UNIVERSIDAD POLITECNICA DE VALENCIA

Second mid term exam FFI
November 28th 2016
Year 2016/17

Applied Physics Dept.

1. (**3 points**) On circuit on picture, the motor is fed by an **ideal generator** with electromotive force **ε=20 V**. The consumed power by the motor is **Pc=40 w** and its efficiency **80 %**. Calculate:

a) (0,6) The power supplied by the generator to the circuit, $\mathbf{P_s}$.

b) (0,6) The intensity of current of circuit, **I**, giving the **polarity of motor** (terminals positive and negative).

c) (0,6) The turned power by the motor into mechanical energy, $\mathbf{P_t}$ and that consumed on its internal resistance $\mathbf{P_{r'}}$.

d) (0,6) The contraelectromotive force **ε'** of motor and its internal resistance **r'**.

e) (0,6) If the **internal resistance of motor** was null, ¿which would be its **efficiency?**

1. (**3 puntos**) En el circuito de la figura, el motor está alimentado por un **generador ideal** de f.e.m. **ε=20 V**. La potencia consumida por el motor es **Pc=40 w** y su rendimiento del **80 %**. Calcular:

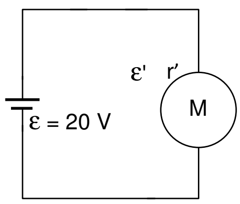
a) (0,6) La potencia suministrada por el generador al circuito, $\mathbf{P_s}$.

b) (0,6) La intensidad de corriente del circuito, **I**, indicando la **polaridad del motor** (terminales positivo y negativo).

c) (0,6) La potencia transformada por el motor en energía mecánica, $\mathbf{P_t}$ y la consumida en su resistencia interna $\mathbf{P_{r'}}$.

d) (0,6) La f.c.e.m. **ε'** y la resistencia interna **r'** del motor.

e) (0,6) Si la **resistencia interna del motor** fuera nula, ¿cuál sería su **rendimiento?**



a) As there only are on circuit generator and motor, all the consumed power on motor must be supplied by the generator. Therefore: $P_s = P_c = 40\,w$

b) As generator is ideal, generated power equals supplied power. Therefore $P_g = \varepsilon I = 40 \Rightarrow I = \frac{40}{\varepsilon} = \frac{40}{20} = 2\,A$

Clockwise direction. Upper terminal of motor is the positive terminal, and lower terminal is the negative one.

c) $\eta = \frac{P_t}{P_c} \Rightarrow 0{,}8 = \frac{P_t}{40} \Rightarrow P_t = 40 \cdot 0{,}8 = 32\,w$ $\quad P_{r'} = P_c - P_t = 40 - 32 = 8\,w$

d) $P_t = \varepsilon' I = 32 \Rightarrow \varepsilon' = \frac{32}{I} = \frac{32}{2} = 16\,V$ $\quad P_{r'} = I^2 r' = 8 \Rightarrow r' = \frac{8}{I^2} = \frac{8}{4} = 2\,\Omega$

e) If internal resistance of motor is null, $P_{r'} = 0$ and then $P_c = P_t$ Therefore $\eta = \frac{P_t}{P_c} = 1$

2. (**3 points**) Given the circuit on picture, compute:

a) (1,2) Intensity of current flowing along each branch with the shown directions, $\mathbf{I_1}$, $\mathbf{I_2}$ and $\mathbf{I_3}$.

b) (0,6) **Potential** of point **B**.

c) (0,6) **Tehevenin's equivalent generator** between points **B** and **D**, clearly showing its polarity.

d) (0,6) **Tehevenin's equivalent generator** between points **A** and **D**, clearly showing its polarity.

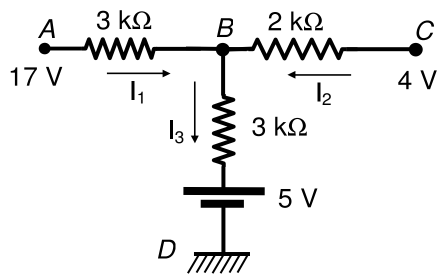
2. (**3 puntos**) Dado el circuito de la figura, calcula:

a) (1,2) La intensidad de corriente en cada rama con los sentidos mostrados, $\mathbf{I_1}$, $\mathbf{I_2}$ y $\mathbf{I_3}$.

b) (0,6) **Potencial** del punto **B**.

c) (0,6) El **generador equivalente de Thevenin** entre los puntos **B** y **D**, indicando claramente su polaridad.

d) (0,6) El **generador equivalente de Thevenin** entre los puntos **A** y **D**, indicando claramente su polaridad.

