Exercise walk-through

Inductance ▪ 13.4

eXercise

You must be able to

- define **inductance** 电感 and its unit the **henry** 亨利
- relate the **back emf** 反电动势 to the rate of change of current, $\varepsilon = -L\dfrac{dI}{dt}$
- calculate the **energy stored** in an inductor, $U = \frac{1}{2}LI^2$
- relate stored energy to the magnetic **energy density** $u = \dfrac{B^2}{2\mu_0}$

Method — Inductance

$L = \dfrac{N\Phi_B}{I}$, measured in henries (H). It measures how much flux linkage a current produces.

Method — Back emf

$\varepsilon = -L\dfrac{dI}{dt}$ — an inductor opposes **changes** in current with an induced (back) emf.

Method — Energy stored

$U = \frac{1}{2} L I^2$, held in the magnetic field (energy density $u = \dfrac{B^2}{2\mu_0}$).

Practice 2.1 ▪ 2 marks

An inductor produces a back emf of 6.0 V when the current changes at 3.0 A s^{-1}. Find its inductance.

Solution 2.1

Method: Back emf

Worked steps

$$L = \frac{|\varepsilon|}{|dI/dt|} = \frac{6.0}{3.0} = 2.0 \text{ H}$$ M1 A1.

Practice 2.2 ▪ 2 marks

Find the energy stored in a 0.50 H inductor carrying 4.0 A.

Solution 2.2

Method: Energy stored

Worked steps

$U = \frac{1}{2}LI^2 = \frac{1}{2}(0.50)(4.0)^2 = 4.0$ J M1 A1.

Practice 2.3 ▪ 1 mark

State the SI unit of inductance.

Solution 2.3

Worked steps

the henry (H) B1.

Exam-style 3.1 ▪ 1 mark

The back emf across an inductor is

A LI

B $-L\dfrac{dI}{dt}$

C $\frac{1}{2}LI^2$

D I/L

Solution 3.1

Method: Back emf

A LI

B $-L\dfrac{dI}{dt}$ ✓

C $\frac{1}{2}LI^2$

D I/L

Worked steps

B.

Exam-style 3.2 ▪ 1 mark

The energy stored in an inductor is

A LI

B $\frac{1}{2}LI^2$

C $\frac{1}{2}L^2I$

D LI^2

Solution 3.2

Method: Energy stored

A LI

B $\frac{1}{2}LI^2$ ✓

C $\frac{1}{2}L^2I$

D LI^2

Worked steps

B.

Exam-style 3.3 ▪ 2 marks

A 0.20 H inductor carries a current rising at 5.0 A s^{-1}.
(a) Find the back emf.
(b) Find the energy stored when the current reaches 3.0 A.

Solution 3.3

Method: Back emf

Worked steps

(a) $|\varepsilon| = L\dfrac{dI}{dt} = 0.20 \times 5.0 = 1.0$ V **M1** **A1**. (b) $U = \frac{1}{2}(0.20)(3.0)^2 = 0.90$ J **M1** **A1**.