13.6 Circuits with Capacitors and Inductors (LC Circuits)

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

Objective

Build the skills to answer exam questions on **circuits with capacitors and inductors (LC circuits)**.

You must be able to:

- describe the **oscillation** 振荡 of charge and current in an LC circuit
- explain the **energy exchange** between the capacitor's electric field and the inductor's magnetic field
- relate the **angular frequency** 角频率 to the elements, $\omega = \dfrac{1}{\sqrt{LC}}$
- compare LC oscillations with the **simple harmonic motion** of a mass on a spring

1 Worked examples

Study these first. Each one shows the method for a question type used later.

LC oscillation

With no resistance, the charge and current **oscillate**: energy sloshes back and forth between the capacitor's electric field and the inductor's magnetic field.

Angular frequency

$$\omega = \frac{1}{\sqrt{LC}}.$$

Like a mass on a spring

The LC circuit is the electrical analogue of simple harmonic motion (L plays the role of mass, $1/C$ the role of stiffness). Conservation of energy links the maximum charge to the maximum current: $\frac{1}{2}\dfrac{Q^2}{C} = \frac{1}{2}LI^2$.

2 Practice

2.1 Find the angular frequency of an LC circuit with $L = 2.0$ H and $C = 8.0\ \mu$F. [2]

2.2 State what oscillates in an LC circuit. [1]

2.3 State the mechanical system that an LC circuit is analogous to. [1]

3 Exam-style questions

3.1 The angular frequency of an LC circuit is [1]

- **A** $\frac{1}{LC}$
- **B** $\frac{1}{\sqrt{LC}}$
- **C** $\sqrt{LC}$
- **D** LC

3.2 In an LC circuit, energy is exchanged between the [1]

- **A** resistor and the battery
- **B** capacitor and the inductor
- **C** two resistors
- **D** two batteries

3.3 An LC circuit has $L = 0.50$ H and $C = 20$ μF.

(a) Find the angular frequency of oscillation. [3]

(b) State the mechanical system this behaves like. [1]

4 Go further

- work through the **13.6 Circuits with Capacitors and Inductors (LC Circuits)** lesson on the **Learn** page;
- read the **Electromagnetic Induction** section of the AP Physics C: E&M handout on the **Know** page.

Solutions

2.1 $\omega = \dfrac{1}{\sqrt{LC}} = \dfrac{1}{\sqrt{(2.0)(8.0 \times 10^{-6})}} = 250 \text{ rad s}^{-1}$.

2.2 the charge on the capacitor and the current in the inductor.

2.3 a mass on a spring (simple harmonic motion).

3.1 B.

3.2 B.

3.3 (a) $\omega = \dfrac{1}{\sqrt{LC}} = \dfrac{1}{\sqrt{(0.50)(20 \times 10^{-6})}} = \dfrac{1}{\sqrt{1.0 \times 10^{-5}}} = 316 \text{ rad s}^{-1}$. (b) a mass oscillating on a spring.