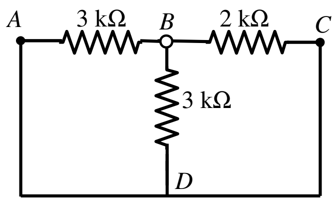


This is a network with 2 junctions and two loops, and so we'll need one equation for junctions and two equations for loops:

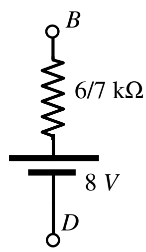
a) $$\left.\begin{aligned} I_1+I_2&=I_3 \\ V_{AD}=17&=3I_1+3I_3-(-5) \\ V_{CD}=4&=2I_2+3I_3-(-5) \end{aligned}\right\} \Rightarrow I_1=3\,mA \quad I_2=-2\,mA \quad I_3=1\,mA$$

b) $V_B=V_B-V_D=3I_3-(-5)=3\cdot 1+5=8\,V$

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



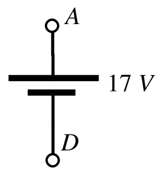
$$\frac{1}{R_{eqBD}}=\frac{1}{3}+\frac{1}{3}+\frac{1}{2}\Rightarrow R_{eqBD}=\frac{6}{7}\,k\Omega$$



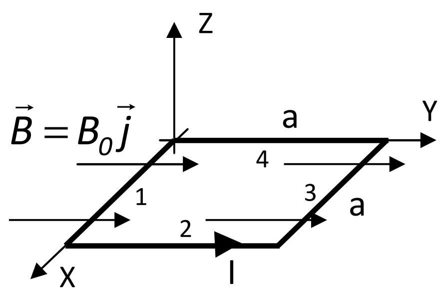
So, Thevenin's equivalent generator between B and D is:

d) $V_A-V_D=17\,V \quad R_{eqAD}=0$

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



3. (**2 points**) The picture shows a square loop (sides 1, 2, 3 and 4) with side **a** flowed by an intensity of current **I**. The loop lies on plane **XY** and it's placed inside a uniform magnetic field $\vec{B}=B_0\vec{j}$. Compute: a) (0,6) The **force** acting on **each side** of loop. Give the results in **vector form**. b) (0,4) The **total force** acting on loop. c) (0,5)The **magnetic moment** of loop. d) (0,5) The **torque** acting over the loop.	**3.** (**2 puntos**) La figura muestra una espira cuadrada (lados 1, 2, 3 y 4) de lado **a** y por la que circula una corriente **I.** La espira está situada en el plano **XY**, dentro de un campo magnético uniforme $\vec{B}=B_0\vec{j}$. Calcula: a) (0,6) La **fuerza** que actúa sobre **cada uno de los lados** de la espira. Da el resultado en **forma vectorial**. b) (0,4) La **fuerza total** que actúa sobre la espira. c) (0,5) El **momento magnético** de la espira. d) (0,5) El **par (momento)** que actúa sobre la espira.



a) $\vec{F}_1 = Ia\vec{i} \times B_0\vec{j} = IaB_0\vec{k}$ $\vec{F}_3 = I(-a\vec{i}\,)\times B_0\vec{j} = -IaB_0\vec{k}$ $\vec{F}_2 = \vec{F}_4 = 0$

b) The total force acting on a loop inside a uniform magnetic field is zero. $\vec{F}_{TOT} = \sum_{i=1,4}\vec{F}_i = 0$

c) As we only have one loop: $\vec{\mu} = I\vec{S} = Ia^2\vec{k}$

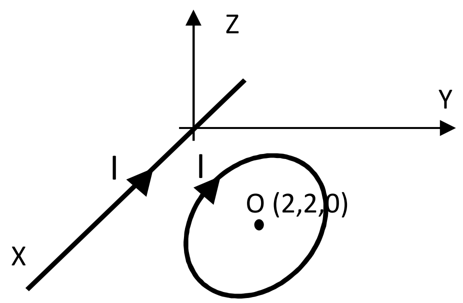
d) $\vec{\tau} = \vec{\mu}\times\vec{B} = Ia^2\vec{k}\times B_0\vec{j} = -Ia^2B_0\vec{i}$

