Retaking Third exam FFI
Recuperación 3er parcial FFI
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Year-Curso 2016/17

UNIVERSIDAD POLITECNICA DE VALENCIA

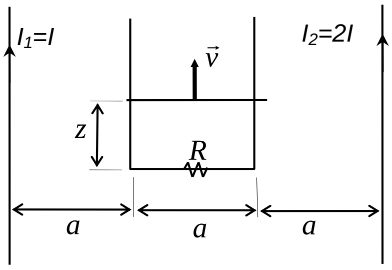
Applied Physics Dept.
Dep. de Física Aplicada

1. (2,5) The rectangular loop on picture, with sides a and z, is placed in the same plane that two infinite and parallel straight carrying current wires, being $I_1=I$ and $I_2=2I$ the intensities flowing along them (equal directions). The upper side of loop is moving with constant speed v to up. Resistance of loop is R. Find as a function of z:

a) (0,5) Magnetic flux through the loop produced by conductor 1.
b) (0,4) Magnetic flux through the loop produced by conductor 2.
c) (0,4) Total magnetic flux through the loop.
d) (0,4) Electromotive force induced on the loop because of both conductors.
e) (0,4) Intensity of current flowing along the loop, justifying its direction.
f) (0,4) Mutual inductance coefficient between conductor 2 and loop.

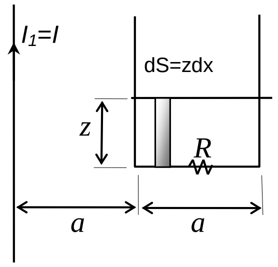
1. (2,5) La espira rectangular de la figura, de lados a y z, se encuentra en el mismo plano que dos conductores rectilíneos, indefinidos y paralelos, situados como se indica en la figura, por los cuales circulan intensidades $I_1=I$ e $I_2=2I$ en el mismo sentido. El lado superior de la espira se mueve con velocidad constante en el sentido indicado en la figura. Determina en función de z:

a) (0,5) La expresión del flujo magnético a través de la espira del campo magnético que crea el hilo 1.
b) (0,4) La expresión del flujo magnético a través de la espira del campo magnético que crea el hilo 2.
c) (0,4) La expresión del flujo magnético total a través de la espira.
d) (0,4) Fuerza electromotriz inducida en la espira.
e) (0,4) Intensidad de corriente en la espira, justificando su sentido, si la resistencia eléctrica es R.
f) (0,4) Coeficiente de inducción mutua entre el hilo 2 y la espira rectangular.



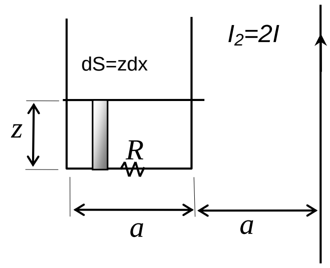
a) Magnetic field at a point over the surface of loop is $B=\dfrac{\mu_0 I_1}{2\pi x}$ where x is the distance of such point to conductor 1. Magnetic field is entering on paper sheet.Therefore the flux is (entering on paper sheet):

$$\Phi_1=\int_S \vec{B}\cdot d\vec{S}=\int_S BdS=\int_a^{2a}\frac{\mu_0 I}{2\pi x}zdx=\frac{\mu_0 Iz}{2\pi}ln\left(\frac{2a}{a}\right)=\frac{\mu_0 Iz}{2\pi}ln\,2$$



b) For flux due to I_2, magnetic flux and so the flux is exiting from paper sheet:

$$B=\frac{\mu_0 I_2}{2\pi x}=\frac{\mu_0 2I}{2\pi x}=\frac{\mu_0 I}{\pi x}\qquad \Phi_2=\int_S \vec{B}\cdot d\vec{S}=\int_S BdS=\int_a^{2a}\frac{\mu_0 I}{\pi x}zdx=\frac{\mu_0 Iz}{\pi}ln\left(\frac{2a}{a}\right)=\frac{\mu_0 Iz}{\pi}ln\,2$$



c) The total magnetic flux $\Phi=\Phi_1+\Phi_2=-\dfrac{\mu_0 Iz}{2\pi}ln\,2+\dfrac{\mu_0 Iz}{\pi}ln\,2=\dfrac{\mu_0 Iz}{2\pi}ln\,2$ exiting from paper sheet

d) Electromotive force is $|\varepsilon_i|=\dfrac{d\Phi}{dt}=\dfrac{\mu_0 I}{2\pi}ln(2)\dfrac{dz}{dt}=\dfrac{\mu_0 I}{2\pi}ln(2)v$

