PHYS 102: General Physics 2 | KOÇ UNIVERSITY | Spring Semester 2015

College of Sciences

Section 1 | Quiz 10 | 14 May 2015

Closed book. No calculators are to be used for this quiz.
Quiz duration: 10 minutes

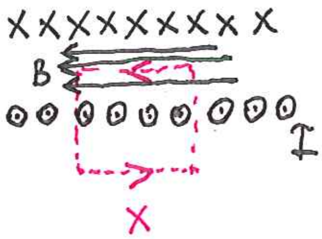
Name: | **Student ID:** | **Signature:**

A long, straight solenoid has N turns, uniform cross-sectional area A, and length l. Show that the inductance of this solenoid is given by $L = \mu_0 A N^2 / l$. Assume that the magnetic field is uniform inside the solenoid and zero outside.

Inductance is defined as:

$$L = \frac{N\Phi_B}{I}$$

And flux is defined as: $\Phi_B = BA$. Using Ampere Law we can calulate the magnetic field of the solenoid:



$$\oint \vec{B}\cdot d\vec{l} = \mu_0 I_{enc} \Rightarrow Bx = \mu_0 n x I$$

$$\Rightarrow B = \mu_0 \frac{N}{l} I$$

Using this magnetic field in the definition of the inductance we have:

$$L = \frac{N\Phi_B}{I} = \frac{NBA}{I} = \frac{NA}{I}\cdot \mu_0 \frac{N}{l} I \Rightarrow$$

$$\Rightarrow \boxed{L = \frac{\mu_0 A N^2}{l}}$$

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Section 2 **Quiz 10** **14 May 2015**

Closed book. No calculators are to be used for this quiz.
Quiz duration: 10 minutes

Name: **Student ID:** **Signature:**

A long, straight solenoid has N turns, uniform cross-sectional area A, length l, and carries a current I_0. Find the total energy contained in the coil's magnetic field assuming the field is uniform.

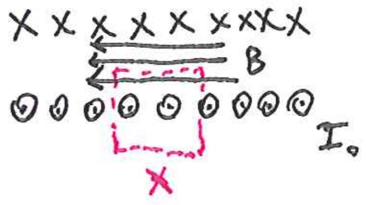
Energy stored in the coil is given as:

$$U = \frac{1}{2} L I_0^2$$

Inductunce is defined as: $L = \frac{N\Phi_B}{I_0}$. where flux is given with $\Phi_B = BA$. Using these:

$$U = \frac{1}{2} L I_0^2 = \frac{N\Phi_B}{2I_0} \cdot I_0^2 = \frac{NBAI_0}{2}$$

Using Ampere's law we can calculate the magnetic field:



$$\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{enc.} \Rightarrow Bx = \mu_0 \frac{N}{l} x I_0$$

$$\Rightarrow B = \frac{\mu_0 N I_0}{l}$$

If we sustitude B to the expression of U we get:

$$U = \frac{NABI_0}{2} = \boxed{\frac{\mu_0 N^2 I_0^2 A}{2l}}$$

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Section 3 Quiz 10 14 May 2015

Closed book. No calculators are to be used for this quiz.
Quiz duration: 10 minutes

Name: **Student ID:** **Signature:**

An LC circuit containing an inductor L_0 and a capacitor C_0 oscillates with a maximum current of I_0. Calculate the maximum charge on the capacitor.

Total charge in the capacitor can be written as:

$$q(t) = Q\cos(\omega t + \phi)$$

where Q is maximum charge, and $\omega = \frac{1}{\sqrt{LC}}$ for LC circuit. Then current is given as:

$$i(t) = \frac{dq}{dt} = -Q\omega\sin(\omega t + \phi)$$

From this equation we see that maximum current is given as:

$$I_0 = Q\omega \Rightarrow Q = \frac{I_0}{\omega} \Rightarrow$$

$$\boxed{Q = I_0\sqrt{LC}}$$

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Section 4 | Quiz 10 | 14 May 2015

Closed book. No calculators are to be used for this quiz.
Quiz duration: 10 minutes

Name: **Student ID:** **Signature:**

An LC circuit containing an inductor L_0 and a capacitor C_0 oscillates with a maximum current of I_0. Assuming the capacitor has its maximum charge at time $t = 0$, calculate the energy stored in the inductor after t seconds.

For inductor energy stored is given as:

$$U = \frac{1}{2} L i^2$$

The current for any LC circuit in general can be written as:

$$i(t) = I_0 \cos(\omega t + \phi) \quad ; \quad \omega = \frac{1}{\sqrt{L_0 C_0}}$$

Since $i(0) = I_0$ we have:

$$\cos(\phi) = 1 \Rightarrow \phi = 0$$

Thus:

$$i(t) = I_0 \cos(\omega t)$$

There fore:

$$U = \frac{1}{2} L_0 (i(t))^2 = \boxed{\frac{1}{2} L_0 I_0^2 \cos^2\left(\frac{t}{\sqrt{L_0 C_0}}\right)}$$

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Section 5 Quiz 10 14 May 2015

Closed book. No calculators are to be used for this quiz.
Quiz duration: 10 minutes

Name: **Student ID:** **Signature:**

An ideal battery with voltage V_0, a resistor with resistance R_0, and an ideal inductor with inductance L_0 are all connected in series with an open switch. The switch is suddenly closed. How long after closing the switch will the current through the inductor reach one-half of its maximum value?

Current of R-L circuit with emf is given as:

$$i = \frac{V_0}{R_0}\left(1 - e^{-(R_0/L_0)t}\right)$$

At $t=0$, $i = \frac{V_0}{R_0}$. Assume at time t_1, the current drop one-half of its maximum value:

$$i_1 = \frac{V_0}{2R_0} = \frac{V_0}{R_0}\left(1 - e^{-(R_0/L_0)t_1}\right) \Rightarrow$$

$$\Rightarrow \frac{1}{2} = \left(1 - e^{-(R_0/L_0)t_1}\right) \Rightarrow 1 = 2 - 2e^{-(R_0/L_0)t_1}$$

$$\Rightarrow e^{-(R_0/L_0)t_1} = \frac{1}{2} \Rightarrow -\frac{R_0}{L_0}t_1 = \ln(1/2) \Rightarrow$$

$$\Rightarrow t_1 = -\frac{L_0}{R_0}\ln\left(\frac{1}{2}\right) \Rightarrow$$

$$\boxed{t_1 = \frac{L_0}{R_0}\ln(2)}$$