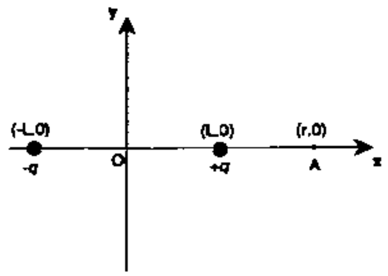
Thewalt, Jenifer **section 1**
SFU Department of Physics
phys102p – Spring 2004 – Assignment 3.
Due Thr, Jan 22, 2004 at 23:59hrs. CAPA ID is **7263**



1. [1 pt.] The diagram above shows a dipole centered at the origin and along the x-axis. Determine an expression for the total electric field at a point A (r=3.5L,0) in terms of q and L. Calculate the magnitude of the total electric field at A, when q=6.90×10^{-7}C and L=12.8cm. 4.19×10^4 [4.15×10^4,4.23×10^4] N/C

2. [1 pt.] Consider the situation outlined in the previous question and the following statements. If the statement is true, answer 'T', if it is false, answer 'F', and if the answer cannot be determined from the information provided, answer 'C'. For example if 'A' and 'E' are true and there is not enough information to answer 'C' and the rest are false, then answer 'TFCFTF'.

A) The magnitude of the net electric field at point A is greater than the magnitude of the net electric field at the origin.
B) The direction of the net electric field at A is →
C) The direction of the net electric field at a point on the positive y-axis is ↖
D) The direction of the net electric field at a point on the negative y-axis is ↘
E) The direction of the net electric field at the point (-r,0) is →
F) The direction of the net electric field at the origin is →

FTFFTF

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3. [1 pt.] Three charges are at rest on the z-axis: q_1 =-6.90mC at z=+2.50m, q_2 =6.50mC at z=0m, and q_3 =-5.30mC at z=-3.25m. What is the potential energy of this system? -1.99×10^5 [-2.01×10^5,-1.97×10^5] J

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4. [1 pt.] The potential difference between two parallel plates is 260V. An α particle with mass of 6.5 ×10^{-27}kg and charge of 3.2 ×10^{-19}C is released from rest near the positive plate. What is the kinetic energy of the α particle when it reaches the other plate? The distance between the plates is 45cm. 8.32×10^{-17} [8.24×10^{-17},8.40×10^{-17}] J

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5. [1 pt.] A balloon of radius 47.5cm is sprayed with a metallic coating so that the surface is conducting. A charge of 1.20×10^{-8}C is placed on the surface. What is the potential on the balloon's surface? 2.27×10^2 [2.25×10^2,2.29×10^2] V

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6. [1 pt.] Suppose that the some air is let out of the balloon, so that the radius shrinks to 10.5cm, what is the new potential on the balloon's surface? 1.03×10^3 [1.02×10^3,1.04×10^3] V

7. [1 pt.] What is the change in electrical potential energy during the shrinking process? For your own interest, what does the work needed to change the potential energy? 4.80×10^{-6} [4.75×10^{-6},4.85×10^{-6}] J

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8. [1 pt.] Two conducting spheres of different sizes are at the same potential. The radius of the larger sphere is eight times larger than that of the smaller sphere. If a total charge Q is placed on this system, what fraction of Q sits on the larger sphere? 8.89×10^{-1} [8.80×10^{-1},8.98×10^{-1}]

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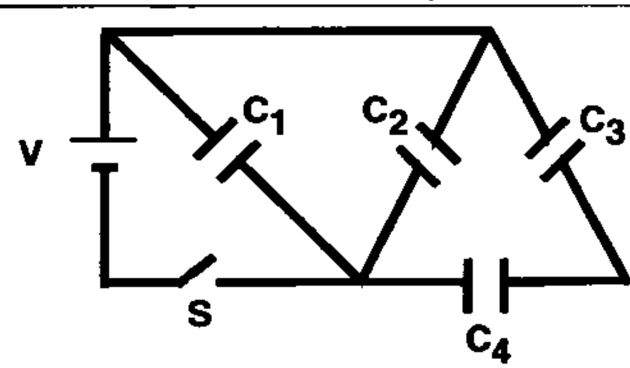
9. [1 pt.] **9.** [1 pt] A capacitor consists of two closely spaced metal conductors of large area, separated by a thin insulating foil. It has an electrical capacity of 3600×10^{-6}C/V (Farads) and is charged to a potential difference of 69.0V. Calculate the amount of energy stored in the capacitor. 8.57 [8.48,8.66] J

