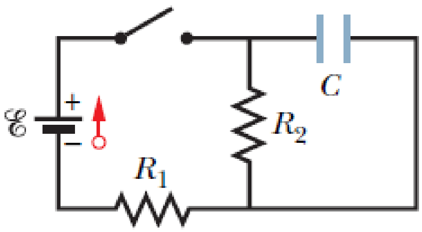
Internal Resistor r: $P'_r = i_1^2 r = (4A)^2 (2\Omega) = 32W$ — r 1

$P_1 + P_2 = P'_1 + P'_2 + P'_r$

$480W = 480W$

3

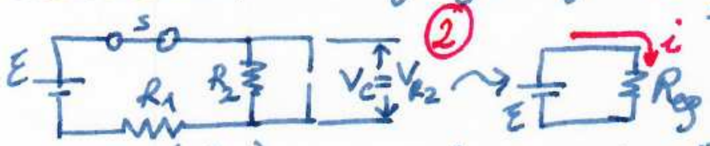
3. In Figure given below, $R_1 = 8.0 \times 10^3\ \Omega$, $R_2 = 10.0 \times 10^3\ \Omega$, $C = 6 \times 10^{-7}\ F$, and the ideal battery has emf $\epsilon = 12.0\ V$. First, the switch is closed a long time so that the steady state is reached. Then the switch is opened at time $t = 0$.



What is the current in resistor 2 at $t = 2.00 \times 10^{-3}\ s$?

$R_1 = 8\ k\Omega$
$R_2 = 10\ k\Omega$
$C = 0.6\ \mu F$
$\mathcal{E} = 12V$

initially, C acts as a connecting wire ①
after a long time, C acts as a broken wire ②
① Charging stage ② fully charged
$\Rightarrow V_C = V_{R_2} = iR_2$



$i = \frac{\mathcal{E}}{R_1+R_2}$ ②

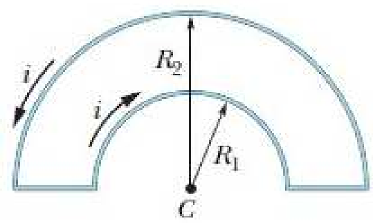
$\rightarrow V_{R_2} = \left(\frac{\mathcal{E}}{R_1+R_2}\right)R_2 = \frac{12V}{(8k\Omega+10k\Omega)}\,10k\Omega = \boxed{\frac{20}{3}V}$ (= V_C) when fully charged ③ ②

③ switch is opened → $t=0$ & $V_C = V_0 = \frac{20}{3}V$ ②
discharging through R_2, $V = V_0 \exp(-t/RC)$ ③

$\rightarrow V = \left(\frac{20}{3}V\right)\exp\left(-\frac{2\,ms}{(10k\Omega)(0.6\mu F)}\right) = \left(\frac{20}{3}V\right)\exp\left(-\frac{2\times10^{-3}s}{10\times10^{3}\Omega\ 0.6\times10^{-6}F}\right)$

$V(t=2ms) = \boxed{4.78V}$ ② $\rightarrow i'_{R_2} = \frac{V}{R_2} = \frac{4.78V}{10k\Omega} = \boxed{4.77\times10^{-4}A}$ ① ② ①

4. In Figure, two semicircular arcs have radii $R_2 = 2.6\ cm$ and $R_1 = 1.05\ cm$, carry current $i = 0.0937\ A$, and share the same center of curvature C.



What are the

i magnitude

ii direction (into or out of the page, why?)

of the net magnetic field at C?
Hint: Use Biot-Savart Law.

Biot-Savart law: $d\vec{B} = \frac{\mu_0}{4\pi}\, \frac{i\, d\vec{s} \times \hat{r}}{r^2}$ →

$dB = \frac{\mu_0}{4\pi}\, \frac{i\, ds \sin 90^\circ}{R^2} = \frac{\mu_0}{4\pi}\, \frac{i\, ds}{R^2}$ {where $ds = R\, d\phi$} → $B = \int dB$

→ $B = \frac{\mu_0}{4\pi}\, i \int_0^{\phi} \frac{R\, d\theta}{R^2} = \frac{\mu_0 i}{4\pi R}\, \phi$ {where ϕ is arc angle} (4)

$R_1 = 1.05 \times 10^{-2}\ m$
$R_2 = 2.6 \times 10^{-2}\ m$
$i = 0.0937\ A$
$\phi = 180^\circ \equiv \pi$

i) $B = B_1 + B_2 = \frac{\mu_0 i}{4\pi}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)\pi$ (4)

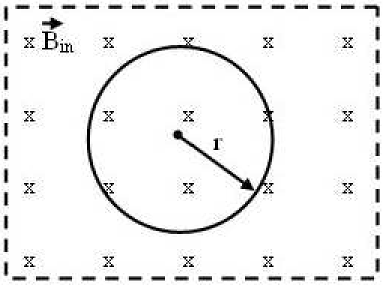
→ $B = \frac{(4\pi \times 10^{-7}\ Tm/A)\ 0.0937A}{4\cancel{\pi}}\left(\frac{1}{1.05 \times 10^{-3}\ m} - \frac{1}{2.6 \times 10^{-3}\ m}\right)\cancel{\pi}$ (4)

