UNIVERSIDAD POLITECNICA DE VALENCIA

Retaking FFI second modular exam
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Applied Physics Dept.

1. An inductor (solenoid) is **10 cm** long and it's made with **500 turns** having a cross section of **5 cm^2**. Along this solenoid flows an intensity of current of **20 A**. a) Assuming that magnetic field is uniform inside the solenoid, compute the magnetic flux through the solenoid. b) Compute the self-inductance coefficient of solenoid. If an electron is thrown inside the solenoid with speed **200 m/s** parallel to the axis of solenoid, c) Compute the magnetic force acting on electron. **2 points**	**1.** Un solenoide de **10 cm** de longitud, **500 espiras** y **5 cm^2** sección está recorrido por una intensidad de corriente de **20 A**. a) Admitiendo que el campo magnético es uniforme dentro del solenoide, calcula el flujo magnético que atraviesa el solenoide. b) Calcula el coeficiente de autoinducción del solenoide. Si un electrón es lanzado dentro del solenoide con velocidad **200 m/s** paralelamente al eje del solenoide, c) Calcula la fuerza magnética que actúa sobre el electrón. **2 puntos**

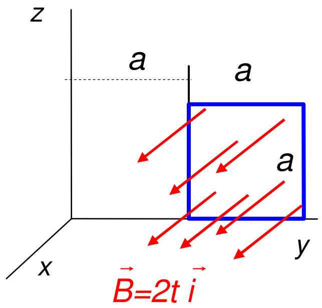
a) Magnetic field inside the solenoid is $B = \frac{\mu_0 N i}{l} = \frac{4\pi 10^{-7} 500 \cdot 20}{10 \cdot 10^{-2}} = 4\pi 10^{-2}\ T$

The magnetic flux $\phi = NBS = 500 \cdot 4\pi 10^{-2} 5 \cdot 10^{-4} = \pi 10^{-2}\ Wb$

b) $L = \frac{\phi}{i} = \frac{\pi 10^{-2}}{20} = \frac{\pi}{2} 10^{-3} = 1{,}57\ mH$

c) Force acting on a moving charge inside a magnetic field is $\vec{F} = q\vec{v} \times \vec{B}$

In this case, as velocity of electron is parallel to magnetic field, F=0.

2. A squared loop with side **a** and resistance **R** is placed motionless inside a uniform magnetic field varying on time according $\vec{\mathbf{B}} = \mathbf{2t\vec{i}}$ **T** where t is the time in s. For any time t, compute: a) Magnetic flux through the loop. b) Induced electromotive force and induced current flowing along the loop, giving and clearly explaining its sense. d) On time **t=1 s**, compute the force acting on right side of loop. **2 points**	**2.** Una espira cuadrada de lado **a** y resistencia **R** se encuentra inmóvil dentro de un campo magnético uniforme que varía con el tiempo, de acuerdo con la expresión $\vec{\mathbf{B}} = \mathbf{2t\vec{i}}$ **T** siendo t el tiempo en s. Para un instante de tiempo t cualquiera, calcula: a) Flujo del campo magnético a través de la espira. b) La fuerza electromotriz inducida en la espira. c) La corriente inducida en la espira, indicando clara y razonadamente su sentido. d) En el instante **t=1 s**, calcula la fuerza que actúa sobre el lado derecho de la espira. **2 puntos**	

Solution:

a) $\phi = \vec{B} \cdot \vec{S} = 2ta^2\ Wb$

b) $|\varepsilon| = \left|\frac{d\phi}{dt}\right| = \frac{d(2a^2 t)}{dt} = 2a^2\ V$ $\quad i = \frac{\varepsilon}{R} = \frac{2a^2}{R}\ A$ Magnetic flux through the loop is increasing on time, and according Lenz's law, induced current should create a magnetic flux opposite to that already crossing the loop. It can be done if induced current flows in <u>clockwise sense</u>.

c) $\vec{F} = i\vec{L} \times \vec{B}(t=1) = \frac{2a^2}{R}(-a\vec{k} \times 2\vec{i}) = -\frac{4a^3}{R}\vec{j}\ N$

3. Explain how can be built an **extrinsic p type** semiconductor from a intrinsic semiconductor. Explain the **differences** between them related to the density of charge carriers.
2 points

3. Explica cómo se puede conseguir un semiconductor **extrínseco tipo p** a partir de un semiconductor intrínseco. Explica las **diferencias** en las concentraciones de portadores de carga entre ambos semiconductores.
2 puntos

A p type extrinsic semiconductor can be built by doping an intrinsic semiconductor with acceptor impurities. This doping means to change a few atoms of pure silicon or germanium (the intrinsic semiconductor) by atoms of a material with only three electrons on its outer layer (B, Al, Ga or In). In this way, we "introduce" into the semiconductor additional holes.
Then, holes become the majority charge carriers, and free electrons the minority charge carriers. The quantity of free electrons decreases because of the increasing of recombination.
On intrinsic semiconductors, instead, the quantity of free electrons and holes is the same, and equal to the intrinsic carrier density (n_i), magnitude depending on temperature.

4. On a RL series circuit, with a **R=2Ω** resistor and a **L=3 mH** inductor, drop of potential on terminals of resistor is $\mathbf{u_R(t) = 4\cos(500t - 40^o)}$ **V**.
Compute intensity of current, drop of potential on terminals of inductor, and drop of potential on terminals of RL series circuit.
2 points

4. En un circuito RL serie, con una resistencia **R=2Ω**, y una bobina **L=3 mH**, la tensión en bornes de la resistencia es $\mathbf{u_R(t) = 4\cos(500t - 40^o)}$ **V**.
Calcula la intensidad de corriente, la caída de tensión en la bobina y la caída de tensión total en los terminales del circuito RL serie.
2 puntos

As we know drop of potential on terminals of <u>resistor</u>, the amplitude of intensity of current flowing along the resistor will be $I_m = \frac{U_{Rm}}{R} = \frac{4}{2} = 2\ A$ Phase lag on a resistor is 0, and then: $i(t) = 2\cos(500t - 40º)\ A$

Amplitude of drop of potential on terminals of inductor will be:

$X_L = L\omega = 3 \cdot 10^{-3} \cdot 5 \cdot 10^2 = 1{,}5\ \Omega$ $\qquad U_{Lm} = I_m X_L = 2 \cdot 1{,}5 = 3\ V$

Phase lag on inductor is 90º: $90 = \varphi_u - \varphi_i = \varphi_u - (-40) \Rightarrow \varphi_u = 90 - 40 = 50º$

Then: $u_L(t) = 3\cos(500t + 50º)\ V$

Concerning the drop of potential on <u>terminals of RL circuit</u>:

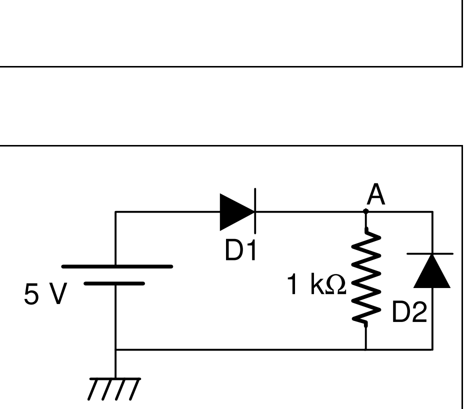
$Z = \sqrt{2^2 + (1{,}5)^2} = 2{,}5\ \Omega$ $\qquad U_m = I_m Z = 2 \cdot 2{,}5 = 5\ V$

$tg\varphi = \frac{1{,}5}{2} = 0{,}75 \Rightarrow \varphi \approx 37º = \varphi_u - (-40) \Rightarrow \varphi_u = 37 - 40 = -3º$

$u(t) = 5\cos(500t - 3º)\ V$

5. Given the circuit on picture, compute the **intensity of current** flowing along each diode (D1 and D2), and the **potential on point A**. Both diodes are made with Silicon, being their forward drop voltage V_u=0,7 V; the internal resistance can be neglected.
2 points

5. Dado el circuito de la figura, calcula la **corriente** que circula por cada uno de los diodos (D1 y D2), y el **potencial en el punto A**. Ambos diodos son de Silicio, siendo su tensión umbral V_u=0,7 V; la resistencia interna puede ser despreciada.
2 puntos



On circuit, diode D1 is forward biased, being D2 reverse biased. Then:

$I_{D2} = 0$ and $I_{D1} = \frac{5 - 0{,}7}{1} = 4{,}3\ mA$

D1 is forward biased, and then, drop of potential between anode and cathode of D1 is 0,7 V. On the other hand, potential on positive terminal of source is 5 V; then $V_A = 5 - 0{,}7 = 4{,}3\ V$.

FORM

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

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) $B = \frac{\mu_0 I}{2\pi x}$

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

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

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

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

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

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