UNIVERSIDAD POLITECNICA DE VALENCIA

Third midterm exam FFI
January 16th 2017
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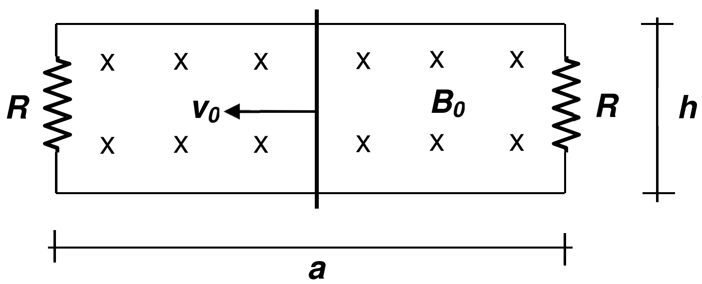
Applied Physics Dept.

1. (3 points) A uniform and stationary magnetic field $\boldsymbol{B_0}$ is directed perpendicularly into the page. A conducting rod is free to slide on two parallel conducting wires of length $\boldsymbol{a}$ and separated a distance $\boldsymbol{h}$ as shown in figure. Two equal resistors $\boldsymbol{R}$ are connected across the ends of the wires. The rod is pulled to the left with constant speed $\boldsymbol{v_0}$, starting the motion in the middle point between both resistors. On a time $\boldsymbol{t}$, find:

a) (1) Magnetic fluxes through both loops: that on left (ϕ_1) and that on right (ϕ_2).
b) (0,5) Induced electromotive force on both loops (ε_1 and ε_2).
c) (0,5) Induced intensities of current flowing along both loops (i_1 and i_2), giving their directions.
d) (0,5) Intensity of current flowing along the rod. Let you say its direction (to up or to down).
e) (0,5) The magnetic force acting over the rod, giving its direction.

1. (3 puntos) Un campo magnético uniforme y estacionario $\boldsymbol{B_0}$ es perpendicular al papel y entrante en él. Una barra conductora puede deslizar libremente sobre dos conductores paralelos de longitud $\boldsymbol{a}$ y separados una distancia $\boldsymbol{h}$, como se ve en la figura. Dos resistencias iguales $\boldsymbol{R}$ unen los extremos de estos conductores. La barra es empujada hacia la izquierda con velocidad constante $\boldsymbol{v_0}$, comenzando su movimiento en el punto medio entre ambas resistencias. En un instante $\boldsymbol{t}$, calcular:

a) (1) Flujos magnéticos a través de las dos espiras formadas: la de la izquierda (ϕ_1) y la de la derecha (ϕ_2).
b) (0,5) Fuerza electromotriz inducida en ambas espiras (ε_1 and ε_2).
c) (0,5) Intensidades de corriente inducidas en ambas espiras (i_1 and i_2), indicando sus sentidos.
d) (0,5) Intensidad de corriente que circula por la barra. Indica su dirección (hacia arriba o hacia abajo).
e) (0,5) La fuerza magnética que actúa sobre la barra, dando su dirección.



a) Magnetic field is uniform and stationary. At a time t, the rod will cover a distance v_0t to left, starting from the middle point between resistors. So, the surfaces of both loops will be:

$$S_1=(\frac{a}{2}-v_0t)h \quad \text{and} \quad S_2=(\frac{a}{2}+v_0t)h$$

And the magnetic fluxes: $\phi_1=(\frac{a}{2}-v_0t)hB_0$ and $\phi_2=(\frac{a}{2}+v_0t)hB_0$

b) The electromotive forces $|\varepsilon_1|=\left|\frac{d\phi_1}{dt}\right|=v_0hB_0$ and $|\varepsilon_2|=\left|\frac{d\phi_2}{dt}\right|=v_0hB_0$

c) $i_1=\frac{\varepsilon_1}{R}=\frac{v_0hB_0}{R}$ Clockwise and $i_2=\frac{\varepsilon_2}{R}=\frac{v_0hB_0}{R}$ Counterclockwise

d) Along the rod will flow the superposition of both intensities, it is, both intensities will flow to down along the rod.