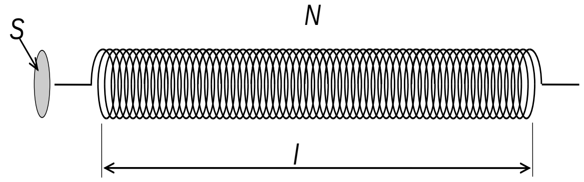
e) The total flux exiting from paper sheet to us is increasing when z increases. So, from Lenz's law, the induced current on loop must be opposite to this increasing of flux, creating a magnetic field opposite to the flux, it is, entering on paper. To do it, the induced current must flow in clockwise direction. Its magnitude is

$$i=\frac{\varepsilon_i}{R}=\frac{\mu_0 I}{2\pi R}v\,ln\,2$$

f) The mutual inductance coefficient: $M=\dfrac{\phi_2}{I_2}=\dfrac{\dfrac{\mu_0 Iz}{\pi}ln\,2}{2I}=\dfrac{\mu_0 z}{2\pi}ln\,2$

2. (2,5) The cross section of a coil made up by 20000 loops is 5 cm^2 and its length 10 cm. If the coil is flowed by a current of 1 A, compute: a) (0,9) The magnetic field inside the coil, assuming that it is uniform. b) (0,8) The magnetic flux through the coil. c) (0,8) The self inductance coefficient of coil.	**2.** (2,5) Un solenoide formado por 20000 espiras tiene una sección 5 cm^2 y una longitud de 10 cm. Si el solenoide es recorrido por una corriente de 1 A, calcula: a) (0,9) El campo magnético en su interior, admitiendo que es uniforme dentro del solenoide. b) (0,8) El flujo magnético que atraviesa el solenoide. c) (0,8) Su coeficiente de autoinducción.

a) $B=\frac{\mu_0 NI}{l}=\frac{4\pi\times10^{-7}\times20.000\times1}{0,1}=0,25\,T$ (0,9 points)



b) $\Phi=N\int_S BdS=NB\int_S dS=NBS$

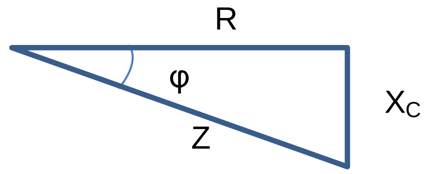
$\emptyset=NBS=20.000\times0,25\times5\times10^{-4}$= 2,5 W (0,8 points)

c) $L=\frac{\emptyset}{I}=\frac{2,5}{1}=2,5\,H$ (0,8 points)

3. (2,5) Along a circuit made up by two basic dipoles in series flows an intensity $i(t)=2\cos(1000t+10°)\ A$. The voltage applied on terminals of circuit is $u(t)=40\cos(1000t-20°)\ V$. a) (1,5) Find out the two basic dipoles and their magnitudes. Draw the impedance triangle. b) (1) Find the voltage on terminals of every basic dipole.	**3.** (2,5) Por un circuito compuesto por dos elementos puros en serie alimentados por una fuente de tensiÓn $u(t)=40\cos(1000t-20°)\ V$, circula una intensidad de corriente $i(t)=2\cos(1000t+10°)\ A$. a) (1,5) Determina los mencionados elementos y dibuja el triángulo de impedancias. b) (1) Determina la tensión en bornes de dichos elementos.

