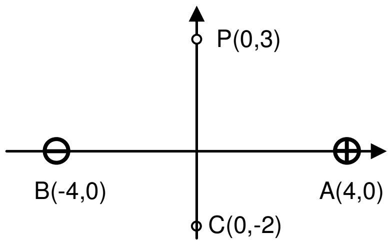
Retaking FFI first modular exam **January 29th 2013** Year 2012/13

Applied Physics Dept.

1. Two point charges with magnitudes **+4µC** and **-4µC** are placed on points **A** and **B,** as can be seen on picture; lengths are given in m. Compute: a) Electric field on point P. b) Electric potential on point P. c) Work done to carry a **3µC** point charge from point **P** to point **(0,-2)**. **2 points**	**1**. Dos cargas puntuales de **+4µC** y **-4µC** se encuentran situadas en los puntos **A** y **B** respectivamente, tal como muestra la figura, con los valores expresados en metros. Calcula: a) El campo eléctrico en el punto P b) El potencial eléctrico en el punto P c) Trabajo realizado para llevar una carga de **3µC** desde el punto **P** hasta el punto **(0,-2)**. **2 puntos**	

a) Electric field on point P will be due to both electric charges:

$$E_P^+ = k\frac{4\cdot 10^{-6}}{25}\frac{-4\vec{i}+3\vec{j}}{5} \qquad E_P^- = k\frac{4\cdot 10^{-6}}{25}\frac{-4\vec{i}-3\vec{j}}{5}$$

And the resulting electric field:

$$\vec{E}_P = -2k\frac{4\cdot 10^{-6}}{25}\frac{4\vec{i}}{5} = -2{,}3\cdot 10^{3}\,\vec{i}\ V/m$$

b) Electric potential on point P is zero, because both charges have the same magnitude (with different sign) and their distances to point P are equal: V_P=0.

c) $W_{PC} = 3\cdot 10^{-6}(V_P - V_C)$

Electric potential on point C is also zero V_C=0 (by the same reason that on point P). Then:

$$W_{PC} = 0 - 0 = 0$$

2. State Gauss's law and apply it to compute the electric field produced by a sphere of radius R charged with surface density of charge σ: a) At a distance *2R* from its center. b) At a distance *R/2* from its center. **2 points**	**2.** Enuncia el teorema de Gauss y aplícalo para calcular el campo eléctrico creado por una esfera de radio *R* cargada con una densidad superficial de carga σ: c) A una distancia *2R* de su centro d) A una distancia *R/2* de su centro **2 puntos**

Gauss's law: The flux of the electric field through a closed surface S equals the total charge enclosed inside such surface divided into the dielectric permittivity of vacuum.

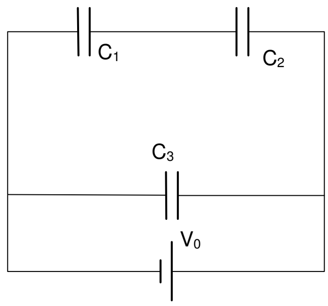
a) As surface S we choose a sphere with radius 2R concentric with the charged sphere. At any point of this surface, surface vector and electric field vector are parallel, and the magnitude of electric will also be constant. Then:

$$\Phi = \oint_S \vec{E}\cdot d\vec{S} = \oint_S E\cdot dS = E\oint_S dS = E\cdot 4\pi(2R)^2 = \frac{\sigma 4\pi R^2}{\varepsilon_0} \Rightarrow E = \frac{\sigma}{4\varepsilon_0}$$

b) In this case, as inside a surface of radius R/2 we won't find any charge, electric flux and then electric field are zero.

3. Picture shows 3 **equal** capacitors with capacitance **C** each, connected to a difference of potential $\boldsymbol{V_0}$
a) Find the charge on each capacitor.
b) The source is removed and a dielectric with relative dielectric permittivity $\varepsilon_r=2$ is inserted between plates of capacitor C_3. Find the charge on each capacitor after inserting the dielectric.
2 points

3. La figura muestra 3 condensadores **iguales** de capacidad ***C***, conectados a una diferencia de potencial $\boldsymbol{V_0}$
a) Halla la carga en cada condensador.
b) Retiramos la fuente de tensión e introducimos un dieléctrico de permitividad relativa 2 en el condensador C_3. Halla la carga en cada condensador después de introducir el dieléctrico.
2 puntos



a) Capacitors 1 and 2 are connected in series, having equal charges: $Q_1=Q_2$.

