University of Alberta
Department of Physics
Physics 230 Midterm Exam

Date:Thursday, October 26, 2006 Place: MEC 2-1
Time: 12:30 – 1:50 pm Instructor: Dr. J. Jung

NAME:_____ I.D.#_____

Formula sheet and calculator allowed. Please complete all questions. Write short and concise answers. You can write on both sides of the exam sheets. Do not spend too much time on one question or part of a question. The weight of this exam is 25%. The total number of points is 75.

Problems:	Mark:
1	
2	
3	
Short answer questions:	
1	
2	
Total:	

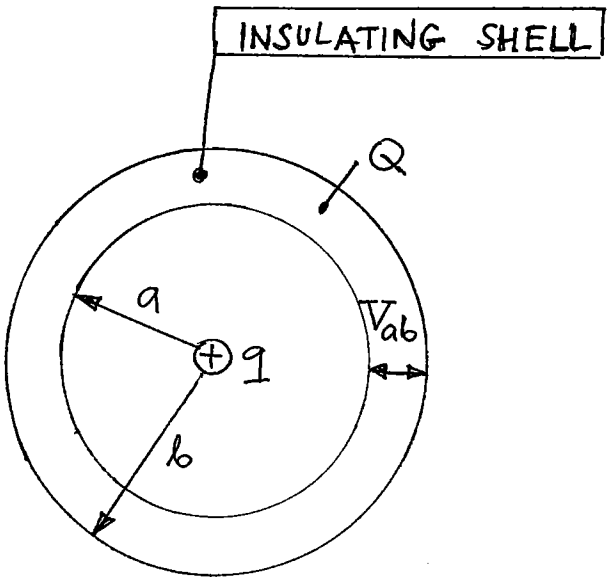
PROBLEM # 1 [25 points]

A point charge q = +6.0 nC is located at the centre of a spherical *non-conducting (insulating)* shell of inner radius a = 5.0 cm and outer radius b = 7.0 cm (see the figure). The spherical shell carries a total unknown charge Q, uniformly distributed throughout its volume.

a) If the magnitude of the electric field at r = 10.0 cm is 2.7×10^3 N/C, find the total charge Q on the spherical shell.

b) Using the Gauss's law find the electric field for:
   (i) $r < a$ and,
   (ii) $a < r < b$

c) Find the potential difference V_{ab} between the two spherical surfaces (inner and outer) of the *non-conducting* shell.



PROBLEM # 2 [20 points]

A *non-conducting* (*insulating*) long cylinder of radius a, which carries a total uniformly distributed charge $-q$, is mounted coaxially (see the figure below) inside a *conducting* cylindrical shell of inner radius b and outer radius c.

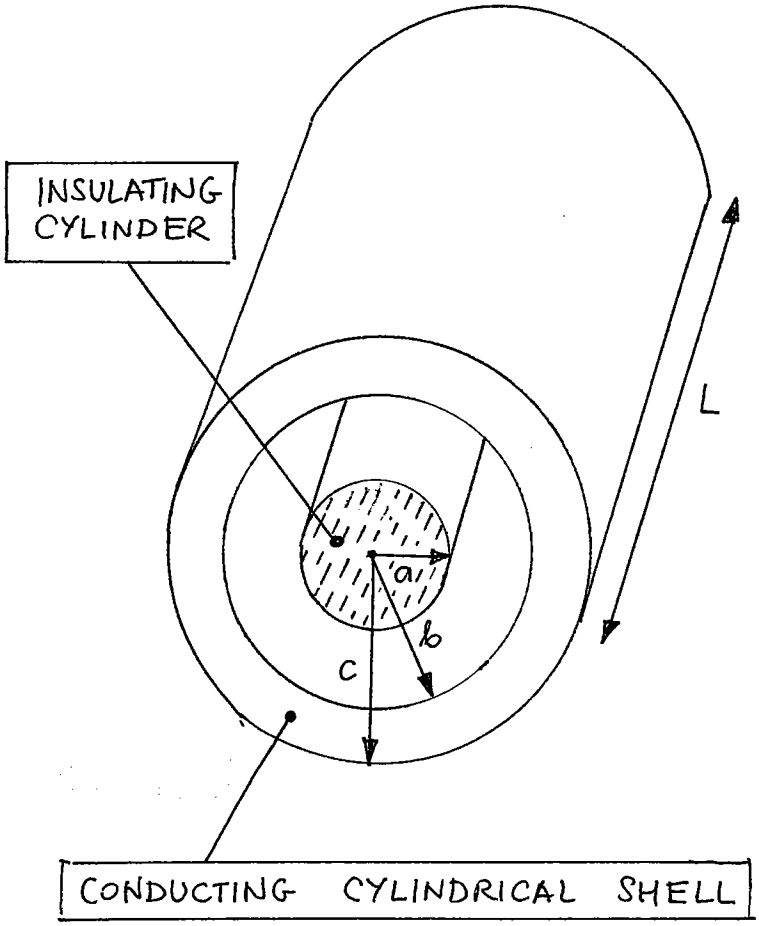
The **net** charge on the *conducting* cylindrical shell is $-q$.

