Homework Week 11

113-2 General Physics II

Due before 4:10 PM on May 05, 2025

Name 保宏宇

1. [30 points] **Example 31.1 Inductance of a Solenoid**

   Consider a uniformly wound solenoid having N turns and length l. Assume l is much longer than the radius of the windings and the core of the solenoid is air.

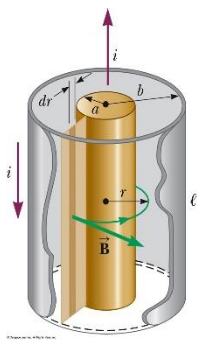
   (A) Find the inductance of the solenoid [20 points].

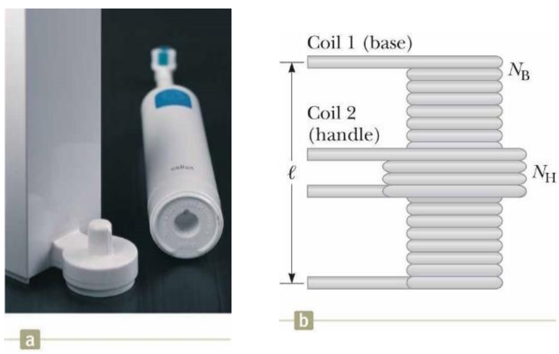
   (B) Calculate the inductance of the solenoid if it contains 300 turns, its length is 25.0 cm, and its cross-sectional area is 4.00 cm^2 [5 points].

   (C) Calculate the self-induced emf in the solenoid if the current it carries decreases at the rate of 50.0 A/s [5 points].

2. [10 points] **Example 31.4 The Coaxial Cable**

   Coaxial cables are often used to connect electrical devices, such as your video system, and in receiving signals in television cable systems. Model a long coaxial cableas a thin, cylindrical conducting shell of radius b concentric with a solid cylinder of radius a as in the figure below. The conductors carry the same current i in opposite directions. Calculate the inductance L of a length l of this cable.



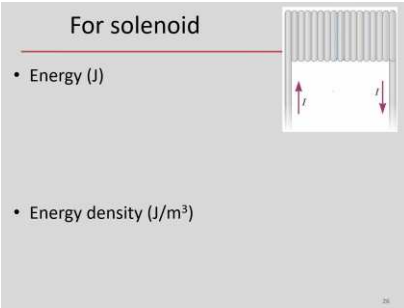


3. [10 points] **Example 31.5 Wireless Battery Charger**

An electric toothbrush has a base designed to hold the tooth-brush handle when not in use. As shown in the figure above, the handle has a cylindrical hole that fits loosely over a matching cylinder on the base. When the handle is placed on the base, a changing current in a solenoid inside the base cylinder induces a current in a coil inside the handle. This induced current charges the battery in the handle.

We can model the base as a solenoid of length l, with N_B turns (the figure above), carrying a current i, and having across-sectional area A. The handle coil contains N_H turns and completely surrounds the base coil. Find the mutual inductance of the system.

4. [15 points] Derive the energy stored per unit volume in the magnetic field of the inductor for a solenoid.



5. [5 points] According to our course schedule, what topics will be covered in the next lecture? __________.

5. [30 points] (A) 嘗試問一個生活中跟物理有關的問題。[10 points]
   (B)列出關鍵字 (用物理思維，把大問題拆解成小問題) 。[10 points]
   (C) Google 關鍵字 or 查閱維基有無文章（注意維基不見得正確）。[10points]
   螢幕截圖/照相，或是附上出處，線上繳交（如前面手寫，可分開繳交）。

   有問就給分，鼓勵同學多方閱讀，自己整理資訊。
   範例問題：為什麼 $q\boldsymbol{v} \times \boldsymbol{B}$ 是右手定則，不是**左**手定則?

Class participation [3 points]

“銀河便車指南”說，「42」是生命、宇宙和一切的終極答案。如果我們看不懂答案，是因為____________。**真正重要的，是了解該問什麼樣的問題**。

當____________的時候，我們可能會問錯問題。因此，我們必須保持對世界的好奇，拓展知識的邊界，勇敢地提出笨的問題，有一天就會問到對的問題。

學習物理，要連結日常生活，把物理______化。

勇敢地提出　　　　　　笨的問題，

有一天就會問到

對的問題

截止後，已繳交需要解答的寄信助教：110104035@nccu.edu.tw

1.

(A) Assume the volume of the solenoid is V

$$L = \frac{\Phi_B}{i} = \frac{NBA}{i}$$

$$\left(\begin{aligned} &\text{Ampere's Law} \\ &\oint \vec{B} \cdot d\vec{s} = \mu_0 I \\ &\Rightarrow B\,l = \mu_0 (N i) \\ &\Rightarrow B = \mu_0 \frac{N}{l} i = \mu_0 n i \end{aligned} \right)$$

$$= \frac{N(\mu_0 n i) A}{i} = \mu_0 \left(\frac{N}{l}\right)^2 (A l) = \mu_0 n^2 V \ \#$$

(B) $$L = \mu_0 n^2 V$$

$$= (4\pi \times 10^{-7}\ T \cdot m/A) \left(\frac{300}{0.25}\ \frac{1}{m} \right)^2 (100 \times 10^{-6}\ m^3)$$

$$\approx 1.8 \times 10^{-4}\ (H) \ \#$$

(C) $$\varepsilon = -L \frac{di}{dt}$$

$$= -(1.8 \times 10^{-4})(50) = -9 \times 10^{-3}\ (V) \ \#$$

2.

$$L = \frac{\Phi_B}{i} = \frac{\int \vec{B} \cdot d\vec{A}}{i}$$

$\vec{B}$ and $\vec{A}$ are perpendicular

$$= \frac{\int B \, dA}{i}$$

Ampere's Law

$$\oint \vec{B} \cdot d\vec{s} = \mu_0 I$$

$$\Rightarrow B(2\pi r) = \mu_0 i$$

$$\Rightarrow B = \frac{\mu_0 i}{2\pi r}$$

$$= \int_a^b \frac{\mu_0 i}{2\pi r} \, l \, dr \; / \; i$$

$$= \frac{\mu_0 l}{2\pi} \int_a^b \frac{dr}{r} = \frac{\mu_0 l}{2\pi} \ln\left(\frac{b}{a}\right) \ \#$$

3.

$$M = \frac{N_H \Phi_{B_H}}{i_{Base}}$$

Ampere's Law

$$\oint \vec{B} \cdot d\vec{s} = \mu_0 I$$

$$\Rightarrow B l = \mu_0 (N i)$$

$$\Rightarrow B = \mu_0 \left(\frac{N}{l}\right) i = \mu_0 n i$$

$$= \frac{N_H \Phi_{Base}}{i_{Base}}$$

$$= \frac{N_H \left(\mu_0 \frac{N_B}{l} \bar{i}_{Base}\right) A}{i_{Base}} = \frac{\mu_0 N_H N_B A}{l} \quad \#$$

4.

①

1° Ampere's Law

$$\oint \vec{B} \cdot d\vec{s} = \mu_0 I$$

$$\Rightarrow B l = \mu_0 (N i)$$

$$\Rightarrow B = \mu_0 \frac{N}{l} i = \mu_0 n i$$

$$\left(\Rightarrow i = \frac{B}{\mu_0 n} \right)$$

2° $L = \frac{\Phi_B}{i} = \frac{NBA}{i}$

$$= \frac{N(\mu_0 n i) A}{i} = \mu_0 \left(\frac{N^2}{l^2}\right)(A l) = \mu_0 n^2 V$$

3° Energy $= \frac{1}{2} L i^2$

$$= \frac{1}{2}(\mu_0 n^2 V)\left(\frac{B}{\mu_0 n}\right)^2$$

$$= \frac{B^2}{2\mu_0} V$$

② Energy Density $= \frac{B^2}{2\mu_0} V / V = \frac{B^2}{2\mu_0}$

5. AC Circuits

6. Why do many electronic devices produce a noticeable spark when switched off?

r/AskElectronics · 12 yr. ago
[deleted]

Why "Physically" Does inductive kickback happen?

theory

I understand that it happens, but what causes the increasing voltage when U short out a path to a fully charged inductor for instance......and why does it reverse polarity? Im more concerned at the physics of whats causing this?

Thank you!

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ModernRonin · 12y ago
programmer w/screwdriver

To simplify and distort ch00f's explanation a bit...

When you start a current flowing through a coil, you're building up a magnetic field in and around the coil. That magnetic field is a form of stored energy, just as surely as the tension in a spring is.

Then when you snap off the current, the magnetic field collapses. But as it does, it gives back the energy it took to create it in the first place. This manifests as the inductor attempting to keep the current flowing through the coil. Even if there's nowhere for that current to go.

If it helps, visualize a balloon around the coil. As you start the current flowing, you're blowing up the balloon. When you stop the current, the balloon stops inflating, and instead starts collapsing, pushing current out of the coil.

10 · Reply · Award · Share · ...

[deleted] · 12y ago

Class Participation

1. 一開始就不知道問題是什麼
2. 眼界不夠開闊
3. 圖像