$= \boxed{1.67 \times 10^{-6}\ T}$ (2) (2)

ii) into the page (4)

$\vec{B}_2$ ← C → $\vec{B}_1$ (into the page) & $|\vec{B}_1| > |\vec{B}_2|$
$\vec{B}_2$ (out of the page)

5. In figure below, the magnetic flux through the circular loop of radius $r = 2.0\ m$ increases according to the relation $\Phi_B = 3t^2 + 3t$, 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 $R = 30\ \Omega$?

i) $\phi_B(t) = 3t^2 + 3t$: increasing flux ⇒ induced $\mathcal{E}, i$ should oppose

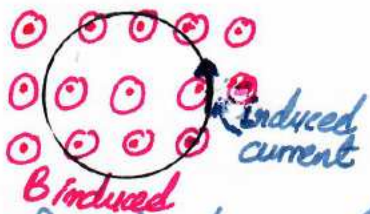
$\underbrace{\mathcal{E}}_{\text{induced}} = -\underbrace{N}_{1} \frac{d\phi_B}{dt}$ 5 $\rightarrow |\mathcal{E}| = \frac{d}{dt}(3t^2+3t)\Big|_{t=2s}$ 3 $= 6t+3\Big|_{t=2s} = \boxed{15\ V}$ 5

ii) $i = \frac{\mathcal{E}}{R}$ 2 $= \frac{15\ V}{30\ \Omega} = \boxed{0.5\ A}$ 2

$\vec{B}_{applied}$ ⊗ ~ in to the page

$\vec{B}_{induced}$ ⊙ ← since it should oppose

by Right Hand Rule ~ direction of induced current is ccw 3



İzmir Kâtip Çelebi University
Department of Engineering Sciences
Phy102 Physics II
Final Examination
January 14, 2022 11:00 – 12:30
Good Luck!

NAME-SURNAME:

SIGNATURE:

ID:

DEPARTMENT:

INSTRUCTOR:

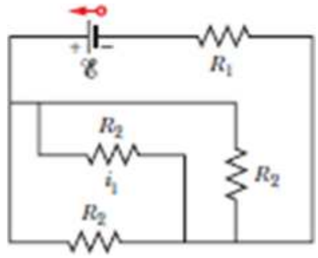
DURATION: 90 minutes

◇ **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

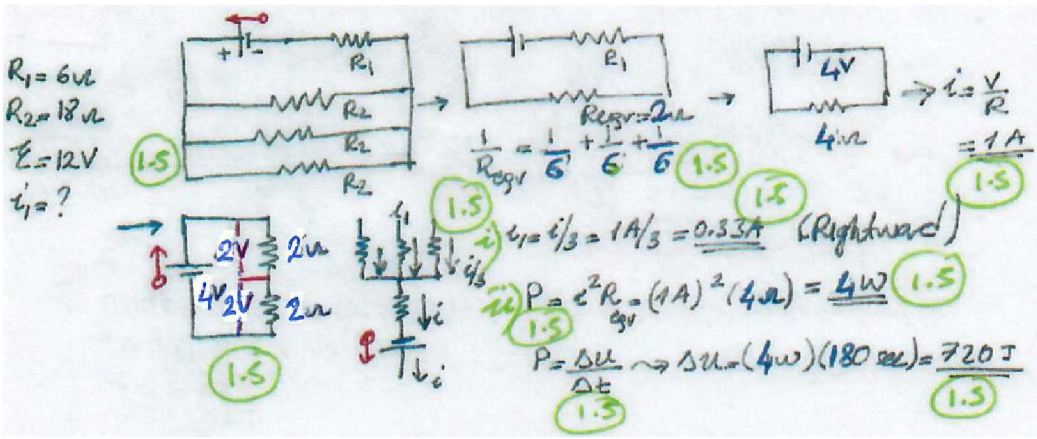
This page is intentionally left blank. Use the space if needed.

1. A) In Figure, $R_1 = 2.0\ \Omega$, $R_2 = 6.0\ \Omega$, and the ideal battery has emf $\varepsilon = 4.0\ V$.



i What are the size and direction (left or right) of current i_1?

ii How much energy is dissipated by all four resistors in 3.00 minutes?



B) A 15.0 $k\Omega$ resistor and a capacitor are connected in series and then a 12.0 V potential difference is suddenly applied across them. The potential difference across the capacitor rises to 5.0 V in 1.30 μs.

a) Calculate the time constant of the circuit.

b) Find the capacitance of the capacitor.

Charging capacitor: $q = C\mathcal{E}(1-e^{-t/RC})$ & $\tau = RC$ 2

$V(t) = \mathcal{E}(1-e^{-t/RC})$ 3

i) $V(t) = \mathcal{E}(1-e^{-t/RC}) \Rightarrow 5V = 12V\left(1-e^{-\frac{1.3\times10^{-6}s}{\underbrace{15\times10^{3}\Omega\, C}_{\tau}}}\right)$ 3

$e^{-1.3\times10^{-6}s/\tau} = 1 - 5/12 \rightsquigarrow \ln e^{-1.3\times10^{-6}/\tau} = \ln 7/12$

$\rightsquigarrow -1.3\times10^{-6}s/\tau = \ln 7/12 \rightsquigarrow \tau = \frac{-1.3\times10^{-6}s}{\ln 7/12} = \frac{-1.3\times10^{-6}s}{-0.54}$ 3

$\Rightarrow \underline{\tau = 2.41\,\mu s}$ 2

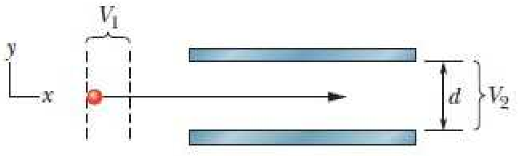
ii) $\tau = RC \rightsquigarrow C = \frac{\tau}{R} = \frac{2.41\times10^{-6}s}{15\times10^{3}\Omega} = 1.61\times10^{-10}F$

$= 0.161\,nF$

$\underline{= 162\,pF}$

2

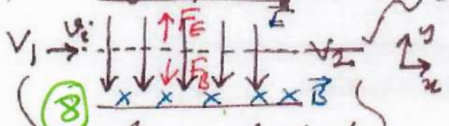
2. In Figure, an electron accelerated from rest through potential difference $V_1 = 1.00\ kV$ enters the gap between two parallel plates having separation $d = 10.0\ mm$ and potential difference $V_2 = 50\ V$. The lower plate is at the lower potential. Neglect fringing and assume that the electron's velocity vector is perpendicular to the electric field vector between the plates.



In unit-vector notation, what uniform magnetic field allows the electron to travel in a straight line in the gap?

$V_1 = 1\ kV$ & $d = 10\times10^{-3}\ m$, $V_2 = 50\ V$, $M_e = 9.11\times10^{-31}\ kg$

higher potential



lower potential

8

$\Delta U = qV_1 - 0$ 2

$= (1.6\times10^{-19}\ C)\ 1\times10^{3}\ V$

$\Delta U = \Delta K = \frac{1}{2} m_e v_i^2$

2

$V_2 = Ed$

$\Rightarrow E = \frac{V_2}{d}$

straight line $\Rightarrow |\vec{F}_B| = |\vec{F}_E|$ 2

$|q| v_i B = |q| E$

$\sqrt{\frac{2qV_1}{m_e}}\, B = \frac{V_2}{d}$ 2

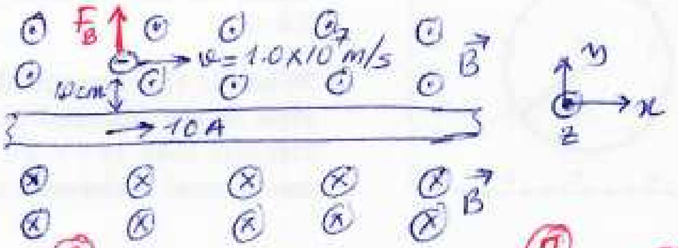
$\rightarrow B = \frac{50\ V}{10\times10^{-3}\ m}\sqrt{\frac{9.11\times10^{-31}\ kg}{2\times1.6\times10^{-19}\ C\ \ 1\times10^{3}\ V}}$

$B = 2.67\times10^{-4}\ T$

$\vec{B} = 2.67\times10^{-4}\ T(-\hat{k})$

2 2

3. 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?



3 $\quad$ 3

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

$$\vec{F}_B = q\,\vec{v} \times \vec{B} \Rightarrow |\vec{F}_B| = (1.602 \times 10^{-19}\ C)(1.0 \times 10^{7}\ m/s)(2 \times 10^{-4}\ T)$$

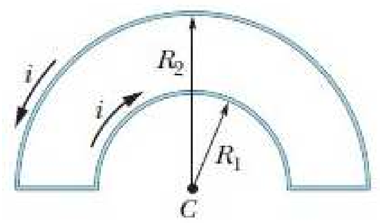
3

$$= \underline{\underline{3.2 \times 10^{-16}\ N}}$$

3 $\quad$ 2

$$\underline{\underline{\vec{F}_B = 3.2 \times 10^{-16}\ N\ \hat{j}}} \quad 4$$

4. In Figure, two semicircular arcs have radii $R_2 = 3.9\ cm$ and $R_1 = 1.575\ cm$, carry current $i = 0.1405\ A$, and share the same center of curvature C.



What are the

i magnitude

ii direction (into or out of the page, why?)

of the net magnetic field at C?
Hint: Use Biot-Savart Law.

