

13.5 Circuits with Resistors and Inductors (LR Circuits)

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS time constant 时间常数 • inductor 电感器 • emf 电动势

Objective

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

You must be able to:

- describe the **growth** and **decay** of current in an LR circuit
- explain how an inductor **opposes changes** in current
- define the **time constant** 时间常数 $\tau = \frac{L}{R}$
- analyse the **initial** and **steady-state** behaviour

1 Worked examples

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

■ Growth and decay

$$I(t) = \frac{\varepsilon}{R} (1 - e^{-t/\tau}) \quad (\text{rising}), \quad I(t) = I_0 e^{-t/\tau} \quad (\text{falling}).$$

■ Time constant

$\tau = \frac{L}{R}$ sets how quickly the current settles.

■ Start and steady state

At $t = 0$ the inductor **opposes** the sudden change, so the current is 0 (it acts like a break); at steady state it passes current freely (like a plain wire), and $I = \varepsilon/R$.

2 Practice

2.1 Find the time constant of a 0.40 H inductor and a 20 Ω resistor. [2]

2.2 State the current in an LR circuit immediately after the switch closes. [1]

2.3 State the steady-state current for an emf of 12 V and $R = 6.0 \Omega$. [1]

3 Exam-style questions

3.1 The time constant of an LR circuit is [1]

- A RC
- B L/R
- C LR
- D R/L

3.2 At $t = 0$ in an LR circuit, an inductor behaves like [1]

- A a plain wire
- B a break (no current)
- C a battery
- D a capacitor

3.3 An LR circuit has $\mathcal{E} = 10 \text{ V}$, $R = 5.0 \, \Omega$, and $L = 0.25 \text{ H}$.

(a) Find the time constant.

[2]

(b) Find the final (steady-state) current.

[2]

Solutions

2.1 $\tau = \frac{L}{R} = \frac{0.40}{20} = 0.020 \text{ s}.$

2.2 zero (the inductor opposes the sudden change).

2.3 $I = \frac{\mathcal{E}}{R} = \frac{12}{6.0} = 2.0 \text{ A}.$

3.1 B.

3.2 B.

3.3 (a) $\tau = \frac{L}{R} = \frac{0.25}{5.0} = 0.050 \text{ s}.$ (b) $I = \frac{\mathcal{E}}{R} = \frac{10}{5.0} = 2.0 \text{ A}.$