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

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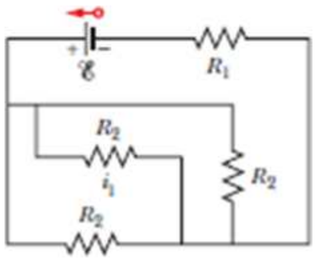
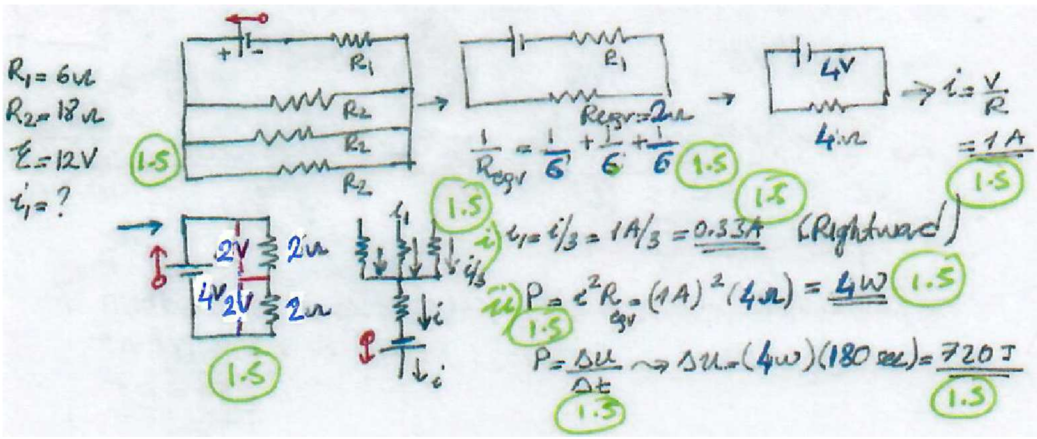
1. A) In Figure, $R_1 = 2.0\ \Omega$, $R_2 = 6.0\ \Omega$, and the ideal battery has emf $\varepsilon = 4.0\ V$.



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

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

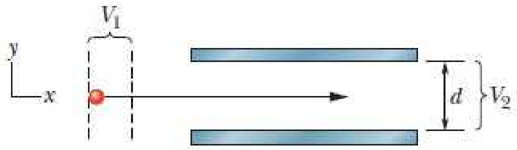
ii) $\tau = RC \rightsquigarrow C = \frac{\tau}{R} = \frac{2.41\times10^{-6}s}{15\times10^{3}\Omega} = 1.61\times10^{-10}F$

$= 0.161\,nF$

$= 162\,pF$

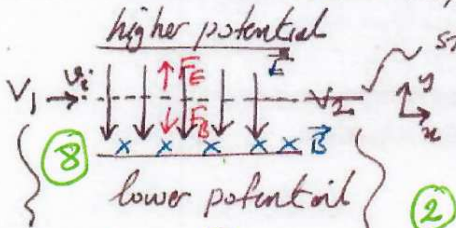
(2)

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?

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



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

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

$\sqrt{\frac{2 q V_1}{m_e}}\, B = \frac{V_2}{d}$ (2)

$\Delta U = qV_1 - 0$ (2)

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

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

(2) $V_2 = Ed$

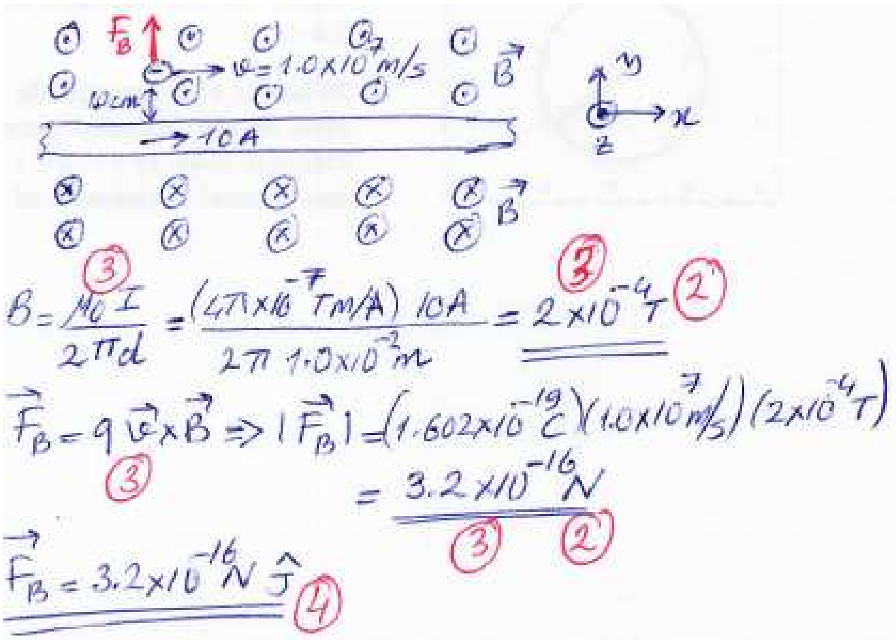
$\Rightarrow E = \frac{V_2}{d}$

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

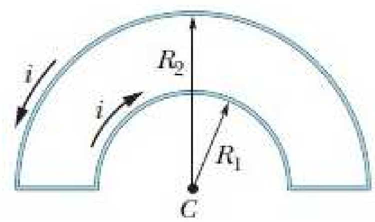
$B = 2.67\times10^{-4}\ T$

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



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.

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

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

$$B = \int dB = \frac{\mu_0}{4\pi} i \int_0^{\phi} \frac{R\,d\phi}{R^2} = \frac{\mu_0 i}{4\pi R}\phi \quad \phi \sim \text{arc angle}$$ (4)

⇒ Solution

$\phi = \pi$, $R_2 = 3.9 \times 10^{-2}\ m$, $R_1 = 1.575 \times 10^{-2}\ m$, $i = 0.1405 A$

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

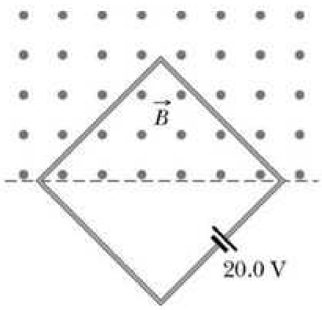
(4) $= (4\pi \times 10^{-7}\ Tm/A)(0.1405 A)\left(\frac{1}{1.575 \times 10^{-2} m} - \frac{1}{3.9 \times 10^{-2} m}\right)$ (4)

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

ii) into the page (4)

out / into: $\vec{B}_2 \leftarrow C \rightarrow \vec{B}_1$

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.

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

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

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

$\mathcal{E}_i = 1.74\,V$. 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 → $\mathcal{E}_{total} = \mathcal{E}_B + \mathcal{E}_i = 20.0\,V + 1.74\,V$

ii) $= 21.74\,V$

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