PHYS 102: General Physics 2 **KOÇ UNIVERSITY** **Spring Semester 2012**

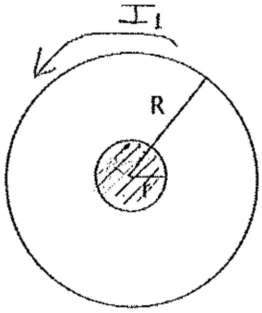
College of Sciences

Section 1 **Quiz 12** **10 May 2012**

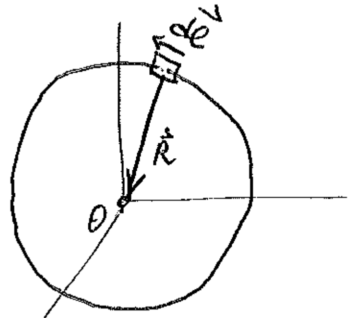
Closed book. No calculators are to be used for this quiz.
Quiz duration: 10 minutes

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

Consider two single-turn co-planar, concentric coils of radii R and r, with R >> r, as shown in Figure. What is the mutual inductance between the two loops?



Magnetic field ~~inside~~ at the ~~axis~~ center of the circular loop:



$$d\vec{B} = \frac{\mu_0}{4\pi} I_1 \frac{d\vec{l} \times \hat{R}}{R^2}$$

$$|\vec{B}| = \oint d\vec{B} = \frac{\mu_0}{4\pi} I_1 \int_{\theta=0}^{\theta=2\pi} \frac{R\, d\theta}{R^2} = \frac{\mu_0 I_1}{2R}$$

* Since $r \ll R$ field inside the inner circle can be taken as uniform and equal to its value at the center.

Thus magnetic flux inside the inner circle is,

$$\Phi_2 = B \cdot A = \frac{\mu_0 I_1}{2R} \pi r^2$$

The mutual inductance is then,

$$M = \frac{N_2 \Phi_2}{I_1} = 1 \cdot \frac{\frac{\mu_0 I_1}{2R} \pi r^2}{I_1} = \frac{\mu_0 \pi}{2R} \frac{r^2}{R}$$

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Section 2 **Quiz 12** **10 May 2012**

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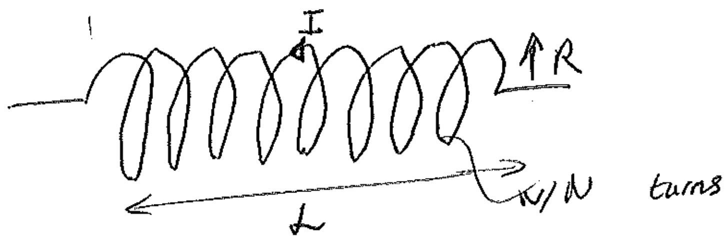
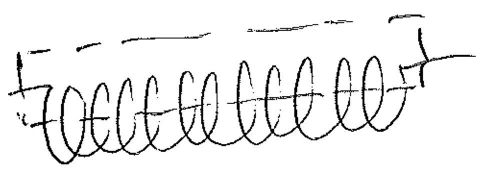
Quiz duration: 10 minutes

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

Compute the self-inductance of a solenoid with N turns, length L, and radius R with a current I flowing through each turn.



field inside a solenoid



$$\oint \vec{B}\cdot d\vec{l} = \mu_0 I_{enc}$$
$$B \cdot L = \mu_0 N I$$
$$B = \mu_0 \frac{N}{L} I$$

Assuming field inside the solenoid uniform, we can calculate flux through its crossection area as

$$\Phi = B \cdot A = \mu_0 \frac{N}{L} I \pi R^2$$

So the inductance is,

$$L'_{sol.} = \frac{N\Phi}{I} = \frac{\mu_0 \pi N^2 R^2}{L}$$

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Section 3 **Quiz 12** **10 May 2012**

