PHYSICS 2B QUIZ 4 WINTER QUARTER 2010
PROF. HIRSCH FEBRUARY 8, 2010

Formulas:

$\sin 30^\circ = \cos 60^\circ = 1/2$, $\cos 30^\circ = \sin 60^\circ = \sqrt{3}/2$, $\sin 45^\circ = \cos 45^\circ = \sqrt{2}/2$

$F = k\frac{q_1 q_2}{r^2}$ Coulomb's law ; $k = 9\times 10^9 \mathrm{N\cdot m^2/C^2}$; $\vec{F}_{12} = \frac{kq_1q_2}{|\vec{r}_2 - \vec{r}_1|^3}(\vec{r}_2 - \vec{r}_1)$

Electric field due to charge q at distance r: $\vec{E} = \frac{kq}{r^2}\hat{r}$; Force on charge Q: $\vec{F} = Q\vec{E}$

Electric field of dipole: along dipole axis / perpendicular: $E = \frac{2kp}{x^3}$ / $E = \frac{kp}{y^3}$ (p=qd)

Energy of and torque on dipole in E-field: $U = -\vec{p}\cdot\vec{E}$, $\vec{\tau} = \vec{p}\times\vec{E}$

Linear, surface, volume charge density : $dq = \lambda\, ds$, $dq = \sigma\, dA$, $dq = \rho\, dV$

Electric field of infinite: line of charge: $E = \frac{2k\lambda}{r}$; sheet of charge: $E = 2\pi k\sigma = \sigma/(2\varepsilon_0)$

Gauss law: $\Phi = \oint \vec{E}\cdot d\vec{A} = \frac{q_{enc}}{\varepsilon_0}$; Φ = electric flux ; $k = \frac{1}{4\pi\varepsilon_0}$; $\varepsilon_0 = 8.85\times 10^{-12} C^2/Nm^2$

$U_B - U_A = \Delta U_{AB} = -W_{AB} = -\int_A^B \vec{F}\cdot\vec{dl} = -\int_A^B q\vec{E}\cdot\vec{dl} = q\Delta V_{AB} = q(V_B - V_A)$ V=N/C

$V = \frac{kq}{r}$; $V = \int \frac{kdq}{r}$; $V = \frac{kp\cos\theta}{r^2}$ (dipole) ; $E_l = -\frac{\partial V}{\partial l}$; $\vec{E} = -\vec{\nabla} V$

Electrostatic energy: $U = k\frac{q_1q_2}{r}$; Capacitors: $Q = CV$; with dielectric: $C = \kappa C_0$; $\varepsilon_0 = 8.85\, pF/m$

$C = \frac{\varepsilon_0 A}{d}$ parallel plates ; $C = \frac{2\pi\varepsilon_0 L}{\ln(b/a)}$ cylindrical ; $C = 4\pi\varepsilon_0\frac{ab}{b-a}$ spherical

Energy stored in capacitor: $U = \frac{Q^2}{2C} = \frac{1}{2}QV = \frac{1}{2}CV^2$; $U = \int dv\, u_E$; $u_E = \frac{1}{2}\varepsilon_0 E^2$

Capacitors in parallel: $C = C_1 + C_2$; in series: $C = C_1C_2/(C_1 + C_2)$

Elementary charge: $e = 1.6\times 10^{-19} C$

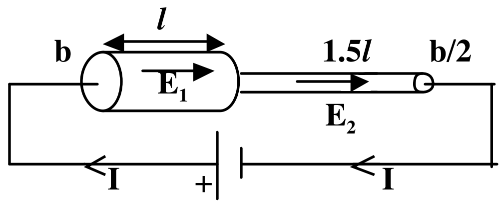
$I = \frac{dq}{dt} = \int \vec{J}\cdot d\vec{A}$; $\vec{J} = ne\vec{v}_d$; $v_d = \frac{eE\tau}{m}$; $\rho = \frac{m}{ne^2\tau}$; $R = \rho\frac{\ell}{A}$; $\vec{E} = \rho\vec{J}$, $\vec{J} = \sigma\vec{E}$

