Physics Department *AUB* | *Physics 211* *Quiz I* | *Date: March 14, 2001* *Time: 1 hour*

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Encircle your section

Section 1.	9 M	J. Katul
Section 2.	9 M	B. Bodakian
Section 3.	9 Tu	J. Katul
Section 4.	9 Tu	B. Bodakian

Show your solution and encircle the correct answer given.

A correct answer without solution is not counted

Useful Information

$$k = \frac{1}{4\pi\varepsilon_o} = 9\times10^9\ MKSA$$

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

10

$\rightarrow U = qV.$

$\Delta K = -\Delta U.$

$\lambda \quad \sigma \quad \rho$

$m \quad m^2 \quad m^3$

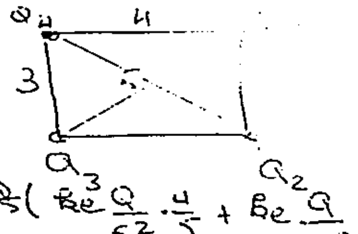
11 5 26

10 marks

1. Identical point charges Q are placed at each of the four corners of a 3.0 m × 4.0 m rectangle. If Q = 40 μC, what is the magnitude of the electrostatic force on any one of the charges?

a. 3.0 N (b.) 2.4 N c. 1.8 N d. 3.7 N e. 2.0 N

Solution:



$\vec{F}_t = q.\vec{E}_q$

$\vec{E}_q = \vec{E}_2 + \vec{E}_3 + \vec{E}_4$

$E_{qx} = E_{2x} + E_{3x} + E_{4x} = 0 + E_3 . \frac{4}{5} + E_4 = Q (k_e \frac{Q}{5^2} . \frac{4}{5} + k_e \frac{Q}{4^2})$

10 ✓

$E_{qx} = 34020$ N/C

$E_{qy} = E_{2y} + E_{3y} + E_{4y} = E_2 + E_3 . \frac{3}{5} + 0 = k_e \frac{Q}{3^2} + k_e \frac{Q}{5^2} . \frac{3}{5}$

$E_{qy} = 48640$ N/C

$E_q = \sqrt{E_{qx}^2 + E_{qy}^2} = 59356.6$ N/C

$|F| = q . E = 40.10^{-6} . 59356.6 = 2.37$ N

10 marks

2. If Q = 80 nC, a = 3.0 m, and b = 4.0 m in the figure, what is the magnitude of the electric field at point P?

a. 45 N/C b. 70 N/C c. 29 N/C (d.) 47 N/C e. 92 N/C

Solution:

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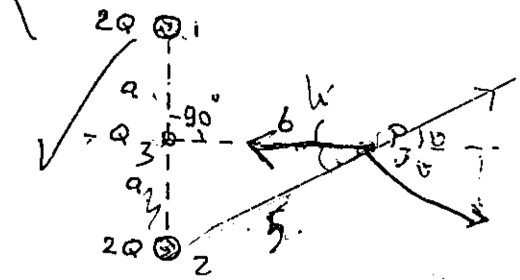


$\vec{E}_p = \vec{E}_{1p} + \vec{E}_{2p} + \vec{E}_{3p}$

$E_{px} = E_{1px} + E_{2px} + E_{3px} = E_1 . \frac{b}{\sqrt{a^2+b^2}} + E_2 \frac{b}{\sqrt{a^2+b^2}} - E$

$E_{px} = 2 . k_e \frac{2Q}{5^2} . \frac{4}{5} - k_e \frac{Q}{4^2}$

$E_{px} = 92.16 - 45 = 47.16$

$E_{py} = E_1 . \frac{3}{5} - E_2 . \frac{3}{5} = 0$

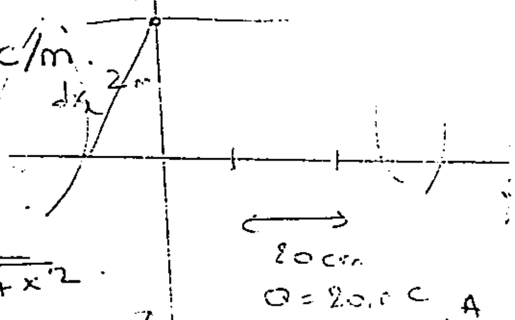
$\Rightarrow E_p = E_{px} = 47.16$ N/C

10 marks

3. Charge is uniformly distributed along the entire x axis. If each 20-cm length of the x axis carries 2.0 nC of charge, what is the magnitude of the electric field at the point, y = 2.0 m, on the y-axis?

   a. 45 N/C (b) 90 N/C c. 18 N/C d. 36 N/C e. 180 N/C

   Solution:



$dq = \lambda = \frac{Q}{L} = \frac{2 \cdot 10^{-9}\ \text{nC}}{20 \cdot 10^{-2}\ \text{m}} = 10^{-8}\ \text{nC/m}$

$dE = k_e \frac{dq}{r^2} = k_e \frac{\lambda\, dx}{4 + x^2}$

$E = 2\int_0^\infty k_e \frac{\lambda\, dx}{\sqrt{4 + x^2}} = 2k_e\lambda \int_0^\infty \frac{dx}{\sqrt{4+x^2}}$