a) The phase lag between voltage and intensity is $\varphi = \varphi_u - \varphi_i = -20^\circ - 10^\circ = -30^\circ$. As it's negative, we know that the two basic dipoles are a resistor and a capacitor. Their magnitude scan be computed from:

$$Z = \frac{U_m}{I_m} = \frac{40}{2} = 20\ \Omega$$
$$R = Z\cos\varphi = 20\cos 30^\circ = 17{,}32\ \Omega$$
$$X_C = \frac{1}{C\omega} = Z\sin\varphi = 20\sin 30^\circ = 10\ \Omega$$
$$C = \frac{1}{10\cdot 1000} = 100\ \mu F$$



(1,5 points)

b) $u_R(t) = RI_m\cos(1000t + 10^\circ) = 34{,}64\cos(1000t + 10^\circ)\ V$ (0,5 points)

$u_c(t) = \frac{1}{C\omega} I_m\cos(1000t - 80^\circ) = 20\cos(1000t - 80^\circ) V$ (0,5 points)

4. (2,5) An extrinsic semiconductor n type is built with Si dopped with 10^{20} atoms of Sb/m^3 (Sb is a donor of e^-). The intrinsic density of Si at 300 K is $n_i = 1{,}5\cdot 10^{16}\ m^{-3}$ and at 500 K $n_i = 3{,}7\cdot 10^{20}\ m^{-3}$

a) (0,9) Find the density of electrons and holes on such semiconductor at 300 K.

b) (0,8) Find the density of electrons and holes on such semiconductor at 500 K.

c) (0,8) Argue if the net electric charge of semiconductor in both cases is positive, negative, or neutral.

4. (2,5) Un semiconductor extrínseco tipo n está formado por Si dopado con 10^{20} átomos de Sb/m^3 (Sb es un donador de e^-). La concentración intrínseca del Si a 300 K es $n_i = 1{,}5\cdot 10^{16}\ m^{-3}$ y a 500 K $n_i = 3{,}7\cdot 10^{20}\ m^{-3}$

a) (0,9) Calcular la concentración de electrones y huecos en dicho semiconductor a 300 K.

b) (0,8) Calcular la concentración de electrones y huecos en dicho semiconductor a 500 K.

c) (0,8) Razona si la carga eléctrica neta del semiconductor en ambos casos en es positiva, negativa, o neutra.

a) $n\cdot p = n_i^2 \Rightarrow n\cdot p = 1{,}5^2\cdot 10^{32}$

(N_D) is very high compared with the intrinsic density (n_i) ($10^{20} >>> 10^{16}$), therefore

$n \approx N_D = 10^{20}\ e^-/m^3 \qquad p = \frac{n_i^2}{n} = \frac{1{,}5^2\cdot 10^{32}}{10^{20}} = 2{,}25\cdot 10^{12}\ h/m^3$ (0,9 points)

b) Now, mu have to solve the system of two equations:

$$n\cdot p = n_i^2 \Rightarrow n\cdot p = (3{,}7\cdot 10^{20})^2$$
$$N_A + n = N_D + p$$
$$n = 10^{20} + p$$

Resulting:

$$n = 4{,}2\cdot 10^{20}\ e^-/m^3$$
$$p = 3{,}2\cdot 10^{20}\ e^-/m^3$$

(0,8 points)

c) Neutral (Because of Charge neutrality law) (0,8 points)

Si te examinas sólo de una parte, debes resolver los cuatro problemas de esa parte.
If you are sitting only one part of the exam, then you have to solve the four problems of that part.

Si te examinas de dos partes, debes resolver los tres primeros problemas de ambas partes.
If you are sitting two parts of the exam, then you have to solve the three first problems of both parts.

Si te examinas de las tres partes, debes resolver los dos primeros problemas de cada una de las partes.
If you are sitting the three parts of the exam, then you have to solve the two first problems of every part.

FORM – FÓRMULAS

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

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

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

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

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

$$P(t) = u(t) \cdot i(t) = U_m I_m \cos\varphi \sin^2 \omega t + \frac{U_m I_m}{2} \sin\varphi \sin \omega t \qquad P_{av} = \frac{U_m I_m}{2} \cos\varphi \qquad f_0 = \frac{1}{2\pi}\sqrt{\frac{1}{LC}}$$

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