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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

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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?

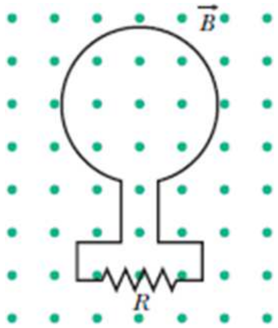
i) $C = \varepsilon_0 \frac{A}{d}$ (3) $\rightarrow 50\times10^{-12}\,F = 8.85\times10^{-12}\,\frac{C^2}{Nm^2}\,\frac{0.35\,m^2}{d}$ (3)

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

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

(2) (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 (1) → induced emf in the loop

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

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

ii) Increasing flux ↔ 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)

→ **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?

$R = 5 \times 10^{-3}\ m$

$J(r) = 2 \times 10^7 r^2\ A/m^2$

$i = ?$ from $r = 0.8R$ to $r = R$

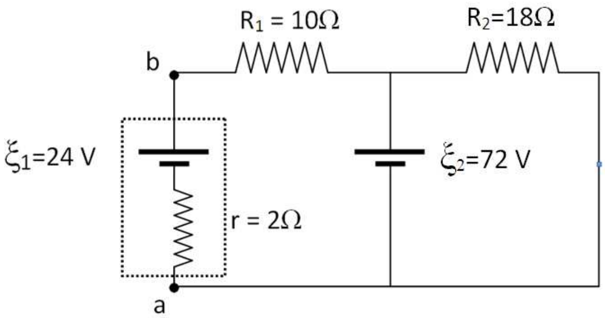
$$i = \int \vec{J} \cdot d\vec{A} = \int_{0.8R}^{R} 2 \times 10^7 r^2\, 2\pi r\, dr$$

$$= 4\pi \times 10^7 \int_{0.8R}^{R} r^3 dr = 4\pi \times 10^7 \frac{r^4}{4} \Big|_{0.8R}^{R}$$

$$= \pi \times 10^7 (R^4 - (0.8R)^4) = \pi \times 10^7 \times 0.59 R^4$$

$$= 0.0116\ A = 11.6 \times 10^{-3}\ A$$

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;