4. (**2 points**) An infinite straight carrying current conductor lies over **X** axis, flowing an intensity **I** along it. A circular loop, flowed by the same intensity **I** is placed on plane **XY** with its centre at point **(2,2,0) m.** Radius of circular loop is **1 m**. The **directions** of both intensities are those shown on picture. Calculate:

a) (1) The **total magnetic field** at the **centre** of circular loop (point O). Give the result as a **vector**, as a function of μ_0 and I.
b) (0,5) An electron (charge **-q**) is released at the centre of circular loop with velocity $\vec{v} = v_0\vec{j}$. Calculate the **vector force** acting on such electron. Give the result as a function of q, v_0, μ_0 and I.
c) (0,5) If we add a new infinite straight carrying current conductor lying along **Y** axis, ¿which should be the intensity along this conductor in order the total **magnetic field** at the **centre** of circular loop was **zero**? Give the **direction** of such intensity (positive or negative direction of Y axis) explaining **why**.

4. (**2 puntos**) Un conductor rectilíneo infinito está situado a lo largo del eje **X**, y lleva una corriente **I**. Una espira circular conduce la misma corriente **I**, y está situada en el plano **XY** con su centro en el punto **(2,2,0) m**. Su radio es de **1 m**. Las **direcciones** de ambas intensidades se pueden ver en el dibujo. Calcula:

a) (1) El **campo magnético total** en el **centro** de la espira circular (punto O). Expresa el resultado en forma **vectorial** en función de μ_0 e I.
b) (0,5) Un electrón (carga **–q**) es liberado en el centro de la espira circular con velocidad $\vec{v} = v_0\vec{j}$. Calcula el **vector fuerza** que actúa sobre el electrón. Expresa el resultado en función de q, v_0, μ_0 e I.
c) (0,5) Si añadimos un nuevo conductor rectilíneo e infinito colocado sobre el eje **Y**, ¿cuál debería ser la corriente que circulara por dicho conductor para que el **campo magnético total** en el **centro** de la espira circular sea **cero**? Da la **dirección** de dicha corriente (dirección positiva o negativa del eje Y) explicando **porqué**.



a) $\vec{B} = -\frac{\mu_0 I}{2\pi 2}\vec{k} - \frac{\mu_0 I}{2\cdot 1}\vec{k} = -\frac{\mu_0 I}{2}(\frac{1}{2\pi}+1)\vec{k}$

b) $\vec{F} = -q\vec{v}\times\vec{B} = -qv_0\vec{j}\times(-\frac{\mu_0 I}{2}(\frac{1}{2\pi}+1)\vec{k}\,) = \frac{qv_0\mu_0 I}{2}(\frac{1}{2\pi}+1)\vec{i}$

c) If we add a new infinite straight carrying current conductor along Y axis, being I' the intensity flowing along it, the magnetic field created by this conductor would be (in modulus): $B' = \frac{\mu_0 I'}{2\pi 2} = \frac{\mu_0 I'}{4\pi}$

This magnetic field should go in the positive direction of Z axis, because the magnetic field calculated on paragraph a) goes in the negative direction of Z axis. For this reason, I' should flow in the negative direction of Y axis. And to obtain null total magnetic field must be verified that

$$\frac{\mu_0 I}{2}(\frac{1}{2\pi}+1) = \frac{\mu_0 I'}{4\pi} \Rightarrow I' = (1+2\pi)I$$

FORM

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

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

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

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

$B = \dfrac{\mu_0 I}{2R}$ $\quad \oint_L \vec{B} \cdot d\vec{l} = \mu_0 \sum I$ $\quad B = \dfrac{\mu_0 N I}{l}$