DEGREE IN COMPUTER ENGINEERING

PHYSICS EXAM **23rd JANUARY 2013**

Surname:

Name:

Group 89

1.- The exam has 4 exercises and 2 questions.
2.- The corresponding marks are attached to each exercise or question.
3.- Each exercise or question must be solved on a separate sheet.
4.- It is compulsory to hand in at least one sheet per exercise, even if it is blank.

CONSTANTS:

Charge of the electron: -1.6×10^{-19} *C*

Permittivity of free space: $\varepsilon_0 = 8.85 \times 10^{-12}\ C^2\ N^{-1}\ m^{-2}$

Permeability of free space: $\mu_0 = 4\pi \times 10^{-7}\ N\ A^{-2}$

Mass of the electron: 9.11×10^{-31} *kg.*

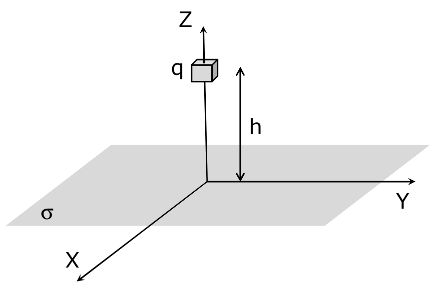
$h = 6.626 \times 10^{-34}\ \text{J s}$

Mass of the proton: 1.67×10^{-27} *kg*

$c = 2.998 \times 10^{8}\ \text{m/s}$

EXERCISES:

E1. ***(2p)*** The XY plane shown in the figure coincides with an infinite charged plane having a uniform surface charge density σ. The plane is located near the Earth's surface. A body of mass M and charge q is located at a height h above the plane, initially at rest.



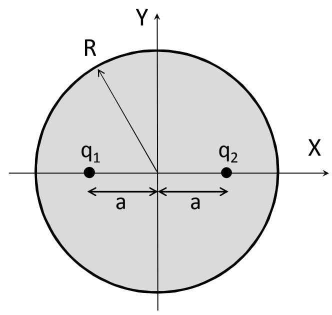
a) Find the electric field vector at the point where the body is located.

b) If the body is released, find its kinetic energy when reaching the plane.

DATA: $\sigma = 2\times10^{-6}$ C/m^2; M = 20 g; q = 0.7 μC; h = 25 m

Consider the body as a point charge.

E2. ***(2p)*** A solid sphere of radius R is uniformly charged with a charge Q = -2q.

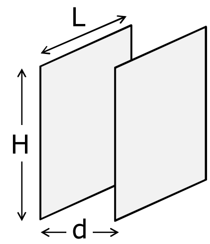


a) <u>Deduce</u> the mathematical expression of the electric field vector due to this charge distribution at point (a, 0, 0), being a<R.

b) A point charge q_1 = q is subsequently placed at (-a, 0, 0). Find the net electric field vector at point (a, 0, 0) in Cartesian coordinates.

c) A second point charge q_2 = q is placed at (a, 0, 0). Find the value of the distance "a" that makes q_2 be in equilibrium.

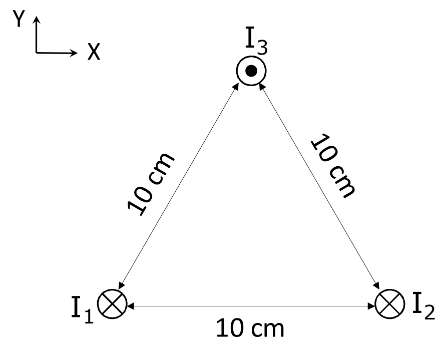
E3. ***(2p)*** A parallel plate capacitor of area $H \times L$ and distance between plates d is connected to a battery which maintains a constant potential difference V_0.



a) Find the charge and charge density on each of the plates of the capacitor.

b) The capacitor is subsequently disconnected from the battery. Without altering its geometry, it is gradually introduced inside a container filled with a liquid of dielectric constant ε_r. Find the expression of the potential difference between the plates of the capacitor as a function of the height Z reached by the liquid inside the capacitor.

E4. ***(2p)*** Three straight, parallel, very long conducting wires pass through the vertices of an equilateral triangle that has sides equal to 10 cm (see figure). The current intensities circulating through the wires are $I_1=I_2=I_3=$ 15 A. Their directions are indicated in the figure.



a) <u>Deduce</u> the mathematical expression of the magnetic field created by an infinite straight wire using Ampère's Law.

b) Find the magnetic field vector at the location of the upper wire due to currents I_1 and I_2 in Cartesian coordinates.

c) Find the force acting on 1m of the upper wire (I_3).

If any student prefers to choose a different Cartesian reference frame, it is mandatory to <u>indicate it clearly</u>.

<u>QUESTIONS:</u>

Q1. ***(1 p)*** Answer the following questions. Explain your reasoning.

a) What can be said about the electric field and electric potential inside a metal in electrostatic equilibrium?

b) How would you connect a system of N capacitors in order to store the maximum amount of charge?

c) A charged particle moving with a velocity $\vec{v}$ enters a region in which there is a constant magnetic field $\vec{B}$. Can the particle slow down while moving within this region?

Q2. ***(1 p)*** Use the band model to describe the differences in the conduction properties of a conductor and an insulator.