Biot-Savart law: $d\vec{B} = \frac{\mu_0}{4\pi} \frac{i\, d\vec{s} \times \hat{r}}{r^2}$ →

$dB = \frac{\mu_0}{4\pi} \frac{i\, ds \sin 90^\circ}{R^2} = \frac{\mu_0}{4\pi}\frac{i\, ds}{R^2}$ $\left\{ \begin{array}{l} \text{where} \\ ds = R\,d\phi \end{array} \right\}$ → $B = \int dB$

→ $B = \frac{\mu_0}{4\pi} i \int_0^{\phi} \frac{R\, d\theta}{R^2} = \underline{\underline{\frac{\mu_0 i}{4\pi R}\phi}}$ (4) $\left\{ \begin{array}{l} \text{where} \\ \phi \text{ is arc angle} \end{array} \right.$

$R_1 = 1.05 \times 10^{-2}\,m$
$R_2 = 2.6 \times 10^{-2}\,m$
$i' = 0.0937\,A$
$\phi = 180^\circ \equiv \pi$

i) $B = B_1 + B_2 = \frac{\mu_0 i}{4\pi}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)\pi$ (4)

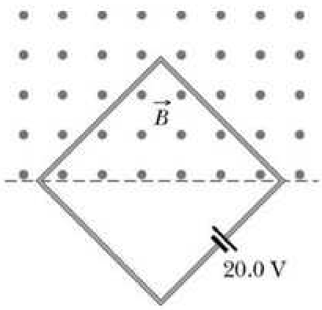
→ $B = \frac{(4\pi \times 10^{-7}\,T\,m/A)\,0.0937\,A}{4\cancel{\pi}}\left(\frac{1}{1.05\times10^{-3}\,m} - \frac{1}{2.6\times10^{-3}\,m}\right)\cancel{\pi}$ (4)

$= \boxed{1.67 \times 10^{-6}\,T}$ (2) (2)

ii) into the page (4)

$\vec{B}_1$ (into the page) & $|\vec{B}_1| > |\vec{B}_2|$
$\vec{B}_2$ (out of the page)
C

5. A square wire loop with 3.00 m sides and resistance 3 Ω is perpendicular to a uniform magnetic field, with half the area of the loop in the field as shown in figure. The loop contains an ideal battery with emf (ε) 20.0 V. The magnitude of the field varies with time according to $B = 0.0420 - 0.3870t$, with B in teslas and t in second.



i Find the value and direction of the induced ε.

ii What is the net emf in the circuit?

iii Find the magnitude and the direction of the net current around the loop?

Hint: Magnetic field is decreasing.

$l = 2.00\,m$
$R = 3\,\Omega$
$\mathcal{E}_B = 20.0\,V$
$B = 0.0420 - 0.870t$
$A = L^2/2$ (1)

i) $\mathcal{E}_i = -\frac{d\Phi_B}{dt}$ (2) $= -\frac{d(BA)}{dt}$ (1) $= -\frac{L^2}{2}\frac{dB}{dt} = -\frac{L^2}{2}\frac{d(0.0420-0.3870t)}{dt}$ (2)

$= -\frac{L^2}{2}(-0.3870\,T/s) = \frac{(3.00\,m)^2}{2}(0.3870\,T/s)$ (3)

$\mathcal{E}_i = 1.74\,V$ (2) $\because$ B is out of page and DECREASING.
→ Induced emf should support the external magnetic field ⇒ ccc; direction of induced emf (current)
⇒ same direction with the battery →

ii) $\mathcal{E}_{total} = \mathcal{E}_B + \mathcal{E}_i = 20.0\,V + 1.74\,V$ (3)
$= 21.74\,V$ (2)

iii) Current is in the ccw. (2) $i = \frac{V}{R} = \frac{\mathcal{E}_{total}}{R} = \frac{21.74\,V}{3\,\Omega} = 7.23\,A$ (2)

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

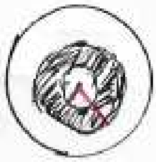
This page is intentionally left blank. Use the space if needed.

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?

$R = 15 \times 10^{-3}\,m$

$J(R) = 6 \times 10^{7} r^2\ A/m^2$

$i = ?$ from $r = 0.2R$ to $r = 0.6R$



$$i = \int \vec{J} \cdot d\vec{A} = \int_{0.2R}^{0.6R} 6 \times 10^{7} r^2\, 2\pi r\, dr$$

2 3 2

$$= 12\pi \times 10^{7} \int_{0.2R}^{0.6R} r^3\, dr = 12\pi \times 10^{7} \frac{r^4}{4} \Bigg|_{0.2R}^{0.6R}$$

3

$$= 3\pi \times 10^{7} \left[(0.6R)^4 - (0.2R)^4\right]$$

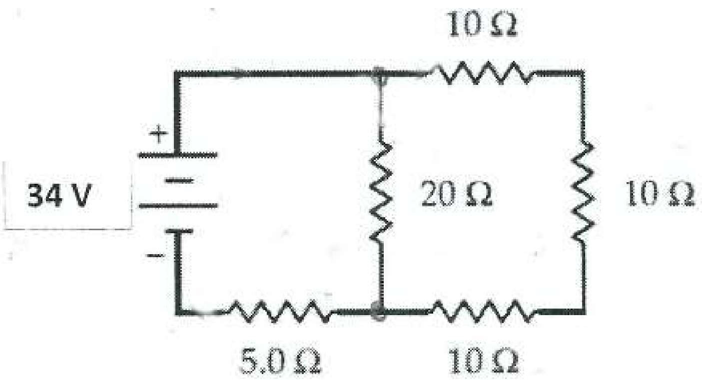
$$= 3\pi \times 10^{7} \times 0.128 R^4 = \underline{\underline{0.61\,A}}$$

