İzmir Kâtip Çelebi University
Department of Engineering Sciences
Phy102 Physics II
Final Examination
June 08, 2026 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		15
1B		15
2		20
3		15
4		20
5		15
TOTAL		100

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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) $R = \frac{V}{I}$ (1) & $R = \rho \frac{L}{A}$ (1) $\rightsquigarrow \rho = \frac{A}{L} R$, $A = \pi r^2$

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

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

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

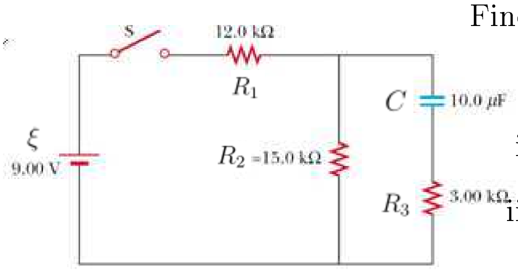
ii) $J = \frac{I}{A}$ (1) $= \frac{140 A}{\pi (10^{-3} m)^2} = \underline{\underline{4.5\times10^{7}\, A/m^2}}$ (1) (1)

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

iii) $\frac{\Delta U}{\Delta t} = P = i^2 R$ (1) $\rightsquigarrow \Delta U = i^2 R \Delta t$

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

B) A circuit is assembled as shown at the figure. If $R_1 = 12\ k\Omega$, $R_2 = 15\ k\Omega$, $R_3 = 3\ k\Omega$, $C = 10\ \mu F$ and $\xi = 9\ V$. 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.

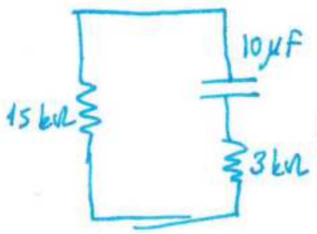
sufficiently long time interval ⇝ C becomes broken wire (steady-state) 2

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 $t=0$, C behaves as a battery; $(\Delta V)_C$

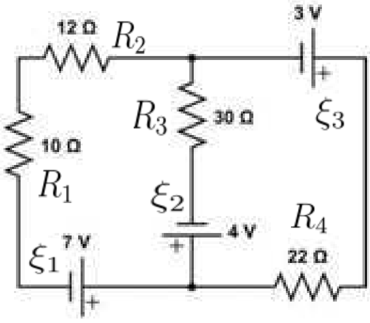


$I_{t=0}=\frac{(\Delta V)_C}{(R_2+R_3)}=\frac{IR_2}{R_2+R_3}=\frac{(333\mu A)(15k\Omega)}{(15k\Omega+3k\Omega)}=278\mu A=I_i$ 2

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

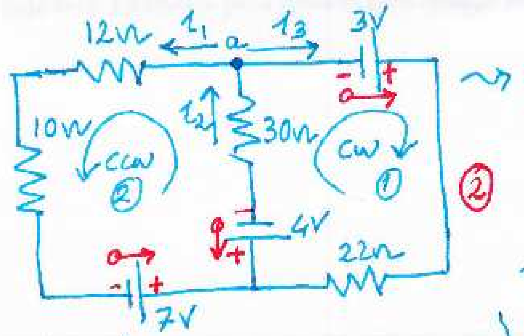
$\boxed{I_{R_2}=I_i e^{-t/\tau}=(278\mu A)e^{-t/0.180s}}$ for $t>0$ 1

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)

$$22i_1 + 30i_2 = 3$$
$$-30i_2 - 22i_3 = 1$$

$$22i_1 + 30(i_1 + i_3) = 3$$
$$-30(i_1 + i_3) - 22i_3 = 1$$

$$52i_1 + 30i_3 = 3$$
$$-30i_1 - 52i_3 = 1$$

$$52i_1 + 30\left(\frac{-1 - 30i_1}{52}\right) = 3$$ (1)

$\Rightarrow i_1 = 0.103\,A$ (1)

