DEGREE IN COMPUTER ENGINEERING

PHYSICS EXAM **1st JULY 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: $-1.6 \times 10^{-19}\ C$

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: $9.11 \times 10^{-31}\ kg.$

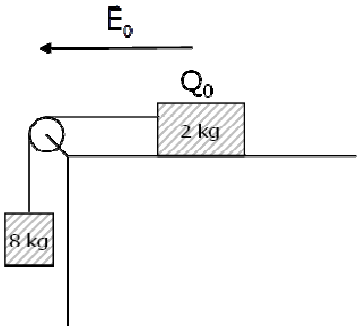
$h = 6.626 \times 10^{-34}$ Js

Mass of the proton/neutron: $1.67 \times 10^{-27}\ kg$

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

EXERCISES:

E1. ***(2p)*** Two masses of 2 kg and 8 kg are connected by a massless string through a frictionless pulley as shown in the figure. The 2 kg mass has a negative charge Q_0, meanwhile the 8 kg mass is discharged. The system is immersed in a region in which there is a uniform electric field of magnitude E_0. The 2 kg mass moves along a rough horizontal surface where the coefficient of kinetic friction is μ.

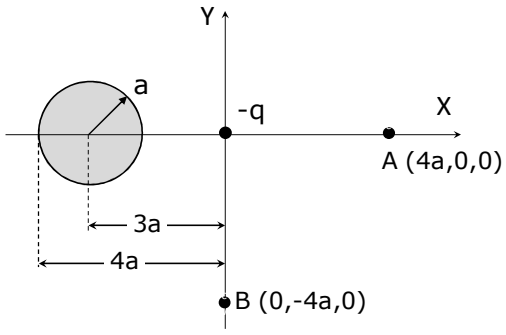


a) Find the acceleration of the system.
b) Find the tension of the string.

Consider the masses as point objects.

DATA: $Q_0 = -\ 2\times10^{-3}$ C; $E_0 = 9000$ N/C; $\mu = 0.2$

E2. ***(2p)*** A solid sphere of radius *a* uniformly charged with *q* and a point charge *–q* are located as shown in the figure. Find:



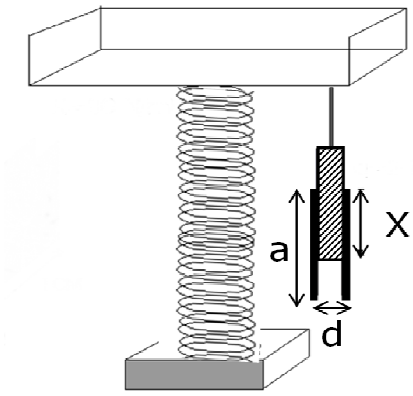
a) The flux of electric field through a spherical surface of radius *5a* centered on the point charge.

b) The electric field at points A (4a,0,0) and B (0,-4a,0) in rectangular coordinates. Use Gauss' Law to find the electric field due to the sphere at these points.

c) The work done by an external agent to take a point charge Q from A to B.

Only for section c): Remember that the potential outside a uniformly charged sphere is equivalent to the one due to a point charge having the total charge of the sphere and located at the center of the sphere. Consider the origin of potential at the infinite.

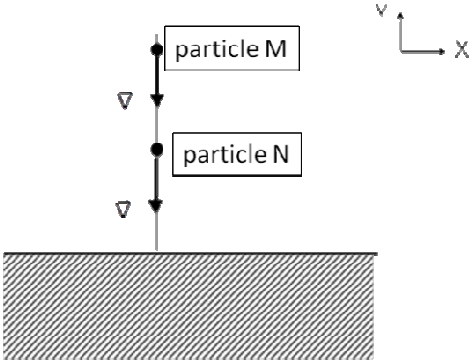
E3. ***(2p)*** A weighing scales is designed using the system shown in the figure. A dielectric of relative permittivity $\varepsilon_r = 2$ is attached to the scales, and can be inserted into a fixed parallel plate capacitor with squared plates of side a = 1 cm and distance between plates d = 0.2 cm as shown. When there is no mass on the scales, the dielectric is completely outside the capacitor. When the scales is turned on, the capacitor is charged through a battery with $q_0 = 2\times10^{-10}$ C. Once charged, the capacitor is disconnected from the battery.



A mass is deposited on the scales, making the scales to descend and the spring to compress until equilibrium is reached so that the weight W equals the elastic force $F_{el} = k \cdot X$, being X the displacement of the spring and k the elastic constant of the spring k = 80 N/m. It can be seen from the figure that X coincides with the penetration distance of the dielectric into the capacitor.

a) A mass M is placed on the scales. The capacitance measured after equilibrium is reached is $C = 6.4\times10^{-13}$ F. Find M.
b) Find V/V_0 at equilibrium, being V the potential difference between the plates when the mass is on the scales and V_0 the potential difference when there is no mass on the scales.

E4. ***(2p)*** Two particles enter a region in which there is a uniform magnetic field (shadowed region in the figure). Before entering the region, the particles follow the same trajectory and have the same velocity . Particle N is a nucleus composed of two protons, while particle M is a nucleus composed of two protons and two neutrons.
Find:



a) The distance between the trajectories of the two particles after leaving the shadowed region.

b) The time spent by each particle in the shadowed region.

c) The kinetic energy of each particle 25 s after leaving the shadowed region.

DATA: $v = 4\times10^6$ m/s; B = 2.5 T

QUESTIONS:

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

a) Two isolated conductors are charged with Q_1 and Q_2. What happens when they are put in electric contact?

b) Describe the process of dielectric breakdown of a dielectric material. What is the dielectric strength?

Q2. ***(1 p)*** Explain from a physical point of view why there is nearly no current flowing in a reverse biased PN junction. Include a drawing of the reverse biased PN junction as an aid to the explanation.