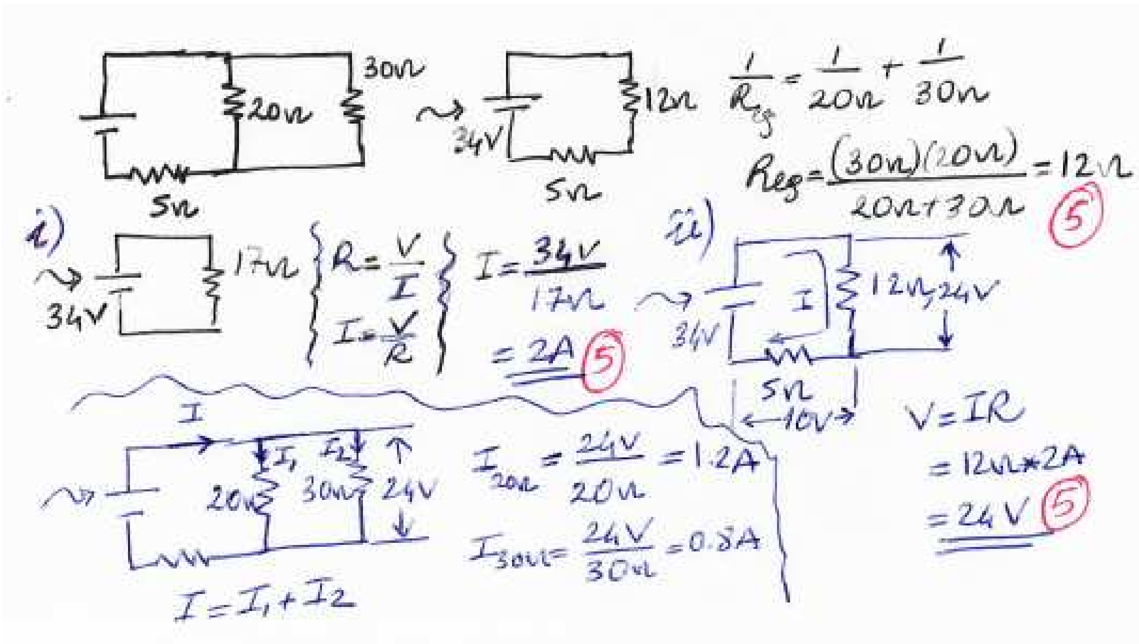
3 2

B) For the circuit shown find

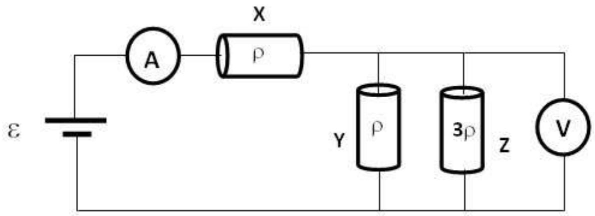
i the current delivered by the battery,

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.



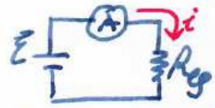
i Find the current i through the ammeter.

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.)

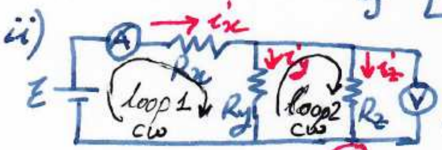
i) $\frac{1}{R_{yz}} = \frac{1}{R_y} + \frac{1}{R_z} \rightarrow R_{yz} = \frac{R_y R_z}{R_y + R_z}$ (2) $\Rightarrow R_{eq} = R_x + R_{yz} = R_x + \frac{R_y R_z}{R_y + R_z}$ (2)

where $R_x = R_y = \rho \frac{L}{A}$ & $R_z = 3\rho \frac{L}{A} \Rightarrow R_{eq} = \rho\frac{L}{A} + \frac{\rho\frac{L}{A} \cdot 3\rho\frac{L}{A}}{\rho\frac{L}{A} + 3\rho\frac{L}{A}} = \frac{7}{4}\rho\frac{L}{A}$ (2)



$\rightarrow i = \frac{\varepsilon}{R_{eq}} = \boxed{\frac{4}{7}\frac{\varepsilon A}{\rho L}} = i_x \rightarrow i_x = i_y + i_z$ (1)

ii)



(2)

Loop1: (2) $\varepsilon - i_x R_x - i_y R_y = 0 \rightarrow i_y = \frac{\varepsilon - i_x R_x}{R_y}$

Loop2: (2) $i_y R_y - i_z R_z = 0 \rightarrow i_z = i_y \frac{R_y}{R_z}$

$\Rightarrow i_y = \frac{\varepsilon - i_x R_x}{R_y}$ & $i_z = \left(\frac{\varepsilon - i_x R_x}{R_y}\right)\frac{R_y}{R_z} = \frac{\varepsilon - i_x R_x}{R_z}$ (1)