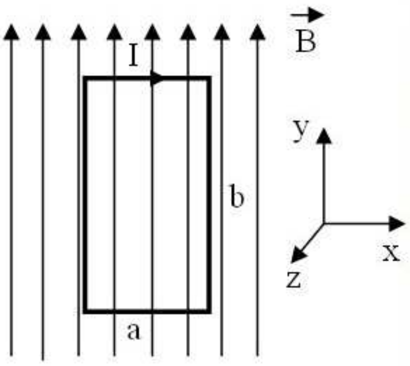
$i_3 = -\frac{1}{52} - \frac{30}{52} i_1 = -0.078\,A$ (1) (1)

$\boxed{i_2 = 0.0244\,A}$ (1) (1) i)

ii) $P = iV = i_1 7V$ (1)

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

3. A loop of wire with dimensions $a = 1.0\ m$ and $b = 2.0\ m$ as shown in the figure is oriented with plane of the loop parallel to a uniform magnetic field of strength $B = 0.5\ T$ in the y-direction. A current $I = 4.0\ A$ is flowing clockwise in the loop.



i Calculate the net force on the loop.

ii Calculate the magnetic dipole moment of the loop.

iii Calculate the torque on the loop.

iv Calculate the amount of work required to rotate the top of the loop 90° into the page so that the plane of the loop is perpendicular with the magnetic field.

<u>State your results in unit vector notation.</u>

i) $\vec{F}_B = i\,\vec{l} \times \vec{B}$ 1 for a closed loop F_B is zero.

ii) $\vec{\mu} = N i \vec{A} = i \vec{A} = i A(-\hat{k}) = 4A(2m)1m(-\hat{k})$ 1 2

$= -8\hat{k}\ Am^2$ 1 1 1

iii) $\vec{\tau} = \vec{\mu} \times \vec{B} = -8\hat{k} \times 0.5T\hat{j} = -4(Am^2)T(\hat{k}\times\hat{j})$ 1

$\hat{k}\times\hat{j} \rightsquigarrow -\hat{i}$

$= 4\ Am^2T\,\hat{i} = \boxed{4\ Nm\,\hat{i}}$ 1 1 1

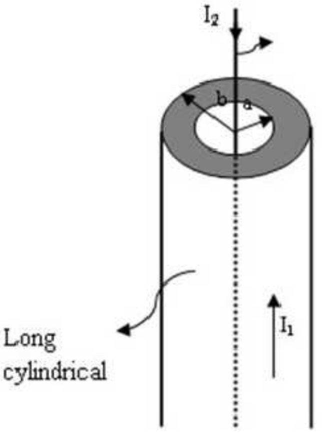
iv) $W = -\Delta U = -U_f + U_i$ 1 & $U_i = -\vec{\mu}\cdot\vec{B}$ 1

$U_f = -\vec{\mu}\cdot\vec{B} = -\mu B \cos 180°$ 1 $= -\mu B \cos 90° = \phi$

$= \mu B = 8 \times 4 = \underline{32J}$ 1

$\rightsquigarrow \boxed{W = -32J}$

4. A long cylindrical shell with inner radius a and outer radius b carries a total current I_1 and a uniform density. A long wire with current $I_2 = 2I_1$ in the opposite direction is located at the center of the cylindrical shell as shown in the figure.



Using the Ampere's Law find magnitude of the magnetic field

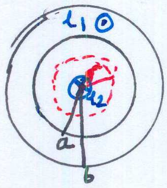
i for the points where $r < a$.

ii for the points where $a < r < b$.

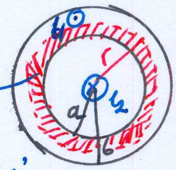
iii for the points where $r > b$.

