Quiz 2 – Electrostatics (29 Jan 2007)

The force on charge q_1 from charge q_2 is $\vec{F}_{12} = k_e \frac{q_1 q_2}{r_{12}^2}\hat{r}_{12}$, where the direction vector $\hat{r}_{12}$ points from q_2 to q_1 and the proportionality constant is $k_e = 8.99\text{x}10^9$ Nm^2/C^2, note also $\varepsilon_0 \equiv \frac{1}{4\pi k_e} = 8.85\text{x}10^{-12}$ C^2/(Nm^2).

Force on a test charge q_0 induced by an electric field, denoted $\vec{E}$, is $\vec{F} = q_0\vec{E}$.

Gauss' Law : $\Phi_e = 4\,\pi\,k_e\,Q_{Total}$ where $\Phi_e \equiv \sum_{All\ Surfaces} EA_\perp = \sum_{All\ Surfaces} EA\cos\theta$ is the electric flux through a surface and θ is the angle between the direction of the electric field and the normal to the surface.

Point charge q at the origin: $\vec{E} = k_e \frac{q}{r^2}\hat{r}$; $\hat{\mathbf{r}}$ is radius vector in spherical coordinates.

Line charge along $\hat{z}$, with charge/length λ: $\vec{E} = 2k_e \frac{\lambda}{r}\hat{r}$; $\hat{\mathbf{r}}$ is radius vector in cyl. coord.

Surface charge in $\hat{x}$-$\hat{y}$ plane, with charge/area σ: $\vec{E} = 2\pi k_e \sigma\,\hat{z}$; $\hat{z}$ is normal to the plane.

Work-Energy Theorem: $W = \Delta KE + \Delta PE$

Electric potential: $\Delta V = -E\,\Delta x\,\cos\theta$, where $\Delta V = \frac{\Delta PE}{Q}$

$V = k_e \frac{q}{r}$ a distance r away from a point charge q.

Capacitance : $Q = C\,\Delta V$ where $C = \frac{\kappa}{4\pi k_e}\frac{A}{d}$ for parallel plates and κ is the dielectric constant κ

Energy Stored = $\frac{1}{2}Q\,\Delta V = \frac{1}{2}C\left(\Delta V\right)^2 = \frac{1}{2C}Q^2$

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1. (1/2 pt) A parallel plate capacitor is formed from two square plates with area A = 2500 cm^2, spaced d = 1.0 mm apart, as in figure 1. The gap between the plates is filled with air (dielectric constant $\kappa = 1$). What is the capacitance?

A. 2.2×10^{-9} V
B. 2.2×10^{-7} V
C. 250 cm^3
D. 2.2×10^{-9} F
E. 2.2×10^{-7} F

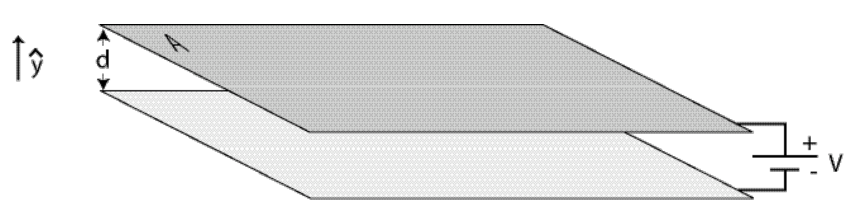

Figure 1

2. (1/2 pt) If the area of the plates were to quadruple, the capacitance would
A. Quadruple
B. Double
C. Remain unchanged
D. Be cut by a factor of 2
E. Be cut by a factor of 4

3. (1/2 pt) A battery is placed across capacitor plates, with C = 2.5 μF, as also illustrated in figure 1. What is the magnitude of the charge on the top plate if the potential across the battery is V = 25 Volts?
A. 1.0×10^{-7} C
B. 6.3×10^{-5} C
C. 3.2×10^{-5} C
D. 6.3×10^{1} C
E. 1.0×10^{7} C

4. (1/2 pt) A negative charged particle is placed in a uniform electric field that points to the right. It is initially at rest. Neglect gravity. What happens?
A. The particle accelerates to the right gaining both kinetic and potential energy
B. The particle accelerates to the right gaining kinetic but losing potential energy
C. Nothing – a particle at rest remains at rest
D. The particle accelerates to the left gaining kinetic but losing potential energy
E. The particle accelerates to the left gaining both kinetic and potential energy

5. (1 pt) The electric field everywhere on the surface of a spherical shell of radius r = 0.1 m is $\vec{E}$ = 4.5 V/m $\hat{r}$, *i.e.*, points radially outward from the center of the shell. What is the net charge on the shell?
A. -5.0×10^{-12} C
B. -5.0×10^{9} C
C. 1.3 C
D. 5.0×10^{9} C
E. 5.0×10^{-12} C

6. (1 pt) A electron with charge $e^- = -1.6\times10^{-19}$C is located at the origin. How much work is required to bring a second electron from infinity to a distance r = 1.0 μm from the first electron?
A. 1.4×10^{-15} J
B. 1.4×10^{-36} J
C. 2.3×10^{-22} J
D. 2.3×10^{-43} J
E. None of the above

7. (1 pt) Find the equivalent capacitance between points A and B for the circuit in figure 2.
A. 0.25 μF
B. 0.40 μF
C. 0.50 μF
D. 1.0 μF
E. 2.0 μF

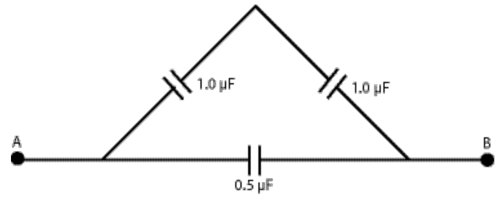

Figure 2