PHYSICS 2B — QUIZ 3 — WINTER QUARTER 2010
PROF. HIRSCH — FEBRUARY 1, 2010

<u>Formulas</u>:

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

$F = k\frac{q_1q_2}{r^2}$ 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: $E = \frac{2kp}{x^3}$ (p=qd)

Electric field of dipole, along direction perpendicular to dipole axis: $E = \frac{kp}{y^3}$

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: $C = \kappa C_0$; $\varepsilon_0 = 8.85 pF/m$

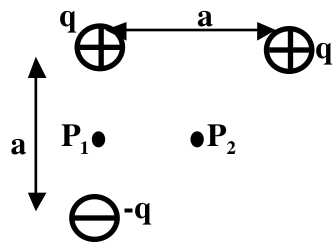
$C = \frac{\varepsilon_0 A}{d}$ parallel plates ; $C = \frac{2\pi\varepsilon_0 L}{\ln(b/a)}$ cylindrical ; $C = 4\pi\varepsilon_0\frac{ab}{b-a}$ spherical

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: $C = C_1C_2/(C_1 + C_2)$

<u>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</u>

Problem 1

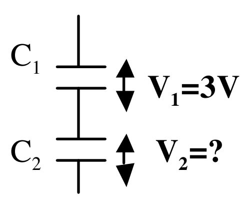


In the arrangement in the figure, the charges are q and -q as indicated. The electric potential is defined so that it is zero at points infinitely far away. The point P_1 is at the center of the left vertical edge, and the point P_2 is at the middle of the diagonal line (at 45 degrees with the horizontal) connecting charges q and -q. The electric potentials at points P_1 and P_2 are V_1 and V_2, with
(a) $V_2=0.58V_1$; (b) $V_2=0.85V_1$; (c) $V_2=1.85V_1$; (d) $V_2=1.58V_1$; (e) $V_2=1.28V_1$

Problem 2
The electrostatic energy of the charge distribution in problem 1 is
$U= \alpha q^2/a$, with a the distance between neighboring charges. The coefficient α is
(a) α=-0.71k ; (b) α=-1.41k ; (c) α=-2.82k ; (d) α=-k ; (e) α=0

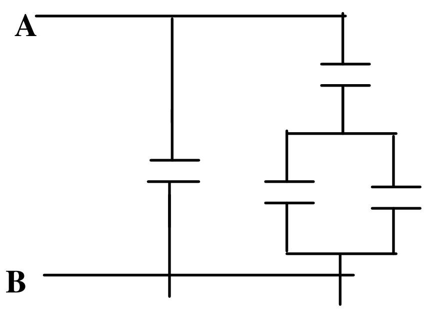
Problem 3
There are 2J of energy stored in a capacitor when the voltage difference across the capacitor is 3V. The charge in this capacitor is
(a) 1C ; (b) 1.25C ; (c) 1.33C ; (d) 1.5C ; (e) 1.67C

Problem 4



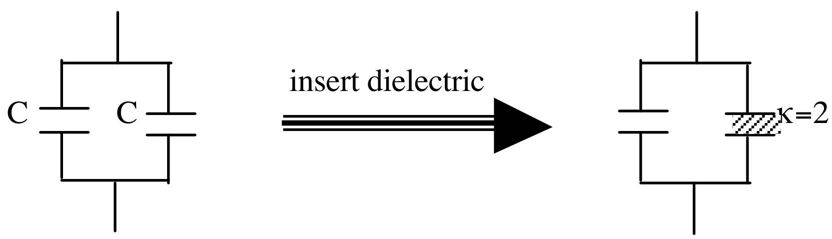
The capacitors in the figure have capacitance $C_1=1\mu F$, $C_2=4\mu F$. The voltage across capacitor C_1 is 3V, the voltage across capacitor C_2 is
(a) 12V ; (b) 6V ; (c) 3V ; (d) 1.5V ; (e) 0.75V

Problem 5



The four capacitors in this arrangement are identical and each has capacitance C. The equivalent capacitance between points A and B is
(a) 4C ; (b) 2C ; (c) 1.33C ; (d) 1.67C ; (e) 2.67C

Problem 6



The two capacitors in the figure are identical, they are not connected to a battery, and each has charge Q. A dielectric material is now inserted in the region between the plates of the capacitor on the right so that it fills ALL the space between the plates. The dielectric constant of the material is $\kappa=2$. The charge on the capacitor with the dielectric is now
(a) Q ; (b) 2Q ; (c) 1.5Q ; (d) 1.33Q ; (e) 1.67Q

Problem 7
In the arrangement of problem 6, the total energy stored in the capacitors before the dielectric is inserted is U. After the dielectric is inserted the total energy stored in the capacitors is
(a) U ; (b) 2U ; (c) 0.33U ; (d) 0.5U ; (e) 0.67U

Problem 8
A sphere of radius R has positive charge uniformly distributed. A positive charge q is at rest at the sphere's surface. The charge q is released and gains speed as it moves away from the surface of the sphere in the radial direction. The sphere doesn't move. At a distance 2R from the center of the sphere the speed of the charge q is v_1, and at a distance 4R from the center of the sphere the speed of the charge q is v_2, with
(a) $v_2=1.11v_1$; (b) $v_2=1.22v_1$; (c) $v_2=1.33v_1$; (d) $v_2=1.44v_1$; (e) $v_2=1.55v_1$