	1º Parcial FFI/First mid term FFI exam	Departamento de Física Aplicada
	5/11/2021	
	Curso/Year 2021/2022	Applied Physics Dept.

1.- The XZ plane of a reference system (infinite plane) is charged with uniform surface density of charge σ=-1 μC/m^2, and there is a positive point charge q=5 μC at point P(0,2,0).

Given points A(0,3,0) m, B(0,5,0) m, C(1,2,0) m and D(2,2,0) m, find:

a) The electric field vector at point A.
b) The difference of potential between points A and B.
c) The difference of potential between points C and D.
d) The difference of potential between points A and C.
e) The coordinates of a point, placed over the Y axis, where the electric field was null.

El plano XZ de un sistema de referencia (plano infinito) está cargado con una densidad superficial de carga homogénea σ=-1 μC/m^2, y en el punto P(0,2,0) hay una carga puntual positiva q=5 μC.

Dados los puntos A(0,3,0) m, B(0,5,0) m, C(1,2,0) m y D(2,2,0) m, calcular:

a) El vector campo eléctrico en el punto A.
b) La diferencia de potencial entre los puntos A y B.
c) La diferencia de potencial entre los puntos C y D.
d) La diferencia de potencial entre los puntos A y C.
e) Da las coordenadas de un punto, situado sobre el eje Y, donde el campo eléctrico se anule.

Solution:

a) $\vec{E}_A = \frac{\sigma}{2\varepsilon_0}\vec{j} + \frac{kq}{d^2}\vec{j} = (-\frac{10^{-6}}{2\cdot 8{,}85\cdot 10^{-12}} + \frac{9\cdot 10^9\cdot 5\cdot 10^{-6}}{1^2})\vec{j} = (-56{,}5+45)\cdot 10^3\vec{j} = -11{,}5\cdot 10^3\vec{j}\ N/C$

b) $V_A - V_B = \frac{\sigma}{2\varepsilon_0}(5-3) + (\frac{kq}{1} - \frac{kq}{3}) = -\frac{10^{-6}}{2\cdot 8{,}85\cdot 10^{-12}}2 + \frac{9\cdot 10^9\cdot 5\cdot 10^{-6}\cdot 2}{3} = (-113+30)\cdot 10^3 = -83000\,V$

c) $V_C - V_D = \frac{kq}{1} - \frac{kq}{2} = \frac{9\cdot 10^9\cdot 5\cdot 10^{-6}}{2} = 22{,}5\cdot 10^3 = 22500\,V$

d) $V_A - V_C = -\frac{\sigma}{2\varepsilon_0}(3-2) + (\frac{kq}{1} - \frac{kq}{1}) = \frac{10^{-6}}{2\cdot 8{,}85\cdot 10^{-12}} = 56{,}5\cdot 10^3 = 56500\,V$

e) Such point must be placed over the Y axis, because at any other point the electric fields due to the plane and the point charge they have different directions and therefore they can't cancel each other. In order the total electric field was null, the electric field created by the plane must cancel that created by the point charge. It is, if d is the distance from the point we are looking for to P, must be verified that

$$\frac{\sigma}{2\varepsilon_0} = \frac{kq}{d^2} \Rightarrow d = \sqrt{\frac{kq2\varepsilon_0}{\sigma}} = \sqrt{\frac{45}{56{,}5}} = 0{,}89\,m$$

At point Y=2-0,89=1,11 m, between P and the plane, the electric fields created by the surface distribution and the point charge are reinforced, reason why the electric field can't be null. But the electric field is null at point with y coordinate Y=2+0,89=2,89 m because at this point both electric fields have opposite directions, being equal their moduli. Therefore, the point where the electric field is null is the point (0, 2,89, 0) m.

2.- The radius of a drop of water is R, and it is charged with a positive charge Q. By assuming that the water is a conductor material and that the drops are always spherical, compute (as a function of Q, R and ε_0)

a) The surface density of charge of the drop.
b) The electric potential of the drop.
c) The electric field inside the drop.

When it falls, it is divided into two equal drops, being the total charge of the drops and the total volume conserved before and after the division. The drops are always spherical. Compute

d) The electric potential of each drop after the division.
e) The electric field outside the drops, at points very close to their surfaces.

Una gota de agua de lluvia tiene un radio R, y está cargada con una carga positiva Q. Admitiendo que el agua es un material conductor y que las gotas son esféricas en todo momento, calcular, en función de Q, R, y ε_0

a) La densidad superficial de carga de la gota
b) El potencial eléctrico de la gota.
c) El campo eléctrico en su interior.

Al caer, se divide en dos gotas iguales, conservándose la carga total y el volumen total antes y después de dividirse la gota, manteniéndose en todo momento la forma esférica. Calcular

d) El potencial eléctrico de cada una de las gotas después de dividirse.
e) El campo eléctrico fuera de las gotas, en puntos muy próximos a sus superficies.

