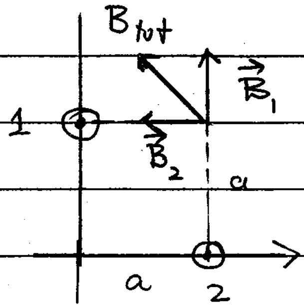
PHY 2049 — Solutions —

Test II – 31 Oct 2016 V. II

(1) (a) 4/



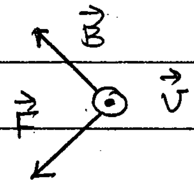
(b) 5/ From figure, $B_{tot} = \sqrt{2}\,B$

$I = 20.0$ A and $a = 2.5 \times 10^{-2}$ m

$\rightarrow B_1 = \mu_0 I / 2\pi a = 1.60 \times 10^{-4}$ T

$\rightarrow \boxed{B_{tot} = 2.26 \times 10^{-4}\ \text{T}}$

(c) 5/

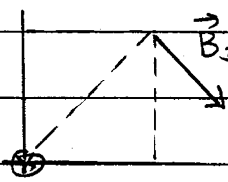


direction from right hand rule $\rightarrow$ toward origin

$q = 3.00 \times 10^{-6}$ C, $v = 2.0 \times 10^{4}$ m/s

$\rightarrow \boxed{F = qvB = 1.36 \times 10^{-5}\ \text{N}}$

(d) 6/



$\vec{B}_3$ must oppose $\vec{B}_1 + \vec{B}_2$

$\rightarrow$ I_3 in the $-z$ direction (into page)

Now $B_3 = \mu_0 I_3 / 2\pi r$

with $B_3 = 2.26 \times 10^{-4}$ T and $r = \sqrt{2}\,a = 3.536 \times 10^{-2}$ m

$\rightarrow \boxed{I_3 = 2\pi r B_3 / \mu_0 = 40.0\ \text{A}}$

(2) (a) $R_1 = 3.00\ \Omega$, $R_2 = 2.00\ \Omega$, $R_3 = 4.00\ \Omega$

6/ R_2 and R_3 in parallel $\Rightarrow R_{23} = R_2 R_3 / (R_2 + R_3) = 1.333\ \Omega$

R_1 and R_{23} in series $\Rightarrow \boxed{R_{equ} = R_1 + R_{23} = 4.33\ \Omega}$

4/ (b) $\mathcal{E} = 20.0$ V $\rightarrow I_1 = \mathcal{E}/R_{equ} = 4.615$ A $\rightarrow \boxed{V_1 = I_1 R_1 = 13.8\ \text{V}}$

5/ (c) Potential drop across 2 and 3 $\rightarrow V_{23} = \mathcal{E} - V_1 = 6.154$ V

Alternatively, $V_{23} = I_1 R_{23} = 6.154$ V

$\rightarrow \boxed{I_2 = V_{23}/R_2 = 3.08\ \text{A}}$ $\boxed{I_3 = V_{23}/R_3 = 1.54\ \text{A}}$ or $I_3 = I_1 - I_2$

5/ (d) $P_{R_1} = I_1^2 R_1 = 63.9$ W $P_{R_2} = I_2^2 R_2 = 18.9$ W $P_{R_3} = I_3^2 R_3 = 9.47$ W

$P_{batt} = \mathcal{E} I_1 = 92.3$ W $\rightarrow$ Note that $P_{R_1} + P_{R_2} + P_{R_3} = P_{batt}$

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— Solns, p. 2 —

V. II

(3) (a) $r = 0.250$ cm $\Rightarrow A = \pi r^2 = 1.963 \times 10^{-5}\ m^2$

5/ $\rho_r = 3.50 \times 10^{-3}\ \Omega\text{-m}$, $l = 1.25$ cm $\rightarrow \boxed{R = \rho_r l / A = 2.23\ \Omega}$

5/ (b) Method 1: $I = 7.50\ A \rightarrow V = IR = 16.71\ V$

$\rightarrow \boxed{E = V/l = 1.34 \times 10^3\ V}$

Method 2: $j = I/A = 3.820 \times 10^5\ A/m^2 \rightarrow E = \rho_r j = 1.34 \times 10^3\ V$

4/ (c) Power $\rightarrow P = I^2 R = 125.3\ W \rightarrow \Delta t = 2.00\ s \rightarrow \boxed{U = P\Delta t = 251\ J}$

6/ (d) Increased current $\rightarrow$ decreased resistance

$\rightarrow$ parallel connection

$I' = 22.5\ A \Rightarrow R_{equ} = R/3$

$R_{equ} = RR_2/(R+R_2)$ for parallel connection

$\Rightarrow R(R+R_2) = 3RR_2 \Rightarrow 2R_2 = R \Rightarrow \boxed{R_2 = \tfrac{1}{2} R = 1.11\ \Omega}$

(4) (a) Energy conservation $\Rightarrow K_B = U_A = eV \Rightarrow \tfrac{1}{2} m v_p^2 = eV$

4/ $v = 4.38 \times 10^5\ m/s \rightarrow \boxed{V = m_p v^2/2e = 1000\ V}$

(b) Cyclotron frequency $\omega_c = eB/m$ with $B = 0.300\ T$

6/ $\rightarrow \omega_c = 2.878 \times 10^7\ rad/s \rightarrow \omega_c = v/r \Rightarrow r = v/\omega_c$

$\Rightarrow d = 2r = 2v/\omega_c = 3.04 \times 10^{-2}\ m \rightarrow \boxed{d = 3.04\ cm}$

(c) $q_\alpha = 2e \Rightarrow K_\alpha = 2K_p$ at point B if V the same

5/ Now $K_\alpha = \tfrac{1}{2} m_\alpha v_\alpha^2 = \tfrac{1}{2}(4m_p)v_\alpha^2 \Rightarrow 2(\tfrac{1}{2} m_p v_\alpha^2) = K_\alpha/2 = K_p$

$\Rightarrow 2v_\alpha^2 = 2K_p/m_p = v_p^2 \Rightarrow \boxed{v_\alpha = v_p/\sqrt{2} = 3.10 \times 10^5\ m/s}$

(d) $q_\alpha/m_\alpha = \tfrac{1}{2}(q_p/m_p) \Rightarrow \omega_c(\alpha) = \tfrac{1}{2}\omega_c(p)$

5/ $\Rightarrow d_\alpha = 2v_\alpha/\omega_c(\alpha) = 2(v_p/\sqrt{2})/[\tfrac{1}{2}\omega_c(p)] = \sqrt{2} d_p \rightarrow \boxed{d_\alpha = 4.30\ cm}$