

Percentages

Long workbook

Questions on GCSE Maths topics, including challenges beyond typical exam questions.

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Topic recap

Multipliers

An increase of 12% has multiplier 1.12. A decrease of 12% has multiplier 0.88.

Percentage change

percentage change = $\frac{\text{change}}{\text{original}} \times 100$. Use the original amount as the denominator.

Working backwards

If the final value is 80% of the original, divide the final value by 0.8.

Repeated change

After n equal changes, $\text{final} = \text{original} \times (\text{multiplier})^n$. A percentage change applies to the current amount each time. An increase followed by the same percentage decrease does not cancel: $1.1 \times 0.9 = 0.99$, a 1% fall overall.

A calculator may be used. Give money to the nearest penny unless the question specifies otherwise.

1. Multipliers and percentage change

Example Problem 1

★ ★

A price rises from £240 to £276. Find the percentage increase.

The idea

1. Find the change first.
2. Divide by £240, the original amount, then multiply by 100.

Worked Solution

$$276 - 240 = 36$$

$$\frac{36}{240} = 0.15$$

$$0.15 \times 100 = 15\%$$

Find the amount of the increase.

Compare it with the original price.

Convert the fraction to a percentage.

1 Multipliers and percentage change

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Q1 Find 18% of £250.

*

Q2 Increase £480 by 15%.

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Q3 A £75 coat is reduced by 24%. Find its sale price.

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Q4 A club grows from 160 members to 196. Find the percentage increase.

**

Q5 A journey time falls from 80 minutes to 66 minutes. Find the percentage decrease.

**

Q6 A price rises from £48 to £60. By what percentage must the new price fall to return to £48?

**

2. Reverse percentages

Example Problem 2

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After a 15% discount, a bag costs £51. Find the original price.

The idea

1. The sale price represents 85% of the original.
2. Divide by 0.85 to return to 100%.

Worked Solution

$$100\% - 15\% = 85\%$$

Identify the percentage that remains.

$$0.85p = 51$$

Let p be the original price.

$$p = 51 \div 0.85 = 60$$

Undo multiplication by 0.85.

2 Reverse percentages

Q7 After a 20% reduction, a jacket costs £68. Find its original price.

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Q8 A salary after a 4% rise is £31,200. Find the salary before the rise.

**

Q9 A bill including 20% VAT is £93.60. Find the bill before VAT.

**

Q10 A population has fallen by 12% to 748. Find its original size.

**

Q11 A price is increased by 25%, then reduced by 10%. The final price is £90. Find the original price.

Q12 A shop reduces a price by 30%. A further 5% discount is applied to the reduced price. The customer pays £133. Find the original price.

3. Repeated percentage change

Example Problem 3

£1,500 earns 4% compound interest annually for 3 years. Find the interest earned.

The idea

1. Calculate the balance using the multiplier 1.04^3 .
2. Subtract the deposit because the question asks for interest.

Worked Solution

$$1500(1.04)^3 = 1687.296$$

Find the final balance using three multipliers.

$$1687.296 - 1500 = 187.296$$

Subtract the original deposit.

$$\text{interest} = \text{£}187.30$$

Round the final money amount to the nearest penny.

3 Repeated percentage change

Q13 £1,200 earns 3% compound interest each year. Find its value after 2 years.

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Q14 A car worth £18,000 depreciates by 15% each year. Find its value after 3 years.

**

Q15 A town has 25,000 residents. Its population grows by 2% each year for 3 years. Find the predicted population.

**

Q16 A machine loses 8% of its value in year one and 12% in year two. Find its overall percentage loss.

Q17 An investment of £2,000 grows by 6% each year. After how many whole years does it first exceed £2,500?

Q18 £800 is invested at 5% simple interest for 3 years. Another £800 is invested at 5% compound interest for 3 years. How much more does the compound account contain?

4. Comparisons and unknown rates

Example Problem 4

A car is worth £12,000 and falls to £8,670 after 2 years at a constant annual depreciation rate. Find the rate.

The idea

1. Divide final value by original value to find the two-year multiplier.
2. Take its square root, then subtract from one.

Worked Solution

$$m^2 = \frac{8670}{12000} = 0.7225$$

$$m = \sqrt{0.7225} = 0.85$$

$$1 - 0.85 = 0.15 = 15\%$$

Let m be the annual remaining-value multiplier.

Take the positive root.

The multiplier shows 15% is lost each year.

4 Comparisons and unknown rates

★★★★

Q19 A shop offers 20% off followed by a further 10% off. Another shop offers 30% off the same starting price. Which is cheaper, and by what percentage of the starting price?

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Q20 A price is increased by 20% and then decreased by 20%. Find the overall percentage change.

★★★

Q21 An account grows from £2,500 to £2,756.25 in 2 years at a fixed annual compound rate. Find that rate.

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Q22 A phone loses 36% of its value over 2 years. It loses the same percentage of its value each year. Find that annual percentage.

Q23 A club has 40% junior members. After 12 juniors join, with no other changes, 50% of its members are juniors. How many members did it originally have?

Q24 A price rises by $p\%$ and then falls by $p\%$, where $0 < p < 100$. The final price is 91% of the original. Find p .

Solving principles

1. Name the starting value

Write which quantity represents 100% before calculating.

2. Multiply successive changes

Combine the multipliers; adding the percentages usually gives the wrong result.

3. Delay rounding

Keep the full calculator value until the final money or percentage answer.

4. Test a comparison

Apply both proposals to the same starting amount. For a threshold, check the years immediately before and after it.