10. [1 pt.] Calculate the charge on this capacitor when the electrical energy stored in the capacitor is 14.580J. 3.24×10^{-1} [3.21×10^{-1},3.27×10^{-1}] C

11. [1 pt.] If the two plates of the capacitor have their separation increased by a factor of 2 while the charge on the plates remains constant, by what factor is the energy stored in the capacitor increased? 2.00 [2.00,2.00]



12. [1 pt.] Calculate the equivalent capacitance of the circuit shown in the diagram above; where C_1=7.60μF, C_2=2.55μF, C_3=6.90μF, and C_4=7.25μF. 1.37×10^1 [1.35×10^1,1.38×10^1] uF

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13. [1 pt.] Two capacitors of 57.5μF and 148μF are separately charged to $158\mu C$ and $336\mu C$, respectively. They are then attached so that the + plate of one is connected to the - plate of the other, and vice versa. Determine the final voltage across the parallel combination of the two capacitors after the charges are redistributed. 8.66×10^{-1} $[8.58 \times 10^{-1}, 8.75 \times 10^{-1}]$ V

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14. [1 pt.] Which statements are true for two oppositely charged, isolated parallel plates: (C=capacitance, U=stored energy, +Q and −Q = charge on the plates). Enter all true statements, so that if statements A and B are true, enter AB.

A) Increasing the distance, increases the E field.
B) Inserting a dielectric decreases U.
C) When distance is doubled, U increases.
D) Inserting a dielectric increases C.
E) When distance is doubled, C increases.
F) Inserting a dielectric increases Q.
G) When distance is halved, Q stays the same.

BCDG

The fluid within a living cell is rich in potassium chloride, while the fluid outside it predominantly contains sodium chloride. The membrane of a resting cell is far more permeable to ions of potassium than sodium, and so there is a transport out of posi tive ions, leaving the cell interior negative. The result is a voltage of about -65.5mV across the membrane, called the *resting potential*.

15. [1 pt.] If the membrane is 5.95nm thick, and assuming the electric field E across it is constant, determine the magnitude of E. 1.10×10^{7} $[1.09 \times 10^{7}, 1.11 \times 10^{7}]$ V/m

16. [1 pt.] The membrane may be thought of as a capacitor: 2 charged surfaces filled with oil (dielectric constant=3.04). Find its capacitance per unit area. 4.52×10^{-3} $[4.48 \times 10^{-3}, 4.57 \times 10^{-3}]$ F/m^2

17. [1 pt.] What is the resting membrane's surface charge density? 2.96×10^{-4} $[2.93 \times 10^{-4}, 2.99 \times 10^{-4}]$ C/m^2

18. [1 pt.] Assume that the membrane's cytoplasmic (interior of cell) charge can be attributed to the presence of a certain fraction of negatively charged phospholipid molecules, each with a cross-sectional area of $0.465 nm^2$. If each negative ly charged lipid carries -1.60×10^{-19}C, how many such molecules are found in $1.0\mu m^2$ of the inner surface of the membrane? 1.85×10^{3} $[1.83 \times 10^{3}, 1.87 \times 10^{3}]$

Physics 102.

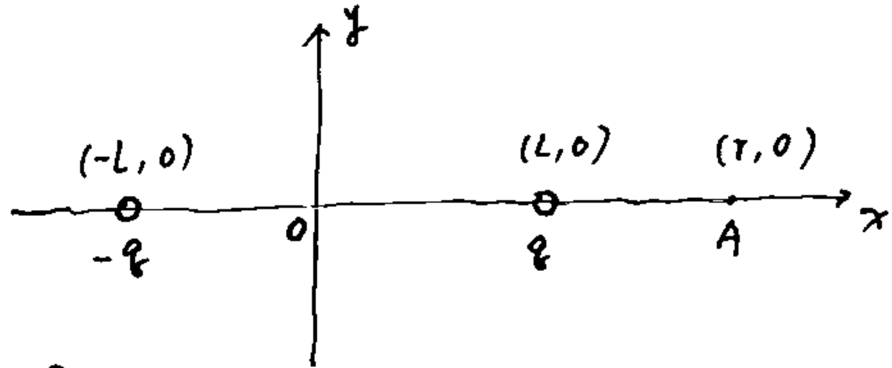
CAPA set #3 Solutions.

1.

$q = 6.9 \times 10^{-7}\,C$.

