PHYSICS 241 - EXAM I

September 25, 2007

This exam consists of 17 problems on 7 pages. **Please check that you have them all.** The maximum score possible is 100.

Useful Equations and constants:

$$F = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2} \qquad \vec{E} = \vec{F}/q_0 \qquad dE = \frac{1}{4\pi\epsilon_0}\frac{dq}{r^2}$$

$$\vec{\tau} = \vec{p} \times \vec{E} \qquad \Phi_E = \oint \vec{E} \cdot d\vec{A} \qquad \epsilon_0 \Phi_E = q$$

$$E = \frac{\lambda}{2\pi\epsilon_0 r} \qquad V_b - V_a = \frac{W_{ab}}{q_0} \qquad V_b - V_a = -\int_a^b \vec{E} \cdot d\vec{l}$$

$$V = \frac{1}{4\pi\epsilon_0}\frac{q}{r} \qquad U = Vq \qquad E = -\left(\frac{dV}{dl}\right)$$

$$q = CV \qquad C = \epsilon_0 \frac{A}{d} \qquad C = \kappa C_0$$

$$R = \rho\frac{L}{A} \qquad V = iR \qquad P = iV \qquad U = \frac{1}{2}CV^2$$

$$U = \frac{1}{2}\frac{q^2}{C} \qquad V = \mathcal{E}(1 - e^{-t/RC})$$

$$i = \frac{\mathcal{E}}{R}e^{-t/RC} \qquad q = q_0 e^{-t/RC}$$

$\varepsilon_o = 8.85 \times 10^{-12}\ C^2/Nm^2$ $\qquad k = 8.99 \times 10^9\ Nm^2/C^2 = 1/4\pi\varepsilon_o$

$g = 9.8\ m/s^2$ $\qquad G = 6.67 \times 10^{-11} Nm^2/kg^2$ $\qquad$ weight = mg

Avogadro's Number $= 6.023 \times 10^{23}$

$e = 1.6 \times 10^{-19}$ C and $m = 9.11 \times 10^{-31}$ kg for an electron.

$m = 1.67 \times 10^{-27}$ kg for a proton

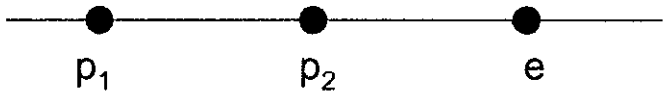
1. (5 points) The electron volt is a unit of

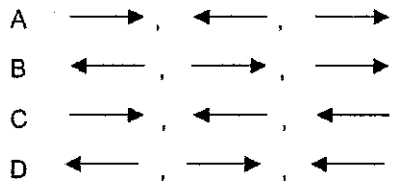
A. capacitance
B. charge
C. energy
D. momentum
E. potential

2. (5 points) An electric field is $\vec{E} = (400\ \text{N/C})\ \hat{i}$ for $x > 0$ and $\vec{E} = (-400\ \text{N/C})\ \hat{i}$ for $x < 0$. A cylinder of length 30 cm and radius 10 cm has its center at the origin and its axis along the x axis such that one end is at $x = +15$ cm and the other is at $x = -15$ cm. What is the flux (in Nm^2/C) through each end of the cylinder?

A) zero
B) 1.3×10^3
C) 13
D) 0.13
E) 0.25×10^3

3. (5 points) Two protons (p_1 and p_2) and an electron (e) lie on a straight line, as shown. The directions of the force of p2 on p1, the force of e on p1, and the total force on p1, respectively, are:



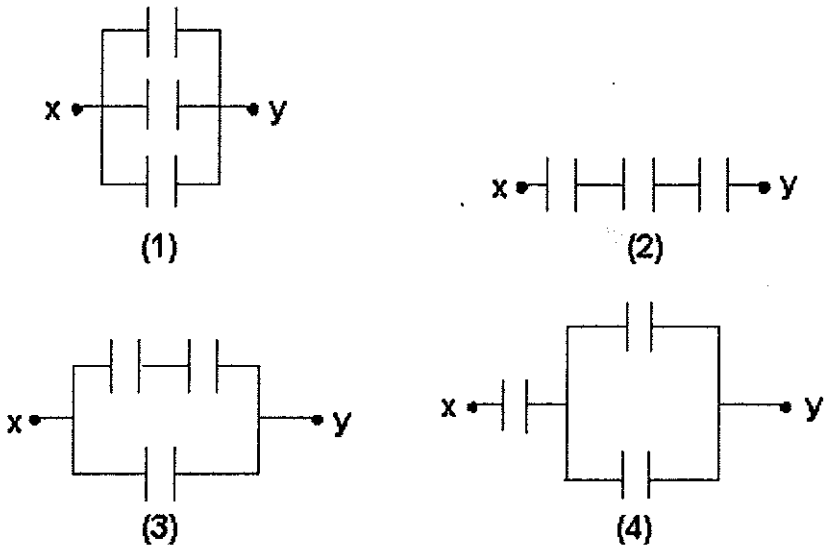


4. (5 points) A uniform electric field of 300 N/C makes an angle of 25° with the dipole moment of an electric dipole. If the moment has a magnitude of 2.0×10^{-9} C-m, the torque exerted by the field has a magnitude of:

A. 6.7×10^{-12} N-m
B. 2.5×10^{-7} N-m
C. 5.4×10^{-7} N-m
D. 6.0×10^{-7} N-m
E. 2.8×10^{-7} N-m

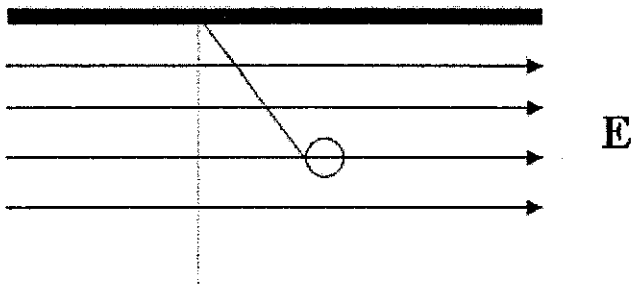
5. (5 points) If you increase the charge on a parallel-plate capacitor from 3 μC to 9 μC and increase the plate separation from 1 mm to 3 mm, the energy stored in the capacitor changes by a factor of

A. 1/3
B. 3
C. 8
D. 9
E. 27



6. (5 points) You want to use three capacitors in a circuit. If each capacitor has a capacitance of 3 pF, the configuration that gives you an equivalent capacitance of 2 pF between points *x* and *y* is

A. 1
B. 2
C. 3
D. 4
E. None of these are correct



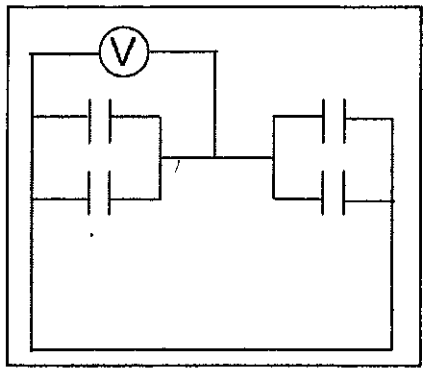
7. (5 points) A bob of mass m (m = 0.500 g), and charge magnitude Q ($|Q|$ = 50.0 μC) is held by a massless string in a uniform electric field E. If the bob makes an angle of 10.0 degrees with the vertical, what is the magnitude of the electric field E *(N/C)* and the sign of the bob charge Q.

A. 17.3 and Q is negative
B. 17.3 and Q is positive
C. 0.18 and Q is positive
D. 98.1 and Q is negative
E. 98.1 and Q is positive

8. (5 points) The voltage between the cathode and the screen of a television set is 22 kV. If we assume a speed of zero for an electron as it leaves the cathode, what is its speed (m/s) just before it hits the screen?