(a) What is the value of the charge on the outer surface of the *conducting* cylindrical shell?

(b) Use the Gauss's law to find the magnitude of the electric field:

(i) at a point inside the *non-conducting* cylinder, a distance r from the axis, and

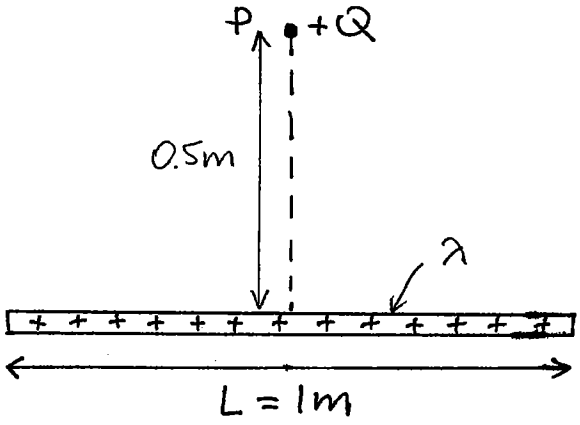
(ii) at a point outside the *conducting* cylindrical shell?



PROBLEM # 3 [20 points]

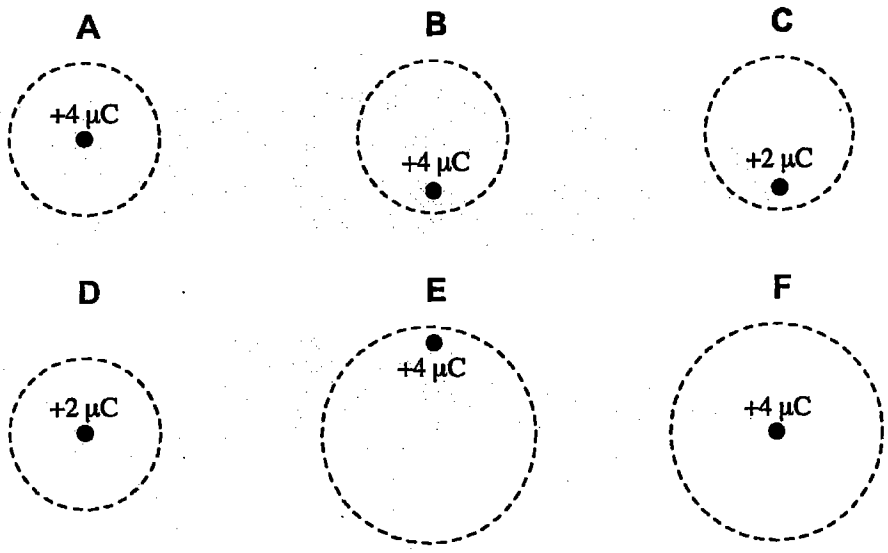
A point charge, +Q =10 nC is sitting at point P on the perpendicular bisector of a line of charge (of length L = 1m) with a uniform charge distribution (see the figure). The distance between Q and the line of charge is 0.5 m. The linear charge density λ on the line is + 10 nC/m.

Find: (a) The electric field direction and magnitude due to the line of charge at point P;
(b) The electrostatic force on the point charge Q.



Short answer questions:

(1) [5 points] Each figure below shows a cross section of a spherical Gaussian surface surrounding a point charge. Rank the total electric flux through the given surfaces, greatest first (indicate any ties).