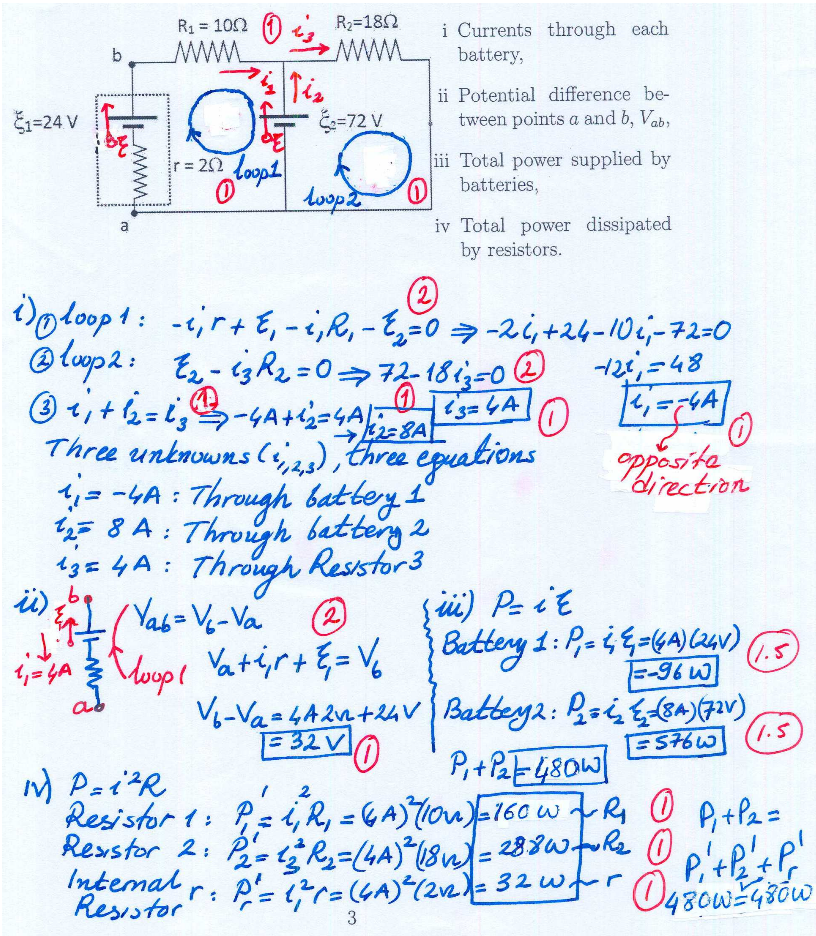


i Currents through each battery,

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

iii Total power supplied by batteries,

iv Total power dissipated by resistors.



i) (1) loop 1: $-i_1 r + \xi_1 - i_1 R_1 - \xi_2 = 0 \Rightarrow -2i_1 + 24 - 10i_1 - 72 = 0$ (2)

$-12 i_1 = 48$, $i_1 = -4A$ (1) opposite direction

(2) loop2: $\xi_2 - i_3 R_2 = 0 \Rightarrow 72 - 18 i_3 = 0$ (2) $i_3 = 4A$ (1)

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

$V_a + i_1 r + \xi_1 = V_b$

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

iii) $P = i\xi$

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

Battery 2: $P_2 = i_2 \xi_2 = (8A)(72V) = 576W$ (1.5)

$P_1 + P_2 = 480W$

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)

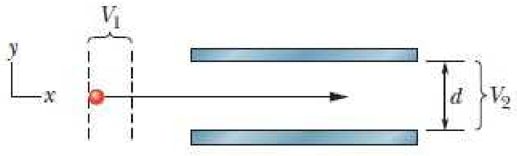
Internal Resistor r: $P_r' = i_1^2 r = (4A)^2(2\Omega) = 32W$ — r (1)

$P_1 + P_2 = P_1' + P_2' + P_r'$

$480W = 480W$

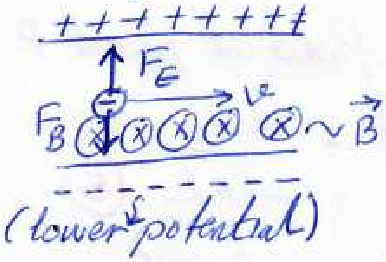
3

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?

Straight line $\rightsquigarrow F_E = F_B \rightsquigarrow qE = q v B \sin 90°$ (3)



since $e^- \rightsquigarrow F_E \uparrow$ $\quad v \perp B$

$F_B \downarrow$ and B into page

$\rightsquigarrow |E| = v|B| \rightsquigarrow B = \frac{E}{v}$ (2)

for v: $PE = KE \rightsquigarrow qV_1 = \frac{1}{2} m_e v^2$ (3)

$v^2 = \frac{2qV}{m_e} = \frac{2(1.6\times10^{-19}C)(1\times10^{3}V)}{9.1\times10^{-31}kg}$

$v = 1.8\times10^{7}\ m/s$ (2)

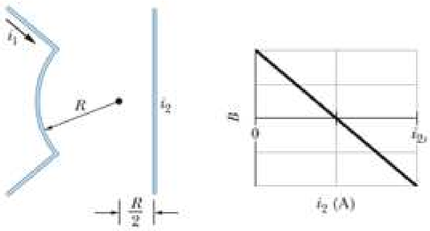
for E: $V_2 = Ed \rightsquigarrow E = \frac{V_2}{d} = \frac{100V}{20\times10^{-3}m} = 5\times10^{3}\ V/m$ (3) (2)

$\Rightarrow B = \frac{E}{v} = \frac{5\times10^{3}V/m}{1.8\times10^{7}m/s} = 2.7\times10^{-4}T$ (3)

in unit vector notation: $\vec{B} = 2.7\times10^{-4}T(-\hat{k})$

(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.



(a) (b)

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

$$B_p = \frac{\mu_0 i_1}{4\pi R}\phi - \frac{\mu_0 i_2}{2\pi R/2}$$

(5) (5)

circular arc (out of page) — straight wire (into page)

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 $= 76.4^0$ (3) (2)

(3.14 rad $\rightsquigarrow$ 180°)