$L = 12.8\,cm = 0.128\,m$.

$r = 3.5\,L$



$$E = \frac{kq}{(r-L)^2} - \frac{kq}{(r+L)^2}.$$

$$= kq\left(\frac{1}{(3.5L-L)^2} - \frac{1}{(3.5L+L)^2}\right)$$

$$= kq\left(\frac{1}{(2.5L)^2} - \frac{1}{(4.5L)^2}\right)$$

$$= 8.99 \times 10^9 \times 6.9 \times 10^{-7}\left[\frac{1}{(2.5 \times 0.128)^2} - \frac{1}{(4.5 \times 0.128)^2}\right]$$

$$= 4.19 \times 10^4\ N/C.$$

2.

A). E at A is weaker than O. (F).

B). E at A due to q is stronger than due to -q. (T)

C). $\vec{E}$ should be along ← (F)

D). ← (F).

E). (T).

F). ← (F).

3.

$$PE = PE_{12} + PE_{23} + PE_{13}.$$

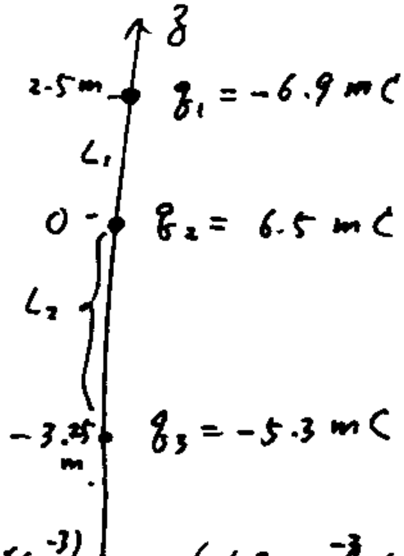
$$= \frac{K q_1 q_2}{r_{12}} + \frac{K q_2 q_3}{r_{23}} + \frac{K q_1 q_3}{r_{13}}$$

$$= K\left[\frac{q_1 q_2}{L_1} + \frac{q_2 q_3}{L_2} + \frac{q_1 q_3}{(L_1+L_2)}\right]$$

$$= 8.99\times10^{9}\left[\frac{(-6.9\times10^{-3})\times6.5\times10^{-3}}{2.5} + \frac{6.5\times10^{-3}\times(-5.3\times10^{-3})}{3.25} + \frac{(-6.9\times10^{-3})\times(-5.3\times10^{-3})}{2.5+3.25}\right]$$

$$= 8.99\times10^{9}\left(-1.794\times10^{-5} - 1.06\times10^{-5} + 6.36\times10^{-6}\right)$$

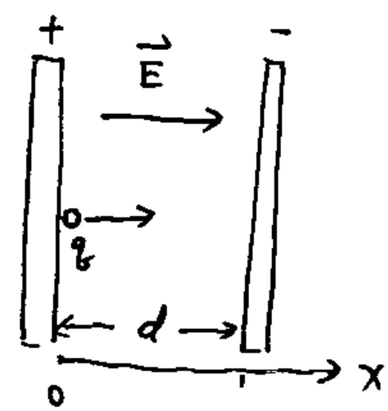
$$= -1.99\times10^{5}\ J.$$



4.

~~$\vec{E}$ field between the plates~~

~~$\left(E = \frac{V}{d} = \frac{260V}{0.45m} = 578\ V/m.\right.$~~



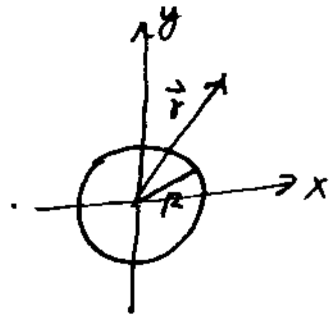
Energy conservation.

$$K_i + U_i = K_f + U_f.$$

$$q\cdot V = K.$$

$$\therefore K = q\cdot V = 3.2\times10^{-19}C \times 260V = 8.32\times10^{-17} J.$$

5\. at any point outside the balloon,



$$E_r = \frac{KQ}{r^2} \quad (r > R).$$

$$V_r = \frac{KQ}{r} \quad (r \geq R)$$

On the surface of the balloon:

$$V_R = \frac{KQ}{R} = \frac{8.99 \times 10^9 \times 1.20 \times 10^{-8}}{0.475} = 227\ V.$$

6\. Now $R = 10.5\ cm = 0.105\ m$

$$V_R = \frac{8.99 \times 10^9 \times 1.20 \times 10^{-8}}{0.105} = 1.03 \times 10^3\ V$$

7\. $\Delta U = U_f - U_{in} = \frac{1}{2} Q V_f - \frac{1}{2} Q V_{in}.$

$$= \frac{1}{2} Q (V_f - V_{in})$$

$$= \frac{1.20 \times 10^{-8}}{2} (1.03 \times 10^3 - 2.27 \times 10^2)$$

$$= 4.82 \times 10^{-6}\ J.$$

8\. $R = 8r$.

$$V_R = \frac{KQ_L}{R} = \frac{Kq_s}{r} = V_r.$$

$$\frac{Q_L}{q_s} = \frac{R}{r} = 8$$

$$\frac{Q_L}{Q_L + q_s} = \frac{Q_L/q_s}{\frac{Q_L}{q_s} + 1} = \frac{8}{1+8} = 0.89$$

9. $U = \frac{1}{2} C V^2$

$= \frac{1}{2} \times 3.6 \times 10^{-3} \times 69.0^2$

$= 8.57\ J$.

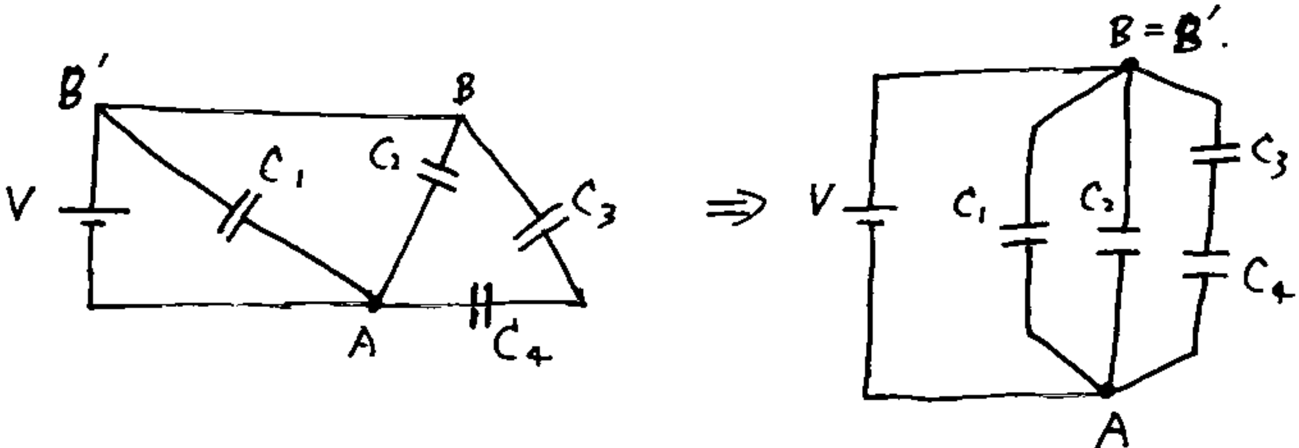
10. $U = \frac{1}{2} \frac{Q^2}{C}$.

$Q = \sqrt{2CU} = \sqrt{2 \times 3.6 \times 10^{-3} \times 14.58} = 0.324\ C$.

11. $C \propto \frac{1}{d}$. $C' = \frac{1}{2} C \left(= \frac{1}{2} \times 3.6 \times 10^{-3} = 1.8 \times 10^{-3} (F) \right)$

$U' = \frac{1}{2} \frac{Q^2}{C'} = 2U = (0.648\ C)$

12.



The total capacitance :

$C = C_1 // C_2 // (C_3 \text{ series } C_4)$

$= C_1 + C_2 + \frac{C_3 C_4}{C_3 + C_4}$

$= 7.60\mu F + 2.[illegible]5 \mu F + \frac{6.9 \times 7.25}{6.9 + 7.25} \mu F$

$= 13.7\ \mu F$.

(C_3 series C_4):

$\frac{1}{C_{34}} = \frac{1}{C_3} + \frac{1}{C_4}$.

$C_{34} = \frac{C_3 \cdot C_4}{C_3 + C_4}$

13 .

$C_1 = 57.5\ \mu F$

$C_2 = 148\ \mu F$.

$Q_1 = 158\ \mu C$

$Q_2 = 336\ \mu C$.

$Q = Q_1 - Q_2 = 158\mu C - 336\mu C$

$= -178\ C$.

