Transformers and the turns ratio

Worked solutions

GCSE science calculations

This topic online

1 **Higher tier**

A step-down transformer has 2000 turns on its primary coil and 100 turns on its secondary coil. The potential difference across the primary coil is 230 V.

Calculate the potential difference across the secondary coil. (2 marks)

$V_p \div V_s = n_p \div n_s$

$$\frac{230}{V_s} = \frac{2000}{100}$$

$$\frac{230}{V_s} = 20$$

$$V_s = 230 \div 20$$

11.5 V

2 **Higher tier**

In a lab, a step-up transformer is connected to a 12 V alternating supply. The primary coil has 50 turns and the secondary coil has 1000 turns.

Calculate the potential difference across the secondary coil. (2 marks)

$V_p \div V_s = n_p \div n_s$

$$\frac{12}{V_s} = \frac{50}{1000}$$

$$50 \times V_s = 12 \times 1000$$

$$V_s = 12\,000 \div 50$$

240 V

3 **Higher tier**

A transformer for a set of garden lights has a primary p.d. of 240 V and a primary current of 0.5 A. The p.d. across the secondary coil is 6 V. Assume the transformer is 100% efficient.

Calculate the current in the secondary coil. (2 marks)

$V_p \times I_p = V_s \times I_s$

$$240 \times 0.5 = 6 \times I_s$$

$$120 = 6 \times I_s$$

$$I_s = 120 \div 6$$

20 A

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4 **Higher tier**

A generator at a power station produces a potential difference of 25 kV. A step-up transformer has 1000 turns on its primary coil and 16 000 turns on its secondary coil.

Calculate the potential difference across the secondary coil in volts.

(3 marks)

Convert kV to V: 1 kV = 1000 V

$V_p = 25\ kV = 25\ 000\ V$

$V_p \div V_s = n_p \div n_s$

$$\frac{25\ 000}{V_s} = \frac{1000}{16\ 000}$$

$1000 \times V_s = 25\ 000 \times 16\ 000$

$V_s = 400\ 000\ 000 \div 1000$

400 000 V

5 **Higher tier**

A phone charger contains a transformer. The primary coil is connected to the 230 V mains. The secondary coil gives 5.0 V and a current of 2.0 A to the phone. Assume the transformer is 100% efficient.

Calculate the current in the primary coil in milliamps.

Give your answer to 2 significant figures.

(3 marks)

$V_p \times I_p = V_s \times I_s$

$230 \times I_p = 5.0 \times 2.0$

$230 \times I_p = 10$

$I_p = 10 \div 230$

$I_p = 0.04347...\ A$

Convert A to mA: multiply by 1000

$I_p = 43.47...\ mA$

43 mA

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6 **Higher tier**

A transformer at an electricity substation near Swindon steps the potential difference down from 132 kV to 11 kV. The current in the primary coil is 50 A. Assume the transformer is 100% efficient.

Calculate the current in the secondary coil. (3 marks)

Convert kV to V: 1 kV = 1000 V

$V_p = 132\ kV = 132\ 000\ V$

$V_s = 11\ kV = 11\ 000\ V$

$V_p \times I_p = V_s \times I_s$

$132\ 000 \times 50 = 11\ 000 \times I_s$

$6\ 600\ 000 = 11\ 000 \times I_s$

$I_s = 6\ 600\ 000 \div 11\ 000$

600 A

7 **Higher tier**

A doorbell runs from a small transformer. The transformer changes 230 V from the mains to 8.0 V for the bell. The primary coil has 1150 turns.

Calculate the number of turns on the secondary coil. (3 marks)

$V_p \div V_s = n_p \div n_s$

$$\frac{230}{8.0} = \frac{1150}{n_s}$$

$230 \times n_s = 1150 \times 8.0$

$230 \times n_s = 9200$

$n_s = 9200 \div 230$

40 turns

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8 **Higher tier**

A neon sign above a café in Brighton needs 9200 V. A step-up transformer connected to the 230 V mains supplies this. The secondary coil has 24 000 turns. The current in the primary coil is 0.40 A.

