University of Bahrain
Physics Department

Electricity and Magnetism – PHYCS 102
Fall 2002-03

Test 1

Name:	**I.D.:**
Instructor:	**Sec.:**

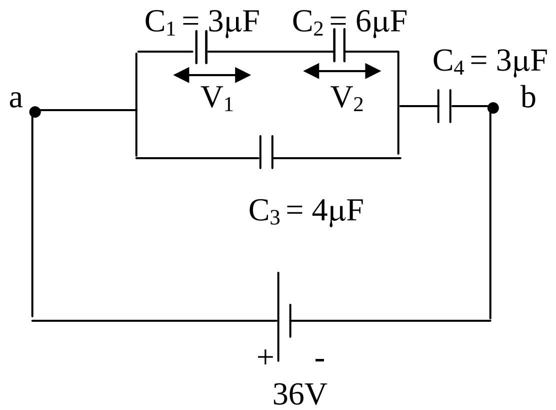
Time Limit : 1 hour

No.	Score	Initial
Total =		**/100**

Useful constants: Permittivity of free space, $\varepsilon_0 = 8.85 \times 10^{-12}\ C^2/N.m^2$
Coulomb's constant, $k_e = 9 \times 10^9\ N.m^2/C^2$

Answer all four problems in the space provided.

1- For the circuit shown in the figure, find:



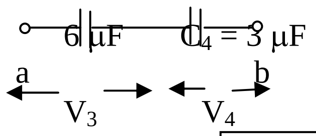
a) The equivalent capacitance between points *a* and *b*. (***12 points***)

$$\frac{1}{C_{eq}} = \frac{1}{3} + \frac{1}{\left[4 + \frac{3\times 6}{3+6}\right]} \quad , \ C_{eq} = 2\mu F$$

$\boxed{C_{eq} = 2\ \mu F}$

b) The charge on capacitor C_4. (***8 points***)

$$36 = \frac{Q_4}{3\mu} + \frac{Q_4}{6\mu}$$



$Q_4 = 72\ \mu C$

$\boxed{Q_4 = 72\ \mu C}$

c) The voltage difference across C_1.(***8 points***)

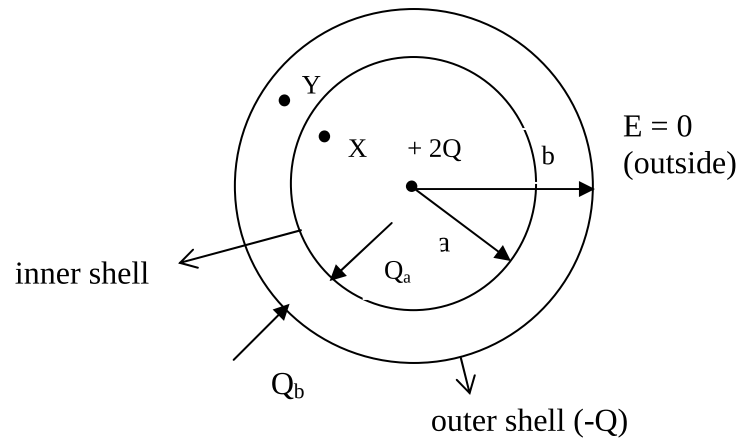
* $6V_3 = 3V_4 = 3(36 - V_3)$, $V_3 = 12V$

* $3V_1 = 6V_2 = 6(12 - V_1)$

$\therefore\ V_1 = 8V$

$\boxed{|\Delta V_1| = 8\ volts}$

2) A point charge (+2Q) is at the center of two spherical concentric thin conducting shells of radii *a* and *b* (with $b > a$). If the charge on the outer shell is (-Q) and if the electric field is zero for ($r > b$), then determine in terms of r and Q:



a) The charge on the inner conductor. ***(12 points)***

$E = 0$, for $r > b$

$\therefore Q_a + Q_b + 2Q = 0$, $Q_b = -Q$

$Q_a = -Q$

Charge on inner conductor = - Q

b) The magnitude of the electric field at X and Y. ***(12 points)***

$$E_X = k\frac{2Q}{r^2}, \quad r < a$$

$$E_y = k\frac{(2Q - Q)}{r^2}, \quad a < r < b$$

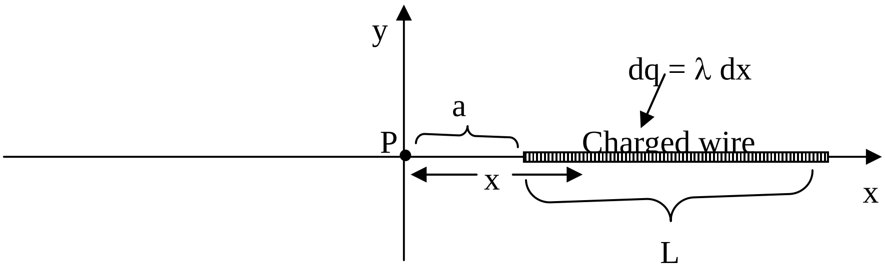
E (at point X) = K $2Q/r^2$

E (at point Y) = KQ/r^2

3). A wire of length L that has a uniform positive linear charge density λ is placed on the x-axis as shown in the figure. Assume the electric potential is zero at infinity.

d) Derive an expression for the potential due to this wire at a point P located at the origin . ***(12 points)***

b) A point charge with positive charge Q is now released at point P with zero initial velocity. Determine its kinetic energy when it reaches infinity. ***(12 points)***



a) $$V_p = k \int_a^{a+L} \frac{\lambda dx}{x} = k\lambda Ln\left(\frac{a+L}{a}\right)$$

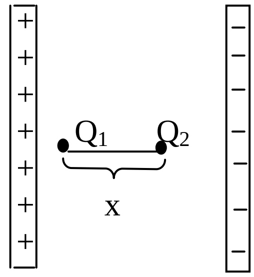
b) $$E_k\left(at\,"\infty"\right) = U_p\left(at\ "\ p"\right) = QV_p$$

$$= KQ\lambda Ln\left(\frac{a+L}{a}\right)$$

V (at point P) =

K (at infinity) =

4) Two point charges $Q_1 = -3\ \mu C$ and $Q_2 = +3\ \mu C$ are located between two oppositely charged parallel plates. The two point charges are connected by an insulating massless string of length $x = 0.2$ m. Assume the electric field produced by the plates is uniform. The plates have surface charge densities, σ, of $+20\ \mu C/m^2$ and $-20\ \mu C/m^2$.

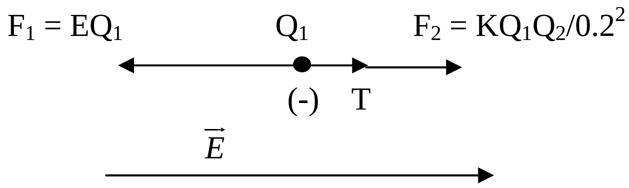


a) Determine the electric field between the plates, ignoring the effects of Q_1 and Q_2. ***(8 points)***

$$E = \frac{\sigma}{\varepsilon_o} = \frac{20\times10^{-6}}{8.85\times10^{-12}} = 2.26\times10^{6}\, N/C$$

E =	N/C

b) Draw a free body diagram for the point charge Q_1 showing all the forces on it. ***(8 points)***



c) If the two charges stay in equilibrium, find the tension in the string ***.(8 points)***

$$T = EQ_1 - K\frac{Q_1Q_2}{(0.2)^2} = 4.755N$$

T =	Newtons