$\Rightarrow V = i_z R_z = \left(\frac{\varepsilon - i_x R_x}{R_z}\right) R_z = \varepsilon - i_x R_x = \varepsilon - \left(\frac{4}{7}\frac{\varepsilon A}{\rho L}\right)\rho\frac{L}{A} = \varepsilon - \frac{4\varepsilon}{7}$

$\boxed{V = \frac{3\varepsilon}{7}}$ (1)

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,

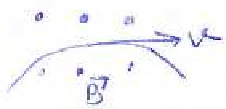
ii the magnetic field magnitude,

iii the circling frequency,

iv the period of the motion.

proton
$KE = 2.1 \times 10^{3}\ eV$
$R = 2.5 \times 10^{-2}\ m$

$$m\frac{v^2}{R} = qvB\sin 90$$
$$v = \frac{qRB}{m} \rightsquigarrow R = \frac{mv}{qB}$$



(4)

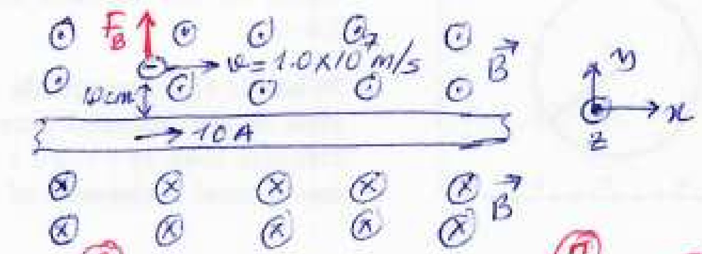
$$i)\ \frac{1}{2}m_p v^2 = 2.1\times10^{3}\,eV \rightsquigarrow v^2 = \frac{2(2.1\times10^{3}\,eV)(1.6\times10^{-19}\,J/eV)}{1.67\times10^{-27}\,kg} = 4.02\times10^{11}\,m^2/s^2$$
$$\rightsquigarrow v = \boxed{0.634\times10^{6}\,m/s}\ (3)$$

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



3 3 2

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

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

3

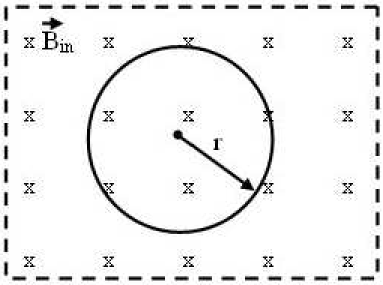
$$= \underline{3.2\times10^{-16}\ N}$$

3 2

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

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) $\phi_B(t) = 3t^2 + 3t$: increasing flux $\Rightarrow$ induced $\mathcal{E}, i$ should oppose

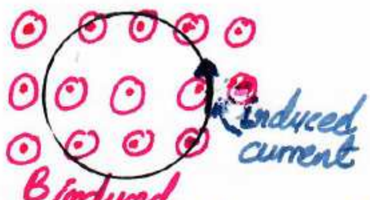
$\underset{\text{induced}}{\mathcal{E}} = -\underset{1}{N}\dfrac{d\phi_B}{dt}$ 5 $\rightarrow |\mathcal{E}| = \dfrac{d}{dt}(3t^2+3t)\Big|_{t=2s} = 6t+3\Big|_{t=2s} = \boxed{15\ V}$ 3 5

ii) $i = \dfrac{\mathcal{E}}{R}$ 2 $= \dfrac{15\ V}{30\ \Omega} = \boxed{0.5 A}$ 2

$\vec{B}_{applied}$ ⊗ ~ in to the page

$\vec{B}_{induced}$ ⊙ ← since it should oppose

by Right Hand Rule ~ direction of induced current is ccw 3



İzmir Kâtip Çelebi University
Department of Engineering Sciences
Phy102 Physics II
Final Examination
January 09, 2018 14:30 – 16:30
Good Luck!

NAME-SURNAME:

SIGNATURE:

ID:

DEPARTMENT:

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

This page is intentionally left blank. Use the space if needed.

1. A) A parallel-plate air-filled capacitor has a capacitance of 50 pF.

i If each of its plates has an area of 0.35 m^2, what is the separation?

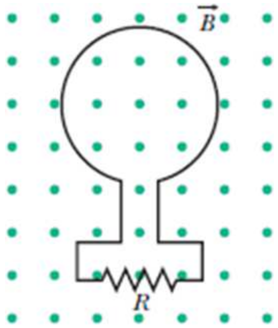
ii If the region between the plates is now filled with material having k=5.6,what is the capacitance?

i) $C = \varepsilon_0 \frac{A}{d}$ ③ $\rightsquigarrow 50\times10^{-12}F = 8.85\times10^{-12}\frac{C^2}{Nm^2}\frac{0.35\,m^2}{d}$ ③

$\rightsquigarrow d = \frac{(8.85\times10^{-12}C^2/Nm^2)(0.35m^2)}{50\times10^{-12}F} = \underline{\underline{0.062\ m}}$ ① ①

ii) $C_1 = KC_0$ ② $= (5.6)(50\times10^{-12}F) = \underline{\underline{280\ pF}}$ ③ ① ①

B) In Figure given below, the magnetic flux through the loop increases according to the relation $\Phi_B = 6.0t^2 + 7.0t$, where Φ_B is in miliwebers and t is in seconds.



i What is the magnitude of the emf (ε) induced in the loop when $t = 2.0\ s$?

ii Is the direction of the current through R to the right or left?