Then: $C = C_1 + C_2$

$= 57.5 + 148$

$= 205.5\ \mu F$.

$Q = Q_1 - Q_2$

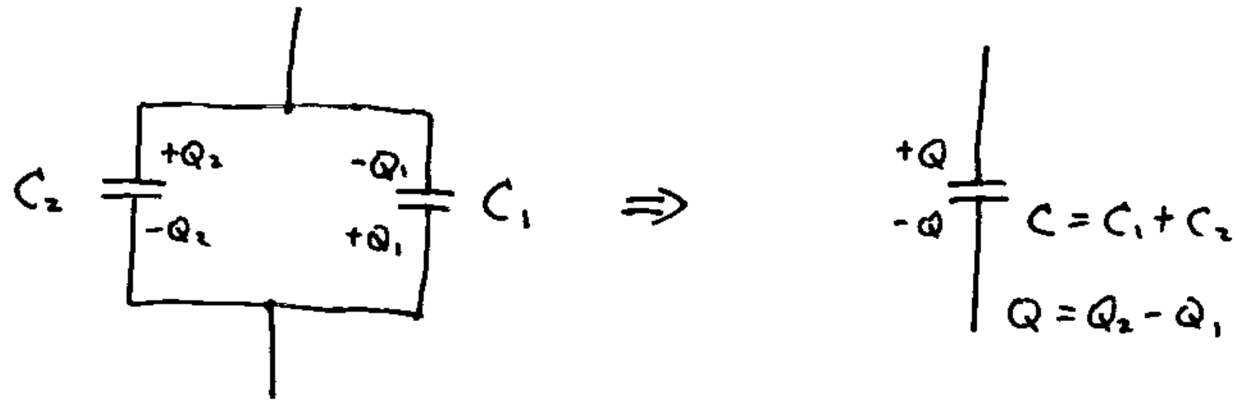
$= -178\ C$.

$|Q| = 178\ C$.

$Q = C\!\!\!/ V$.

$V = \frac{Q}{C} = \frac{178\ C}{205.5\ \mu F} = \frac{178}{2.055 \times 10^{-4}} =$

13.



$$V = \frac{Q}{C} = \frac{Q_2 - Q_1}{C_1 + C_2} = \frac{(336 - 158)\times 10^{-6}}{(57.5 + 148)\times 10^{-6}} = \frac{178}{205.5} = 0.866\ V.$$

14. × A). E field remains the same when the distance increases.

✓ B). $U = \frac{1}{2} C V^2 = \frac{1}{2} \frac{Q^2}{C}$. Now. Q remains the same. (isolated).

C increases.

∴ U will decrease.

✓ C). when distance increases,

C decreases.

∴ U will increase.

✓ D). Yes. The induced polarization charge will partially cancel the charges on the plates. Therefore the capacitor can hold more charges.

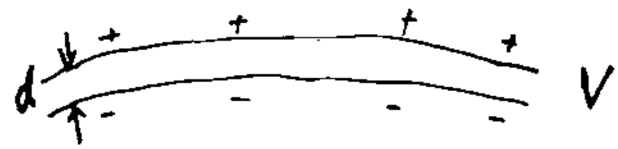
× E). No.

× F). No.

✓ G) Yes. Because the plates are isolated. the charges have no where to go.

15.

$$|E| = \frac{|\Delta V|}{d}$$



$$= \frac{65.5 \text{ mV}}{5.95 \text{ nm}} = \frac{6.55 \times 10^{-2}}{5.95 \times 10^{-9}}$$

$$= 1.10 \times 10^{7} \text{ V/m}.$$

16. $$C = \frac{\varepsilon_0 K A}{d} = \frac{8.85 \times 10^{-12} \times 3.04 \times 1}{5.95 \times 10^{-9}} = 4.52 \times 10^{-3}$$

17. $$E = \frac{\sigma}{K\varepsilon_0} \Longrightarrow. \quad \sigma = K\varepsilon_0 E = 8.85 \times 10^{-12} \times 1.1 \times 10^{7} \times 3.04$$

$$= 2.96 \times 10^{-4} \text{ C/m}^2$$

18. $$\#\text{ of molecules in area } A = \frac{\text{Total charge in area } A}{\text{charge of each molecule}}.$$

$$= \frac{\sigma A}{q}. \quad = \frac{2.96 \times 10^{-4} \times 1.0 \times 10^{-12}}{1.6 \times 10^{-19}}.$$

$$= 1850.$$