$V = IR$; $P = VI = I^2R = V^2/R$; $P_{emf} = \varepsilon I$; $R_{eq} = R_1 + R_2$ (series) ; $R_{eq}^{-1} = R_1^{-1} + R_2^{-1}$ (parallel)

Charging capacitor: $Q(t) = C\varepsilon(1 - e^{-t/RC})$; Discharging capacitor: $Q(t) = Q_0 e^{-t/RC}$

There are 8 problems. You get 1 point for correct answer, 0 points for incorrect answers, 0.2 points for no answer (up to 5 non-answers). This is Test Form A

Problem 1



In the figure, the left and right cylinders are connected to each other and to a battery, and an electric current flows. The left cylinder has radius b and length l and is made of copper, with resistivity $1.68\times10^{-8}\Omega$ m. The right cylinder has radius b/2 and length 1.5 l and is made of aluminum with resistivity $2.65\times10^{-8}\Omega$ m. The electric field in the left cylinder is E_1=4V/cm. The electric field in the right cylinder is E_2=?
(a) 4V/cm ; (b) 6V/cm ; (c) 16V/cm ; (d) 25V/cm ; (e) 12V/cm

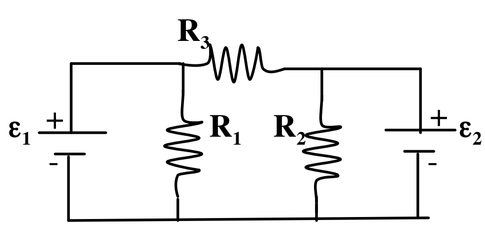
Problem 2
In the circuit of problem 1, the drift velocity of the carriers in the left cylinder is 0.5mm/s and the drift velocity of the carriers in the right cylinder is 1.5 mm/s. The ratio of the carrier number density (number of carriers per unit volume) in the right cylinder (n_2) to the carrier number density in the left cylinder (n_1) is
(a) $n_2/n_1=1$; (b) $n_2/n_1=1.33$; (c) $n_2/n_1=1.5$; (d) $n_2/n_1=1.67$; (e) $n_2/n_1=2$

Problem 3
A 1.5 V ideal battery stores 4.5 kJ of energy. How long can it light a flashbulb of resistance 6Ω?
(a) 3.3h ; (b) 1.3h ; (c) 2.7h ; (d) 1.7h ; (e) 3.0h

Problem 4
The total power dissipated by two identical light bulbs connected in series to an ideal emf is 200W. When connected in parallel to the same emf the total power they dissipate is
(a) 100W ; (b) 400W ; (c) 800W ; (d) 200W ; (e) 600W

Problem 5
A 10Ω resistor connected to a battery dissipates the same power (in the resistor alone) as a 50Ω resistor connected to this battery. What is the internal resistance of this battery?
(a) 22Ω ; (b) 16Ω ; (c) 30Ω ; (d) 42Ω ; (e) 36Ω

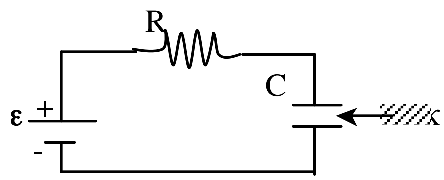
Problem 6



In the circuit in the figure, ε_1=8V, ε_2=2V, R_1=1Ω, R_2=2Ω, R_3=3Ω. The current through R_3 is
(a) 1A ; (b) 2A ; (c) 3A ; (d) 4A ; (e) 6A

Problem 7
In an RC circuit with the capacitor initially uncharged, the charge in the capacitor is 1C one second after the capacitor starts charging, and 3C after a very long time. What is the charge 2 seconds after it started charging?
(a) 1.20C ; (b) 1.33C ; (c) 1.5C ; (d) 1.67C ; (e) 2C

Problem 8



In the RC circuit in the figure ε=6V and R=4Ω. The circuit has been connected for a long time and the current through the resistor is 0. Then, a dielectric material with dielectric constant κ=3 is inserted very rapidly in the region between the plates of the capacitor so that it fills all the space between the plates. The current through the resistor immediately after the dielectric is inserted is
(a) 1.5A ; (b) 4.5A ; (c) 0A ; (d) 2A ; (e) 1A