# TEST 2

This test is on the final sections of this session's syllabus and

should be attempted by all students.

Anything written here will not be marked.

QUESTION 1   [Marks 12]

(a)   Explain what is meant by the term "a neutral atom"?

(b)   What is meant by the term "negatively charged atom"?

(c)   (i)   Three point charges, q, $3q$ and $-q$
            are distributed as shown in the
            diagram. What is the force on the
            $3q$ charge?

       (ii)   What is the electric potential at the
            origin due to the three charges?
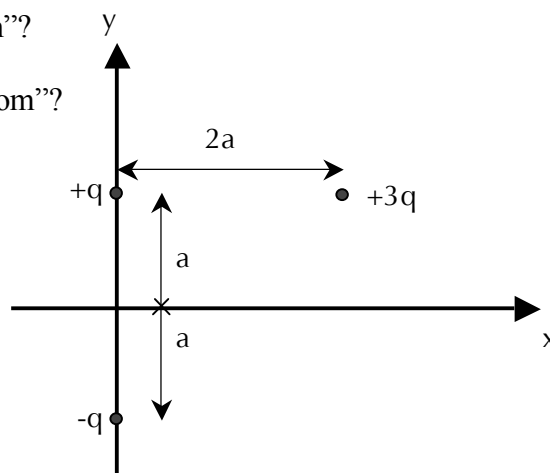
QUESTION 2   [Marks 6]

(a)   If more electric field lines leave a Gaussian surface than enter it, what can you conclude about
       the net charge enclosed by that surface? Explain.

(b)   (i)   A point charge q is located at the
            centre of a uniform ring having
            linear charge density λ and radius a,
            as shown in the diagram. Determine
            the total electric flux through a
            sphere centred on the point charge
            and having radius R, where $R < a$?

       (ii)   Now determine the flux through a sphere with radius $R = 2a$ surrounding the same
            charge distribution.
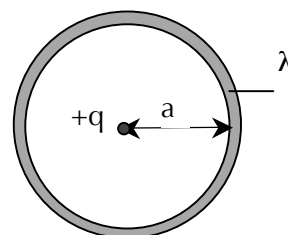
QUESTION 3   [Marks 12]

(a)   A negative charge moves in the direction of a uniform electric field. Does the potential
       energy of the charge-field system increase or decrease? Does the charge move to a position
       of higher or lower potential? Explain both answers you give.

(b)   How would you shield an electronic circuit from stray electric fields which could disrupt its
       operation? Why does this work?

(c)   A rod of length L lies along the x-axis with its left end at the origin. It has a non-uniform
       linear charge density $\lambda = \alpha x$, where α is a positive constant. What are the units of α?
       Calculate the electric potential at a point which is at $x = -D$. You may like to make use of the
   integral $\int \dfrac{xdx}{a+bx} = \dfrac{x}{b} - \dfrac{a}{b^2} \ln(a+bx)$.

QUESTION 4   [Marks 10]

(a)   The plates of a capacitor are connected to a battery. What happens to the charge on the plates if the connecting wires are removed from the battery? What happens to the charge if the wires are then connected to each other? Write one or two clear sentences.

(b)   Two identical parallel plate capacitors, each with charge C, are charged to potential difference ΔV, disconnected from the battery and connected in parallel. While they are still connected, the separation of the plates for one of the capacitors is doubled.

   (i)   Find the total energy of the system of two capacitors *before* the plate separation is doubled.

   (ii)   Find the potential difference across each capacitor *after* the plate separation is doubled.

   (iii)   Find the total energy of the system after the plate separation is doubled.

   (iv)   Reconcile the difference in the answers to parts (i) and (iii) with the conservation of energy.

## QUESTION 5   [Marks 13]

(a)   A proton is moving in a direction which is up this page. It then enters a region where there is a magnetic field directed out of the page. Explain what happens to the proton. What would have happened if the particle had been an electron, travelling at the same speed?

(b)   The cube shown in the figure has sides of length $r = 40.0$ cm. Four straight segments of wire – *ab, bc, cd* and *da* – form a closed loop that caries a current $I = 5.00$ A, in the direction shown. A uniform magnetic field of magnitude $B = 0.020$ T in the y-direction passes through the cube. Determine the magnitude and direction of the magnetic force on
   (i)   segment *ab*,
   (ii)   segment *bc*,
   (iii)   segment *cd* and
   (iv)   segment *da*.

(c)   Justify the statement "it is impossible for a constant, time-independent, magnetic field to alter the speed of a charged particle".
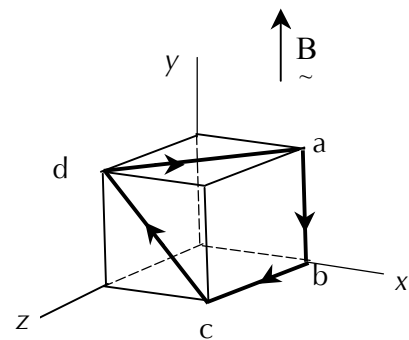
QUESTION 6   [Marks 9]

(a) Describe the similarities between Ampere's law in magnetism and Gauss's law in electrostatics.

(b) The figure shows a cross-sectional view of a co-axial cable. The centre conductor is surrounded by a non-conducting plastic layer. This is surrounded by an outer conductor, and this is surrounded by another non-conducting plastic layer. The current through the inner conductor is 1.00 A out of the page and the current through the outer conductor is 3.00 A into the page.
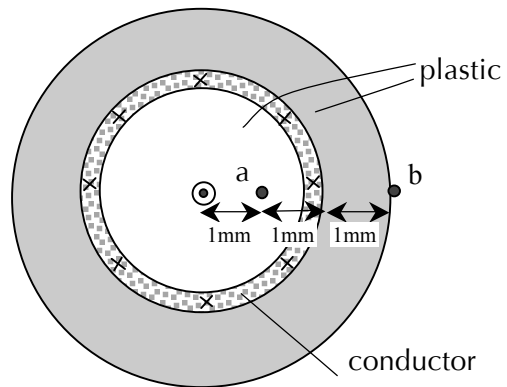
Determine the magnitude and direction of the magnetic field at points a and b, which are 1 mm and 3 mm, respectively from the centre of the cable, along the positive x-axis.

QUESTION 7   [Marks 8]

(a) State, in words, Faraday's Law of Induction.

(b) A wire of mass 0.5 kg in the shape of a rectangle of width $a = 1$ m and length $b = 6$ m has resistance $R = 2\ \Omega$. The wire falls through a magnetic field directed perpendicular to it, as shown. It accelerates until it reaches a constant speed $v = 8$ m/s. Determine the value of the magnetic induction, B.