Increasing magnetic flux $\rightarrow$ induced emf in the loop 1

i) $|\mathcal{E}| = \left|\frac{d\Phi_B}{dt}\right|$ 3 $\rightarrow \mathcal{E}\Big|_{t=2s} = \frac{d}{dt}\left(6.0t^2+7.0t\right)\Big|_{t=2s}$ 2 $= 12t+7\Big|_{t=2s}$ 2

$\rightarrow \boxed{\mathcal{E} = 31\ mV}$ 2

ii) Increasing flux $\leftrightarrow$ induced emf should create a magnetic flux to oppose (to decrease external field)

To have an inward (induced) B, we should have a clockwise current at the loop. 3

$\rightarrow$ $\boxed{\text{Left through R}}$ 2

2. The magnitude J of the current density in a certain lab wire with a circular cross section of radius R=5.00 mm is given by $J = (2.00 \times 10^7)r^2$, with J in amperes per square meter and radial distance r in meters. What is the current through the outer section bounded by r=0.800R and r=R?

$R = 15 \times 10^{-3}$ m

$J(R) = 6 \times 10^{7} r^2$ A/m²

$i = ?$ from $r = 0.2R$ to $r = 0.6R$

$$i = \int \vec{J} \cdot d\vec{A} = \int_{0.2R}^{0.6R} 6 \times 10^7 r^2 \, 2\pi r \, dr$$

2 3 2

$$= 12\pi \times 10^7 \int_{0.2R}^{0.6R} r^3 dr = 12\pi \times 10^7 \frac{r^4}{4} \Big|_{0.2R}^{0.6R}$$

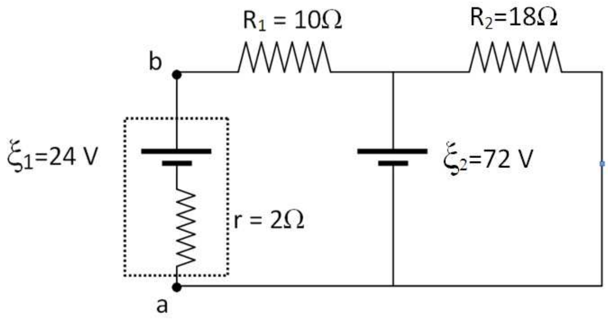
3

$$= 3\pi \times 10^7 \left[(0.6R)^4 - (0.2R)^4 \right]$$

$$= 3\pi \times 10^7 \times 0.128 R^4 = \underline{\underline{0.61 \text{ A}}}$$

3 2

3. Consider circuit as shown in figure which consists of two batteries. One of the following batteries has an internal resistance r, while the other battery is an ideal battery. Calculate;

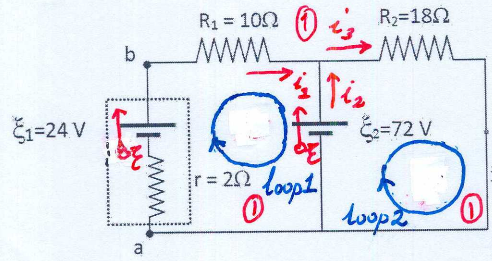


i Currents through each battery,

ii Potential difference between points a and b, V_{ab},

iii Total power supplied by batteries,

iv Total power dissipated by resistors.



i Currents through each battery,

ii Potential difference between points a and b, V_{ab},

iii Total power supplied by batteries,

iv Total power dissipated by resistors.

i) ① loop 1: $-i_1 r + \mathcal{E}_1 - i_1 R_1 - \mathcal{E}_2 = 0 \Rightarrow -2i_1 + 24 - 10i_1 - 72 = 0$ (2)

$-12 i_1 = 48$ $\quad \boxed{i_1 = -4A}$ (1) opposite direction

② loop 2: $\mathcal{E}_2 - i_3 R_2 = 0 \Rightarrow 72 - 18 i_3 = 0$ (2) $\quad \boxed{i_3 = 4A}$ (1)

③ $i_1 + i_2 = i_3$ (1) $\Rightarrow -4A + i_2 = 4A \rightarrow \boxed{i_2 = 8A}$ (1)