$$i=i_1+i_2=\frac{2v_0hB_0}{R} \quad \text{to down}$$

e) The force acting on the rod will be (magnetic field uniform):

$$F_{rod} = ihB_0 = \frac{2v_0hB_0}{R}hB_0 = \frac{2v_0h^2B_0^2}{R}$$ Direction to right

2. (2 points) An inductor **3 *mH*** sized is flowed by an intensity of current increasing on time with a rate ***1000 A/s*** (***I=10³t A***).	2. (2 puntos) Una autoinducción de ***3 mH*** es recorrida por una corriente que aumenta a razón de ***1000 A/s*** (**I=10³t A**).
a) (0,8) Calculate the induced electromotive force on terminals of inductor. b) (0,7) The length of coil is ***d*** and the number of turns ***N.*** Calculate the magnetic field inside the inductor on time ***t=1 s***. c) (0,5) A circular loop with radius ***R*** (lower than that of inductor) is placed inside the coil, with the axes of loop and coil being coincident. Calculate the mutual inductance coefficient between coil and loop.	a) (0,8) Calcula la fuerza electromotriz inducida en los bornes de la autoinducción. b) (0,7) La longitud de la autoinducción es ***d*** y su número de espiras ***N.*** Calcular el campo magnético en el interior de la autoinducción en el instante ***t=1 s***. c) (0,5) Una espira circular de radio ***R*** (menor que el de la autoinducción) se coloca dentro de la autoinducción, de manera que los ejes de autoinducción y espira son coincidentes. Calcular el coeficiente de inducción mutua entre autoinducción y espira.

a) Intensity is $I=10^3t$ A. So, $\frac{di}{dt} = 10^3\ A/s$ Therefore, electromotive force on terminals of inductor is:

$$\varepsilon = L\frac{di}{dt} = 3\cdot 10^{-3}10^3 = 3\,V$$

b) On time t=1 s, the intensity of current flowing along inductor is $I=10^3$ A. Therefore, the magnetic field inside the inductor on time t=1 s is: $B = \mu_0 nI = \mu_0\frac{N}{d}10^3 = \frac{4\pi\cdot 10^{-7}N}{d}10^3 = \frac{4\pi N}{d}10^{-4}$

c) If a circular loop is placed inside the inductor, perpendicular to its axis, the mutual inductance coefficient between inductor and loop is: $M = \frac{\phi_{loop}}{I} = \frac{BS}{I} = \frac{\mu_0 nI\pi R^2}{I} = \mu_0\frac{N}{d}\pi R^2 = \frac{4\pi^2NR^2}{d}10^{-7}$

3. (3 points) A ***3 mH*** sized coil and a resistor ***4 Ω*** sized are connected in series (dipole RL). The voltage on terminals of coil is ***u_L(t)=30cos(1000t) V***. Compute:	3. (3 puntos) Una autoinducción de ***3 mH*** y una resistencia de ***4 Ω*** están conectadas en serie (dipolo RL). La tensión en los terminales de la autoinducción es ***u_L(t)=30cos(1000t) V***. Calcular:
a) (0,8) The instantaneous intensity i(t) flowing along the dipole. b) (0,7) Instantaneous voltage on resistor u_R(t). c) (0,8) Impedance Z and phase lag φ of dipole. d) (0,7) Instantaneous voltage on terminals of dipole u(t). **Note: You can both use degrees or radians to solve this exercise.**	a) (0,8) La intensidad instantánea i(t) que recorre el dipolo. b) (0,7) La tensión instantánea en la resistencia u_R(t). c) (0,8) La impedancia Z y ángulo de desfase φ del dipolo. d) (0,7) La tensión instantánea entre los terminales del dipolo u(t). **Nota: Podéis utilizar tanto grados sexagesimales como radianes para resolver este ejercicio.**

a) On a coil, $X_L = L\omega = 3\cdot 10^{-3}10^3 = 3\,\Omega$. On the other hand, phase lag between voltage and intensity is 90º. So,

