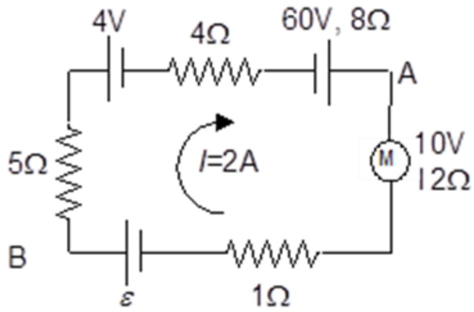
UNIVERSIDAD POLITECNICA DE VALENCIA

Retaking Second exam FFI
January 25th 2016
Year 2015/16

App lied Physics Depto.

1. (2,5 puntos) Dado el circuito de la figura:	**1.** (2,5 points) Given the circuit on picture:
a) Determina el valor de la fuerza electromotriz ε para que la intensidad que circula por el circuito sea de ***2*** **A** en el sentido indicado.	a) Determine the electromotive force ε in order the intensity of current flowing along the circuit was ***2*** **A** in the shown direction.
b) Calcula la D.Ed. entre los puntos **A** y **B** (V_A-V_B).	b) Compute the difference of potential between points **A** and **B** (V_A-V_B).
c) Indica que elementos del circuito aportan energía y cuales consumen. Haz un balance de potencias.	c) State which devices on circuit produce energy and which of them consume energy. Carry out a power balance.
d) Calcula el rendimiento del motor.	d) Calculate the efficiency of motor.



a) According the direction of intensity, the positive terminal of motor is the upper terminal. So, by applying Pouillet's law:

$$I=\frac{\sum\varepsilon}{\sum R}\ \Rightarrow\ 2=\frac{\varepsilon+60\text{-}4\text{-}10}{5+4+8+12+1}=\frac{\varepsilon+46}{30}\Rightarrow\varepsilon=14V$$

b) By taking the path along the motor:

$$V_A-V_B=I\sum R-\left(\sum\varepsilon\right)=2(12+1)-(-10+14)=22V$$

c) Every resistors are consuming energy, (even the internal resistors of generators and receptors) being the power on each one according Joule's law ($P=I^2R$):

$$P_5=5\cdot 4=20W\qquad P_4=4\cdot 4=16W\qquad P_8=8\cdot 4=32W\qquad P_{12}=12\cdot 4=48W\qquad P_1=1\cdot 4=4W$$

The motor turns into mechanical power: $P_t=\varepsilon' I=10\cdot 2=20W$

The battery with 4 V of electromotive force acts as a receptor, so consuming $P_t=\varepsilon I=4\cdot 2=8W$

Only generators having 60 V and ε (14 V) as electromotive force are generating power:

$$P_{g60}=\varepsilon I=60\cdot 2=120W\qquad P_{g14}=\varepsilon I=14\cdot 2=28W$$

Therefore, the total consumed power is: $P_C=20+16+32+48+4+20+8=148W$

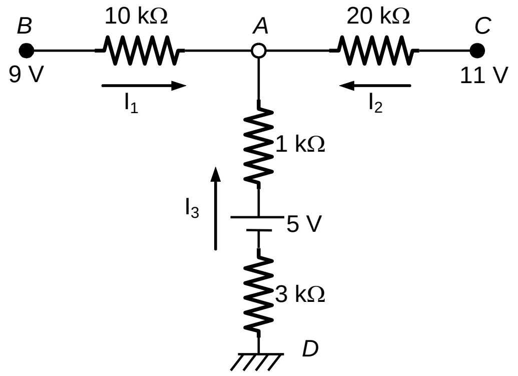
And the total generated power: $P_g=120+28=148W$

So, this power balance shows that the conservation of energy is verified.

d) The efficiency of motor is: Motor: $\eta=\frac{P_t}{P_c}=\frac{20}{20+48}=0{,}294\Rightarrow 29{,}4\%$

2. (2,5 puntos) Dado el circuito de la figura, calcula:
a) La intensidad que circula por cada una de las ramas en el sentido indicado.
b) El generador equivalente de Thevenin entre **A** y **D**, indicando claramente su polaridad.
c) La intensidad de corriente que circularía por una resistencia de **5 kΩ** que conectásemos a los puntos **A** y **D**.

