First modular FFI exam
November, 25th , 2013
Year 2013/14

Applied Physics Dept.

1. Given the point charges q_1 and q_2 on picture, placed on points (0,0) m and (2,0) m, compute:

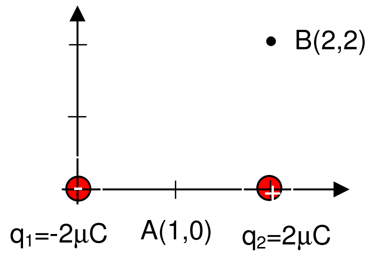
a) (1 point) Electric field due to both charges on point B(2,2,).
b) (1 point) Electric potential due to both charges on points A and B.
c) (0,5 points) Work done by the forces of the electric field to carry a -2 μC negative charge from point A to point B.

2,5 points

1. Dadas las cargas puntuales q_1 y q_2 de la figura, situadas respectivamente en los puntos (0,0) m y (2,0) m calcula:

a) (1 punto) El campo eléctrico debido a ambas cargas en el punto B(2,2).
b) (1 punto) El potencial eléctrico debido a ambas cargas en los puntos A y B.
c) (0,5 puntos) Trabajo realizado por las fuerzas del campo eléctrico para llevar una carga negativa de -2 μC del punto A al punto B.

2,5 puntos



a)

$$\vec{E}_B=\vec{E}_{q_1}+\vec{E}_{q_2}=k\frac{2\cdot 10^{-6}}{8}\frac{(-\vec{i}-\vec{j})}{\sqrt{2}}+k\frac{2\cdot 10^{-6}}{4}\vec{j}=9\cdot 10^{9}\frac{2\cdot 10^{-6}}{4}\left(\frac{-\vec{i}-\vec{j}}{2\sqrt{2}}+\vec{j}\right)=-1591\vec{i}+2909\vec{j}\quad N/C$$

b) $V_A=V_{A q_1}+V_{A q_2}=k\frac{-2\cdot 10^{-6}}{1}+k\frac{2\cdot 10^{-6}}{1}=0\quad V$

$$V_B=V_{B q_1}+V_{B q_2}=k\frac{-2\cdot 10^{-6}}{\sqrt{8}}+k\frac{2\cdot 10^{-6}}{2}=9\cdot 10^{9}\frac{2\cdot 10^{-6}}{2}\left(\frac{-1}{\sqrt{2}}+1\right)=2636\quad V$$

c) $W_{AB}=q(V_A-V_B)=-2\cdot 10^{-6}(0-2636)=5{,}27\cdot 10^{-3}\quad J$

2. State Gauss's law.
Based on Gauss's law, state the magnitude of electric field at any point inside the hollow of a hollow and conductor charged, without any charge inside the hollow.
1 point

2. Enuncia el teorema de Gauss.
Basándote en el teorema de Gauss, razona el valor del campo eléctrico en cualquier punto del hueco de un conductor hueco cargado, sin cargas en dicho hueco.
1 punto

The flux of the electric field through an enclosed surface *S* is equal to the net charge enclosed inside *S* divided into ε_0. $\int_S \vec{E}\cdot d\vec{S}=\frac{\sum Q}{\varepsilon_0}$

If we choose a point inside the hollow and we imagine a closed surface enclosing such point, as none charge exists inside this surface, the electric flux through this surface is zero, and the electric field is also zero.

3. Two parallel plate capacitors (1) and (2) with equal capacitance *C* are connected in parallel to a battery giving a difference of potential V_0.

a) (0,5 points) Find electric charge on each capacitor.

Battery is removed and the distance between plates of capacitor (1) is decreased to a half of the initial distance.

b) (0,5 points) Compute the new capacitance of capacitor (1).
c) (1 point) Compute electric charge on each capacitor and the new difference of potential.

2 points

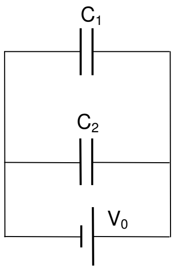
3. Dos condensadores planos (1) y (2) de la misma capacidad *C* están conectados en paralelo a una batería que da una diferencia de potencial V_0

a) (0,5 puntos) Halla la carga en cada condensador.

Retiramos la fuente de tensión y reducimos a la mitad la separación entre las placas del condensador (1).

b) (0,5 puntos) Halla la nueva capacidad del condensador (1).
c) (1 punto) Halla la carga en cada condensador y la nueva diferencia de potencial.