Three unknowns ($i_{1,2,3}$), three equations

$i_1 = -4A$: Through battery 1

$i_2 = 8A$: Through battery 2

$i_3 = 4A$: Through Resistor 3

ii) $V_{ab} = V_b - V_a$ (2)

b, $\mathcal{E}_1$, $i_1 = 4A$, a, loop 1

$V_a + i_1 r + \mathcal{E}_1 = V_b$

$V_b - V_a = 4A\,2\Omega + 24V$ $\boxed{= 32V}$ (1)

iii) $P = i\mathcal{E}$

Battery 1: $P_1 = i_1\mathcal{E}_1 = (4A)(24V)$ $\boxed{= -96W}$ (1.5)

Battery 2: $P_2 = i_2\mathcal{E}_2 = (8A)(72V)$ $\boxed{= 576W}$ (1.5)

$P_1 + P_2 \boxed{= 480W}$

iv) $P = i^2 R$

Resistor 1: $P'_1 = i_1^2 R_1 = (4A)^2(10\Omega) = 160W$ ~ R_1 (1)

Resistor 2: $P'_2 = i_3^2 R_2 = (4A)^2(18\Omega) = 288W$ ~ R_2 (1)

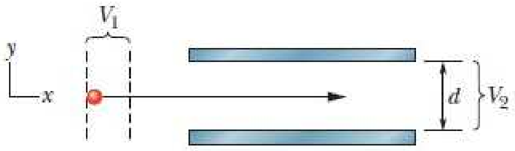
Internal Resistor r: $P'_r = i_1^2 r = (4A)^2(2\Omega) = 32W$ ~ r (1)

$P_1 + P_2 = P'_1 + P'_2 + P'_r$

$480W = 480W$

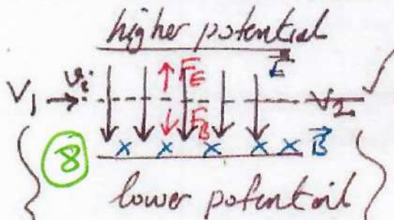
3

4. In Figure, an electron accelerated from rest through potential difference $V_1 = 1.00\ kV$ enters the gap between two parallel plates having separation $d = 20.0\ mm$ and potential difference $V_2 = 100\ V$. The lower plate is at the lower potential. Neglect fringing and assume that the electron's velocity vector is perpendicular to the electric field vector between the plates.



In unit-vector notation, what uniform magnetic field allows the electron to travel in a straight line in the gap?

$V_1 = 1\ kV$ & $d = 10 \times 10^{-3}\ m$, $V_2 = 50\ V$, $M_e = 9.11 \times 10^{-31}\ kg$



straight line $\Rightarrow |\vec{F_B}| = |\vec{F_E}|$ 2

$|q| v_i B = |q| E$

$\sqrt{\frac{2qV_1}{m_e}}\, B = \frac{V_2}{d}$ 2

2

$\Delta U = qV_1 - 0$ 2

$= (1.6 \times 10^{-19} C)\ 1 \times 10^{3} V$

$\Delta U = \Delta K = \frac{1}{2} m_e v_i^2$

$V_2 = Ed$

$\Rightarrow E = \frac{V_2}{d}$

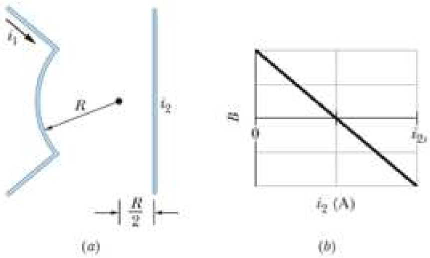
$\rightarrow B = \frac{50V}{10 \times 10^{-3} m} \sqrt{\frac{9.11 \times 10^{-31} kg}{2 \times 1.6 \times 10^{-19} C\ 1 \times 10^{3} V}}$

$B = 2.67 \times 10^{-4}\ T$

$\vec{B} = 2.67 \times 10^{-4}\ T(-\hat{k})$

2 2

5. Figure(a) shows two wires, each carrying a current. Wire 1 consists of a circular arc of radius R and two radial lengths; it carries current $i_1 = 3.0\ A$ in the direction indicated. Wire 2 is long and straight; it carries a current i_2 that can be varied; and it is at distance R/2 from the center of the arc. The net magnetic field B due to the two currents is measured at the center of curvature of the arc.



Figure(b) is a plot of the component of B in the direction perpendicular to the figure as a function of current i_2. The horizontal scale is set by $i_{2s} = 2.00\ A$. What is the angle subtended by the arc?

$i_1 = 3A$, R
i_2: variable, R/2

net magnetic field at point P

$$B_P = \underbrace{\frac{\mu_0 i_1}{4\pi R}}_{\substack{\text{circular arc} \\ \text{(out of page)}}} \phi - \underbrace{\frac{\mu_0 i_2}{2\pi R/2}}_{\substack{\text{straight wire} \\ \text{(into page)}}}$$

5 5

at $i_2 = 1A \rightsquigarrow B_P = 0 \rightsquigarrow \frac{\mu_0 3A}{4\pi R}\phi = \frac{\mu_0 1A}{\pi R}$ 5

$\rightsquigarrow \phi = \frac{4}{3}$ radians $= \underline{\underline{76.4^\circ}}$ 3 2

$(3.14 \text{ rad} \rightsquigarrow 180^\circ)$