Solution:

a) $\sigma = \frac{Q}{S} = \frac{Q}{4\pi R^2}$

b) $V = \frac{Q}{4\pi\varepsilon_0 R}$

c) $E = 0$

d) When the first drop is divided, each of the new drop will have a charge Q/2, and the radius r of the new drops will verify that

$$\frac{4}{3}\pi R^3 = 2\frac{4}{3}\pi r^3 \Rightarrow r = \sqrt[3]{\frac{R^3}{2}} = \frac{R}{1,26}$$

Then, the potential of the new drops will be $V' = \frac{Q/2}{4\pi\varepsilon_0 \frac{R}{1,26}} = \frac{Q}{6,35\pi\varepsilon_0 R}$

e) At points very close to the surface of a conductor the electric field is, according Coulomb's theorem

$$E=\frac{\sigma}{\varepsilon_0}=\frac{Q/2}{4\pi(\frac{R}{1,26})^2\varepsilon_0}=\frac{Q}{5,04\pi R^2\varepsilon_0}$$

3.- An electric motor (a receptor) shows an efficiency of 90 %. The motor is connected to an ideal generator with electromotive force 12 V, being the intensity flowing along the motor 1,25 A. With these data, find:

a) The power consumed by the motor.
b) The power turned by the motor into mechanical energy.
c) The contraelectromotve force of the motor.
d) The internal resistance of motor.
e) By assuming that the contraelectromotive force and the internal resistance you have just computed don't change, find the intensity would flow along the motor if the electromotive force of the generator was 15 V instead 12 V.

De un motor eléctrico (un receptor) se sabe que tiene un rendimiento del 90 %. Se conecta a un generador ideal de f.e.m. 12 V, siendo 1,25 A la intensidad que circula por el motor. Con estos datos, determina:

a) La potencia consumida por el motor.
b) La potencia transformada por el motor en energía mecánica.
c) La fuerza contraelectromotriz del motor.
d) La resistencia interna del motor.
e) Suponiendo que la f.c.e.m. y la resistencia interna calculadas no cambian, calcular la intensidad que recorrería el motor si el generador ideal fuera de f.e.m. 18 en lugar de 12 V.

Solution:

a) $P_c=VI=12\cdot 1,25=15\,w$
b) $P_t=\eta' P_c=0,9\cdot 15=13,5\,w$
c) $P_t=\varepsilon' I=13,5\Rightarrow \varepsilon'=\frac{13,5}{1,25}=10,8\,V$
d) $P_{r'}=P_c-P_t=15-13,5=1,5=I^2r'\Rightarrow r'=\frac{1,5}{1,25^2}=0,96\,\Omega$
e) $I=\frac{18-10,8}{0,96}=7,5\,A$

4.- State clearly Kirchoff's rules. Tell if any of them are related to the principle of the conservation of the energy, and if yes, explain this relationship.

Enuncia claramente las leyes de Kirchoff. Di si alguna de ellas tiene alguna relación con el principio de conservación de la energía, y en caso afirmativo, explica esta relación.

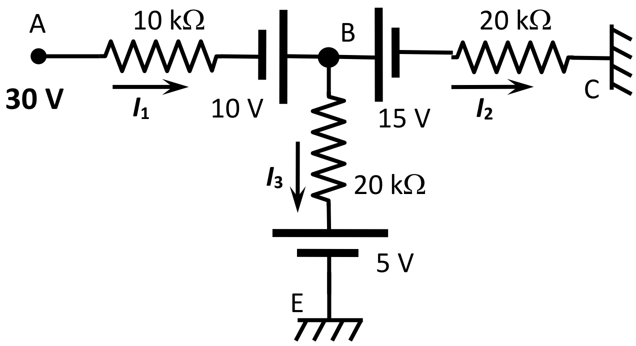
Solution:

First Kirchoff's rule states that the algebraic summatory of every intensity on a junction of an electric network is zero.

Second Kirchoff's rule states that the algebraic summatory of the differences of potential on every element along a closed circuit is zero.

Second Kirchoff's, rule is related to the principle of conservation of energy. The difference of potential between two points equals the work done over a 1 C charge when it moves from one point to another one. To tell that the summatory of differences of potential along a closed circuit is zero is equivalent to tell that the work done over a charge when it follows a closed circuit is zero, it is, that the energy supplied to the charge equals the energy spent by the charge.

5.- On the network on picture



a) Find the currents I_1, I_2 and I_3, according the directions given.
b) Compute the equivalent Thevenin´s generator between points A and E.
c) Compute the total consumed power on the resistors of circuit.
d) Compute the power supplied to the circuit by the 30 V generator placed on the branch between A and E (not drawn on the picture).
e) Which current would flow along a 5 KΩ resistor added to the circuit between points C and E?

5.- En la red de la figura,

a) Determina las corrientes I_1, I_2 e I_3, de acuerdo con los sentidos indicados.
b) Calcula el generador equivalente de Thevenin entre los puntos A y E
c) Calcula la potencia total consumida en las resistencias del circuito.
d) Calcula la potencia aportada al circuito por el generador de 30 V colocado en la rama entre A y E (no dibujado).
e) ¿Qué corriente circularía por una resistencia de 5 KΩ añadida al circuito entre los puntos C y E?

Solución:

a) $$\begin{array}{l} I_1 = I_2 + I_3 \\ 30 = 10I_1 - 10 + 20I_3 + 5 \\ 0 = -20I_2 - 15 + 20I_3 + 5 \end{array}$$ By solving this system $I_1 = \frac{3}{2} mA$ $\quad I_2 = \frac{1}{2} mA$ $\quad I_3 = 1\, mA$

b) $V_A - V_E = 30\,V$ The equivalent resistor between A and E is: $R_{AE} = 0$

c) $P_R = (\frac{3}{2})^2 10 + (\frac{1}{2})^2 20 + 1^2 20 = 47,5\, mW$

d) Tthe power supplied by the generator on branch AE is: $P_{30} = 30 \cdot I_1 = 30 \cdot \frac{3}{2} = 45\, mW$

e) As points C and E have potential null both, the current flowing along a resistor placed between these points would be null.