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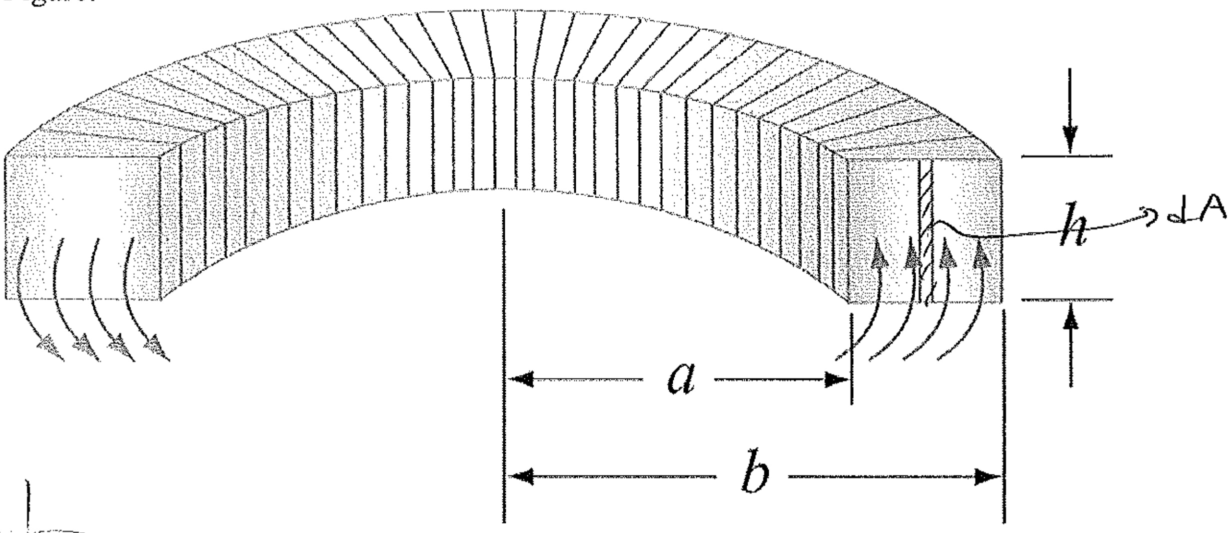
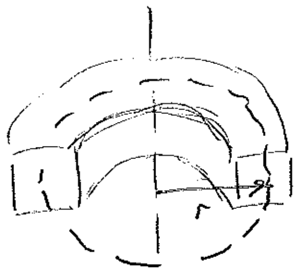
Quiz duration: 10 minutes

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

Calculate the self-inductance of a toroid which consists of N turns and has a rectangular cross section, with inner radius a, outer radius b and height h, as shown in Figure.





field inside a toroid:

$$\oint B \cdot dl = \mu_0 I_{enc}$$

$$B \cdot 2\pi r = \mu_0 N I$$

$$B(r) = \frac{\mu_0 N I}{2\pi r}$$

flux through the strip:

$$d\Phi = \vec{B} \cdot d\vec{A} = \frac{\mu_0 N I}{2\pi r} h\, dr$$

total flux:

$$\Phi = \int d\Phi = \frac{\mu_0 N I h}{2\pi} \int_a^b \frac{dr}{r} = \frac{\mu_0 N I h}{2\pi} \ln\left(\frac{b}{a}\right)$$

Inductance

$$L = \frac{N\Phi}{I} = \frac{\mu_0 N^2 h}{2\pi} \ln\left(\frac{b}{a}\right)$$

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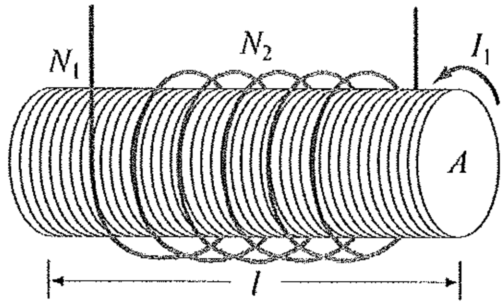
Section 4 Quiz 12 10 May 2012

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

Name: Student ID: Signature:

A long solenoid with length l and a cross-sectional area A consists of N_1 turns of wire. An insulated coil of N_2 turns is wrapped around it, as shown in Figure. (i) Calculate the mutual inductance M, assuming that all the flux from the solenoid passes through the outer coil. (ii) Relate the mutual inductance M to the self-inductances and of the solenoid and he coil.



(i) $M = \frac{N_2 \Phi_{B2}}{I_1}$

$\Phi_{B2} = BA$ where $B = \frac{\mu_0 N_1 I_1}{l}$

$= \frac{\mu_0 N_1 I_1 A}{l}$

$\Rightarrow M = \frac{\mu_0 N_1 N_2 I_1 A}{I_1 l} = \frac{\mu_0 N_1 N_2 A}{l}$

(ii) Since $M = \frac{N_2 \Phi_{B2}}{I_1} = \frac{N_1 \Phi_{B1}}{I_2} \Rightarrow I_2 = \frac{N_1 \Phi_{B1}}{M}$

$I_1 = \frac{N_2 \Phi_{B2}}{M}$

and $L_1 = \frac{N_1 \Phi_{B1}}{I_1}$ $L_2 = \frac{N_2 \Phi_{B2}}{I_2}$

$\Rightarrow L_1 L_2 = M^2$

$\Rightarrow M = \sqrt{L_1 L_2}$

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Section 5 Quiz 12 10 May 2012

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

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

A long solenoid with length l and a radius R consists of N turns of wire. A current I passes through the coil. Find the energy stored in the system.

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

$$L = \frac{N\Phi_B}{I} \quad , \quad \Phi_B = \vec{B} \cdot \vec{A} = BA = \underbrace{\left(\frac{\mu_0 N I}{l}\right)}_{\text{magnitude of magnetic field of solenoid}} \left(\pi R^2\right)$$

$$\Rightarrow L = \frac{\mu_0 N^2 R^2 \pi}{l}$$

$$\Rightarrow U = \frac{1}{2} \frac{\mu_0 N^2 I^2 R^2 \pi}{l}$$