

Exercise walk-through

21.1

Characteristics of alternating currents

A-Level Physics

What we will cover

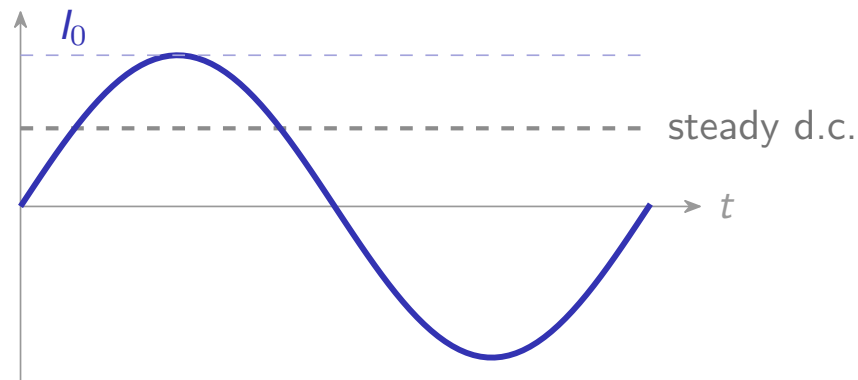
- 1 Alternating current basics
- 2 Power in a resistor
- 3 Root-mean-square values
- 4 Rectification and smoothing
- 5 Recap

Current that keeps reversing

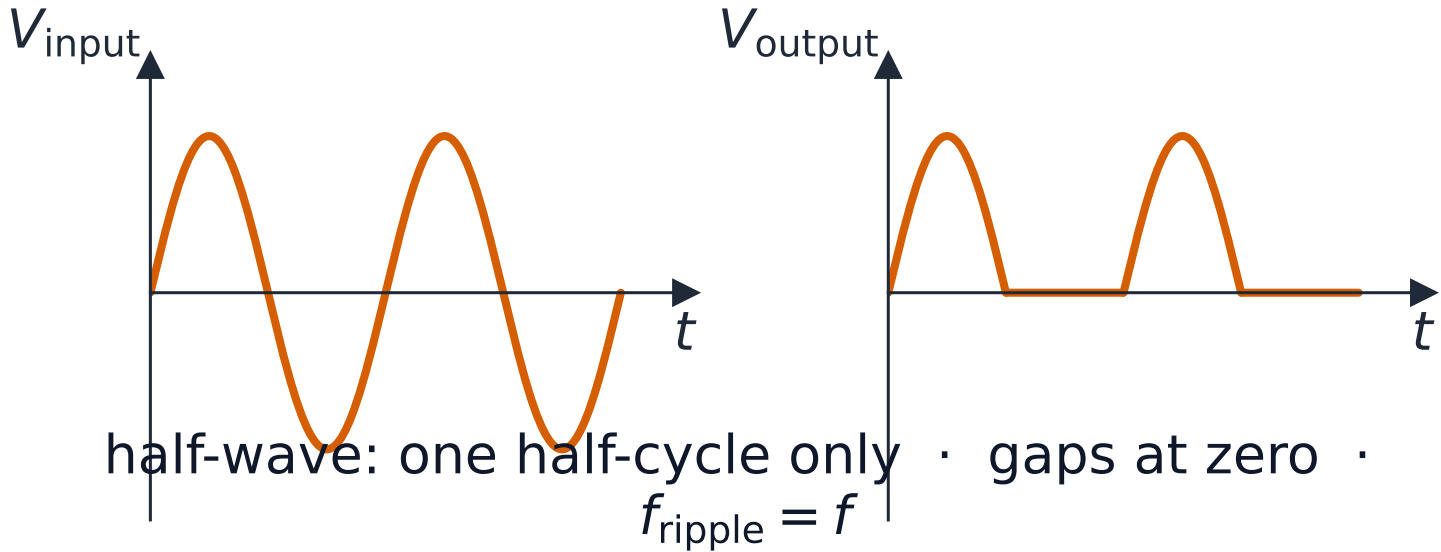
An **alternating current** keeps reversing direction. Mains is sinusoidal:

$$I = I_0 \sin(\omega t), \quad V = V_0 \sin(\omega t)$$

For a purely resistive load, V and I are in phase.



Half-wave rectification



In half-wave rectification a single diode passes only the positive half-cycles

Exercises 2.1-2.3

2.1 Define the **peak value** and the **period** of an alternating current. [2]

2.2 An a.c. has a peak current of 5.0 A. Find the **r.m.s.** current. [2]

2.3 State the relationship between the r.m.s. and peak **voltage**. [1]

Exercises 2.1·2.3

2.1 Define the **peak value** and the **period** of an alternating current.

[2]

2.1

- **peak value** – the maximum value in a cycle
- **period** – the time for one complete cycle

2.2 An a.c. has a peak current of 5.0 A. Find the **r.m.s.** current.

[2]

