	First modular FFI exam **November, 19th , 2012** Year 2012/13	Applied Physics Dept.

1. Given the point charges on the picture, placed on point (0,3) and on origin of coordinates, compute:

a) (1 point) Electric field due to both charges on point *A*(4,0) m. Apply superposition principle, drawing on picture electric field due to each charge separately.

b) (1 point) Work done by the forces of the electric field to carry a negative charge sized 1μC from point A (4,0) to point B (4,3).

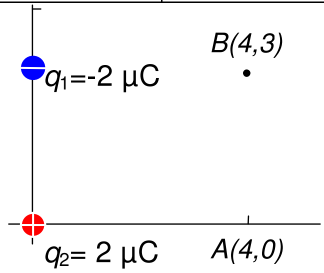
2 points

a) Dadas las cargas puntuales de la figura, situadas respectivamente en el origen de coordenadas y en el punto (0,3) calcula:

a) (1 punto) El campo eléctrico resultante en el punto *A*(4,0) m. Aplica el principio de superposición dibujando en el gráfico los campos que ejerce cada carga por separado.

b) (1 punto) Trabajo realizado por las fuerzas del campo eléctrico para llevar una carga negativa de 1 μC del punto A (4,0) al punto B (4,3).

2 puntos



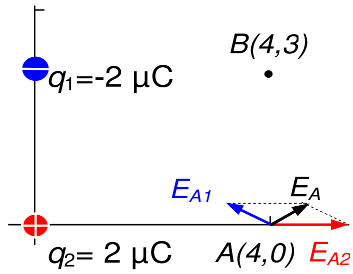
a) Applying definition of electric field from Coulomb's law:

$$\vec{E}_{A1} = k\frac{Q}{r^2}\vec{u}_r = k\frac{2\cdot 10^{-6}}{(\sqrt{4^2+3^2})^2}\frac{-4\vec{i}+3\vec{j}}{\sqrt{4^2+3^2}} = 9\cdot 10^9\frac{2\cdot 10^{-6}}{25}\frac{-4\vec{i}+3\vec{j}}{5} =$$

$$= \frac{18}{125}10^3(-4\vec{i}+3\vec{j}) = -576\vec{i}+432\vec{j}\ N/C$$

$$\vec{E}_{A2} = k\frac{Q}{r^2}\vec{u}_r = k\frac{2\cdot 10^{-6}}{4^2}\vec{i} = 9\cdot 10^9\frac{2\cdot 10^{-6}}{16}\vec{i} = \frac{9}{8}10^3\vec{i} = 1125\vec{i}\ N/C$$

$$\vec{E}_A = \vec{E}_{A1}+\vec{E}_{A2} = -576\vec{i}+432\vec{j}+1125\vec{i} = 549\vec{i}+432\vec{j}\ N/C$$



b) $V_A = V_{A1}+V_{A2} = k\frac{-2\cdot 10^{-6}}{\sqrt{4^2+3^2}} + k\frac{2\cdot 10^{-6}}{4} = k\cdot 2\cdot 10^{-6}(-\frac{1}{5}+\frac{1}{4}) = 900\,V$

$$V_B = V_{B1}+V_{B2} = k\frac{-2\cdot 10^{-6}}{4} + k\frac{2\cdot 10^{-6}}{\sqrt{4^2+3^2}} = k\cdot 2\cdot 10^{-6}(-\frac{1}{4}+\frac{1}{5}) = -900\,V$$

$$W_{AB} = q(V_A - V_B) = -1\cdot 10^{-6}\cdot(900+900) = -1{,}8\cdot 10^{-3}\ J$$

2. Which are the values of electric field and electrostatic potential inside a conductor in electrostatic equilibrium? Explain why. Explain what happens with both magnitudes if conductor is connected to ground.

1,5 points

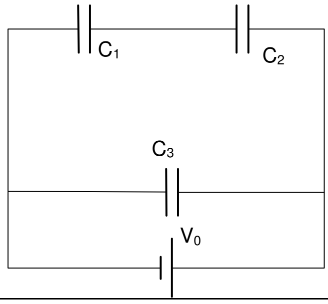
2. ¿Cuánto valen el campo eléctrico y el potencial en el interior de un conductor cargado en equilibrio electrostático? Explica porqué. Explica qué ocurre con ambos valores si el conductor es conectado a tierra.

1,5 puntos

Electric field inside a conductor in electrostatic equilibrium is always zero, because electrostatic equilibrium means that there isn't mouvement of charges, and so the electric field must be zero. As the difference of potential between two points of conductor equals the integral of electric field along a path between such points, electrostatic potential inside a conductor in electrostatic equilibrium is constant.

If conductor is connected to ground, as the electrostatic equilibrium is kept, electric field is also zero. Electrostatic potential is zero, because ground is a conductor always having potential zero.