The total difference of potential on both capacitors (1 and 2) equals the potential of source: $\frac{Q_1}{C}+\frac{Q_2}{C}=V_0$

Difference of potential on capacitor 3 is V_0: $\frac{Q_3}{C}=V_0$

Solving this system of three equations with three unknowns, it becomes:

$$Q_1=Q_2=\frac{CV_0}{2} \qquad \text{and} \qquad Q_3=CV_0$$

b) When source is disconnected and a dielectric is inserted inside capacitor 3, the new capacitance of such capacitor will be: $C_3^{'}=2C$

Charge on capacitors 1 and 2, as they are connected in series, will be equal, but different to that of before point: $Q'_1=Q'_2$.

Total difference of potential on both capacitors (1 and 2) equals the potential on capacitor 3, being different than V_0 : $\frac{Q'_1}{C}+\frac{Q'_2}{C}=\frac{Q'_3}{2C}$

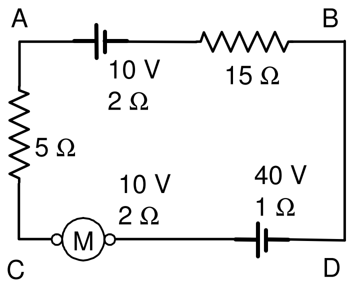
On the other hand, the total charge on capacitors 1 and 3 can't change before and after disconnecting the source, and then: $Q'_1+Q'_3=Q_1+Q_3=\frac{3}{2}CV_0$

Solving this system of three equations with three unknowns, it becomes:

$$Q'_1=Q'_2=\frac{3}{10}CV_0 \qquad \text{and} \qquad Q'_3=\frac{6}{5}CV_0$$

4. Given the circuit on picture, compute:
a) Intensity of current flowing along the circuit (magnitude and sense).
b) Difference of potential between points *A* and *B* ($\boldsymbol{V_{AB}}$)
c) Supplied power by the 40 V generator.
d) Consumed power by the engine.
2 points

4. Dado el circuito de la figura, calcula:
a) Intensidad que circula por el circuito (valor y sentido)
b) Diferencia de potencial entre *A* y *B* ($\boldsymbol{V_{AB}}$)
c) Potencia suministrada por el generador de 40 V.
d) Potencia consumida por el motor.
2 puntos



a) Assuming the intensity flows in clockwise sense:

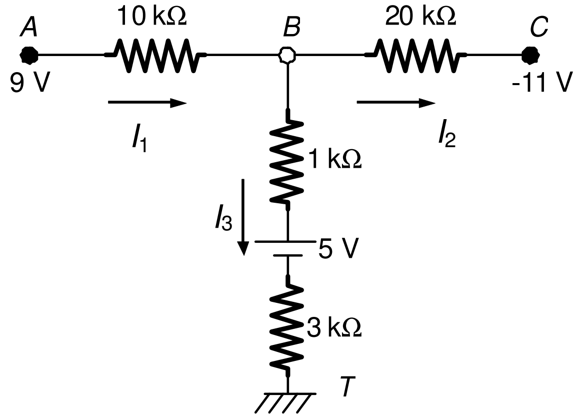
$$I=\frac{40-10-10}{1+2+5+2+15}=\frac{20}{25}=0{,}8 \text{ A}$$

As result is positive, the assumed sense for intensity is correct.

b) $V_{AB}=0{,}8(2+15)-(-10)=23{,}6$ V

c) $P_S=\varepsilon I-I^2r=40\cdot 0{,}8-0{,}8^2\cdot 1=31{,}36$ w

d) $P_C=\varepsilon' I+I^2r'=10\cdot 0{,}8+0{,}8^2\cdot 2=9{,}28$ w

5. Given the circuit on picture, compute: a) The intensity of current flowing along each branch. b) The equivalent resistance of circuit between A and B. c) Thevenin's equivalent generator between A and B and the intensity of current that would flow along a 5 kΩ resistor connected between A and B. **2 points**	**5.** Dado el circuito de la figura, calcula: a) La intensidad que circula por cada una de las ramas. b) La resistencia equivalente entre A y B. c) El generador equivalente de Thevenin entre A y B, y la intensidad de corriente que circularía por una resistencia de 5 kΩ que conectásemos entre A y B. **2 puntos**	

a) Applying Kirchhoff's rules:

Rule of junctions:
$$\Sigma I = 0$$
$$I_1 = I_2 + I_3$$

Rule of loops:
$$V_A - V_T = 9 = 10I_1 + 4I_3 + 5$$
$$V_C - V_T = -11 = -20I_2 + 4I_3 + 5$$

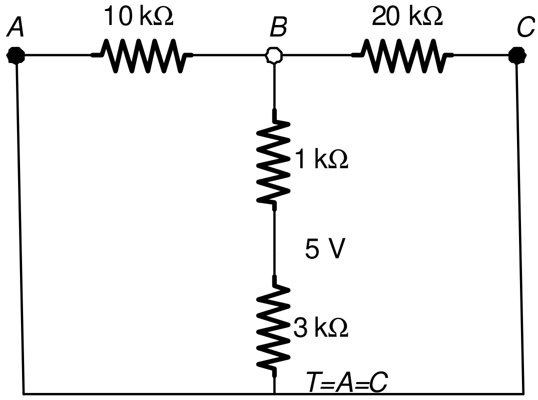
Solving this system:

$$I_1 = 0{,}5\,mA \quad I_2 = 0{,}75\,mA \quad I_3 = -0{,}25\,mA$$

b) Equivalent resistance between A and B:

On circuit can be seen that resistors of 1 and 3 KΩ are connected in series, and their equivalent resistor is connected in parallel with 20 and 10 KΩ resistors. Then:

$$\frac{1}{4} + \frac{1}{20} + \frac{1}{10} = \frac{1}{R_{eq}}; \qquad R_{eq} = 2{,}5K\Omega$$

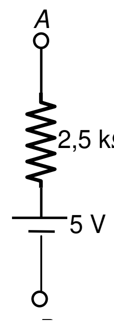


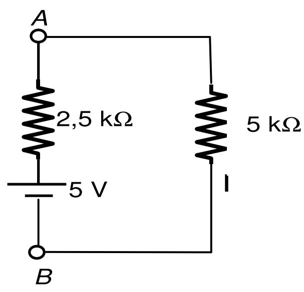
c) Thèvenin's equivalent generator between A and B:

$$\varepsilon_T = V_A - V_B = 10 \cdot 0{,}5 = 5V$$
$$R_{eq} = 2{,}5K\Omega$$

If a 5KΩ resistor is connected between A and B, intensity flowing this resistor is:

$$I = \frac{\Sigma\varepsilon}{\Sigma R} = \frac{5}{2{,}5 + 5} = 0{,}66mA$$





FORM

Electrostatics

$\vec{F} = K\frac{q_1 q_2}{r^2}\vec{u}_r$ $\vec{E} = \frac{\vec{F}}{q}$ $K = \frac{1}{4\pi\varepsilon_0} = 9\cdot 10^9 \text{(S.I.)}$ $V_A - V_B = \int_A^B \vec{E}\cdot\vec{dr}$

$\vec{E} = K\frac{q}{r^2}\vec{u}_r$ $V = K\frac{q}{r}$ $\int_S \vec{E}\cdot\vec{dS} = \frac{\sum Q}{\varepsilon_0}$ $W_{AB} = q(V_A - V_B)$

Conductors and capacitors $E = \frac{\sigma}{\varepsilon_0}$ $C = \frac{Q}{V}$ $C = \frac{\varepsilon_0 S}{d}$

$C_{eq} = \sum C_i$ $\frac{1}{C_{eq}} = \sum \frac{1}{C_i}$ $E_d = \frac{E}{\varepsilon_r}$ $C_d = \varepsilon_r C$ $W = \frac{Q^2}{2C} = \frac{QV}{2} = \frac{V^2 C}{2}$

Direct Current $\vec{J} = n\cdot e\cdot \vec{v}_a$ $\vec{J} = \sigma\cdot\vec{E}$ $R = \frac{V_1 - V_2}{I}$ $R = \rho\frac{L}{S}$

$\rho = \rho_0(1 + \alpha(T - T_0))$ $V_A - V_B = I\sum R - \sum \varepsilon$ $I = \frac{\sum \varepsilon}{\sum R}$ $P = V\cdot I$

$\varepsilon = \frac{dW}{dq}$ $P_R = R\cdot I^2$ $P_g = \varepsilon\cdot I$ $P_t = \varepsilon' \cdot I$ $P_g - P_r = P_s$ $P_t + P_{r'} = P_c$

$\eta_g = \frac{P_s}{P_g}$ $\eta_r = \frac{P_t}{P_c}$