2 puntos



a) If Q_1, and Q_2 are the charges on each capacitor when battery is connected:

$$V_0 = \frac{Q_1}{C} = \frac{Q_2}{C} \Rightarrow Q_1 = Q_2 = CV_0$$

b) If distance between plates of capacitor (1) is decrased up to a half of initial distance, as capacitance of a parallel plate capacitor is $C = \dfrac{\varepsilon_0 S}{d}$ the new capacitance will be C_1'=2C.

c) If battery is removed and capacitance of (1) is changed, the charges on capacitors, Q'_1 and Q'_2 will also change, but the addition of charge on both capacitors will be preserved. As both capacitors are connected in parallel, the difference of potential on both capacitors will be the same, V'. So:

$$\left.\begin{array}{r} Q_1^{'} + Q_2^{'} = Q_1 + Q_2 = 2CV_0 \\ V' = \dfrac{Q_1^{'}}{2C} = \dfrac{Q_2^{'}}{C} \end{array}\right\} \Rightarrow Q_1^{'} = \frac{4}{3}CV_0 \quad Q_2^{'} = \frac{2}{3}CV_0 \quad V' = \frac{2}{3}V_0$$

4. The internal resistance of an electric engine (linear receptor) is 2 Ω, flowing a intensity of current 2 A, as can be seen on picture. If its efficiency is 90 %:

a) (1 point) Compute lost power on internal resistance ($P_{r'}$) and turned power (P_t) into mechanical energy.

b) (1 point) Compute contraelectromotive force of engine, ε', and difference of potential between its terminals, V_A-V_B.

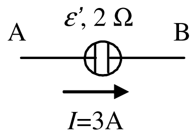
2 points

4. Un motor eléctrico (receptor lineal) tiene una resistencia interna de 2 Ω, y por él circula una corriente de 3 A, tal y como se muestra en la figura. Si su rendimiento es del 90%:

a) (1 punto) Calcula la potencia disipada en la resistencia interna ($P_{r'}$) y la transformada (P_t) en energía mecánica.

b) (1 punto) Calcula la fuerza contraelectromotriz del motor, ε', y la diferencia de potencial entre sus terminales, V_A-V_B.

2 puntos



The intensity of current is diferent on statements in english or spanish, due to a mistake, but the method to solve this problem is not affected by this mistake. Taking 3 A as correct intensity:

a) $P_{r'} = I^2 r' = 3^2 \cdot 2 = 18\ w$ (8 w if 2 A is taken). Turned power can be got from efficiency:

$$\eta_r = \frac{P_t}{P_c} = \frac{P_t}{P_t + P_{r'}} = \frac{P_t}{P_t + 18} = 0{,}9$$ Solving for P_t P_t=162 w (72 w if 2 A is taken).

b) $P_t = 162 = \varepsilon' I = \varepsilon' 3 \Rightarrow \varepsilon' = \dfrac{162}{3} = 54\,V$ (36 V if 2 A is taken).

$V_A - V_B = \varepsilon' + Ir' = 54 + 3 \cdot 2 = 60\,V$ (40 V if 2 A is taken).

5. Given the circuit on picture, compute:

a) (1,5 points) Intensity of current flowing along each branch of circuit with the shown senses, I_1, I_2 and I_3.

b) (1 point) Difference of potential between points B and D, V_B-V_D and Thevenin's equivalent generator between points B and D, clearly showing its polarity.

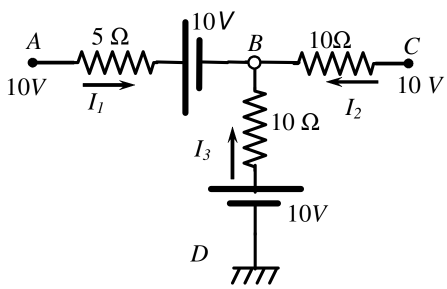
2,5 points

5. Dado el circuito de la figura, calcula:

a) (1,5 puntos) La intensidad de corriente en cada rama con los sentidos mostrados, I_1, I_2 y I_3.

b) (1 punto) La diferencia de potencial entre los puntos B y D, V_B-V_D,y el generador equivalente de Thevenin entre los puntos B y D, indicando claramente su polaridad.

2,5 puntos

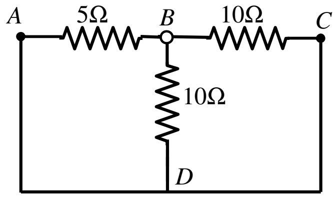


a) This is a network with 2 junctions and two loops, and so we'll need one equation for junctions and two equations for loops:

$$\left.\begin{array}{r} I_1 + I_2 + I_3 = 0 \\ V_{AD} = 10 = I_1 5 - (-10) - I_3 10 - (-10) \\ V_{CD} = 10 = I_2 10 - I_3 10 - (-10) \end{array}\right\} \Rightarrow I_1 = -1\ A \quad I_2 = 0{,}5\ A \quad I_3 = 0{,}5\ A$$

b) $V_B - V_D = -10 I_3 - (-10) = -5 + 10 = 5\ V$

Passive circuit and equivalent resistance between B and D (removing all the generators) will be:



$$\frac{1}{R_{eq}} = \frac{1}{5} + \frac{1}{10} + \frac{1}{10} \Rightarrow R_{eq} = 2{,}5\ \Omega$$

So, Thevenin's equivalent generator between B and D will be: