Solution of Final Exam 17/06/2004

Part I: MCQ

Q1: F = k $\frac{Q^2}{(0.15)^2} = 4x\,10^{11} Q^2$

$F_{net} = 2F\cos 30^o = 6.928 \times 10^{11}\ Q^2$
$F_{net} = 24.9\ \mu N$, (for Q = 6 n C)

Q2: $E\,(2\pi r\ell) = \frac{(-80-30)x\,10^{-9}\ell}{8.85x\,10^{-12}},\ E = \frac{1980}{r}$

E = 16.5 kN/C, (for r = 120 mm)

Q3: $V_A = k\left(\frac{24x\,10^{-9}}{0.32} - \frac{67x\,10^{-9}}{0.18}\right) = -2675V$

$V_B = k\left(\frac{24x\,10^{-9}}{0.4} - \frac{67x\,10^{-9}}{0.9}\right) = -130\ V$

$\Delta V = 2545 \quad \therefore W = q_3 \Delta V = 5.09\,\mu J\,,(for\ q_3 = 2\,nc)$

Q4: Q = CV = $\frac{\epsilon_o A}{d}$ Ed = ϵ_0 AE = 61.9 n C, (for E = 10^6 V/m)

Q5: $J = \frac{I}{A} = \frac{V}{RA} = \frac{V}{\left(\frac{\rho_1\ell_1}{A} + \frac{\rho_2\ell_2}{A}\right)A} = \frac{V}{(\rho_1\ell_1 + \rho_2\ell_2)}$

J = 625 A/m^2, (6 r V= 2V)

Q6: $I = \frac{\varepsilon}{5 + \frac{3x\,6}{3+6}} = 0.1428\varepsilon,\ \varepsilon = (0.1428\varepsilon)x\,5 + V$

$V = 0.2857\varepsilon \quad \therefore I_{2\Omega} = \frac{V}{3} = 0.0952\varepsilon$

$P = I_{2\Omega}^2 x\ 2 = 0.16W\ ,(for\,\varepsilon = 3V\ )$

Q7:

$$I = \frac{12}{10+2} = 1.0A,\ V_{ab} = +1x10 - (\varepsilon) = 10 - \varepsilon, V_{ab} = 2V\ ,\ (for\,\varepsilon = 8V\ )$$

Q8:

$$qvB = qE \quad \therefore v = \frac{E}{B} = \frac{4x10^3}{B}\ \ m/s$$

$$K = \frac{1}{2}mv^2 = \frac{\frac{1}{2}\left(9.1x10^{-31}\right)\left(\frac{4x10^3}{B}\right)^2}{1.6x10^{-19}}$$

$$= \frac{4.55x10^{-5}}{B^2} = 0.71\ \ eV\ ,(forB = 8mT\ )$$

Q9:

$$B_1 = \frac{\mu_o x\,20}{2\pi(0.1)} = 4x10^{-5}T\ ,\ B_2 = \frac{\mu_o I_2}{2\pi(0.1)} = 0.2I_2x10^{-5}T$$

$$B = \sqrt{B_1^2 + B_2^2} = 41.2\mu T\ ,\ \ (for\ \ I_2 = 5A)$$

Q10:

$$B = \frac{\mu_o Ir}{2\pi R^2} = 2.4Ix10^{-5}T\ = 24\,\mu T\ ,\ (for\ \ \ I\ = 1.0A)$$

Q11:

$$\Phi = BA = 0.2(4 + 3t^2),\ \mathrm{E} = -N\ \frac{d\Phi}{dt}$$

$$E = -6t = -6V\ ,\ \ (for\ \ t = 1.0s)$$

Q12:

$$F = F_m = I_i LB \quad \therefore LB = 0.6/I_i$$

$$I_i = \frac{\varepsilon_i}{12} = \frac{B\,Lv}{12} = \frac{\left(\ \frac{0.6}{I_i}\ \right)v}{12} \quad \therefore\ I_i = \sqrt{0.05v}$$

$$I_i = 0.22A, \qquad (for\ \ v = 1.0\ m/s)$$

Part II:

Problem 1

$$V_1 = \int_R^{3R} k \ \frac{\lambda dx}{x} = \ k \ \lambda Ln3 \qquad , \qquad V_3 = V_1$$

$$V_2 = \int_0^{\pi} k \ \frac{\lambda R d\theta}{R} = k \ \lambda \pi$$

Problem 2

$$V_{ab} = \frac{9}{12k + 15k} 15k = 5V$$

(a) $Q = CV_c = CV_{ab} = 50 \mu C$

$$\tau = RC = 18k \ x \ 10\mu = 0.18s$$

$$Q = Q_0 e^{-t/\tau}$$

(b) $t = -\tau Ln 0.25 = 0.25 \ s$

Problem 3

$$B_1 = 0, \quad B_3 = 0$$

$$B_2 = \frac{\mu_o}{4\pi} I_1 \int_0^{\pi R} \frac{dl}{R^2} = \frac{\mu_o I_1}{4R} = \pi \ \ \mu T$$

(a) $B_{net} = \pi \ \ \mu T \quad \vec{\otimes}$

$$B_{"O"} = \frac{\mu_o I_2}{2\pi(0.9)} - \pi x 10^{-6} = 0$$

(b) $I_2 = 7.85A$

Problem 4

(a) $\Phi = AB = 2ab \ \ e^{-0.5t}$

(b) $$\mathrm{E}_i = -\frac{d\Phi}{dt} = ab\ \ e^{-0.5t}$$

(c) Use Kirchhoff's Voltage rule

$$\varepsilon_i = \frac{q}{C} + I\ R$$

$$\frac{dq}{dt} + \frac{1}{RC}\ q = \frac{ab}{R}\ e^{-0.5t} \qquad\qquad QED$$