2. (2,5 points) Given the circuit on picture, compute:
a) Intensitiy of current flowing along each branch with the shown direction.
b) Tehevenin's equivalent generator between points **A** and **D**, clearly showing its polarity.
c) The intensity would flow along a **5 kΩ** resistor connected between points **A** and **D**.

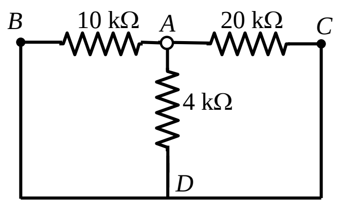


a) This is a network with 2 junctions and two loops, and so we'll need one equation for junctions and two equations for loops:

$$\left.\begin{aligned} I_1+I_2+I_3=0 \\ V_{BD}=9=10I_1-4I_3-(-5) \\ V_{CD}=11=20I_2-4I_3-(-5) \end{aligned}\right\} \Rightarrow I_1=0{,}225\,mA \quad I_2=0{,}212\,mA \quad I_3=-0{,}437\,mA$$

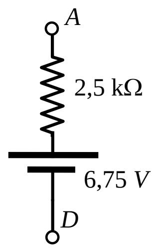
b) Difference of potential between A and D is $V_A-V_D=-4I_3-(-5)=6{,}75\,V$

Passive circuit and equivalent resistance between A and D (removing all the generators) is

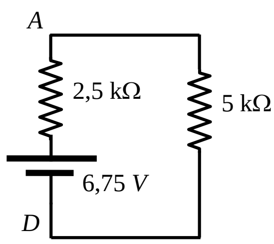


$$\frac{1}{R_{eq}}=\frac{1}{10}+\frac{1}{4}+\frac{1}{20}\Rightarrow R_{eq}=2{,}5\,k\Omega$$

So, Thevenin's equivalent generator between A and D is:



c) If a 5 KΩ resistor is connected between A and D, taking in account the calculated Thevenin's equivalent generator, the resulting circuit is that on picture:

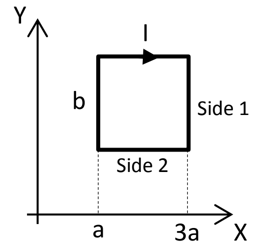


The intensity flowing along the 5 KΩ resistor:

$$I=\frac{\Sigma\varepsilon}{\Sigma R}=\frac{6{,}75}{2{,}5+5}=0{,}9mA$$

3. (2,5 puntos) Sea la espira rectangular de la figura de lados **2*a*** y ***b***, recorrida por una corriente ***I*** en el sentido indicado, situada en el interior de un campo magnético no uniforme $\vec{B} = B_0 \frac{a}{x}\vec{k}$ (**B_0** constante positiva). Calcular:
a) La fuerza sobre el lado 1 de la espira.
b) La fuerza sobre el lado 2 de la espira.
c) El momento magnético de la espira.

3. (2,5 points) The rectangular loop on picture (sides **2*a*** and ***b***) is flowed by a current **I** in the shown direction; the loop is placed inside a non-uniform magnetic field $\vec{B} = B_0 \frac{a}{x}\vec{k}$ (**B_0** positive constant). Compute:
a) The force acting on side 1 of loop.
b) The force acting on side 2 of loop.
c) The magnetic moment of loop.



a) Along side 1, magnetic field is constant, being its modulus $\vec{B}_1 = B_0 \frac{a}{3a}\vec{k} = \frac{B_0}{3}\vec{k}$

Taking in account the direction of intensity, the force acting on side 1 is:

$$\vec{F}_1 = I\vec{L}_1 \times \vec{B}_1 = I(-b\vec{j} \times \frac{B_0}{3}\vec{k}) = -\frac{IbB_0}{3}\vec{i}$$

b) Along side 2, magnetic field isn't constant (it depends on x) and then the force must be integrated:

$$\vec{F}_2 = \int_{Side2} Id\vec{x} \times \vec{B} = I\int_a^{3a} (-dx\vec{i}\,) \times B_0 \frac{a}{x}\vec{k} = IB_0 a \int_a^{3a} \frac{dx}{x}\vec{j} = IB_0 a \ln 3\vec{j}$$

c) As we only have a loop with area 2ab and the intensity is clockwise: $\vec{\mu} = I\vec{S} = I2ab(-\vec{k}\,) = -2Iab\vec{k}$

4. (2,5 puntos) Enuncia el teorema de Ampere y aplícalo para determinar el campo magnético creado por un hilo rectilíneo de longitud infinita, por el que circula una intensidad **I**, a una distancia **x** del hilo. Justifica la respuesta.

