AP PHYSICS C: ELECTRICITY AND MAGNETISM • EXERCISE SHEET

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 $\tau = \dfrac{L}{R}$
- 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**

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

■ **Time constant**

$\tau = \dfrac{L}{R}$ 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 B C D

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 B C D

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

3.3 An LR circuit has $\varepsilon = 10$ V, $R = 5.0\ \Omega$, and $L = 0.25$ H.

(a) Find the time constant. [2]

(b) Find the final (steady-state) current. [2]