Homework Week 12

113-2 General Physics II

Due before 4:10 PM on May 12, 2025

Name 110703056 資科四 徐亭

1. [20 points] **Inductors in an AC Circuit**

Consider an AC circuit consisting only of an inductor connected to the terminals of an AC source as shown in Figure 32.6. (a) Show $i_L = \dfrac{\Delta V_{\max}}{\omega L} \sin\left(\omega t - \dfrac{\pi}{2}\right)$ [10 points] (b) Under what condition the current in an inductive circuit reaches its maximum value $I_{\max} = \dfrac{\Delta V_{\max}}{\omega L}$? [5 points] (c) What is the inductive reactance X_L = ? (in ω, L) [5 points]

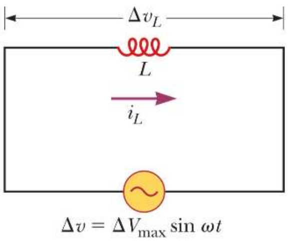

Figure 32.6 A circuit consisting of an inductor of inductance L connected to an AC source.

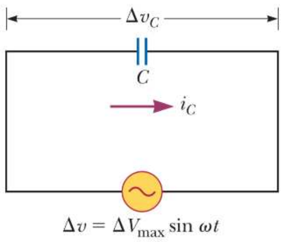

Figure 32.9 A circuit consisting of a capacitor of capacitance C connected to an AC source.

2. [20 points] **Capacitors in an AC Circuit**

Figure 32.9 shows an AC circuit consisting of a capacitor connected across the terminals of an AC source. (a) Show $i_C = \omega C \Delta V_{\max} \sin\left(\omega t + \dfrac{\pi}{2}\right)$ [10 points] (b) Under what condition the current in a capacitor circuit reaches its maximum value $I_{\max} = \omega C \Delta V_{\max} = \dfrac{\Delta V_{\max}}{(1/\omega C)}$? [5 points] (c) What is the capacitive reactance X_C = ? (in ω, C) [5 points]

3. [15 points] **Example 33.7** P

An electricity-generating station needs to deliver energy at a rate of 20 MW to a city 1.0 km away. A common voltage for commercial power generators is 22 kV, but a step up transformer is used to boost the voltage to 230 kV before transmission. (a) If the resistance of the wires is 2.0 Ω and the energy costs are about 0.11 $/kWh, estimate the cost of the energy converted to internal energy in the wires during one day. [10 points] (b) Repeat the calculation for the situation in which the Power plant delivers the energy at its original voltage of 22 kV. [5 points]

4. [10 points] **Example 32.4 Analyzing a Series RLC Circuit**

A series *RLC* circuit has $R = 425\,\Omega$, $L = 1.25\,H$, and $C = 3.50\,\mu F$. It is connected to an AC source with $f = 60.0\,Hz$ and $\Delta V_{max} = 150\,V$.

(a) Determine the inductive reactance, the capacitive reactance, and the impedance of the circuit. [3 points] (b) Find the maximum current in the circuit. [2 points] (c) Find the phase angle between the current and voltage. [2 points] (d) Find the maximum voltage across each element. [3 points]

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

6. [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：很慢很慢地把悠遊卡靠近讀卡機，可以感應成功嗎?

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) $\Delta V + \Delta V_L = 0$ (KVL)

$\Rightarrow \Delta V - L\frac{di}{dt} = 0$

$\Rightarrow L\frac{di}{dt} = \Delta V_{max} \sin \omega t$

$\Rightarrow di = \frac{\Delta V_{max}}{L} \sin \omega t \, dt$

$\Rightarrow i = \frac{\Delta V_{max}}{L} \int \sin \omega t \, dt$

Let $a = \omega t$

$\Rightarrow da = \omega dt$

$\Rightarrow i = \frac{\Delta V_{max}}{\omega L} \int \sin a \, da$

$\Rightarrow i = -\frac{\Delta V_{max}}{\omega L} \cos(\omega t)$

$\cos(\omega t)$

$= \sin(\frac{\pi}{2} - \omega t)$

$= -\sin(\omega t - \frac{\pi}{2})$

$\Rightarrow i = \frac{\Delta V_{max}}{\omega L} \sin(\omega t - \frac{\pi}{2})$ ✓

(b) When $\cos(\omega t) = -\sin(\omega t - \frac{\pi}{2}) = \pm 1$ ✓

(c) From (a), $X_L = \omega L$ ✓

2.

(a) $\Delta V + \Delta V_c = 0$

$\Rightarrow \Delta V - \frac{q}{C} = 0$

$\Rightarrow \Delta V = \frac{q}{C}$

$\Rightarrow q = C(\Delta V_{max} \sin \omega t)$

$\Rightarrow i = \frac{dq}{dt} = C \Delta V_{max} \sin \omega t \; dt$

$\Rightarrow i = \omega C \Delta V_{max} \cos \omega t$

$\Rightarrow i = \frac{\Delta V_{max}}{\frac{1}{\omega C}} \sin\left(\omega t + \frac{\pi}{2}\right)$

(b) When $\cos(\omega t) = \sin\left(\omega t + \frac{\pi}{2}\right) = \pm 1$

(c) From (a), $X_c = \frac{1}{\omega C}$

3.

(a)

$I_{rms} = \frac{P_{avg}}{\Delta V_{rms}} = \frac{20 \times 10^6}{230 \times 10^3} = 87 \text{ A}$

$$P_{wires} = I_{rms}^2 R = (87)^2 \times 2 = 15\ kW$$

$$T_{ET} = P_{wires}\,\Delta t = (15k)(24h) = 363\ kWh$$

$$Cost = 363 \times 0.11 = \$\,40$$

(b) $$I_{rms} = \frac{P_{avg}}{\Delta V_{rms}} = \frac{20\times 10^6}{22\times 10^3} = 909\ A$$

$$P_{wires} = I_{rms}^2 R = (909)^2\, 2 = 1.7\times 10^3\ kW$$

$$T_{ET} = P_{wires}\,\Delta t = (1.7\times 10^3\ kW)(24h)$$

$$= 4\times 10^4\ kWh$$

$$Cost = (4\times 10^4)(0.11) = \$\,4.4\times 10^3$$

4.

(a)

$$\omega = 2\pi f = 2\pi(60) = 120\pi\ (rad/s)$$

$$X_L = \omega L = (120\pi)(1.25) \approx 471\ (\Omega)$$

$$X_C = \frac{1}{\omega C} = \frac{1}{(120\pi)(3.5\times 10^{-6})} \approx 758\ (\Omega)$$

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

$$= \sqrt{(425)^2 + (471 - 758)^2} \approx 513\ (\Omega)$$

(b) $\Delta V_{max} = I_{max} \cdot Z$

$$\Rightarrow I_{max} = \frac{\Delta V_{max}}{Z}$$

$$= \frac{150}{513} \approx 0.29\ (A)$$

(c) $\phi = \tan^{-1} \frac{X_L - X_C}{R}$

$$= \tan^{-1} \frac{471 - 758}{425}$$

$$\approx -0.59\ (\text{rad})$$

(d) $\Delta V_{R\_max} = i_{max} R = 0.29 \times 425$

$$\approx 123\ (V)$$

$$\Delta V_{L\_max} = i_{max} X_L = 0.29 \times 471$$
$$\approx 137 \text{ (V)}$$

$$\Delta V_{C\_max} = i_{max} X_C = 0.29 \times 758$$
$$\approx 220 \text{ (V)}$$

5. Electromagnetic Waves

6.

(a) Why does the Z of a speaker matter when choosing an audio amplifier?

(b) impedance matching, amplifier output impedance, load compatibility

(c)

UNDERSTANDING SPEAKER IMPEDANCE AND ITS IMPACT ON SOUND QUALITY

ARTICLE SUMMARY

- Speaker impedance measures resistance to electrical current, crucial for optimal audio performance.
- Common impedance ratings are 4, 6, 8, and 16 ohms; matching them with amplifiers is vital.
- A mismatch can lead to distortion, poor sound quality, or even damage to your equipment.
- Enhance your audio-visual setup with the 1723 Tower THX for an immersive listening experience.
- Consider total impedance when wiring multiple speakers to achieve high-fidelity sound in your home theater.

WHAT IS SPEAKER IMPEDANCE?

When we talk about speaker impedance, we are referring to the resistance a speaker offers to the current and voltage applied to it. Impedance is measured in ohms, symbolized by the Greek letter Omega (Ω), and it plays a critical role in the performance of your home theater's audio system. Understanding impedance is essential for matching your speakers with the appropriate amplifier or receiver to ensure optimal sound quality and to avoid damaging your equipment.