$$i(t) = \frac{30}{3}\cos(1000t - 90º) = 10\cos(1000t - 90º)\,A$$

b) On resistor, phase lag is null. Therefore

$$u_R(t) = 10\cdot 4\cdot\cos(1000t - 90º) = 40\cos(1000t - 90º)\,V$$

c) $Z = \sqrt{R^2 + X_L{}^2} = \sqrt{4^2 + 3^2} = 5\,\Omega$ $\qquad tg\varphi = \frac{X_L}{R} = \frac{3}{4} = 0{,}75 \Rightarrow \varphi = 36{,}9º = 0{,}64\,rad$

d) $\varphi = \varphi_u - \varphi_i = 36{,}9º \Rightarrow \varphi_u = \varphi + \varphi_i = 36{,}9 + (-90) = -53{,}1º$ So, instantaneous voltage on terminals of dipole is:

$u(t) = 10 \cdot 5 \cdot cos(1000t - 53,1º) = 50cos(1000t - 53,1º) V$

4. (2 points) On circuit on picture every diodes have drop forward voltage $\boldsymbol{V_u=0,7\ V}$, and internal resistance negligible (also for the battery).

a) (0,7) On next table, mark with a cross the correct bias (forward or reverse) for every diode:

Diode	Forward	Reverse
D_1		
D_2		
D_3		

b) (0,7) Compute intensities I_1, I_2 and I_3 flowing along diodes D_1, D_2 and D_3.

c) (0,6) Compute the differences of potential V_A-V_C and V_C-V_B.

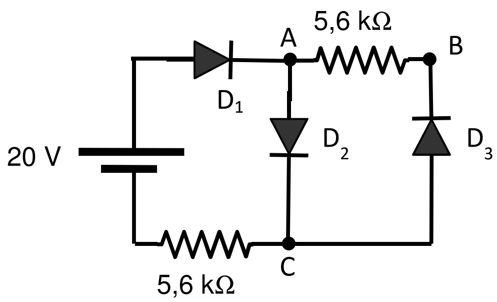
4. (2 puntos) En el circuito de la figura, todos los diodos tienen tensión umbral $\boldsymbol{V_u=0,7\ V}$, y resistencia interna despreciable (también para el generador).

a) (0,7) En la siguiente tabla, marca con una cruz la correcta polarización de cada diodo:

Diodo	Directa	Inversa
D_1		
D_2		
D_3		

b) (0,7) Calcula las intensidades I_1, I_2 e I_3 que circulan por los diodos D_1, D_2 y D_3.

c) (0,6) Calcula las diferencias de potencial V_A-V_C y V_C-V_B.



a)

Diode	Forward	Reverse
D_1	X	
D_2	X	
D_3		X

b) $I_1 = I_2 = \dfrac{20 - 0,7 - 0,7}{5,6} = 3,32\ mA$ $\qquad I_3 = 0$

c) As D_2 is forward biased $V_A - V_C = 0,7\ V$

On the other hand, as I_3=0, $V_A - V_B = 0$ and therefore $V_C - V_B = V_C - V_A = -0,7\ V$

FORM

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

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

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

Electromagnetic induction $|\varepsilon| = \dfrac{d\phi}{dt}$ $\quad \phi = L \cdot I$ $\quad \phi_{21} = M \cdot I_1$ $\quad \varepsilon = L\dfrac{di}{dt}$ $\quad W_L = \dfrac{1}{2} L \cdot I^2$

Alternating current $\varphi = \varphi_u - \varphi_i$ $X_L = L\omega$ $X_C = \frac{1}{C\omega}$ $U_{rms} = \frac{U_m}{\sqrt{2}}$ $I_{rms} = \frac{I_m}{\sqrt{2}}$

$$tg\varphi = \frac{L\omega - 1/C\omega}{R}$$

$$Z = \frac{U_m}{I_m} = \sqrt{R^2 + (L\omega - 1/c\omega)^2}$$

$$P(t) = u(t)\cdot i(t) = U_m I_m \cos\varphi \sin^2 \omega t + \frac{U_m I_m}{2} \sin\varphi \sin\omega t$$

$$P_{av} = \frac{U_m I_m}{2}\cos\varphi$$

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{1}{LC}}$$

Semiconductors $n \cdot p = n_i^2$ $N_A + n = N_D + p$