$E = 2k_e\lambda \cdot \ln(x + \sqrt{4+x^2})\Big|_0^\infty = \lim_{A\to\infty} 2k_e\lambda \ln(x+\sqrt{4+x^2})\Big|_0^A$

$\lim_{A\to\infty} E = 2k_e\lambda(\ln(A+\sqrt{4+A}) - \ln 2)$

Gauss's law: $\oint E \cdot dA = \frac{q_{in}}{\varepsilon_0} \Rightarrow E \cdot 2\pi r h = \frac{\lambda \cdot h}{\varepsilon_0}$

$E = \frac{\lambda}{2\pi r \varepsilon_0} = 2k_e\frac{\lambda}{r} = 2 \cdot 9 \cdot 10^9 \cdot \frac{10^{-8}}{2} = 90\ \text{N/C}$

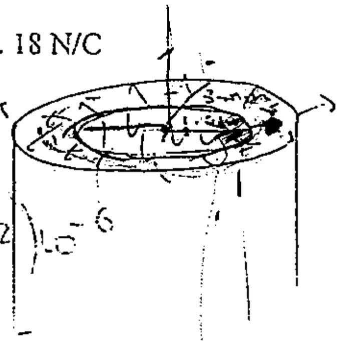
10

10 marks

4. Charge of uniform density (80 nC/m^3) is distributed throughout a hollow cylindrical region formed by two coaxial cylindrical surfaces of radii, 1.0 mm and 3.0 mm. Determine the magnitude of the electric field at a point which is 2.0 mm from the symmetry axis.

   a. 7.9 N/C (b) 9.0 N/C (c) 5.9 N/C (d) 6.8 N/C e. 18 N/C

   Solution:



$dE = k_e \frac{dq}{r^2} = k_e\, \rho \ldots$

$\oint E \cdot dA = \frac{q_{in}}{\varepsilon_0}$

$E \cdot 2\pi r h = \frac{q_{in}}{\varepsilon_0}$

$E\, 2\pi r l = \frac{\rho\, V}{\varepsilon_0}$

0

10 marks

5. Three identical point charges (+2.0 nC) are placed at the corners of an equilateral triangle with sides of 2.0-m length. If the electric potential is taken to be zero at infinity, what is the potential at the midpoint of any one of the sides of the triangle?

a. 16 V   b. 10 V   c. 70 V   (d.) 46 V   e. 44 V

Solution:

$$\Delta V_P = k_e \left(\frac{q}{1} + \frac{q}{1} + \frac{q}{\sqrt{4-1}} \right)$$

$$\Delta V_P = k_e \left(2q + \frac{q\sqrt{3}}{3} \right)$$

$$\Delta V_P = 9.10^9 \left(2.2.10^{-9} + \frac{2.10^{-9}.\sqrt{3}}{3} \right)$$

$$\Delta V_P = 46.3V$$

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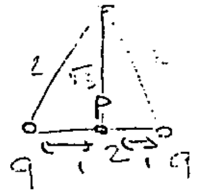


10 marks

6. Two identical particles, each with a mass of 4.5 mg and a charge of 30 nC, are moving directly toward each other with equal speeds of 4.0 m/s at an instant when the distance separating the two is equal to 25 cm. What minimum separation distance will the two achieve?

a. 9.8 cm   b. 12 cm   (c.) 7.8 cm   d. 15 cm   e. 20 cm

Solution:

each particle is subject to an electrostatic force $\vec{F} = q_s . \vec{E}$ in the opposite of its direct°. $E = k_e \frac{q}{r^2}$

$q.E = a.m \qquad a = \frac{q.E}{m} < 0$

$x_f = \frac{1}{2}at^2 + v_i t + v_0$

$v_f = at^2 + v_i$ with $v_i = 4m/s$.

$v_f = 0 \Rightarrow at^2 + v_i = 0$.

$t = \frac{-v_i}{a} = \frac{-4}{\frac{q.E}{m}} = \frac{-4m}{q.E} = -\frac{4mx^2}{k_e q^2} = 2.23x^2$

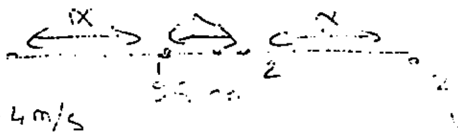
$v_f - v_i = at^2$

$-4 =$

$qEd - \frac{1}{2}mv^2 = qEx$

$k\frac{q^2}{d} + \frac{1}{2}mv_i^2 = k\frac{q^2}{x}$

$\frac{1}{x} = \frac{1}{d} + \frac{mv^2}{2kq^2}$

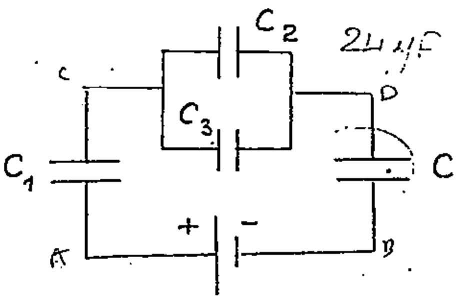


10 marks

7. In the figure, if $C_1 = 20\ \mu F$, $C_2 = 10\ \mu F$, $C_3 = 14\ \mu F$, $C_4 = 30\ \mu F$, and $V_o = 45$ V, determine the charge stored by C_4.

a. 0.250 mC b. 0.28 mC c. 0.300 mC d. 300 mC e. (0)360 mC

Solution:



Ceq of the system is.