2.2

- $I_{\text{r.m.s.}} = I_0 / \sqrt{2}$

$$I_{\text{r.m.s.}} = \frac{I_0}{\sqrt{2}} = \frac{5.0 \text{ A}}{\sqrt{2}} = \mathbf{3.5 \text{ A}}$$

2.3 State the relationship between the r.m.s. and peak **voltage**.

[1]

2.3

- $V_{\text{r.m.s.}} = V_0 / \sqrt{2}$

Exercises 2.4·2.5

2.4 Mains frequency is 50 Hz. Find the **period**.

[1]

2.5 An a.c. voltage is $V = 18 \cos(40\pi t)$. State the **peak voltage** and the **angular frequency**.

[2]

Exercises 2.4·2.5

2.4 Mains frequency is 50 Hz. Find the **period**.

[1]

2.4

- $T = 1/f = 1/(50 \text{ Hz}) = \mathbf{0.020 \text{ s}}$

2.5 An a.c. voltage is $V = 18 \cos(40\pi t)$. State the **peak voltage** and the **angular frequency**.

[2]

2.5

- peak $V_0 = 18 \text{ V}$
- $\omega = 40\pi \text{ rad s}^{-1} (\approx 126 \text{ rad s}^{-1})$

Exercise 3.1

3.1 The r.m.s. value of a sinusoidal a.c. of peak I_0 is:

[1]

☐

A I_0

B $I_0/2$

C $I_0/\sqrt{2}$

D $2I_0$

Exercise 3.1

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[1]

☐

A I_0

B $I_0/2$

C $I_0/\sqrt{2}$

D $2I_0$

3.1 C

- $I_{\text{r.m.s.}} = I_0/\sqrt{2}$

Exercises 3.2-3.3

3.2 A sinusoidal supply has a peak voltage of 340 V. Calculate (a) the r.m.s. voltage,
(b) the mean power delivered to a $100\ \Omega$ resistor. [4]

3.3 Explain why the **mean power** in a resistor is **half** the peak power for a sinusoidal
a.c. [2]

Exercises 3.2-3.3

3.2 A sinusoidal supply has a peak voltage of 340 V. Calculate (a) the r.m.s. voltage, (b) the mean power delivered to a $100\ \Omega$ resistor. [4]

3.2

(a) $V_{\text{r.m.s.}} = V_0/\sqrt{2}$

$$V_{\text{r.m.s.}} = \frac{V_0}{\sqrt{2}} = \frac{340\ \text{V}}{\sqrt{2}} = \mathbf{240\ \text{V}}$$

(b) $P = V_{\text{r.m.s.}}^2/R$

$$P = \frac{V_{\text{r.m.s.}}^2}{R} = \frac{(240\ \text{V})^2}{100\ \Omega} = \mathbf{576\ \text{W}}$$

3.3 Explain why the **mean power** in a resistor is **half** the peak power for a sinusoidal a.c. [2]

3.3

- the power $P = I^2R$ varies as $\sin^2$, whose **average over a cycle is** $\frac{1}{2}$
- so the mean power is half the peak power I_0^2R

Exercise 3.4

3.4 An a.c. has a period of 0.020 s. Find the **angular frequency** ω .

[2]

Exercise 3.4

3.4 An a.c. has a period of 0.020 s. Find the **angular frequency** ω .

[2]

3.4

- $\omega = 2\pi/T$

$$\omega = \frac{2\pi}{T} = \frac{2\pi}{0.020 \text{ s}} = \mathbf{3.1 \times 10^2 \text{ rad s}^{-1}}$$

Exercise 3.5 (a)

3.5 A mains voltage is $V = 340 \sin(100\pi t)$, with V in volts and t in seconds.

(a) Show that the **period** is 0.020 s.

[2]

Exercise 3.5 (a)

3.5 A mains voltage is $V = 340 \sin(100\pi t)$, with V in volts and t in seconds.

(a) Show that the **period** is 0.020 s.

[2]

(a) $\omega = 100\pi \text{ rad s}^{-1}$

$$T = \frac{2\pi}{\omega} = \frac{2\pi}{100\pi \text{ rad s}^{-1}} = \mathbf{0.020 \text{ s}}$$

Exercise 3.5 (b)

3.5 A mains voltage is $V = 340 \sin(100\pi t)$, with V in volts and t in seconds.

(b) Calculate the **r.m.s. voltage** and the **mean power** delivered to a $60 \, \Omega$ heater. [3]

Exercise 3.5 (b)

3.5 A mains voltage is $V = 340 \sin(100\pi t)$, with V in volts and t in seconds.

(b) Calculate the **r.m.s. voltage** and the **mean power** delivered to a $60 \, \Omega$ heater. [3]

$$(b) \, V_{\text{r.m.s.}} = V_0/\sqrt{2} = 340 \, \text{V}/\sqrt{2} = 240 \, \text{V}$$

$$\langle P \rangle = \frac{V_{\text{r.m.s.}}^2}{R} = \frac{(240 \, \text{V})^2}{60 \, \Omega} = \mathbf{9.6 \times 10^2 \, \text{W}}$$