DEPARTMENT OF PHYSICS

PHYCS 102

TEST # 1

Tuesday, 4/04/2006 **12:00 – 12:50 pm**

Question	Marks
MCQ	(/50)
Problem 1	(/25)
Problem 2	(/25)
Total	(/100)
Total	(/15)

Use BLOCK LETTERS:

*Full Name:*_____________________________

*Student ID #.:*____________________________

*Section :*_____________________________

Student Signature:________________________

***Date*: April 4th 2006**

*** Use:**

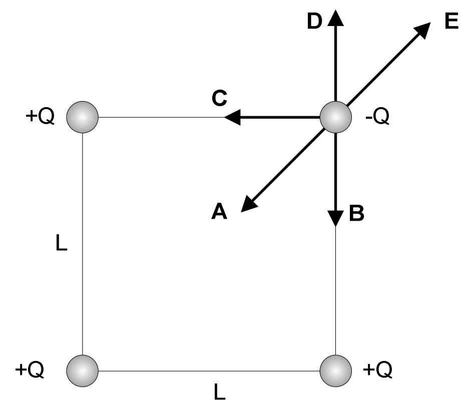
$e = 1.6\times10^{-19}$C, $m_e = 9.11\times10^{-31}$ kg, $m_p = 1.67\times10^{-27}$ kg

$k = 9\times10^9$ Nm^2/C^2, $\varepsilon_0 = 8.84\times10^{-12}$ C^2/Nm^2

PART A: MCQs

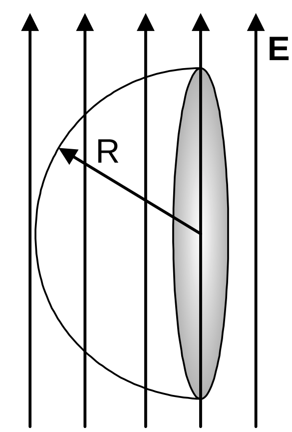
*** Choose the correct answer.**
*** Each one of the 10 questions carries the same weight (5 Marks).**

1) Four charges are placed at the corners of a square of side L as shown in the figure. The direction of the net electric force on the – Q is:



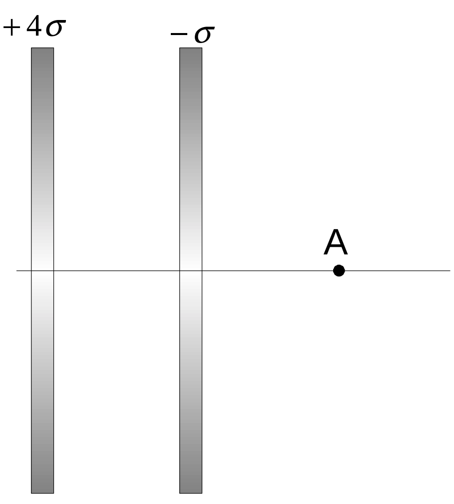
a) A
b) B
c) C
d) D
e) E

2) A hemisphere of radius R is placed in a uniform electric field E directed upward as shown in the figure. The electric flux through the base of the hemisphere is:



a) R^2E
b) πR^2E
c) zero
d) $4\pi R^2E$
e) $2\pi R^2E$

3) Two infinite sheets carry charge densities as shown in the figure. The net electric field at point A is:



a) zero
b) $\frac{\sigma}{2\varepsilon_0}$
c) $\frac{\sigma}{\varepsilon_0}$
d) $\frac{3\sigma}{2\varepsilon_0}$
e) $\frac{2\sigma}{\varepsilon_0}$

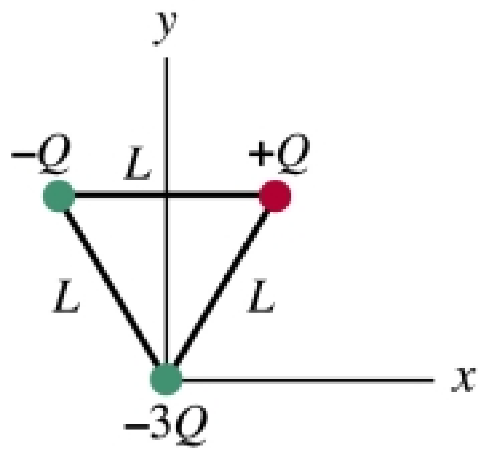
4) A conducting sphere has radius R = *10 cm*. If the electric potential on its surface with respect to infinity is 8 V, then the electric potential (in V) at a radial distance r = 5 cm from its centre is:

a) zero
b) 4
c) 8
d) 12
e) 16

---

5) The electrostatic potential energy involved in assembling the shown three-charge system is:

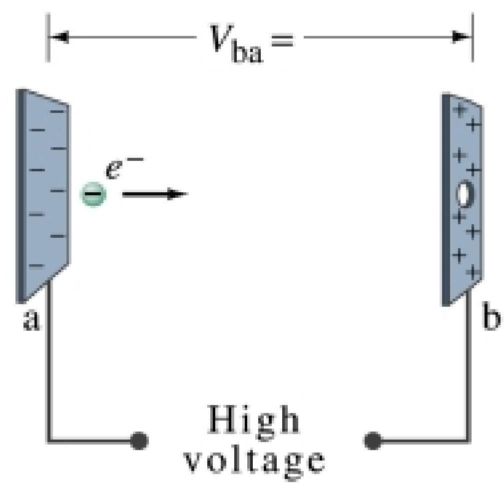
a) $\frac{-kQ^2}{L}$
b) $\frac{3kQ^2}{L}$
c) zero
d) $\frac{-3kQ^2}{L}$
e) $\frac{7kQ^2}{L}$



---

6) An electron is released from rest near the negative plate. If the voltage difference between the plates V_{ba} = 10 kV, what would its velocity be when it reaches the positive plate?

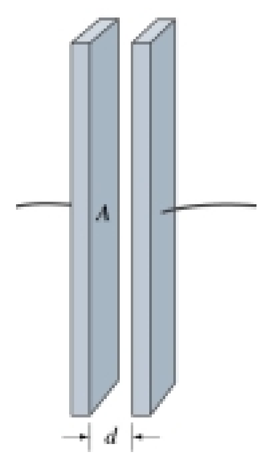
a) 8.4×10^7 m/s
b) 5.9×10^7 m/s
c) 4.2×10^7 m/s
d) 7.3×10^7 m/s
e) 9.5×10^7 m/s



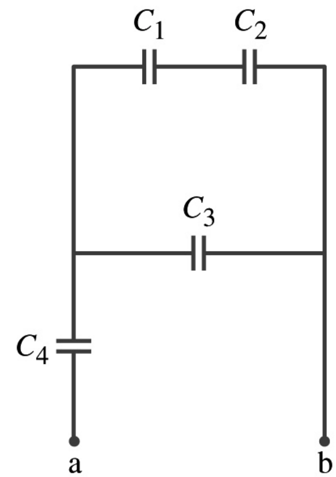
---

7) For an air filled parallel plate capacitor of plate area A = 10 d^2, where d is the plate separation, the capacitance is:

a) $\frac{10\varepsilon_0}{d}$
b) $\frac{\varepsilon_0 d}{100}$
c) $100\ \varepsilon_0$
d) $\frac{\varepsilon_0 d}{10}$
e) $10\varepsilon_0 d$



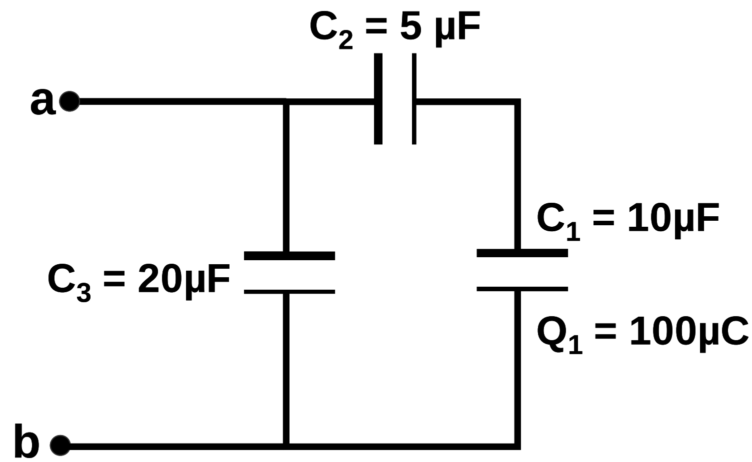
8) Consider the circuit shown in the figure. If C_1 = 5μF, C_2 = 5μF, C_3 = 7.5μF, and C_4 = 10μF, then the equivalent capacitance (in μF) between point a and b is:



a) 20
b) 15
c) 10
d) 5
e) 1

---

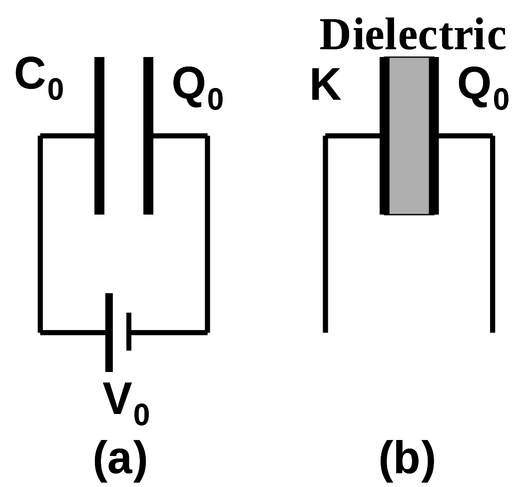
9) Consider the circuit shown in the figure, the charge Q_3 on the capacitor C_3 is:



a) 100 μC
b) 200 μC
c) 300 μ C
d) 400 μC
e) 600 μC

---

10) A capacitor with capacitance 5 μF is connected to a battery with V_0 = 9 V, as shown in figure (a). The capacitor is disconnected from the battery and is completely filled with a dielectric material with K = 3, as shown in figure (b), the potential difference (in V) between the plates will be:



a) 27
b) 3
c) 9
d) 18
e) 6

Answers for multiple choices (MCQ) of test one

MCQ #	1	2	3
Ans	A	C	D

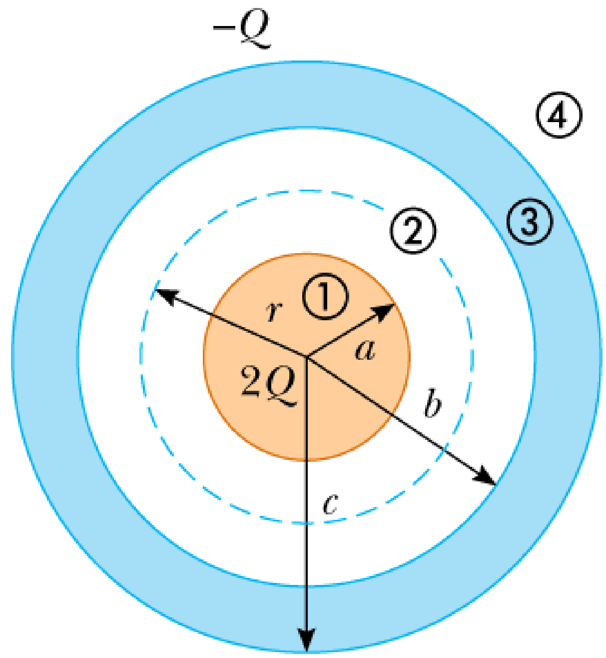
MCQ #	4	5	6	7
Ans	C	A	B	E

MCQ #	8	9	10
Ans	D	E	B

PART B: Problems : Each problem carries 25 marks.

Problem # 1:

A conducting spherical shell of inner radius b and outer radius c has a net charge –Q. A solid conducting sphere of radius *a* and a net positive charge 2Q is placed inside, at the centre of, the spherical shell as shown in the figure.



a) What is the net charge on the inner surface of the spherical shell? [2.5 Marks]

Ans: -2Q

b) What is the net charge on the outer surface of the spherical shell? [2.5 Marks]

Ans: +Q

c) Find the electric field in the region labelled ① (*r* < *a*) [4 Marks]

Ans: since ΣQ = 0, ∴ From Gausses' Law: E= 0

d) Find the electric field in the region labelled ② (*a*<*r* <*b*) [4 Marks]

Ans: since ΣQ= 2Q, ∴ From Gausses' Law: $E = 2kQ/r^2$

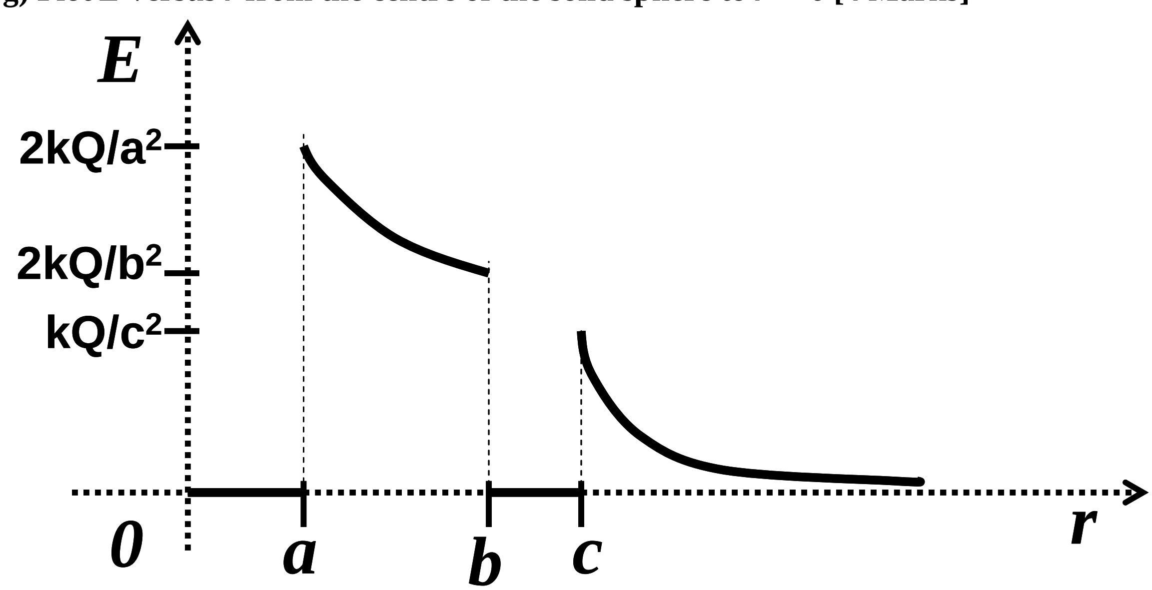
e) Find the electric field in the region labelled ③ (*b*<*r* <*c*) [4 Marks]

Ans: since ΣQ = 0, ∴ From Gausses' Law: E= 0

f) Find the electric field in the region labelled ④ (*r* > *c*) [4 Marks]

Ans: since ΣQ = Q, ∴ From Gausses' Law: $E = kQ/r^2$

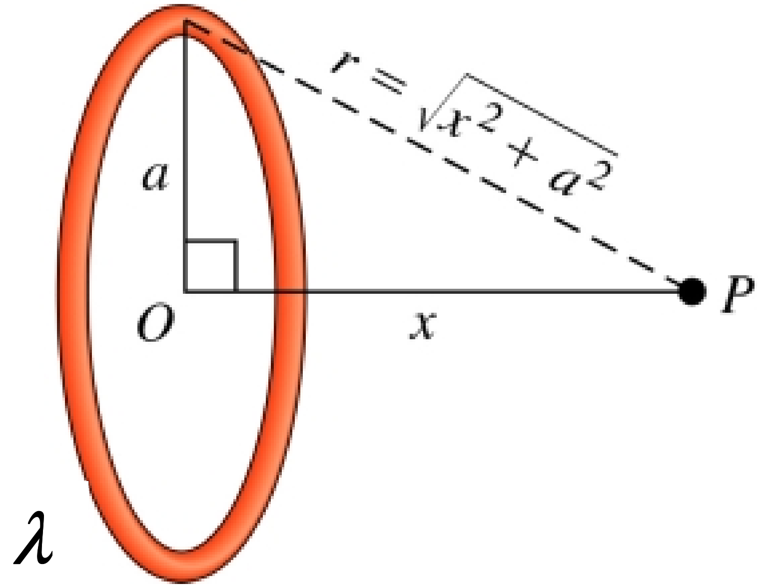
g) Plot *E* versus *r* from the centre of the solid sphere to *r*>> *c* [4 Marks]



Problem # 2:

[10 marks] I) Show that the electric potential at a point P located on the axis of a uniformly charged ring of radius *a* and a linear charge density λ is given as:

$$V = k\frac{(2\pi a\lambda)}{\sqrt{x^2 + a^2}}$$



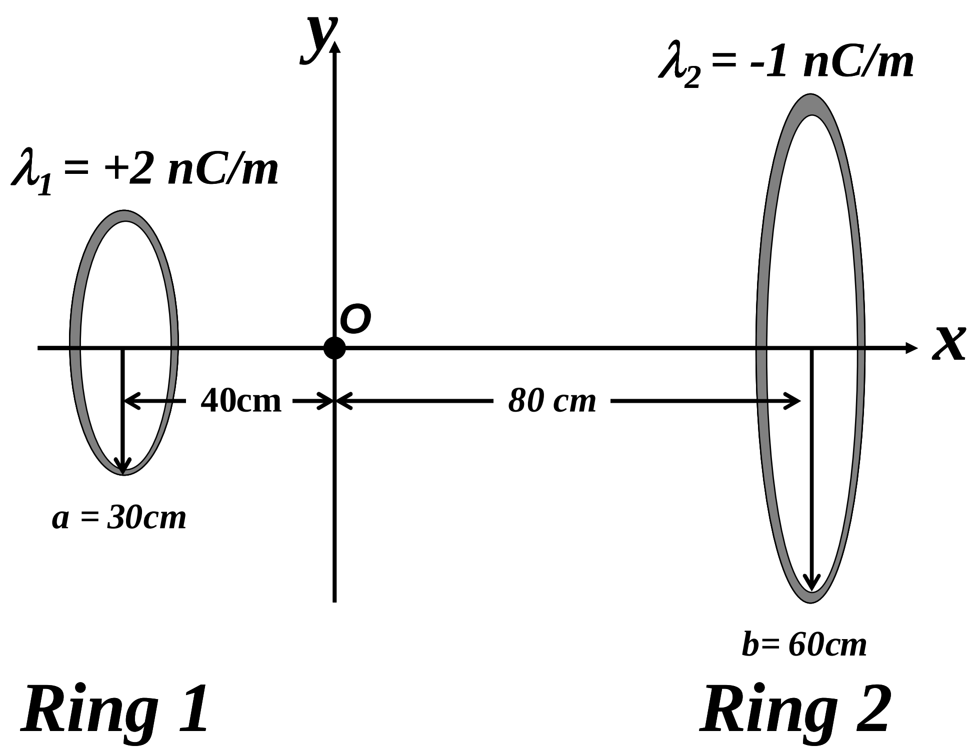
In general :

$$V = k\int \frac{dq}{r}$$

$$V = k\int \frac{dq}{\sqrt{x^2 + a^2}} = \frac{k}{\sqrt{x^2 + a^2}}\int dq$$

$$\therefore V = \frac{kQ}{\sqrt{x^2 + a^2}} = k\frac{(2\pi a\lambda)}{\sqrt{x^2 + a^2}}$$

II) Two uniformly charged thin rings are placed such that the x-axis passes normally through their centres, as shown in the figure. Ring 1 has a radius *a* = 30 cm, a uniform linear charge density λ_1 = +2nC/m, and is placed at x = -40 cm. Ring 2 has radius b = 60 cm, a uniform linear charge density λ_2 = -1nC/m, and is placed at x = + 80 cm.



a) What is the electric potential V, at the origin O (with respect to infinity)? [10 marks]

Voltage at the origin is :

$$V_o = V_1 + V_2$$

Using the derived expression of V in section I :

$$V_o = k\left\{\left(\frac{2\pi a\lambda_1}{\sqrt{(0.3)^2 + (0.4)^2}}\right) + \left(\frac{2\pi b\lambda_2}{\sqrt{(0.6)^2 + (0.8)^2}}\right)\right\}$$

$$V_o = +67.9 \quad V + (-33.9V)$$

$$\therefore V_o = 33.9V \cong 34V$$

b) How much external work, W, is needed to move a charge q = + 5 μC from infinity to the origin O? [5 Marks]

$$\because\ W_{ext} = q\left(V_O - V_\infty\right)$$

$$W_{ext} = q\left(V_O - 0\right) = qV_O$$

$$\therefore\ W_{ext} = \left(+5 \times 10^{-6}\,C\right) \times \left(34V\right) = 170\,\mu J$$