A. 2.8×10^6
B. 5.3×10^7
C. 6.2×10^7
D. 8.8×10^7
E. 7.7×10^{15}

9. (5 points) Each of the four capacitors shown is 500 μF. The voltmeter reads 1000 V. The magnitude of the charge, in coulombs, on each capacitor plate is:



A. 0.2
B. 0.5
C. 20
D. 50
E. none of these

10. (10 points) Positive charge Q is distributed uniformly throughout an insulating sphere of radius R, centered at the origin. A positive point charge Q is placed at $x = 2R$ on the x-axis. The magnitude of the electric field at $x=R/2$ on the x-axis is:

A. $\frac{Q}{4\pi\varepsilon_o R^2}$

B. $\frac{Q}{8\pi\varepsilon_o R^2}$

C. $\frac{Q}{72\pi\varepsilon_o R^2}$

D. $\frac{17Q}{72\pi\varepsilon_o R^2}$

E. none of these

11. (5 points) A solid spherical conductor of radius 15 cm has a charge $Q = 6.5$ nC on it. A second, initially uncharged, spherical conductor of radius 10 cm is moved toward the first until they touch and is then moved far away from it. How much charge is there on the second sphere after the two spheres have been separated?

A. 4.3 nC
B. 2.2 nC
C. 3.2 nC
D. 2.6 nC
E. 3.9 nC

12. (10 points) The capacitance of a spherical capacitor with inner radius a and outer radius b is proportional to:

A. $\frac{a}{b}$
B. $b-a$
C. b^2-a^2
D. $\frac{ab}{b-a}$
E. $\frac{ab}{b^2-a^2}$

13. (5 points) Find the magnitude of the electric field, E, in V/m at the point (1.5m, -1.5m) in the x-y plane for a the potential function $V(x,y,) = (x^2y - y^2x - 10)$V.

A) zero B) 7.75 C) 9.55 D) 15.5 E) 77.5

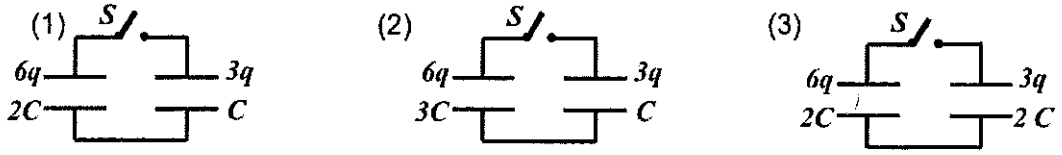
14. (5 points) An active thundercloud has a potential exceeding 3 MV relative to the Earth's surface. A typical cloud system (whose bottom is 1.6 km above the earth) has an area of 100 km^2. Estimate the energy, U, stored in this cloud assuming you can treat it and the Earth as a giant capacitor.

A) 0.83 MJ
B) 2.49 MJ
C) 4.98 MJ
D) 8.30 MJ
E) 9.96 MJ

15. (5 points) Charge is distributed uniformly along a long straight wire. The electric field 2 cm from the wire is 20 N/C. The electric field 4 cm from the wire is:

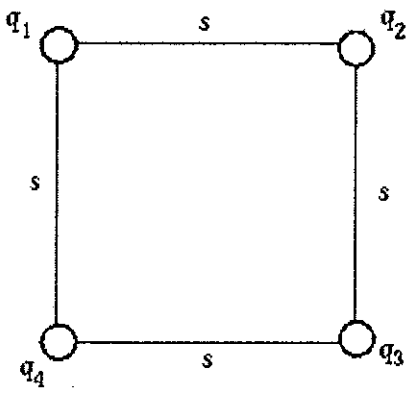
A. 5 N/C
B. 10 N/C
C. 40 N/C
D. 80 N/C
E. 120 N/C

16. (5 points) Three circuits, each consisting of a switch and two capacitors are initially charged as indicated. After the switches have been closed, in which circuit will the charge on the left-hand capacitor decrease?



A) 1
B) 2
C) 3
D) None of these

17. (10 points) Four point charges $q_1 = -1$ μC, $q_2 = 2$ μC, $q_3 = 3$ μC, and $q_4 = 4$ μC are located at the corners of a square whose side $s = 1$ m. The electrostatic potential energy of this system of charges is



A. 0.492 J
B. 0.337 J
C. 0.286 J
D. 0.176 J
E. 0.140 J