(2) [5 points] The following equations for the electric potential and the electric field were determined at a point near two charges:

$$V = k\left[\frac{q}{d} - \frac{q}{d}\right] = 0$$

$$|E| = k\left[\frac{q}{d^2} + \frac{q}{d^2}\right] = 2k\frac{q}{d^2}$$

What configuration of two charges and at which point produces this potential and electric field?

Derivatives and Integrals

In what follows, the letters u and v stand for any functions of x, and a and m are constants. To each of the indefinite integrals should be added an arbitrary constant of integration. The *Handbook of Chemistry and Physics* (CRC Press Inc.) gives a more extensive tabulation.

1. $\dfrac{dx}{dx} = 1$
2. $\dfrac{d}{dx}(au) = a\dfrac{du}{dx}$
3. $\dfrac{d}{dx}(u + v) = \dfrac{du}{dx} + \dfrac{dv}{dx}$
4. $\dfrac{d}{dx}x^m = mx^{m-1}$
5. $\dfrac{d}{dx}\ln x = \dfrac{1}{x}$
6. $\dfrac{d}{dx}(uv) = u\dfrac{dv}{dx} + v\dfrac{du}{dx}$
7. $\dfrac{d}{dx}e^x = e^x$
8. $\dfrac{d}{dx}\sin x = \cos x$
9. $\dfrac{d}{dx}\cos x = -\sin x$
10. $\dfrac{d}{dx}\tan x = \sec^2 x$
11. $\dfrac{d}{dx}\cot x = -\csc^2 x$
12. $\dfrac{d}{dx}\sec x = \tan x \sec x$
13. $\dfrac{d}{dx}\csc x = -\cot x \csc x$
14. $\dfrac{d}{dx}e^u = e^u\dfrac{du}{dx}$
15. $\dfrac{d}{dx}\sin u = \cos u\dfrac{du}{dx}$
16. $\dfrac{d}{dx}\cos u = -\sin u\dfrac{du}{dx}$

1. $\displaystyle\int dx = x$
2. $\displaystyle\int au\,dx = a\int u\,dx$
3. $\displaystyle\int (u + v)\,dx = \int u\,dx + \int v\,dx$
4. $\displaystyle\int x^m\,dx = \frac{x^{m+1}}{m+1} \quad (m \neq -1)$
5. $\displaystyle\int \frac{dx}{x} = \ln|x|$
6. $\displaystyle\int u\frac{dv}{dx}\,dx = uv - \int v\frac{du}{dx}\,dx$
7. $\displaystyle\int e^x\,dx = e^x$
8. $\displaystyle\int \sin x\,dx = -\cos x$
9. $\displaystyle\int \cos x\,dx = \sin x$
10. $\displaystyle\int \tan x\,dx = \ln|\sec x|$
11. $\displaystyle\int \sin^2 x\,dx = \tfrac{1}{2}x - \tfrac{1}{4}\sin 2x$
12. $\displaystyle\int e^{-ax}\,dx = -\frac{1}{a}e^{-ax}$
13. $\displaystyle\int xe^{-ax}\,dx = -\frac{1}{a^2}(ax + 1)e^{-ax}$
14. $\displaystyle\int x^2e^{-ax}\,dx = -\frac{1}{a^3}(a^2x^2 + 2ax + 2)e^{-ax}$
15. $\displaystyle\int_0^\infty x^ne^{-ax}\,dx = \frac{n!}{a^{n+1}}$
16. $\displaystyle\int_0^\infty x^{2n}e^{-ax^2}\,dx = \frac{1\cdot 3\cdot 5\cdot\cdots\cdot(2n-1)}{2^{n+1}a^n}\sqrt{\frac{\pi}{a}}$
17. $\displaystyle\int \frac{dx}{\sqrt{x^2 + a^2}} = \ln(x + \sqrt{x^2 + a^2})$
18. $\displaystyle\int \frac{x\,dx}{(x^2 + a^2)^{3/2}} = -\frac{1}{(x^2 + a^2)^{1/2}}$
19. $\displaystyle\int \frac{dx}{(x^2 + a^2)^{3/2}} = \frac{x}{a^2(x^2 + a^2)^{1/2}}$
20. $\displaystyle\int_0^\infty x^{2n+1}\,e^{-ax^2}\,dx = \frac{n!}{2a^{n+1}} \quad (a > 0)$
21. $\displaystyle\int \frac{x\,dx}{x + d} = x - d\ln(x + d)$