$C_5 = C_3 + C_2 = 24\ \mu F$.

$\frac{1}{C_{eq}} = \frac{1}{C_5} + \frac{1}{C_1} + \frac{1}{C_4}$

$\frac{1}{C_{eq}} = \frac{1}{24} + \frac{1}{20} + \frac{1}{30}$

$C_{eq} = \frac{24 \cdot 20 \cdot 30}{20 \cdot 30 + 24 \cdot 30 + 24 \cdot 20} = 8\ \mu F$.

$Q_4 = Q_t = C_{eq} \Delta V = 8 \cdot 10^{-6} \cdot 45 = 360\ \mu C = 0.360$ mC

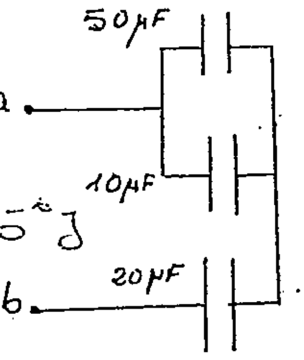
10 ✓

10 marks

8. What total energy is stored in the group of capacitors shown if the potential difference V_{ab} is equal to 50 V ?

a. 48 mJ b. 27 mJ c. 37 mJ (d.) 19 mJ e. 10 mJ

Solution:



$C_{eq_1} = 50\ \mu F + 10\ \mu F = 60\ \mu F$

$\frac{1}{C_{eq}} = \frac{1}{60} + \frac{1}{20} = \frac{1+3}{60}$

$C_{eq} = 15\ \mu F$.

$Q_t = C_{eq} \cdot \Delta V = 15 \cdot 10^{-6} \cdot 50 = 750 \cdot 10^{-6}$ J

$\Delta U_t = \frac{1}{2} C_{eq} \cdot \Delta V^2 = \frac{1}{2} \cdot 15 \cdot 10^{-6} \cdot 50^2 = 0.018$ mJ

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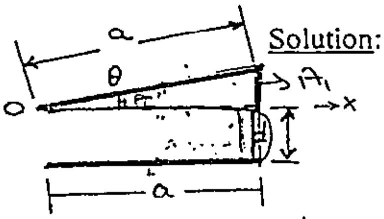
10 marks

9. A capacitor has square plates, each of side a, making a small angle with each other as shown in the figure. Find the capacitance.

a. $C = \frac{\varepsilon_o a^2}{d}(1 + \frac{a\theta}{2d})$ b. $C = \frac{\varepsilon_o a^2}{d}(1 + \frac{a\theta}{d})$ (c.) $C = \frac{\varepsilon_o a^2}{d}(1 - \frac{a\theta}{2d})$

d. $C = \frac{\varepsilon_o a^2}{d}(1 - \frac{a\theta}{d})$ e. none of the above my answer is :____________

0



Solution:

$A_1' = A_1 \cos\theta = a^2 \cos^2\theta$

$C = \frac{\varepsilon_0 \cdot A'}{d} = \frac{\varepsilon_0 \cdot a^2 \cos^2\theta}{d}$

$C = \frac{\varepsilon_0 A}{d}$

10 marks

10. Consider two widely separated conducting spheres, 1 and 2, the second having twice the diameter of the first. The smaller sphere initially has a positive charge q and the larger one is initially uncharged. You connect the spheres with a long thin wire. The final charges q_1 and q_2 on the spheres in term of q are :

(a.) $q_1 = \frac{q}{3}$, $q_2 = \frac{2q}{3}$ b. $q_1 = +\frac{q}{2}$, $q_2 = +\frac{3q}{2}$ c. $q_1 = +\frac{2q}{3}$, $q_2 = +\frac{q}{3}$

d. $q_1 = +\frac{3q}{2}$, $q_2 = +\frac{q}{2}$ e) none of the above, my answer is:____________

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Solution:

$d_1 = 2d_2$ $q_1 = q$, $q_{2i} = 0$

$\Delta V = k_e \frac{q_{1f}}{d_1/2} = k_e \frac{q_{2f}}{d_2/2}$

$k_e \frac{q_{1f}}{d_2} = k_e \frac{q_{2f}}{d_2/2}$ $\frac{2 q_{1f}}{d_2} = \frac{q_{2f}}{d_2}$

$q = q_{1f} + q_{2f}$ $2q_{1f} = q_{2f}$

$q = q_{1f} + 2q_{1f} = 3q_{1f}$

$q_{1f} = \frac{q}{3}$

$q_{2f} = \frac{2q}{3}$