Calculate the number of turns on the primary coil. (3 marks)

Turns and p.d.s only, so the 0.40 A current is not needed

$V_p \div V_s = n_p \div n_s$

$$\frac{230}{9200} = \frac{n_p}{24\,000}$$

$$n_p \times 9200 = 230 \times 24\,000$$

$$n_p \times 9200 = 5\,520\,000$$

$$n_p = 5\,520\,000 \div 9200$$

600 turns

9 **Higher tier**

Rhys finds an old transformer in the school prep room. The coil that connects to the supply has 3000 turns. The coil that connects to a lamp has 250 turns. The lamp is working at 20 V and takes a current of 3.0 A.

Calculate the potential difference of the supply. (3 marks)

Only p.d.s and turns are needed, so the 3.0 A lamp current is not used

Supply coil = primary, so $n_p = 3000$

Lamp coil = secondary, so $n_s = 250$ and $V_s = 20$ V

$V_p \div V_s = n_p \div n_s$

$$\frac{V_p}{20} = \frac{3000}{250}$$

$$\frac{V_p}{20} = 12$$

$$V_p = 20 \times 12$$

240 V

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10 **Higher tier**

Ms Kowalski builds a model of the National Grid on a lab bench. Her step-up transformer has 100 turns on the primary coil and 2500 turns on the secondary coil. The primary coil is connected to a 12 V supply and the current in it is 2.5 A. Assume the transformer is 100% efficient.

a. Calculate the potential difference across the secondary coil.

b. Calculate the current in the secondary coil. Show your working.

(4 marks)

a)

$V_p \div V_s = n_p \div n_s$

$$\frac{12}{V_s} = \frac{100}{2500}$$

$100 \times V_s = 12 \times 2500$

$V_s = 30\,000 \div 100$

300 V

b)

$V_p \times I_p = V_s \times I_s$

$12 \times 2.5 = 300 \times I_s$

$30 = 300 \times I_s$

$I_s = 30 \div 300$

0.1 A

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11 **Higher tier**

A 60 W, 12 V lamp in a fish tank is powered from the 230 V mains through a step-down transformer. The lamp works at its normal power. The primary coil has 1150 turns. Assume the transformer is 100% efficient.

a. Calculate the current in the lamp.

b. Calculate the current in the primary coil. Give your answer to 2 significant figures.

c. Calculate the number of turns on the secondary coil. Show your working. (5 marks)

a)

Power = potential difference × current

$60 = 12 \times I$

$I = 60 \div 12$

5 A

b)

The lamp current is the secondary current, $I_s = 5$ A

$V_p \times I_p = V_s \times I_s$

$230 \times I_p = 12 \times 5$

$230 \times I_p = 60$

$I_p = 60 \div 230$

$I_p = 0.2608...$ A

0.26 A

c)

$V_p \div V_s = n_p \div n_s$

$$\frac{230}{12} = \frac{1150}{n_s}$$

$230 \times n_s = 1150 \times 12$

$n_s = 13\,800 \div 230$

60 turns

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12 **Higher tier**

At a substation, a step-down transformer takes electricity from 400 kV transmission cables and supplies a town at 11 kV. The primary coil has 8000 turns. The current supplied to the town by the secondary coil is 1200 A. Assume the transformer is 100% efficient.

a. Calculate the number of turns on the secondary coil.

b. Calculate the current in the transmission cables connected to the primary coil. Show your working.

(5 marks)

Convert kV to V: 1 kV = 1000 V

$V_p = 400\ kV = 400\ 000\ V$

$V_s = 11\ kV = 11\ 000\ V$

a)

$V_p \div V_s = n_p \div n_s$

$$\frac{400\ 000}{11\ 000} = \frac{8000}{n_s}$$

$400\ 000 \times n_s = 8000 \times 11\ 000$

$n_s = 88\ 000\ 000 \div 400\ 000$

220 turns

b)

$V_p \times I_p = V_s \times I_s$

$400\ 000 \times I_p = 11\ 000 \times 1200$

$400\ 000 \times I_p = 13\ 200\ 000$

$I_p = 13\ 200\ 000 \div 400\ 000$

33 A

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