Hint: Ampere's Law: $\oint \vec{B} \cdot \vec{ds} = \mu_0 i_{enc}$

$\oint \vec{B} \cdot \vec{ds} = \mu_0 i_{enc}$: Ampere's Law



i) $r < a \rightarrow B\,2\pi r = \mu_0 i_2 \rightarrow \boxed{B = \frac{\mu_0 i_2}{2\pi r}}$ 3 3



ii) $a < r < b \rightarrow B\,2\pi r = \mu_0 (i_2 - i_{1,enc})$

$i_{1,enc} = ?$ $\quad \pi b^2 - \pi a^2 \quad i_1$

$\pi r^2 - \pi a^2 \quad i_{1,enc}$ 4

$i_{1,enc} = i_1 \left(\frac{r^2 - a^2}{b^2 - a^2}\right)$ & $i_2 = 2i_1$

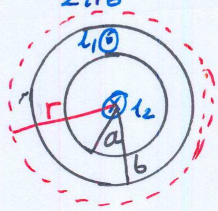
$\rightarrow B\,2\pi r = \mu_0 \left(2i_1 - i_1\left(\frac{r^2-a^2}{b^2-a^2}\right)\right) = \mu_0 i_1 \left(\frac{2b^2 - 2a^2 - r^2 + a^2}{b^2 - a^2}\right)$ 2

$\rightarrow \boxed{B = \frac{\mu_0 i_1}{2\pi r}\left(\frac{2b^2 - a^2 - r^2}{b^2 - a^2}\right)}$ 2 $\quad$ when $r = a \sim B = \frac{\mu_0 i_2}{2\pi a}$ ✓

$r = b \sim B = \frac{\mu_0 i_1}{2\pi b}$ ✓

iii) $r > b \rightarrow B\,2\pi r = \mu_0 \underbrace{(i_2 - i_1)}_{i_{enc}} = \mu_0 (2i_1 - i_1)$ 3

$\rightarrow \boxed{B = \frac{\mu_0 i_1}{2\pi r}}$ 3



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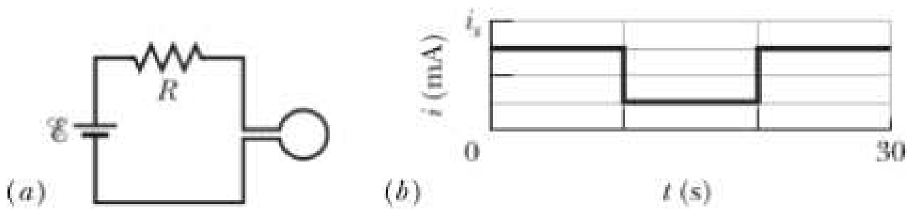
5. Figure a shows a circuit consisting of an ideal battery with emf $\xi = 6.00\ \mu V$, a resistance R, and a small wire **loop** of area 5.0 cm^2. For the time interval $t = 10\ s$ to $t = 20\ s$, an external magnetic field is set up **throughout the loop**. The field is uniform, its direction is into the page in Figure a, and the field magnitude is given by $B = at$, where B is in teslas, a is a constant, and t is in seconds. Figure b gives the current i in the circuit before, during, and after the external field is set up. The vertical axis scale is set by is $i_s = 2.0\ mA$.



Find the constant a in the equation for the field magnitude.

$V_{battery} = 6\mu V$

$A = 5\times10^{-4} m^2$

$\mathcal{E}_{ind} = -\dfrac{d\Phi_B}{dt}$ 2

$\Phi_B = BA$ 1

$t < 10s$ & $t > 20s \rightsquigarrow B = \phi$, $i = 1.5mA$

$R = \dfrac{V_{battery}}{i} = \dfrac{6\mu V}{1.5mA}$ 1

$= 4\times10^{-3}\Omega$ (which does not change under aplied $\vec{B}$) 1 1

$10 \le t \le 20s \rightsquigarrow B = at$, $i = 0.5mA$

$\rightsquigarrow R = 4\times10^{-3}\Omega = \dfrac{V_{battery} + \mathcal{E}_{ind}}{i} = \dfrac{6\mu V + \mathcal{E}_{ind}}{0.5mA}$ 2 1

$\rightsquigarrow \mathcal{E}_{ind} = -4\mu V$ 1

$\mathcal{E}_{ind} = -4\mu V = -A\dfrac{dB}{dt}$ 2 $\Rightarrow 4\times10^{-6} V = 5\times10^{-4} m^2 (a)$

$\rightsquigarrow \boxed{a = 8\times10^{-3}\ T/s}$ 2 1