3. Picture shows three equal capacitors with capacitance C each, connected to a difference of potential V_0 **a)** (1 point) Find electric charge on each capacitor. **b)** (1 point) Battery is removed and a dielectric with dielectric relative permitivity 5 is inserted on capacitor C_3. Compute electric charge on each capacitor after dielectric has been inserted. 2 points	**3.** La figura muestra 3 condensadores iguales de capacidad *C*, conectados a una diferencia de potencial V_0 **a)** (1 punto) Halla la carga en cada condensador. **b)** (1 punto) Retiramos la fuente de tensión e introducimos un dieléctrico de permitividad relativa 5 en el condensador C_3. Halla la carga en cada condensador después de introducir el dieléctrico. 2 puntos



a) If Q_1, Q_2 and Q_3 are the charges on each capacitor after battery is connected:

$$V_0 = \frac{Q_3}{C} \Rightarrow Q_3 = CV_0$$

$$\left.\begin{array}{c} V_0 = \dfrac{Q_1}{C} + \dfrac{Q_2}{C} \\ Q_1 = Q_2 \end{array}\right\} \Rightarrow Q_1 = Q_2 = \frac{1}{2}CV_0$$

b) If battery is removed, the new charge on capacitors 1 and 2 is also the same ($Q'_1 = Q'_2$), and the addition of charges on capacitors 1 and 3 (or on 1 and 2) must be preserved, being equal to that obtained on a) ($Q'_1 + Q'_3 = Q_1 + Q_3 = \frac{1}{2}CV_0 + CV_0 = \frac{3}{2}CV_0$). When a dielectric having ε_r=5 is inserted on capacitor 3, the new capacitance will be C'_3=5C, and the difference of potential on capacitor 3 will be equal to the addition of differences of potential on capacitors 1 and 2. Then:

$$\left.\begin{array}{c} Q'_1 = Q'_2 \\ Q'_1 + Q'_3 = \dfrac{3}{2}CV_0 \\ \dfrac{Q'_3}{5C} = \dfrac{Q'_1}{C} + \dfrac{Q'_2}{C} \end{array}\right\} \Rightarrow Q'_1 = Q'_2 = \frac{3}{22}CV_0 \quad Q'_3 = \frac{15}{11}CV_0$$

4. Given the circuit on picture:

a) (1 point) Compute electromotive force of generator, ε, in order to get an intensity of 2A flowing along the circuit in the shown sense.

b) (1 point) Compute efficiency of generator and receptor.

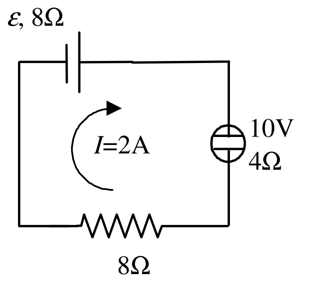
2 points

4. Dado el circuito de la figura:

a) (1 punto) Determina el valor de la fuerza electromotriz ε para que la intensidad que circula por el circuito sea de 2A en el sentido indicado.

b) (1 punto) Calcula el rendimiento del generador y del receptor.

2 puntos



a) According the sense given for intensity of current, the upper terminal of receptor must be the positive terminal, and the lower terminal, the negative terminal. So, the equation for this circuit: $2 = \dfrac{\varepsilon - 10}{8+4+8} \Rightarrow \varepsilon = 50\,V$

b) $\eta_g = \dfrac{P_s}{P_g} = \dfrac{P_g - P_r}{P_g} = \dfrac{\varepsilon I - I^2 r}{\varepsilon I} = \dfrac{50\cdot 2 - 2^2\cdot 8}{50\cdot 2} = \dfrac{68}{100} = 68\%$

$\eta_r = \dfrac{P_t}{P_c} = \dfrac{P_t}{P_t + P_{r'}} = \dfrac{\varepsilon' I}{\varepsilon' I + I^2 r'} = \dfrac{10\cdot 2}{10\cdot 2 + 2^2\cdot 4} = \dfrac{20}{36} = 55{,}5\%$

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_{AB}, I_{BC} and I_{BD}.

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.

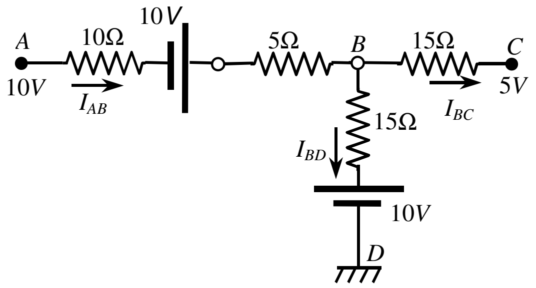
2,5 points

5. Dado el circuito de la figura, calcula:

a) (1,5 puntos) la intensidad en cada rama con los sentidos mostrados, I_{AB}, I_{BC} y I_{BD}.

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

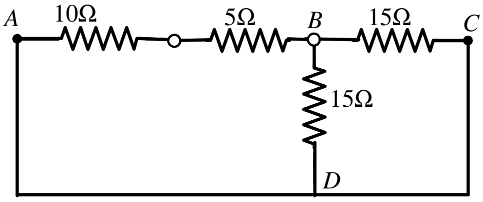


a) This is a network with 2 junctions and two loops, and so we'll need one equation for junctions and two equations for loops:

$$\left.\begin{aligned} I_{AB} &= I_{BC} + I_{BD} \\ V_{AD} = 10 &= I_{AB}10 - (10) + I_{AB}5 + I_{BD}15 - (-10) \\ V_{CD} = 5 &= -I_{BC}15 + I_{BD}15 - (-10) \end{aligned}\right\} \Rightarrow I_{AB} = \frac{5}{9}\,A \quad I_{BC} = \frac{4}{9}\,A \quad I_{BD} = \frac{1}{9}\,A$$

b) $V_B - V_D = 15 I_{BD} - (-10) = 15\cdot\dfrac{1}{9} + 10 = \dfrac{35}{3}\,V$

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



$$\frac{1}{R_{eq}} = \frac{1}{15} + \frac{1}{15} + \frac{1}{15} \Rightarrow R_{eq} = 5\,\Omega$$

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