

Exercise walk-through

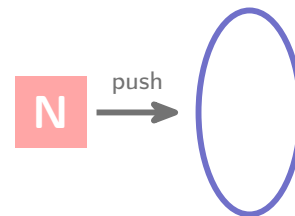
13.6

Circuits with Capacitors and Inductors (LC Circuits)

AP Physics C: Electricity and Magnetism

What we will cover

- 1 Magnetic flux
- 2 Faraday's law and Lenz's law
- 3 Induced currents and forces
- 4 Inductance
- 5 LR and LC circuits



The sliding rod on rails

$$L = 0.20 \text{ m at } 3.0 \text{ m/s across } 0.50 \text{ T}$$

$$\varepsilon = BLv = 0.50(0.20)(3.0) = 0.30 \text{ V}$$

The rod sliding on conducting rails, closed by a resistor, is the setup every question is built from: the growing loop area changes the flux.

Once a current flows, the field pushes back on it ($\vec{F} = \int I d\vec{l} \times \vec{B}$), and by Lenz's law that force always **resists the motion** that caused it. Push harder, get more current, feel more drag – the mechanical work is what becomes electrical energy.

Faraday's law is also the third of **Maxwell's equations** :
a changing magnetic flux creates a **circulating electric field**.

Exam tips

- Compute **flux** $\Phi_B = \int \vec{B} \cdot d\vec{A}$ and get the induced EMF from **Faraday's law**
 $\varepsilon = -\frac{d\Phi_B}{dt}$.
- Use **Lenz's law** (the minus sign) to fix the direction: the induced current opposes the change in flux.
- Flux changes three ways – changing B , changing area, or changing angle – identify which and differentiate.
- For a rod of length L moving at speed v , the motional EMF is BLv .
- An inductor stores energy $\frac{1}{2}LI^2$ and resists **changes** in current (RL time constant $\tau = L/R$).

Exercises 2.1-2.3

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

Exercises 2.1-2.3

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

2.1

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

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

2.2

- the charge on the capacitor and the current in the inductor

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

2.3

- a mass on a spring (simple harmonic motion)

Exercise 3.1

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

Exercise 3.1

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

3.1 B

• $\frac{1}{\sqrt{LC}}$.

Exercise 3.2

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

Exercise 3.2

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

3.2 B

- capacitor and the inductor.

Exercise 3.3 (a)

3.3 An LC circuit has $L = 0.50$ H and $C = 20 \mu\text{F}$.

(a) Find the angular frequency of oscillation.

[3]

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(a) Find the angular frequency of oscillation.

[3]

(a)

$$\bullet \quad \omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{(0.50)(20 \times 10^{-6})}} = \frac{1}{\sqrt{1.0 \times 10^{-5}}} = 316 \text{ rad s}^{-1}$$

Exercise 3.3 (b)

3.3 An LC circuit has $L = 0.50$ H and $C = 20 \mu\text{F}$.

(b) State the mechanical system this behaves like.

[1]

Exercise 3.3 (b)

3.3 An LC circuit has $L = 0.50$ H and $C = 20 \mu\text{F}$.

(b) State the mechanical system this behaves like.

[1]

(b)

- a mass oscillating on a spring