4. (2,5 points) State Ampère's law and apply it to compute the magnetic field created by an infinite straight carrying current wire, flowed by an intensity of current **I**, at a point placed at a distance **x** from wire. Justify the answer.

Ampére's law statement appears on point 7.5 of notes:
"The circulation of magnetic field vector along any enclosed curve equals the product of the constant μ0 by the addition of the intensities of current crossing any surface bordered by the curve. The sign of the intensity will be positive when it was in accordance with the screw or the right hand rule with the sense of the circulation, and negative in another case."

$$C = \oint \vec{B} d\vec{l} = \mu_0 \sum I$$

Related to the magnetic field created by a straight carrying current wire, on a point placed at a distance x, appears on next page:

In order to apply Ampère's law, we choose a circumference of radius *x*, perpendicular to conductor and centered on a point of such conductor. This circumference is a field line of magnetic field, being the magnetic field vector tangent to this line at any point. On the other hand, as distance to conductor is the same for all the points of line, modulus of magnetic field will also be the same. So, circulation of magnetic field along this circumference is $C = \oint \vec{B} d\vec{l} = B2\pi x$

Considering the surface of a disk bordered by this circumference, the intensity crossing this disk is *I* (positive because its sense is in accordance with the sense of circulation chosen). Then, applying Ampère's law becomes

$$C = \oint \vec{B} d\vec{l} = B2\pi x = \mu_0 I \Rightarrow B = \frac{\mu_0 I}{2\pi x}$$

FORM

Direct current $V_A - V_B = I\sum R - \sum \varepsilon$ $I = \frac{\sum \varepsilon}{\sum R}$ $P = V \cdot I$ $\varepsilon = \frac{dW}{dq}$ $P_R = R \cdot I^2$

$P_g = \varepsilon \cdot I$ $P_t = \varepsilon' \cdot I$ $P_g - P_r = P_s$ $P_t + P_{r'} = P_c$ $\eta_g = \frac{P_s}{P_g}$ $\eta_r = \frac{P_t}{P_c}$

Magnetic Forces $\vec{F} = q(\vec{v} \times \vec{B})$ $d\vec{F} = I d\vec{l} \times \vec{B}$ $\vec{\mu} = N \cdot I \cdot \vec{S}$ $\vec{\tau} = \vec{\mu} \times \vec{B}$ $V_H = \frac{I \cdot B \cdot d}{n \cdot e \cdot S}$

Sources of magnetic field $d\vec{B} = \frac{\mu_0 I}{4\pi} \frac{d\vec{\ell} \times \vec{r}}{r^3}$ $\mu_0 = 4\pi 10^{-7}$ (I.S.units) $B = \frac{\mu_0 I}{2\pi x}$

$B = \frac{\mu_0 I}{2R}$ $\oint_L \vec{\mathbf{B}} \cdot \vec{\mathbf{dl}} = \mu_0 \sum I$ $B = \frac{\mu_0 N I}{l}$

1. Si te examinas de un único parcial: Debes resolver los cuatro ejercicios de ese parcial.
2. Si te examinas de dos parciales: Debes resolver los ejercicios 1, 2 y 3 de cada uno de los dos parciales (en total 6 ejercicios). Los 6 ejercicios puntúan igual.
3. Si te examinas de los tres parciales: Debes resolver los ejercicios 1 y 2 de cada uno de los tres parciales (en total 6 ejercicios). Los 6 ejercicios puntúan igual.

1. If you are sitting only one midterm exam: You must solve the four exercises of this midterm exam.
2. If you are sitting two midterm exams: You must solve exercises 1, 2 and 3 of both midterm exams. (6 exercises as a whole). Every exercises weight equal.
3. If you are sitting three midterm exams: You must solve exercises 1 and 2 of three midterm exams, (6 exercises as a whole). Every exercises weight equal.