Topics 4.5–4.8
Full edition:
Topics 5–8

Paper 2 Revision Booklet

ANSWERS AQA GCSE Physics 8463 · Foundation & Higher



Name _____ Class _____ Target grade _____

4.5 Forces	**4.6** Waves	**4.7** Magnetism	**4.8** Space physics

Work through a topic, then come back to it on the dates in your planner. Little and often beats one long cram.

Revise like a scientist

This booklet uses six revision techniques that research shows work best. Every activity is labelled with the technique it uses and the grade it targets.

Retrieval practice
Pulling ideas out of your memory makes them stick far better than re-reading. Brain dumps, quizzes and cover-and-recall tasks.

Spaced practice
Revisit each topic after 2 days, 1 week and 3 weeks. Forgetting a little, then remembering again, strengthens memory.

Interleaving
Mixed-topic questions train you to spot which idea a question needs, just like the real exam.

Dual coding
Words plus diagrams: graphs, ray diagrams and labelled apparatus give your memory two routes in.

Elaboration
Asking 'why?' and 'how?' and linking ideas together turns facts into understanding.

Worked examples
I do → We do → You do: study a full solution, finish a half-done one, then do one alone.

KEY

Grade pathways

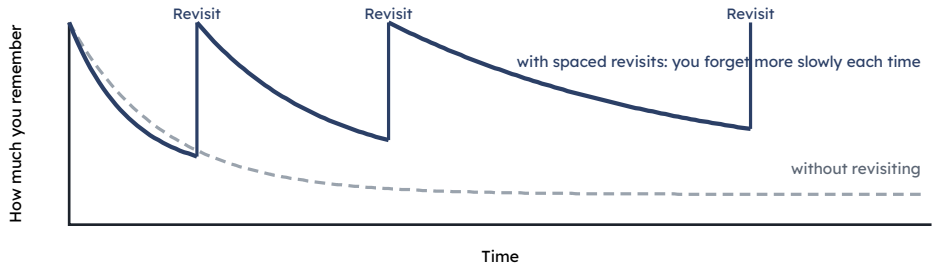
GRADE 4
Secure the basics: recall definitions and units, pick the right equation from the equation sheet, and do one-step calculations.

GRADE 5
Rearrange equations, convert units, describe practicals and explain in two linked steps.

GRADE 7+
Multi-step calculations, evaluate methods and data, and write logical 6-mark answers.

SPACED PRACTICE DUAL CODING

Why spacing works



SPACED PRACTICE

My spaced revision planner

Write the date you'll do each session. Tick it off when it's done.

Topic	First go	+2 days	+1 week	+3 weeks	Before the mock
4.5 Forces					
4.6 Waves					
4.7 Magnetism					
4.8 Space physics					
Paper 2 mixed quiz					

What's inside

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ROUTINE

The routine for every page

1. Try it cold. Answer from memory first, without notes. Struggling a bit is good: it's what makes learning stick.

2. Check and correct. Mark it with the answer booklet in a different colour pen. Fix every mistake.

3. Come back later. Redo anything you got wrong on your next spaced session.

ONLINE

Use it with mrsullyphysics.com

Flashcards for retrieval practice: cards you get wrong come back until you get them right.

Quizzes and Aim higher for extra Grade 5+ and 7+ questions with mark schemes.

Animations to see the physics move (dual coding).

Brain dump and checklist

RETRIEVAL PRACTICE | GRADE 4 | GRADE 5 | GRADE 7

Brain dump

Set a timer for 5 minutes. Write or draw everything you remember about forces. No notes! Afterwards, add anything you missed in a different colour.

Prompts if you get stuck: scalar/vector? · contact forces? · W = mg? · resultant force? · F = ke? · speed-time graphs? · Newton's laws? · stopping distance? · momentum?

METACOGNITION

How confident am I?

Rate each statement now (before) by shading R, A or G. Rate again at the end of the topic (after).

I can...	Before			After		
	R	A	G	R	A	G
Describe scalars and vectors, and contact and non-contact forces	○	○	○	○	○	○
Calculate weight (W = mg) and work done (W = Fs)	○	○	○	○	○	○
Calculate resultant forces, including with free body diagrams (vector diagrams: Higher)	○	○	○	○	○	○
Use F = ke and describe the force and extension practical (RP6)	○	○	○	○	○	○
Calculate moments and explain levers and gears (Physics only)	○	○	○	○	○	○
Calculate pressure in fluids and explain upthrust (Physics only)	○	○	○	○	○	○
Interpret distance–time and velocity–time graphs	○	○	○	○	○	○
Use $a = \Delta v \div t$ and $v^2 - u^2 = 2as$	○	○	○	○	○	○
Apply Newton's three laws and explain terminal velocity (RP7)	○	○	○	○	○	○
Explain the factors affecting thinking and braking distance	○	○	○	○	○	○
Use p = mv and conservation of momentum (Higher)	○	○	○	○	○	○

Extra practice

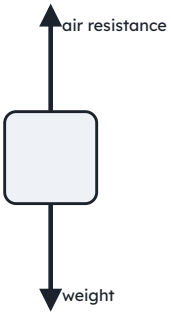
Retrieval · answers in the answer booklet

1 Fill the gap: The area under a velocity–time graph gives the _____ travelled. [1]

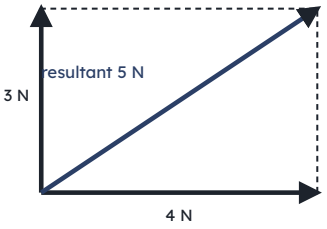
distance. Gradient = acceleration, area = distance (Higher).

DUAL CODING | GRADE 4 | GRADE 5 | GRADE 7

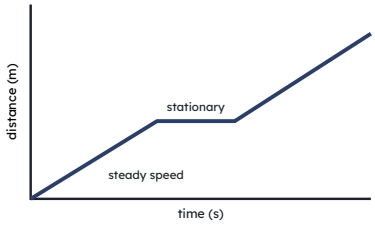
FORCES AND RESULTANTS · MOTION GRAPHS



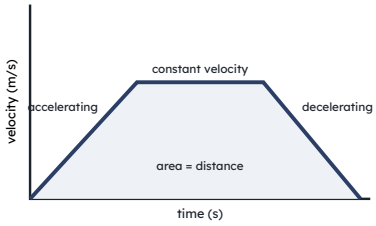
Free body diagram: skydiver



Vector diagram: forces added tip-to-tail (Higher)



gradient = speed



gradient = acceleration

KEY EQUATIONS: ALL GIVEN ON THE PHYSICS EQUATIONS SHEET IN THE EXAM

Equation	Quantities and units	Watch out
W = m g	weight (N), mass (kg), gravitational field strength (N/kg)	g = 9.8 N/kg on Earth
W = F s	work done (J), force (N), distance moved along the line of the force (m)	1 J = 1 N m
F = k e	force (N), spring constant (N/m), extension (m)	Only up to the limit of proportionality
M = F d	moment (N m), force (N), perpendicular distance from the pivot (m) (Physics only)	Perpendicular distance
p = F ÷ A	pressure (Pa), force normal to the surface (N), area (m^2) (Physics only)	1 Pa = 1 N/m^2
p = h ρ g	pressure (Pa), height of column (m), density (kg/m^3), g (N/kg) (Physics only, Higher)	Pressure increases with depth
s = v t	distance (m), speed (m/s), time (s)	km → m, minutes → s
a = Δv ÷ t	acceleration (m/s^2), change in velocity (m/s), time (s)	Negative a = deceleration
$v^2 - u^2 = 2$ a s	final velocity (m/s), initial velocity (m/s), acceleration (m/s^2), distance (m)	Square the velocities
F = m a	resultant force (N), mass (kg), acceleration (m/s^2)	Use the resultant force
p = m v	momentum (kg m/s), mass (kg), velocity (m/s) (Higher)	Momentum has a direction
F = m Δv ÷ Δt	force (N) = rate of change of momentum (Higher)	Longer time → smaller force

TURN OVER

Key words, misconceptions, required practicals and Grade 7+ links are on the next page.

Knowledge organiser: key words, misconceptions, practicals

ELABORATION | GRADE 4 | GRADE 5 | GRADE 7

KEY WORDS: LEARN THESE WORD FOR WORD (SAME AS SIDE 2 OF YOUR KNOWLEDGE ORGANISER)

Scalar: size only (speed, distance, mass, energy, time).
Vector: size and direction (velocity, displacement, force, acceleration, momentum).
Weight: the force acting on an object due to gravity; acts at the centre of mass.
Resultant force: a single force that has the same effect as all the original forces acting together.
Work done: energy transferred when a force moves an object through a distance.
Limit of proportionality: the point beyond which extension is no longer proportional to force.
Terminal velocity: the constant velocity reached when the resultant force on a falling object is zero.
Newton's First Law: if the resultant force is zero, a stationary object stays still and a moving object continues at the same velocity.
Newton's Second Law: acceleration is proportional to the resultant force and inversely proportional to the mass (F = ma).
Newton's Third Law: whenever two objects interact, the forces they exert on each other are equal and opposite.
Inertia (Higher): the tendency of objects to continue in their state of rest or of uniform motion.
Stopping distance: thinking distance (during reaction time) + braking distance (under the braking force).

MISCONCEPTIONS: SPOT THE MISTAKE

× Common mistake	✓ What's actually true
× A moving object needs a resultant force.	✓ Constant velocity means zero resultant force (Newton's First Law).
× Mass and weight are the same.	✓ Mass (kg) doesn't change; weight (N) depends on g.
× Third Law pairs cancel out.	✓ They act on different objects, so they can't cancel.

RP6: FORCE AND EXTENSION

Aim: Investigate how adding weights affects the extension of a spring.
Change: Force (weight added) · **Measure:** Extension · **Control:** Same spring
Must include: Measure the original length; Calculate extension, not just length; Add equal force steps; Plot force against extension.
Common mistake: Plotting length instead of extension.

RP7: ACCELERATION

Aim: Investigate how force and mass affect the acceleration of an object.
Change: Force (or mass) · **Measure:** Acceleration · **Control:** Mass (when changing force), force (when changing mass), surface
Must include: Investigate both effects: varying force at constant mass, and varying mass at constant force; Identify which variable is changed and which is kept constant; Keep the total mass constant when changing force; Measure acceleration with light gates or timings.
Common mistake: Adding masses to the hanger without removing them from the trolley.

AIM FOR GRADE 7+

- $v^2 - u^2 = 2as$ for braking distances; $F = m\Delta v \div \Delta t$ for collisions (Higher).
- Explain terminal velocity in steps: forces → resultant → acceleration.
- Describe RP7 with how to keep the investigation valid (constant total mass).

Extra practice

Retrieval · answers in the answer booklet

1 Which law says force = mass × acceleration? [1]

A Newton's Second Law **B** Newton's First Law **C** Newton's Third Law **D** Hooke's law

A: Newton's Second Law. F = ma.

RETRIEVAL PRACTICE | SPACED PRACTICE | GRADE 4 | GRADE 5

Equation sheet skills: which equation, which unit?

Every equation is on the Physics Equations Sheet, but it won't tell you which one a question needs or what unit the answer has. Cover the knowledge organiser and fill in the table. Redo it on another day.

Situation	Which equation?	Unit of the answer	Redo 1 ✓/×	Redo 2 ✓/×
A 70 kg astronaut stands on Mars. What is her weight?	**W = m g**	**N (newtons)**		
A box is pushed 12 m along the floor. How much energy is transferred?	**W = F s**	**J**		
A spring stretches when a mass is hung on it. What is the force?	**F = k e**	**N (extension in m)**		
A car speeds up from 10 m/s to 25 m/s in 5 s. How quickly?	**a = Δv ÷ t**	**m/s²**		
A car brakes from 20 m/s to rest. How far does it travel?	**v² – u² = 2 a s**	**m**		
What resultant force accelerates a 1200 kg car at 2 m/s²?	**F = m a**	**N**		

RETRIEVAL PRACTICE | GRADE 4 | GRADE 5

Fill the gaps

Use the AQA key words. No word bank: that's the point.

1. A quantity with size and direction is a **vector** quantity.
2. The force acting on an object due to gravity is its **weight**.
3. When a force moves an object, work is **done** and energy is transferred.
4. Stopping distance = thinking distance + **braking** distance.
5. The tendency of objects to continue in their state of rest or uniform motion is called **inertia** (Higher).

ELABORATION | GRADE 5

Odd one out

Circle the odd one out in each row and explain why.

1. speed · mass · velocity · distance

Velocity: it's a vector; the others are scalars.

2. friction · air resistance · gravity · tension

Gravity: it's a non-contact force.

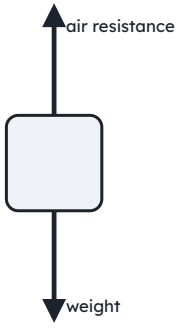
3. W = mg · F = ma · W = Fs · v = fλ

v = fλ: it is a waves equation; the others are forces equations.

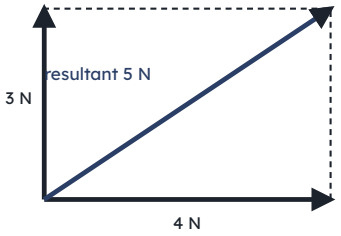
DUAL CODING | GRADE 4 | GRADE 5 | GRADE 7

Forces in diagrams

Use the diagrams to answer.



Free body diagram: skydiver



Vector diagram: forces added tip-to-tail (Higher)

a Name the two forces on the skydiver. [2]

Weight (down) and air resistance (up)

b Weight = 700 N, air resistance = 700 N. Describe the motion. [2]

Resultant force is zero,

so she falls at a constant (terminal) velocity.

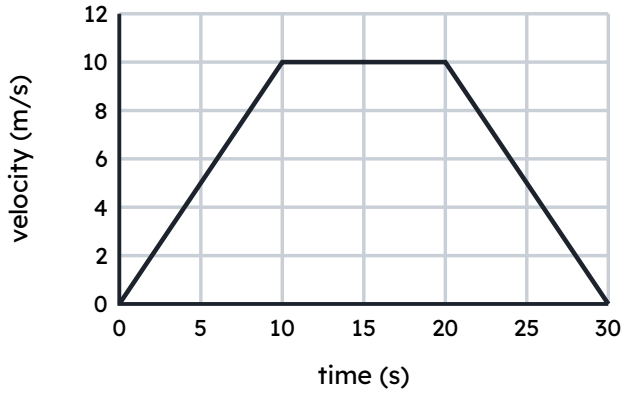
c Two forces of 4 N and 3 N act at right angles. Calculate the resultant. (Higher) [2]

5 N (3-4-5 triangle / scale drawing)

DUAL CODING | GRADE 5 | GRADE 7

Read the velocity–time graph

A cyclist's journey. Use the graph.



a Calculate the acceleration in the first 10 s. [2]

a = 10 ÷ 10 = 1 m/s²

b Describe the motion from 10 s to 20 s. [1]

Constant velocity of 10 m/s

c Calculate the total distance travelled (area under the graph). [3]

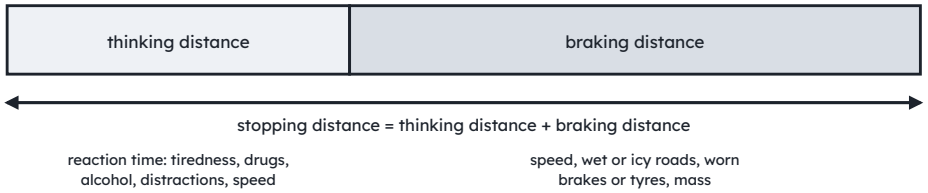
½×10×10 + 10×10 + ½×10×10

= 50 + 100 + 50 = 200 m

Picture it (continued)

DUAL CODING GRADE 4 GRADE 5

Stopping distances



a A driver has been drinking alcohol. Which part of the stopping distance increases? [1]

Thinking distance (longer reaction time)

b The road is icy. Which part increases, and why? [2]

Braking distance,

because there is less friction between tyres and road.

Extra practice

Retrieval · answers in the answer booklet

1 Grade 5 A 10 kg trolley has a 50 N force to the right and a 30 N force to the left acting on it. Calculate the resultant force and the acceleration. [3]

Resultant = 50 – 30 = 20 N to the right

$a = F \div m = 20 \div 10$

$a = 2\ m/s^2$ (to the right)

2 Grade 5 A cyclist travels 1.2 km in 4 minutes. Calculate their average speed in m/s. [2]

1.2 km = 1200 m; 4 min = 240 s

$v = s \div t = 1200 \div 240 = 5\ m/s$

3 Grade 5 A car accelerates from rest to 24 m/s in 8 s. Calculate its acceleration. [2]

$a = \Delta v \div t = 24 \div 8$

$a = 3\ m/s^2$

4 Grade 7+ A 0.15 kg ball moving at 20 m/s is caught and stopped in 0.05 s. Calculate the force on the hand, then explain why pulling your hands back reduces it. [4]

$F = m\Delta v \div \Delta t = 0.15 \times 20 \div 0.05$

F = 60 N

Pulling back increases the time taken to stop the ball

Same change in momentum over a longer time, so smaller rate of change of momentum and

smaller force

WORKED EXAMPLES | GRADE 4 | GRADE 5

Weight and work done

I do (worked example)

Calculate the weight of a 5 kg bag. (g = 9.8 N/kg)

1. W = mg
2. W = 5 × 9.8
3. **W = 49 N**

Mass in kg, weight in N

We do (finish it)

Push a box with 40 N for 6 m.

1. W = Fs
2. W = 40 × ___ **6**
3. W = ___ J **240**

You do

A 60 kg person on the Moon (g = 1.6).

W = mg

= 60 × 1.6

= 96 N

WORKED EXAMPLES | GRADE 4 | GRADE 5

Acceleration and F = ma

I do (worked example)

A car goes from 5 to 25 m/s in 4 s.

1. a = Δv ÷ t
2. Δv = 25 − 5 = 20 m/s
3. a = 20 ÷ 4
4. **a = 5 m/s²**

We do (finish it)

Resultant 600 N on a 300 kg boat.

1. a = F ÷ m
2. a = 600 ÷ ___ **300**
3. a = ___ m/s² **2**

You do

Calculate the force needed to accelerate 1500 kg at 3 m/s².

F = ma

= 1500 × 3

= 4500 N

WORKED EXAMPLES | GRADE 7

Rearranging: the next step

Grade 7+ questions often need two equations or a rearrangement.

1 A car travelling at 20 m/s brakes with a deceleration of 5 m/s². Calculate the braking distance. [3]

$v^2 - u^2 = 2as$: $0 - 20^2 = 2 \times (-5) \times s$

$-400 = -10s$

$s = 40$ m

2 A spring (k = 25 N/m) is stretched by 8 cm. Calculate the force and the energy stored. [4]

$e = 0.08$ m; $F = ke = 25 \times 0.08 = 2$ N

$Ee = \frac{1}{2}ke^2 = 0.5 \times 25 \times 0.08^2$

$= 0.08$ J

WORKED EXAMPLES | GRADE 5 | GRADE 7

Momentum (Higher)

I do (worked example)

A 2 kg trolley at 3 m/s hits a still 1 kg trolley; they stick.

1. p before = 2 × 3 = 6 kg m/s
2. Momentum is conserved (closed system)
3. 6 = (2 + 1) × v
4. **v = 2 m/s**

We do (finish it)

A 1000 kg car at 12 m/s.

1. p = mv
2. p = 1000 × ___ **12**
3. p = ___ kg m/s **12 000**

You do

A 70 kg skater at 4 m/s.

p = mv

= 70 × 4

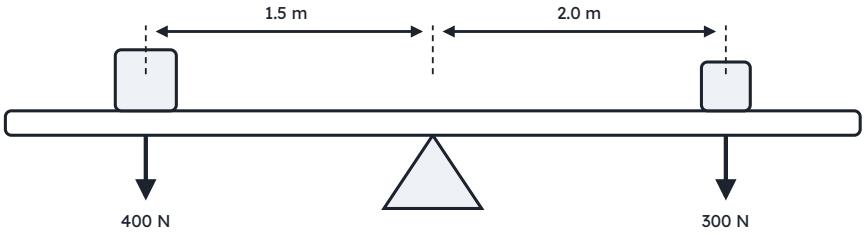
= 280 kg m/s

WORKED EXAMPLES | GRADE 5

Moments (Physics only)

Balanced when clockwise moment = anticlockwise moment (Physics only)

400 × 1.5 = 600 N m 300 × 2.0 = 600 N m



a Calculate the moment of the 400 N child about the pivot. [2]

M = Fd = 400 × 1.5 = 600 N m

b Show the see-saw is balanced. [2]

300 × 2.0 = 600 N m

Clockwise = anticlockwise moments, so balanced.

ELABORATION | GRADE 5

Spot the mistake

Each student has made one mistake. Find it and correct it.

1 Dev: "A 50 kg girl has a weight of 50 N." [1]

Weight = mg = 50 × 9.8 = 490 N; mass (kg) ≠ weight (N).

2 Eli: "A car going from 10 to 30 m/s in 4 s has a = 30 ÷ 4 = 7.5 m/s²." [2]

Use the change in velocity: (30 – 10) ÷ 4 = 5 m/s².

3 Fin: "A spring stretched 5 cm with k = 40 N/m has F = 40 × 5 = 200 N." [2]

Convert to metres: F = 40 × 0.05 = 2 N.

Why? How? Explaining forces

ELABORATION GRADE 4 GRADE 5 GRADE 7

Build an explanation

Answer each question in two steps. Use the starter, then push yourself with the Grade 7+ extension.

1 Explain how a skydiver reaches terminal velocity.

Grade 4–5 starter: "At first, weight is bigger than air resistance, so…"

At first weight is bigger than air resistance, so there is a resultant force downwards and the skydiver accelerates.

Grade 7+ extension: "As speed increases, air resistance… so the resultant force…"

As speed increases, air resistance increases, so the resultant force and acceleration decrease; when air resistance = weight, resultant force is zero: terminal velocity.

2 Explain why an airbag reduces injury in a crash. (Higher)

Grade 4–5 starter: "The airbag increases the time…"

The airbag increases the time taken for the driver to stop. So the force on the driver is smaller.

Grade 7+ extension: "Link to momentum: force = rate of change of momentum, so…"

Force = change in momentum ÷ time; the same change in momentum over a longer time gives a smaller force.

3 Explain why driving faster makes the braking distance much longer.

Grade 4–5 starter: "Kinetic energy depends on speed squared, so…"

Kinetic energy depends on speed squared, so doubling the speed gives four times the kinetic energy. The brakes must transfer more energy.

Grade 7+ extension: "Link to work done by the brakes: W = F s, so…"

Work done by brakes = braking force × distance; with the same maximum braking force, the distance must be about four times longer.

ELABORATION GRADE 5

True or false? Justify it.

Saying why is worth more marks than saying true or false.

4 "A moving object must have a resultant force acting on it." [2]

False: an object moving at constant velocity has zero resultant force (Newton's First Law).

5 "The forces in a Newton's Third Law pair cancel out." [2]

False: they act on different objects, so they can't cancel each other.

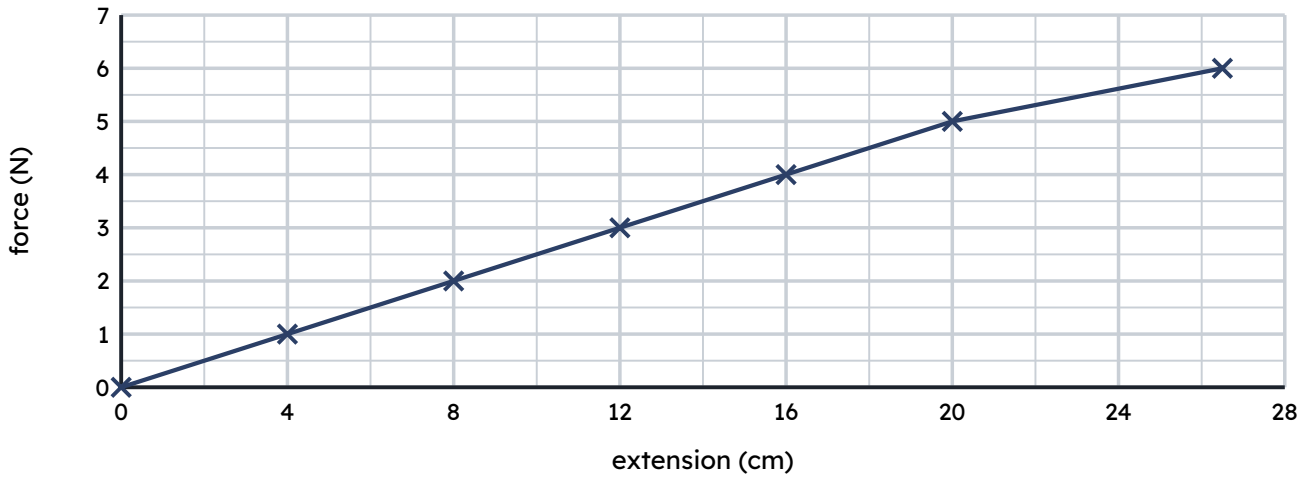
RP6: force and extension

DUAL CODING | WORKED EXAMPLES | GRADE 4 | GRADE 5 | GRADE 7

RP6: force and extension

A student hangs masses on a spring and measures its length. Original length = 5.0 cm.

Force (N)	0	1	2	3	4	5	6
Length (cm)	5.0	9.0	13.0	17.0	21.0	25.0	31.5
Extension (cm)	**0**	**4.0**	**8.0**	**12.0**	**16.0**	**20.0**	**26.5**



a Complete the extension row and plot force against extension. [3]

Points plotted; straight line through the origin up to 5 N, curving after.

b Use the straight section to calculate the spring constant. [2]

k = F ÷ e = 5 ÷ 0.20 m

= 25 N/m

c What does the last point show? [1]

The limit of proportionality has been exceeded.

d Suggest how to reduce parallax error. [1]

Read the ruler at eye level, using a pointer fixed to the spring.

Extra practice

Retrieval · answers in the answer booklet

1 Grade 7+ A 1200 kg car travelling at 20 m/s brakes and stops in 40 m. Calculate the average braking force. [4]

Ek = ½ × 1200 × 20² = 240 000 J

Work done by brakes = kinetic energy lost

F × 40 = 240 000

F = 6000 N

RP7: acceleration

RETRIEVAL PRACTICE | ELABORATION | GRADE 4 | GRADE 5 | GRADE 7

RP7: acceleration

A trolley is pulled by masses on a string over a pulley. Light gates measure the acceleration.

a To change the force, the student moves masses from the trolley to the hanger. Why? [2]

It keeps the total mass of the system constant,

so only the force changes (fair test).

b Why are light gates better than a stopwatch? [1]

They remove human reaction time, so timings are more accurate.

Force (N)	0.2	0.4	0.6	0.8	1.0
Acceleration (m/s²)	0.19	0.39	0.58	0.79	0.98

c Describe the relationship shown by the results. [2]

Acceleration is directly proportional to the resultant force

(doubling the force doubles the acceleration).

d Estimate the total mass of the system. [2]

m = F ÷ a = 1.0 ÷ 0.98

≈ 1.0 kg

e Then the force is kept at 0.5 N and the mass is doubled. Predict the effect on the acceleration. [1]

It halves: a is inversely proportional to mass.

f Give one hazard and a control measure. [1]

Falling masses: put a box/cushion under the hanger; stop the trolley at the end.

Extra practice

Retrieval · answers in the answer booklet

1 Grade 5 Explain the difference between a scalar and a vector, giving an example of each. [3]

A scalar has magnitude (size) only

A vector has magnitude and direction

Example pair, e.g. speed (scalar) and velocity (vector)

2 Grade 7+ A 2 kg trolley moving at 3 m/s collides with a stationary 1 kg trolley and they stick together. Calculate their velocity after the collision. [3]

Momentum before = 2 × 3 = 6 kg m/s

In a closed system momentum is conserved: total mass after = 3 kg

v = 6 ÷ 3 = 2 m/s

GRADE RADE 4

Secure the basics

1 Which of these is a vector? Tick one. ☐ speed ☐ mass ☐ velocity ☐ energy [1]

Velocity

2 Calculate the weight of a 2 kg book. (g = 9.8 N/kg) [2]

W = mg = 2 × 9.8

= 19.6 N

3 A person pushes a trolley with 30 N for 10 m. Calculate the work done. [2]

W = Fs = 30 × 10

= 300 J

4 Give two factors that increase thinking distance. [2]

Tiredness / alcohol / drugs

Distractions / higher speed

5 A runner covers 400 m in 80 s. Calculate her average speed. [2]

v = s ÷ t = 400 ÷ 80

= 5 m/s

GRADE RADE 5

Apply and rearrange

6 A resultant force of 2400 N acts on an 800 kg car. Calculate its acceleration. [2]

a = F ÷ m = 2400 ÷ 800

= 3 m/s²

7 A spring has a spring constant of 40 N/m. Calculate its extension when a 2 N force is applied. [3]

e = F ÷ k = 2 ÷ 40

= 0.05 m (5 cm)

8 Explain why a car moving at a steady speed on a flat road still needs a driving force. [2]

To balance the resistive forces (friction and air resistance),

so the resultant force is zero and the speed stays constant.

9 A ball is dropped and accelerates at 9.8 m/s². Calculate its speed after falling 5 m from rest. [3]

$v^2 - u^2 = 2as$: $v^2 = 2 \times 9.8 \times 5 = 98$

v = 9.9 m/s

GRADE RADE 7+

Stretch

10 A 1200 kg car moving at 15 m/s collides with a wall and stops in 0.2 s. Calculate the average force on the car. (Higher) [3]

Δp = 1200 × 15 = 18 000 kg m/s

F = Δp ÷ Δt = 18 000 ÷ 0.2

= 90 000 N

11 A student investigates how the mass of a trolley affects its acceleration when the force is constant. Describe a method and explain how to make the results valid. [6]

Trolley on a runway, string over a pulley to a hanging mass (constant force).

Light gates and interrupt card connected to a data logger measure acceleration.

Add masses to the trolley to change the mass; keep the hanging mass the same.

Compensate for friction by tilting the runway slightly.

Repeat each mass three times and calculate a mean; use at least five masses.

Plot a against 1/m: straight line → a ∝ 1/m. Hazard: falling masses (box underneath).

Total: _____ / 28

RETRIEVAL PRACTICE SPACED PRACTICE GRADE 4

Quick-fire retrieval: Forces

Cover everything. Answer in under 3 minutes. Redo it on your next spaced session.

1 Unit of momentum?

kg m/s

2 Gradient of a distance–time graph?

Speed

3 Area under a v–t graph? (Higher)

Distance travelled

4 g on Earth?

9.8 N/kg

5 Typical reaction time?

0.2–0.9 s

6 Newton's First Law, in a few words?

Zero resultant force: velocity doesn't change

Extra practice

Retrieval · answers in the answer booklet

1 Grade 7+ A 400 N child sits 1.5 m from the pivot of a see-saw. How far from the pivot must a 300 N child sit on the other side to balance it? [3]

Moment = Fd = 400 × 1.5 = 600 N m

Balanced: clockwise moment = anticlockwise moment

d = 600 ÷ 300 = 2.0 m

METACOGNITION

Re-rate yourself

Go back to the checklist at the start of this topic and fill in the 'After' column.

METACOGNITION GRADE 4 GRADE 5 GRADE 7

Exam wrapper: why did I drop marks?

After marking the exam practice, write the question numbers you got wrong in the right row.

Reason I lost marks	Question numbers	What to do next
I didn't know or remember it (knowledge gap)		Flashcards and brain dumps
I knew it but misread the question or command word		Underline command words
Maths slip: units, rearranging, standard form		Redo the "we do / you do" pages
I ran out of time or didn't finish		Timed practice: 1 mark per minute

METACOGNITION

Two things I'm now confident about

METACOGNITION

One thing I still need to work on, and how I'll fix it

e.g. 'Rearranging equations → redo the Grade 7+ questions and use the website's Aim higher section.'

SPACED PRACTICE

Book my next spaced sessions

Write the dates in the planner at the front: +2 days, +1 week, +3 weeks.

Extra practice

Retrieval · answers in the answer booklet

1 Fill the gap: The area under a velocity–time graph gives the _____ travelled. [1]

distance. Area = distance (or displacement) (Higher).

Brain dump and checklist

RETRIEVAL PRACTICE · GRADE 4 · GRADE 5 · GRADE 7

Brain dump

Set a timer for 5 minutes. Write or draw everything you remember about waves. No notes! Afterwards, add anything you missed in a different colour.

Prompts if you get stuck: transverse/longitudinal? · v = fλ? · EM spectrum order? · uses and dangers? · refraction? · lenses? · black body? · ultrasound? · seismic waves?

METACOGNITION

How confident am I?

Rate each statement now (before) by shading R, A or G. Rate again at the end of the topic (after).

I can...	Before			After		
	R	A	G	R	A	G
Describe transverse and longitudinal waves with examples	○	○	○	○	○	○
Define amplitude, wavelength, frequency and period; use v = fλ and T = 1/f	○	○	○	○	○	○
Describe how to measure wave speed in a ripple tank and on a string (RP8)	○	○	○	○	○	○
Describe reflection, refraction and the reflection/refraction practical (RP9, Physics only)	○	○	○	○	○	○
Explain refraction using wavefronts (Higher)	○	○	○	○	○	○
Recall the EM spectrum in order, with uses and dangers	○	○	○	○	○	○
Explain ultrasound and seismic waves (Physics only, Higher)	○	○	○	○	○	○
Use magnification and draw lens ray diagrams (Physics only)	○	○	○	○	○	○
Explain colour and filters (Physics only)	○	○	○	○	○	○
Describe the infrared practical and black body radiation (RP10)	○	○	○	○	○	○

Extra practice

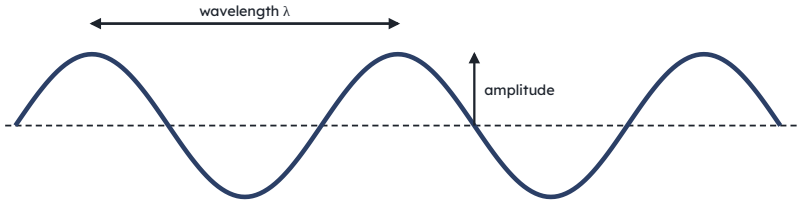
Retrieval · answers in the answer booklet

1 True or false? Microwaves are ionising radiation. Explain. [2]

False. Microwaves are not ionising. X-rays and gamma rays are ionising (and UV can damage skin cells).

DUAL CODING | GRADE 4 | GRADE 5 | GRADE 7

TRANSVERSE AND LONGITUDINAL WAVES



Transverse: oscillations perpendicular to the direction of energy transfer (e.g. light, water ripples)



Longitudinal: oscillations parallel to the direction of energy transfer (e.g. sound)

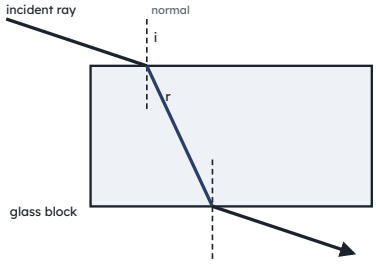
THE ELECTROMAGNETIC SPECTRUM

wavelength increases

Radio	Microwave	Infrared	Visible	Ultraviolet	X-ray	Gamma
TV, radio	satellites, cooking	heaters, IR cameras	fibre optics	tanning, energy-efficient lamps	medical imaging	medical imaging and treatment

frequency increases · shaded = can harm body tissue (UV, X-rays, gamma)

REFRACTION



Entering glass: slows down, changes direction towards the normal

Leaving glass: speeds up, changes direction away from normal

Measure angles from the normal

KEY EQUATIONS: ALL GIVEN ON THE PHYSICS EQUATIONS SHEET IN THE EXAM

Equation	Quantities and units	Watch out
v = f λ	wave speed (m/s), frequency (Hz), wavelength (m)	MHz → Hz: × 10^6
T = 1 ÷ f	period (s), frequency (Hz)	Period: time for one wave
magnification = image height ÷ object height	no units (Physics only)	Same units top and bottom

EM WAVES

Transverse; all travel at the same speed (3 × 10^8 m/s) in a vacuum; transfer energy from a source to an absorber.
Ionising: UV, X-rays, gamma: can damage cells; UV causes skin ageing and skin cancer risk.
Radiation dose is measured in sieverts (Sv).

TURN OVER

Key words, misconceptions, required practicals and Grade 7+ links are on the next page.

Knowledge organiser: key words, misconceptions, practicals

ELABORATION GRADE 4 GRADE 5 GRADE 7

KEY WORDS: LEARN THESE WORD FOR WORD (SAME AS SIDE 2 OF YOUR KNOWLEDGE ORGANISER)

Transverse: oscillations are perpendicular to the direction of energy transfer.
Longitudinal: oscillations are parallel to the direction of energy transfer; compressions and rarefactions.
Amplitude: the maximum displacement of a point on a wave away from its undisturbed position.
Wavelength: the distance from a point on one wave to the equivalent point on the adjacent wave.
Frequency: the number of waves passing a point each second (Hz).
Refraction: a change in direction when a wave changes speed crossing a boundary.
Perfect black body (PO): an object that absorbs all of the radiation incident on it; the best possible emitter.

MISCONCEPTIONS: SPOT THE MISTAKE

× Common mistake	✓ What's actually true
× Water travels along with the wave.	✓ Waves transfer energy, not matter.
× Sound travels through a vacuum.	✓ Sound needs particles to vibrate.
× All EM waves are dangerous.	✓ Only UV, X-rays and gamma rays harm body tissue; X-rays and gamma rays are ionising.
× Light bends when it goes into glass.	✓ Light travels in straight lines. It changes direction at the boundary because its speed changes.

RP8: WAVES

Aim: Make observations to identify suitable apparatus to measure the frequency, wavelength and speed of waves in a ripple tank and waves in a solid (a stretched string), and take appropriate measurements.
Change: Frequency (string) · **Measure:** Wavelength · **Control:** Water depth (ripple tank), tension and string length
Must include: Take measurements for both the ripple tank and waves in a solid (string); Justify why the apparatus is suitable; Measure across several wavelengths and divide; Determine frequency by counting over a set time or from the signal generator.
Common mistake: Measuring one wavelength only.

RP9: LIGHT (REFLECTION AND REFRACTION) (PO)

Aim: Investigate the reflection of light by different types of surface and the refraction of light by different substances.
Change: Angle of incidence · **Measure:** Angle of reflection or refraction · **Control:** Ray box, block material, width of ray
Must include: Test reflection from different types of surface; Test refraction in different substances; Draw a normal; Measure angles from the normal with a protractor.
Common mistake: Measuring angles from the surface instead of the normal.

RP10: RADIATION AND ABSORPTION

Aim: Investigate how the amount of infrared radiation absorbed or radiated by a surface depends on the nature of that surface.
Change: Type of surface · **Measure:** Infrared emitted (detector reading) · **Control:** Water temperature, distance from detector
Must include: Investigate absorption as well as emission; Same water temperature for all faces; Same distance from the detector; Record a reading for each surface.
Common mistake: Drawing a line graph for categoric data.

AIM FOR GRADE 7+

- Standard form and unit prefixes in $v = f\lambda$ (MHz, kHz, 3×10^8 m/s).
- Explain refraction using wavefronts (Higher).
- Echo questions: halve the total distance (Physics only, Higher).

RETRIEVAL PRACTICE SPACED PRACTICE GRADE 4 GRADE 5

Equation sheet skills: which equation, which unit?

Every equation is on the Physics Equations Sheet, but it won't tell you which one a question needs or what unit the answer has. Cover the knowledge organiser and fill in the table. Redo it on another day.

Situation	Which equation?	Unit of the answer	Redo 1 ✓/ ×	Redo 2 ✓/ ×
A sound has a frequency of 680 Hz and a wavelength of 0.5 m. How fast does it travel?	**$v = f\lambda$**	**m/s**		
A radio station broadcasts at 100 MHz. What is the wavelength?	**$\lambda = v \div f$**	**m (convert MHz → Hz)**		
A wave passes a point every 0.25 s. What is its frequency?	**$f = 1 \div T$**	**Hz**		
A ripple has a frequency of 4 Hz. How long is one oscillation?	**$T = 1 \div f$**	**s**		
A lens makes a 2 cm object look 10 cm tall. How much bigger?	**magnification = image ÷ object**	**no unit**		
Light travels at 3×10^8 m/s. Calculate λ for 6×10^{14} Hz.	**$\lambda = v \div f$**	**m**		

RETRIEVAL PRACTICE GRADE 4 GRADE 5

Fill the gaps

Use the AQA key words. No word bank: that's the point.

1. In a transverse wave the oscillations are **perpendicular** to the direction of energy transfer.
2. Sound waves are **longitudinal** waves.
3. When light enters glass it slows down and changes direction **towards** the normal.
4. The EM wave with the longest wavelength is **radio** waves.
5. A perfect black body **absorbs** all of the radiation incident on it (Physics only).

ELABORATION GRADE 5

Odd one out

Circle the odd one out in each row and explain why.

1. radio · microwave · sound · gamma

Sound: it's a longitudinal mechanical wave, not electromagnetic.

2. UV · X-rays · infrared · gamma

Infrared: the others can harm body tissue.

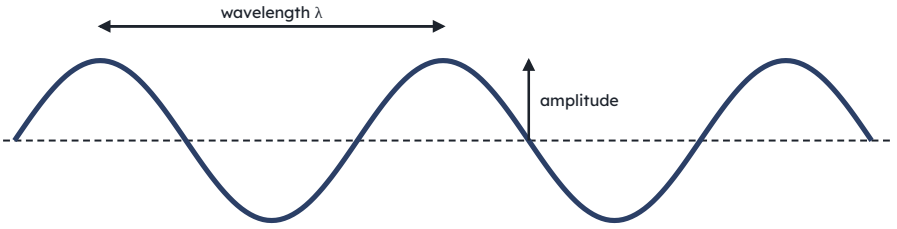
3. frequency · amplitude · wavelength · speed in a vacuum

Speed in a vacuum: it's the same for all EM waves; the others vary.

DUAL CODING GRADE 4 GRADE 5

Label the wave

Use the diagram.



Transverse: oscillations perpendicular to the direction of energy transfer (e.g. light, water ripples)

a The wave has 3 full waves in 0.6 m. Calculate the wavelength. [1]

λ = 0.6 ÷ 3 = 0.2 m

b Its frequency is 15 Hz. Calculate the wave speed. [2]

v = fλ = 15 × 0.2 = 3 m/s

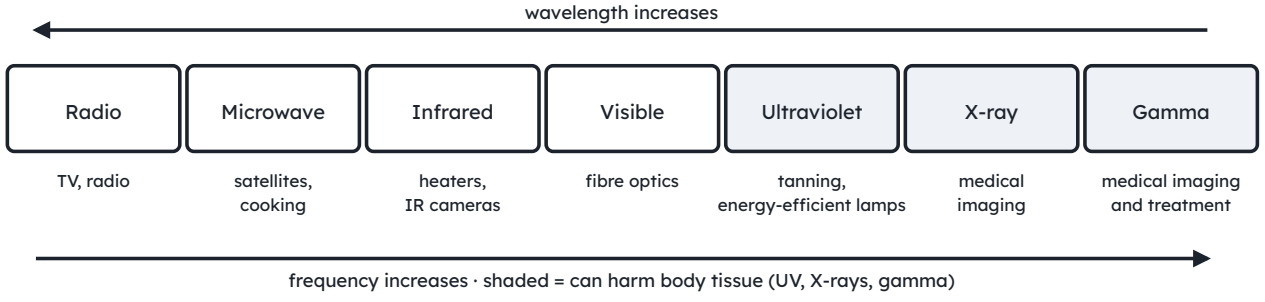
c Is it transverse or longitudinal? Explain. [2]

Transverse:

oscillations are perpendicular to the direction of energy transfer.

DUAL CODING GRADE 4

EM spectrum: order and uses



a Which EM wave is used for satellite communications? [1]

Microwaves

b Name the three ionising EM waves and one hazard. [2]

UV, X-rays and gamma; they can damage cells / cause cancer.

Extra practice

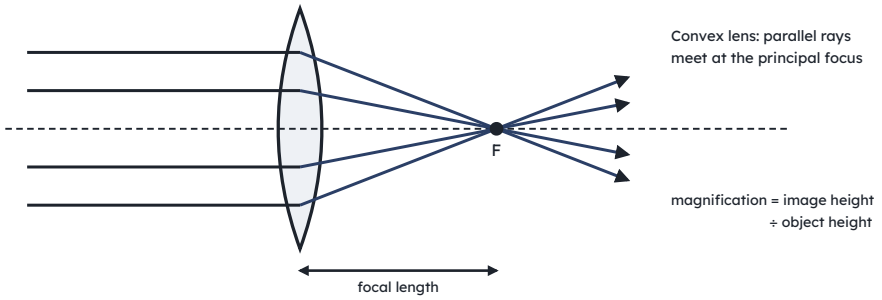
Retrieval · answers in the answer booklet

1 True or false? S-waves can travel through liquids. Explain. [2]

False. S-waves are transverse and can't pass through liquids, which is evidence for a liquid outer core.

DUAL CODING GRADE 5

Lens ray diagram (Physics only)



a What is the point where the rays meet called? [1]

The principal focus

b An image is 6 cm tall; the object is 1.5 cm tall. Calculate the magnification. [2]

6 ÷ 1.5 = 4

c Is an image formed on a screen real or virtual? [1]

Real

Extra practice

Retrieval · answers in the answer booklet

1 Grade 5 A wave has a period of 0.25 s. Calculate its frequency. [2]

f = 1 ÷ T = 1 ÷ 0.25

f = 4 Hz

2 Grade 7+ Explain why X-rays are used to image broken bones, but ultrasound is used to scan unborn babies. [4]

X-rays pass through soft tissue but are absorbed by bone, so bones show up

X-rays are ionising, so they could damage the cells of a developing baby

Ultrasound is not ionising, so it is much safer

Ultrasound is partially reflected at boundaries between tissues, and the echoes are used to build an image

3 Grade 5 Put these in order of increasing wavelength: X-rays, radio waves, visible light, microwaves. [2]

X-rays, visible light, microwaves, radio waves

(Shortest wavelength = highest frequency)

4 True or false? All electromagnetic waves travel at the same speed in a vacuum. Explain. [2]

True. 3×10^8 m/s.

I do, we do, you do

WORKED EXAMPLES | GRADE 4 | GRADE 5

The wave equation

I do (worked example)

f = 50 Hz, λ = 0.4 m. Calculate v.

1. v = fλ
2. v = 50 × 0.4
3. **v = 20 m/s**

Units: Hz × m = m/s

We do (finish it)

f = 200 Hz, λ = 1.7 m.

1. v = fλ
2. v = 200 × ___ **1.7**
3. v = ___ m/s **340**

You do

f = 2 Hz, λ = 0.15 m.

v = fλ

= 2 × 0.15

= 0.3 m/s

WORKED EXAMPLES | GRADE 5 | GRADE 7

Rearranging and standard form

I do (worked example)

100 MHz radio. Calculate λ.

1. 100 MHz = 1×10^8 Hz
2. λ = v ÷ f
3. λ = $3 \times 10^8 \div 1 \times 10^8$
4. **λ = 3 m**

We do (finish it)

Sound: v = 330 m/s, λ = 0.66 m.

1. f = v ÷ λ
2. f = 330 ÷ ___ **0.66**
3. f = ___ Hz **500**

You do

f = 50 Hz. Calculate the period.

T = 1 ÷ f

= 1 ÷ 50

= 0.02 s

WORKED EXAMPLES | GRADE 7

Echoes: the next step (Physics only, Higher)

Grade 7+ questions often involve a there-and-back journey.

1 A ship sends an ultrasound pulse to the seabed. The echo returns after 0.8 s. Sound travels at 1500 m/s in water. Calculate the depth. [3]

Distance travelled = 1500 × 0.8 = 1200 m

This is there and back,

so depth = 600 m

2 Explain why S-waves are not detected on the opposite side of the Earth to an earthquake. [2]

S-waves are transverse and can't travel through liquids;

part of the Earth's core is liquid, so S-waves don't pass through it.

ELABORATION GRADE 4 GRADE 5 GRADE 7

Build an explanation

Answer each question in two steps. Use the starter, then push yourself with the Grade 7+ extension.

1 Explain why a ray of light changes direction when it enters a glass block at an angle.

Grade 4–5 starter: "Light slows down when it enters glass, so…"

Light slows down when it enters glass,

so it changes direction, towards the normal.

Grade 7+ extension: "Use wavefronts (Higher): one side of the wavefront…"

One side of each wavefront enters the glass first and slows down while the rest is still faster,

so the wavefront changes direction.

2 Explain why a red object looks black in blue light. (Physics only)

Grade 4–5 starter: "A red object reflects…"

A red object reflects red light

and absorbs other colours, including blue.

Grade 7+ extension: "Link to absorption of wavelengths:…"

Blue light is all absorbed, so no light is reflected to the eye,

so the object appears black.

3 Explain why the Earth's temperature stays roughly constant. (Higher)

Grade 4–5 starter: "The Earth absorbs radiation from the Sun and…"

The Earth absorbs radiation from the Sun

and emits radiation into space.

Grade 7+ extension: "Link to rates: if absorption equals emission…"

When the rate of absorption equals the rate of emission,

the temperature stays constant (it also depends on the atmosphere).

ELABORATION GRADE 5

True or false? Justify it.

Saying why is worth more marks than saying true or false.

4 "Sound can travel through a vacuum." [2]

False: sound needs particles to vibrate;

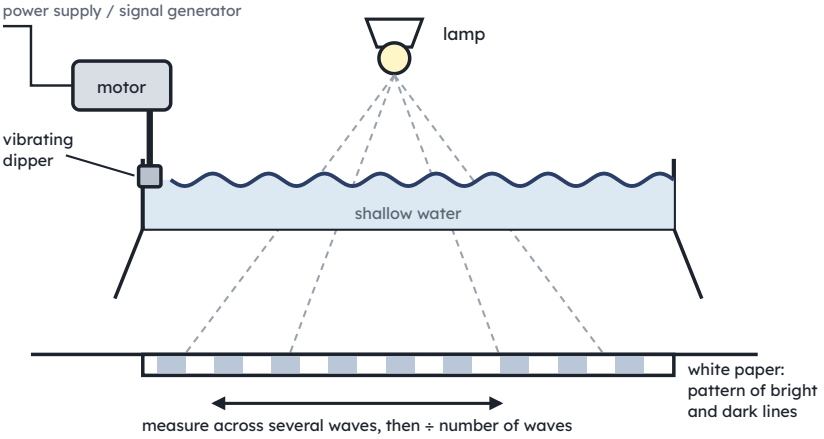
a vacuum has no particles.

5 "Gamma rays have a longer wavelength than radio waves." [1]

False: gamma has the shortest wavelength (highest frequency).

DUAL CODING | WORKED EXAMPLES | GRADE 4 | GRADE 5 | GRADE 7

RP8: waves in a ripple tank and on a string



Required practical 8 (waves in water)

Wavelength λ: measure the length of 10 waves on the paper, then ÷ 10

Frequency f: count the waves passing a point in 10 s, then ÷ 10

Wave speed: $v = f\lambda$

Freeze the pattern with a stroboscope or a phone photo next to a ruler.

Low frequency → longer waves that are easier to measure.

a Why measure across 10 waves and divide, rather than measure one wavelength? [1]

It reduces the uncertainty (more accurate wavelength).

b Suggest a piece of apparatus that would make the waves easier to measure. [1]

A stroboscope (freezes the waves) or a camera with a ruler in shot

c Ten ripples span 0.30 m and 20 waves pass a point in 10 s. Calculate the wave speed. [3]

λ = 0.30 ÷ 10 = 0.03 m

f = 20 ÷ 10 = 2 Hz

v = fλ = 2 × 0.03 = 0.06 m/s

d On a string, 4 loops stretch over 1.2 m at 40 Hz. Calculate the wave speed. [3]

λ = 2 × (1.2 ÷ 4) = 0.6 m (each loop = half a wavelength)

v = 40 × 0.6 = 24 m/s

Extra practice

Retrieval · answers in the answer booklet

1 Grade 5 A sound wave has a frequency of 200 Hz and a wavelength of 1.7 m. Calculate its speed. [2]

v = fλ = 200 × 1.7

v = 340 m/s

2 Grade 5 Water waves have a wavelength of 0.4 m and travel at 1.2 m/s. Calculate their frequency. [3]

v = fλ, so f = v ÷ λ

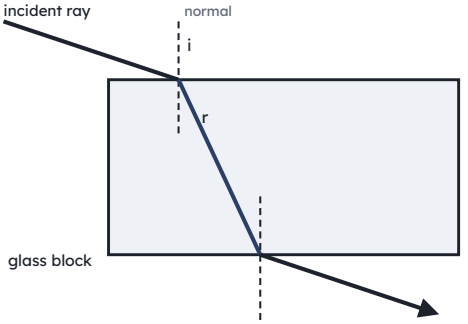
f = 1.2 ÷ 0.4

f = 3 Hz

RP9 and RP10

RETRIEVAL PRACTICE GRADE 4 GRADE 5

RP9: reflection and refraction (Physics only)



Entering glass: slows down, changes direction towards the normal

Leaving glass: speeds up, changes direction away from normal

Measure angles from the normal

a Why is a narrow ray of light used? [1]

So the centre of the ray can be marked accurately.

b What should every angle be measured from? [1]

The normal

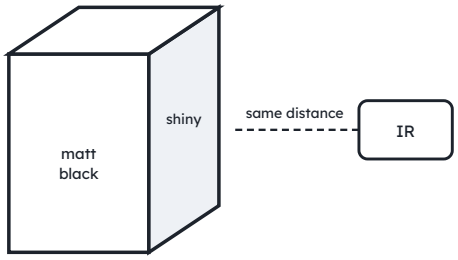
c Describe what is seen when the ray hits a mirror and then matt paper. [2]

Mirror: clear reflected ray, angle i = angle r (specular).

Paper: light scattered in many directions (diffuse).

RETRIEVAL PRACTICE GRADE 4 GRADE 5

RP10: infrared radiation



Leslie cube full of hot water: matt black emits most infrared, shiny silver emits least

Good emitters are good absorbers. Perfect black body absorbs all incident radiation (Physics only)

a Name the independent and dependent variables. [2]

Independent: type of surface

Dependent: infrared detector reading

b Why must the detector be the same distance from each face? [1]

Distance affects the reading, so it must be controlled (fair test).

c Which surface emits the most infrared? [1]

Matt black

Exam practice

GRADE RADE 4

Secure the basics

1 Name the type of wave in which oscillations are parallel to the direction of energy transfer. [1]

Longitudinal

2 Give one use of X-rays. [1]

Medical imaging

3 A wave has a frequency of 5 Hz and a wavelength of 2 m. Calculate its speed. [2]

$v = f\lambda = 5 \times 2$

$= 10$ m/s

4 State the speed of all EM waves in a vacuum. [1]

3×10^8 m/s

5 Give one hazard of ultraviolet radiation. [1]

Skin ageing / increased risk of skin cancer

GRADE RADE 5

Apply and rearrange

6 A wave has a speed of 340 m/s and a frequency of 170 Hz. Calculate its wavelength. [2]

$\lambda = v \div f = 340 \div 170$

$= 2$ m

7 Explain why microwaves are used to communicate with satellites. [2]

Microwaves can pass through the Earth's atmosphere

to reach satellites in space.

8 Describe the difference between specular and diffuse reflection. [2]

Specular: smooth surface, reflected in a single direction.

Diffuse: rough surface, scattered in many directions.

9 A wave has a period of 0.04 s. Calculate its frequency. [2]

$f = 1 \div T = 1 \div 0.04$

$= 25$ Hz

Extra practice

Retrieval · answers in the answer booklet

1 Grade 5 Give one use of infrared and one use of microwaves. [2]

Infrared: electrical heaters / cooking food / infrared cameras

Microwaves: satellite communications / cooking food

Exam practice (continued)

GRADE RADE 7+

Stretch

10 A radio station broadcasts on a wavelength of 1500 m. Calculate the frequency, giving your answer in kHz. ($v = 3 \times 10^8$ m/s) [3]

f = v ÷ λ = 3 × 10^8 ÷ 1500

= 200 000 Hz

= 200 kHz

11 Describe a method to measure the speed of water waves in a ripple tank. Explain how to make the measurements accurate. [6]

Set up the ripple tank with a lamp above so the waves are projected onto paper below.

Switch on the vibrating bar to make plane waves.

Measure across 10 wavelengths with a metre rule; divide by 10 to find λ.

Count the waves passing a point in 10 s; divide by 10 to find f.

Calculate v = fλ; repeat and take a mean.

Accuracy: use a stroboscope or photo with a ruler to freeze the waves; keep water depth constant.

Total: _____ / 23

RETRIEVAL PRACTICE SPACED PRACTICE GRADE 4

Quick-fire retrieval: Waves

Cover everything. Answer in under 3 minutes. Redo it on your next spaced session.

1 Unit of frequency?

Hertz (Hz)

2 Fastest EM wave?

All the same speed in a vacuum

3 Human hearing range?

20 Hz – 20 kHz

4 Best emitter of infrared?

Matt black surface

5 EM wave used in fibre optics?

Visible light

6 Waves that can't pass through liquids?

S-waves

Extra practice

Retrieval · answers in the answer booklet

1 Grade 5 Explain why sound can't travel through a vacuum. [2]

Sound is a longitudinal wave that needs particles to vibrate

A vacuum has no particles to pass on the vibrations

METACOGNITION

Re-rate yourself

Go back to the checklist at the start of this topic and fill in the 'After' column.

METACOGNITION GRADE 4 GRADE 5 GRADE 7

Exam wrapper: why did I drop marks?

After marking the exam practice, write the question numbers you got wrong in the right row.

Reason I lost marks	Question numbers	What to do next
I didn't know or remember it (knowledge gap)		Flashcards and brain dumps
I knew it but misread the question or command word		Underline command words
Maths slip: units, rearranging, standard form		Redo the "we do / you do" pages
I ran out of time or didn't finish		Timed practice: 1 mark per minute

METACOGNITION

Two things I'm now confident about

METACOGNITION

One thing I still need to work on, and how I'll fix it

e.g. 'Rearranging equations → redo the Grade 7+ questions and use the website's Aim higher section.'

SPACED PRACTICE

Book my next spaced sessions

Write the dates in the planner at the front: +2 days, +1 week, +3 weeks.

Extra practice

Retrieval · answers in the answer booklet

1 True or false? All electromagnetic waves travel at the same speed in a vacuum. Explain. [2]

True. 3×10^8 m/s for every EM wave.

Brain dump and checklist

RETRIEVAL PRACTICE · GRADE 4 · GRADE 5 · GRADE 7

Brain dump

Set a timer for 5 minutes. Write or draw everything you remember about magnetism. No notes! Afterwards, add anything you missed in a different colour.

Prompts if you get stuck: poles? · field lines? · permanent vs induced? · compass? · solenoid? · electromagnet? · motor effect? · F = BIl? · generator effect? · transformers?

METACOGNITION

How confident am I?

Rate each statement now (before) by shading R, A or G. Rate again at the end of the topic (after).

I can...	Before			After		
	R	A	G	R	A	G
Describe attraction and repulsion between poles	○	○	○	○	○	○
Explain the difference between permanent and induced magnets	○	○	○	○	○	○
Draw magnetic field patterns and plot them with a compass	○	○	○	○	○	○
Explain how a compass shows that the Earth's core is magnetic	○	○	○	○	○	○
Describe the field around a wire and in a solenoid, and how to make an electromagnet stronger	○	○	○	○	○	○
Use Fleming's left-hand rule and F = BIl (Higher)	○	○	○	○	○	○
Explain how an electric motor works (Higher)	○	○	○	○	○	○
Explain how a loudspeaker works (Physics only, Higher)	○	○	○	○	○	○
Explain the generator effect, alternators, dynamos and microphones (Physics only, Higher)	○	○	○	○	○	○
Use the transformer equations (Physics only, Higher)	○	○	○	○	○	○

Extra practice

Retrieval · answers in the answer booklet

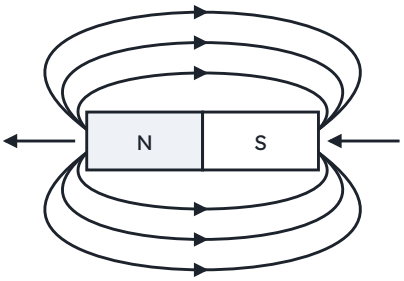
1 True or false? Induced magnetism always causes a force of attraction. Explain. [2]

True. An induced magnet is always attracted, never repelled.

Knowledge organiser

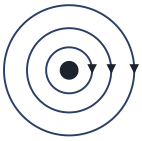
DUAL CODING | GRADE 4 | GRADE 5 | GRADE 7

MAGNETIC FIELDS AND ELECTROMAGNETISM

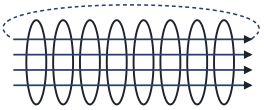


Field lines: N → S
closest at the poles,
where the field is strongest

Like poles repel,
unlike poles attract

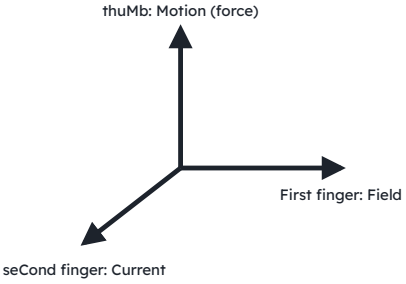


Wire (current into page):
circular field; stronger near the wire



Solenoid: strong, uniform field inside;
add an iron core → electromagnet

THE MOTOR EFFECT (HIGHER)



Fleming's left-hand rule (Higher)

F = B I l

F = force (N)
B = magnetic flux density (T)
I = current (A); l = length (m)

Reverse the current or the field
→ the force reverses

KEY EQUATIONS: ALL GIVEN ON THE PHYSICS EQUATIONS SHEET IN THE EXAM

Equation	Quantities and units	Watch out
F = B I l	force (N), magnetic flux density (T), current (A), length (m) (Higher)	Wire at right angles to the field
Vp ÷ Vs = np ÷ ns	p.d. (V) and number of turns on the primary and secondary coils (Physics only, Higher)	Same ratio both sides
Vs × Is = Vp × Ip	for a 100% efficient transformer: power in = power out (Physics only, Higher)	Step up p.d. → current down

GENERATOR EFFECT (PHYSICS ONLY, HIGHER)

A p.d. is induced when a wire moves relative to a magnetic field, or the field around it changes.
The induced current's field opposes the change that caused it.
Alternator → a.c.; **dynamo** → d.c.; **transformer** needs a.c.

TURN OVER

Key words, misconceptions, required practicals and Grade 7+ links are on the next page.

Knowledge organiser: key words, misconceptions, practicals

ELABORATION GRADE 4 GRADE 5 GRADE 7

KEY WORDS: LEARN THESE WORD FOR WORD (SAME AS SIDE 2 OF YOUR KNOWLEDGE ORGANISER)

Permanent magnet: produces its own magnetic field.
Induced magnet: becomes a magnet when placed in a magnetic field; induced magnetism always causes attraction.
Magnetic field: the region around a magnet where a force acts on another magnet or magnetic material.
Solenoid: a coil of wire; the field inside is strong and uniform. With an iron core: an electromagnet.
Motor effect (Higher): a force on a current-carrying conductor in a magnetic field.
Generator effect (PO, Higher): a p.d. is induced when a conductor moves relative to a magnetic field, or the field changes.
Magnetic flux density: the strength of a magnetic field, in tesla (T).

MISCONCEPTIONS: SPOT THE MISTAKE

× Common mistake	✓ What's actually true
× All metals are magnetic.	✓ Only iron, steel, cobalt and nickel.
× Field lines can cross.	✓ Field lines never cross.
× Transformers work with d.c.	✓ They need a changing (a.c.) field to induce a p.d.

AIM FOR GRADE 7+

- Rearrange F = BIl; convert cm to m.
- Two-step transformer questions: p.d. from turns ratio, then current from power in = power out.
- Explain motors, loudspeakers and microphones as chains of cause and effect.

Extra practice

Retrieval · answers in the answer booklet

1 Grade 7+ A transformer has 2000 turns on its primary coil and 100 turns on its secondary. The primary is connected to 230 V. Calculate the secondary p.d. and, if the secondary current is 2 A, the primary current (assume 100% efficiency). [4]

Vs = Vp × ns ÷ np = 230 × 100 ÷ 2000

Vs = 11.5 V

Vp × Ip = Vs × Is, so Ip = 11.5 × 2 ÷ 230

Ip = 0.1 A

2 Grade 7+ A force of 0.06 N acts on a 0.15 m length of wire in a 0.2 T magnetic field. Calculate the current in the wire. [3]

F = BIl, so I = F ÷ (Bl)

I = 0.06 ÷ (0.2 × 0.15)

I = 2 A

3 Grade 5 Describe the magnetic field around a straight wire carrying a current. [2]

Concentric circles around the wire

Stronger closer to the wire and when the current is larger

RETRIEVAL PRACTICE | SPACED PRACTICE | GRADE 4 | GRADE 5

Equation sheet skills: which equation, which unit?

Every equation is on the Physics Equations Sheet, but it won't tell you which one a question needs or what unit the answer has. Cover the knowledge organiser and fill in the table. Redo it on another day.

Situation	Which equation?	Unit of the answer	Redo 1 ✓/×	Redo 2 ✓/×
A 0.2 m wire carries 3 A at right angles to a 0.5 T field. Force?	**F = B I l**	**N**		
A force of 0.06 N acts on 0.15 m of wire in 0.2 T. What current?	**I = F ÷ (B l)**	**A**		
A transformer has 100 primary and 2000 secondary turns. Output p.d.?	**Vp ÷ Vs = np ÷ ns**	**V**		
A transformer steps 230 V down to 12 V. Output current?	**Vs × Is = Vp × Ip**	**A**		
Which magnetic field strength unit appears in F = BIl?	**B: magnetic flux density**	**T (tesla)**		
What is the length of wire in 25 cm?	**convert**	**0.25 m**		

RETRIEVAL PRACTICE | GRADE 4 | GRADE 5

Fill the gaps

Use the AQA key words. No word bank: that's the point.

1. Like poles ___**repel**___ and unlike poles attract.
2. An induced magnet always causes a force of ___**attraction**___.
3. Magnetic field lines go from the north pole to the ___**south**___ pole.
4. A solenoid with an iron core is called an ___**electromagnet**___.
5. The force on a current-carrying wire in a magnetic field is called the ___**motor**___ effect (Higher).

ELABORATION | GRADE 5

Odd one out

Circle the odd one out in each row and explain why.

1. iron · steel · copper · nickel

Copper: it isn't a magnetic material.

2. alternator · dynamo · motor · microphone

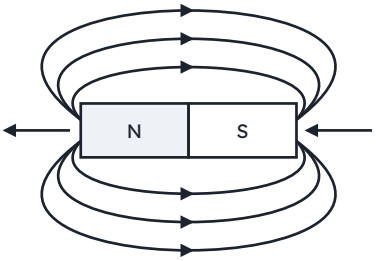
Motor: it uses the motor effect; the others use the generator effect.

3. more turns · bigger current · iron core · plastic core

Plastic core: it doesn't make an electromagnet stronger.

DUAL CODING GRADE 4 GRADE 5

Field patterns



Field lines: N → S
closest at the poles,
where the field is strongest

Like poles repel,
unlike poles attract

a Where is the magnetic field strongest? How does the diagram show this? [2]

At the poles;

the field lines are closest together there.

b Describe how to plot the field lines using a compass. [3]

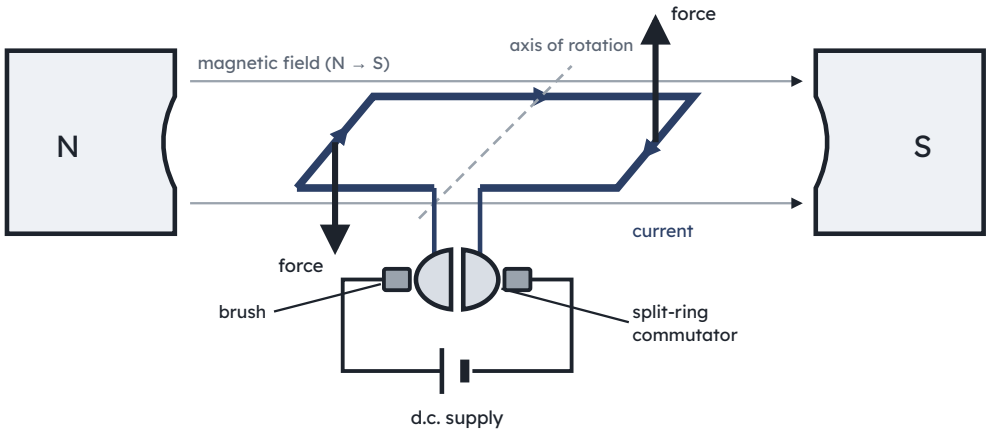
Place the compass near one pole and mark the needle's direction.

Move the compass to the end of the needle; mark again and repeat.

Join the marks to make a field line.

DUAL CODING GRADE 5 GRADE 7

The electric motor (Higher)



a Explain why the coil turns. [3]

A current flows through the coil in a magnetic field;

each side experiences a force (motor effect) in opposite directions,

so the coil rotates.

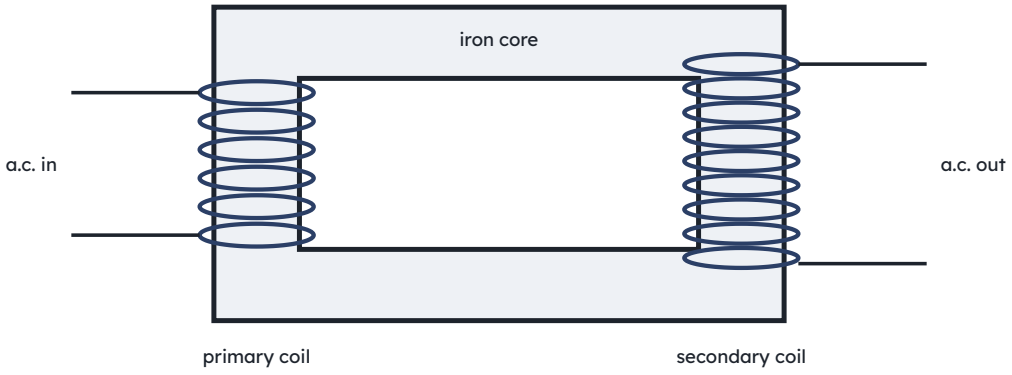
b What does the split-ring commutator do? [1]

Reverses the current every half turn so the coil keeps turning the same way.

Picture it (continued)

DUAL CODING GRADE 7

The transformer (Physics only, Higher)



Vp ÷ Vs = np ÷ ns
Vs × Is = Vp × Ip
(Physics only, Higher)

a Why is the core made of iron? [1]

Iron is easily magnetised.

b Explain why a transformer only works with a.c. [2]

a.c. produces a changing magnetic field in the core,

which induces a p.d. in the secondary coil; d.c. gives a steady field.

Extra practice

Retrieval · answers in the answer booklet

1 Grade 7+ Explain how the direction of rotation of a simple electric motor can be reversed, and why. [3]

Reverse the direction of the current, or reverse the magnetic field (swap the poles)

The force on each side of the coil depends on the directions of current and field (Fleming's

left-hand rule)

Reversing either one reverses the forces, so the coil turns the other way

2 Grade 7+ Explain why a transformer will not work with a direct current supply. [3]

A p.d. is only induced in the secondary coil if the magnetic field through it is changing

Direct current produces a steady (unchanging) magnetic field

So no p.d. is induced in the secondary coil

3 Grade 5 Name the four magnetic materials and describe a simple test for whether a metal is magnetic. [2]

Iron, steel, cobalt and nickel

Bring a magnet close: a magnetic material is attracted to it

I do, we do, you do

WORKED EXAMPLES | GRADE 5 | GRADE 7

Force on a wire, F = BIl (Higher)

I do (worked example)

B = 0.5 T, I = 3 A, l = 0.2 m. Calculate F.

1. F = BIl
2. F = 0.5 × 3 × 0.2
3. **F = 0.3 N**

Length in metres

We do (finish it)

B = 0.08 T, I = 4 A, l = 0.25 m.

1. F = BIl
2. F = 0.08 × 4 × ___ **0.25**
3. F = ___ N **0.08**

You do

F = 0.06 N, B = 0.2 T, l = 0.15 m. Calculate I.

I = F ÷ (Bl)

= 0.06 ÷ (0.2 × 0.15)

= 2 A

WORKED EXAMPLES | GRADE 7

Transformers (Physics only, Higher)

I do (worked example)

Vp = 12 V, np = 200, ns = 1000. Calculate Vs.

1. Vp ÷ Vs = np ÷ ns
2. Vs = Vp × ns ÷ np
3. Vs = 12 × 1000 ÷ 200
4. **Vs = 60 V**

We do (finish it)

230 V → 11.5 V; np = 2000. Calculate ns.

1. ns = np × Vs ÷ Vp
2. ns = 2000 × 11.5 ÷ ___ **230**
3. ns = ___ **100**

You do

Vp = 230 V, Ip = 0.5 A, Vs = 12 V. Calculate Is.

Vs × Is = Vp × Ip

12 × Is = 115

Is = 9.6 A

ELABORATION | GRADE 5 | GRADE 7

Spot the mistake

Each student has made one mistake. Find it and correct it.

1 Gus: "A 30 cm wire with 2 A in a 0.1 T field: F = 0.1 × 2 × 30 = 6 N." [2]

Length must be in metres: F = 0.1 × 2 × 0.3 = 0.06 N.

2 Hana: "A step-up transformer increases the current." [1]

It increases the p.d. and decreases the current (power in = power out).

3 Ivy: "Any metal can be made into an induced magnet." [1]

Only magnetic materials: iron, steel, cobalt and nickel.

Extra practice

Retrieval · answers in the answer booklet

1 In Fleming's left-hand rule, the first finger points in the direction of the... [1]

A field **B** current **C** force **D** motion

A: field. First finger = Field, seCond finger = Current, thuMb = Motion.

ELABORATION GRADE 4 GRADE 5 GRADE 7

Build an explanation

Answer each question in two steps. Use the starter, then push yourself with the Grade 7+ extension.

1 Explain how a loudspeaker produces sound. (Physics only, Higher)

Grade 4–5 starter: "An alternating current flows through the coil, which is in a magnetic field, so…"

An alternating current flows through a coil in a magnetic field,

so the coil feels a force (motor effect) that keeps changing direction.

Grade 7+ extension: "Link the cone's vibration to a sound wave:…"

The coil and cone vibrate in and out,

creating pressure variations in the air: a sound wave.

2 Explain why a compass needle points north.

Grade 4–5 starter: "The compass is a small magnet, so…"

A compass contains a small bar magnet,

which lines up with the Earth's magnetic field.

Grade 7+ extension: "What does this tell us about the Earth?"

So the Earth has a magnetic field,

which is evidence that the Earth's core is magnetic.

3 Explain how a moving-coil microphone works. (Physics only, Higher)

Grade 4–5 starter: "Sound waves make the diaphragm and coil vibrate…"

Sound waves make the diaphragm and coil vibrate

in the field of a permanent magnet.

Grade 7+ extension: "Use the generator effect:…"

The coil moves relative to the field, inducing a p.d. (generator effect);

the p.d. varies in the same pattern as the sound wave.

ELABORATION GRADE 5

True or false? Justify it.

Saying why is worth more marks than saying true or false.

4 "Magnetic field lines can cross." [1]

False: field lines never cross.

5 "Reversing the current in a motor reverses its direction of rotation." [1]

True: the forces on the coil reverse (Higher).

Extra practice

Retrieval · answers in the answer booklet

1 True or false? Magnetic field lines point from north to south. Explain. [2]

True. Outside the magnet they go from the north pole to the south pole.

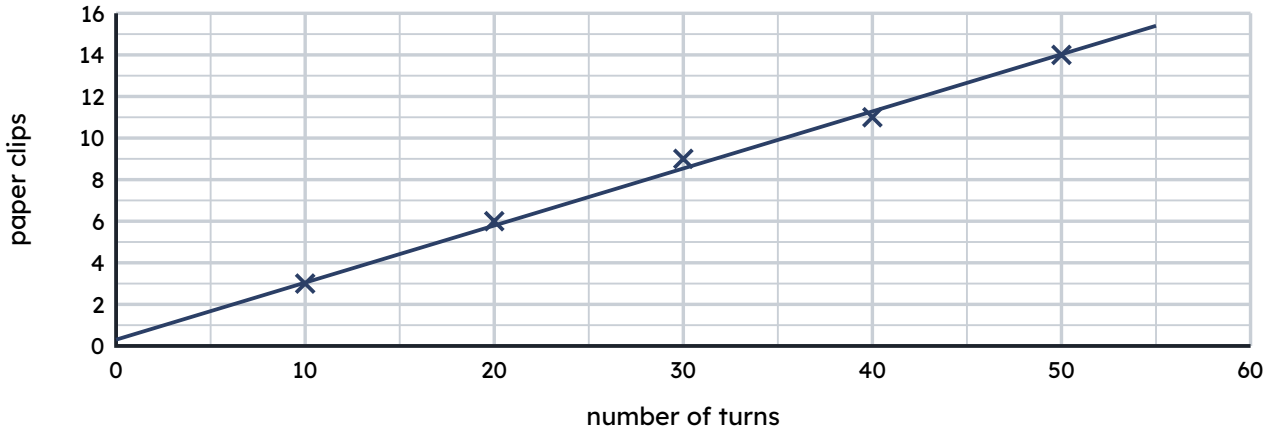
DUAL CODING | ELABORATION | GRADE 4 | GRADE 5 | GRADE 7

Investigate an electromagnet

This isn't a required practical, but exam questions often use it to test practical skills.

A student wraps wire around an iron nail, connects it to a power supply and counts how many paper clips it picks up.

Number of turns	10	20	30	40	50
Paper clips (mean)	3	6	9	11	14



a Name the independent, dependent and one control variable. [3]

Independent: number of turns

Dependent: number of paper clips picked up

Control: current / type of core / size of paper clips

b Plot the results and describe the pattern. [2]

As the number of turns increases, the number of clips increases (roughly proportional).

c Suggest why the student repeated each reading and calculated a mean. [1]

To reduce the effect of random errors / identify anomalies.

d Suggest one other way to make the electromagnet stronger. [1]

Increase the current.

Extra practice

Retrieval · answers in the answer booklet

1 Grade 5 Describe how to use a plotting compass to show the shape of the magnetic field around a bar magnet. [2]

Place the compass near the magnet and mark the direction the needle points

Move the compass to the end of the needle, repeat, then join the marks to draw a field line

2 Fill the gap: A coil of wire is called a _____. [1]

solenoid. Its field is strong and uniform inside.

Exam practice

GRADE RADE 4

Secure the basics

1 Name the four magnetic materials. [2]

Iron, steel, cobalt and nickel

2 What happens when two south poles are brought together? [1]

They repel.

3 Describe the shape of the magnetic field around a long straight wire carrying a current. [1]

Circles around the wire

4 Give two ways to make an electromagnet stronger. [2]

More turns on the coil

Bigger current / add an iron core

5 State the difference between a permanent magnet and an induced magnet. [2]

A permanent magnet produces its own field;

an induced magnet only becomes magnetic in a field.

GRADE RADE 5

Apply and rearrange

6 A wire 0.5 m long carries 2 A at right angles to a 0.3 T field. Calculate the force. (Higher) [2]

F = BIl = 0.3 × 2 × 0.5

= 0.3 N

7 Explain why an electromagnet is used in a scrapyard crane rather than a permanent magnet. [2]

It can be switched off,

so the scrap can be dropped where it's needed.

8 State two ways to reverse the direction of the force on a current-carrying wire in a magnetic field. [2]

Reverse the current

Reverse the magnetic field (swap the poles)

9 Describe the magnetic field inside a solenoid. [2]

Strong

and uniform (parallel field lines)

Exam practice (continued)

GRADE RADE 7+

Stretch

10 A transformer has 500 turns on the primary coil and 25 turns on the secondary coil. The primary p.d. is 230 V and the primary current is 0.2 A. Calculate the secondary p.d. and the secondary current, assuming 100% efficiency. [4]

Vs = Vp × ns ÷ np = 230 × 25 ÷ 500 = 11.5 V

Vs × Is = Vp × Ip

11.5 × Is = 230 × 0.2 = 46

Is = 4 A

11 Explain how a simple d.c. electric motor works. (Higher) [6]

A coil of wire carrying a current is placed between the poles of a magnet.

Each side of the coil experiences a force (motor effect), given by F = BIl.

The current flows in opposite directions on the two sides, so the forces act in opposite directions.

This makes the coil rotate.

A split-ring commutator reverses the current every half turn,

so the forces keep turning the coil in the same direction.

Total: _____ / 26

RETRIEVAL PRACTICE SPACED PRACTICE GRADE 4

Quick-fire retrieval: Magnetism

Cover everything. Answer in under 3 minutes. Redo it on your next spaced session.

1 Unit of magnetic flux density?

Tesla (T)

2 Field direction outside a magnet?

North to south

3 Rule for the motor effect?

Fleming's left-hand rule

4 Generator that makes a.c.?

Alternator

5 Why an iron core?

Easily magnetised

6 Does an induced magnet attract or repel?

Always attracts

Extra practice

Retrieval · answers in the answer booklet

1 Grade 5 State two ways to reverse the direction of the force on a current-carrying wire in a magnetic field. [2]

Reverse the direction of the current

Reverse the direction of the magnetic field (swap the poles)

METACOGNITION

Re-rate yourself

Go back to the checklist at the start of this topic and fill in the 'After' column.

METACOGNITION GRADE 4 GRADE 5 GRADE 7

Exam wrapper: why did I drop marks?

After marking the exam practice, write the question numbers you got wrong in the right row.

Reason I lost marks	Question numbers	What to do next
I didn't know or remember it (knowledge gap)		Flashcards and brain dumps
I knew it but misread the question or command word		Underline command words
Maths slip: units, rearranging, standard form		Redo the "we do / you do" pages
I ran out of time or didn't finish		Timed practice: 1 mark per minute

METACOGNITION

Two things I'm now confident about

METACOGNITION

One thing I still need to work on, and how I'll fix it

e.g. 'Rearranging equations → redo the Grade 7+ questions and use the website's Aim higher section.'

SPACED PRACTICE

Book my next spaced sessions

Write the dates in the planner at the front: +2 days, +1 week, +3 weeks.

Extra practice

Retrieval · answers in the answer booklet

1 Fill the gap: A coil of wire that carries a current is called a _____. [1]

solenoid. Add an iron core and it becomes an electromagnet.

Brain dump and checklist

RETRIEVAL PRACTICE · GRADE 4 · GRADE 5 · GRADE 7

Brain dump

Set a timer for 5 minutes. Write or draw everything you remember about space physics. No notes! Afterwards, add anything you missed in a different colour.

Prompts if you get stuck: solar system? · nebula → ? · main sequence? · supernova? · orbits? · red-shift? · Big Bang? · dark mass and dark energy?

METACOGNITION

How confident am I?

Rate each statement now (before) by shading R, A or G. Rate again at the end of the topic (after).

I can...	Before			After		
	R	A	G	R	A	G
Describe our solar system and the Milky Way	○	○	○	○	○	○
Explain how a star forms from a nebula	○	○	○	○	○	○
Explain why a main sequence star is stable	○	○	○	○	○	○
Describe the life cycle of a star the size of the Sun	○	○	○	○	○	○
Describe the life cycle of a star much more massive than the Sun	○	○	○	○	○	○
Explain how fusion and supernovas produce the elements	○	○	○	○	○	○
Explain how gravity keeps planets and satellites in orbit	○	○	○	○	○	○
Explain why orbiting objects accelerate and how speed affects orbit radius (Higher)	○	○	○	○	○	○
Describe red-shift and what it shows	○	○	○	○	○	○
Explain the evidence for the Big Bang and what is still not understood	○	○	○	○	○	○

Extra practice

Retrieval · answers in the answer booklet

1 Grade 5 Explain why a main sequence star stays the same size for billions of years. [2]

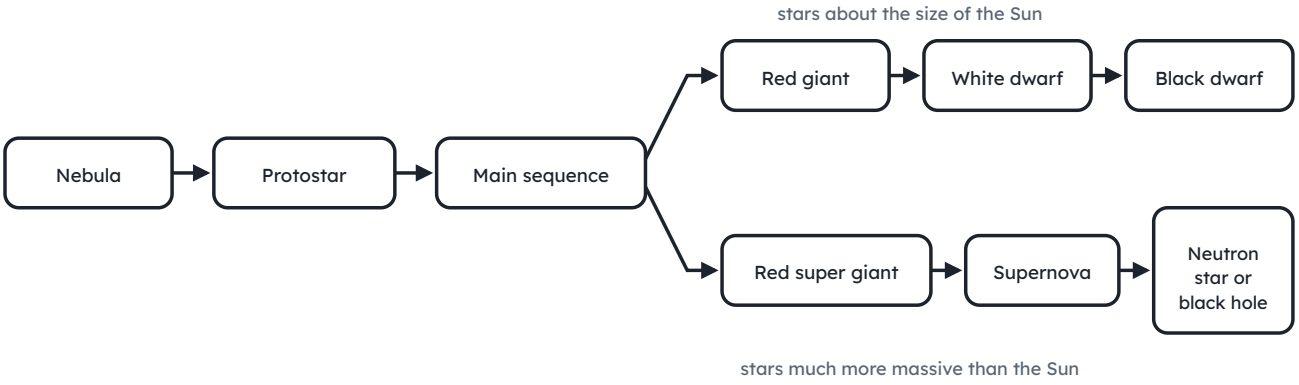
The inward force of gravity

is balanced by the outward force (pressure) from fusion energy

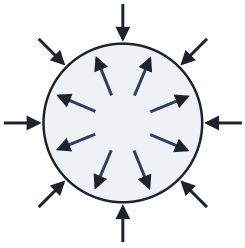
Knowledge organiser

DUAL CODING | GRADE 4 | GRADE 5 | GRADE 7

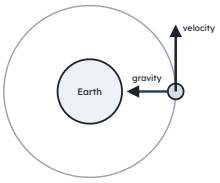
LIFE CYCLE OF STARS



STABLE STARS AND ORBITS



Main sequence star is stable:
inward gravity balances the outward force from fusion energy (equilibrium)



Gravity provides the force towards the centre, so speed stays the same but direction (velocity) changes: the satellite is accelerating (Higher)

Smaller orbit → must move faster to stay in orbit (stable orbit: if speed changes, radius changes)

RED-SHIFT



Red-shift: lines move to longer wavelengths → galaxy moving away. Further away = bigger red-shift → universe is expanding → evidence for the Big Bang

BIG IDEAS

Fusion makes elements up to iron; elements heavier than iron are made in supernovas, which distribute them through the universe.
The universe began from a very small region that was extremely hot and dense (Big Bang).
Dark mass and dark energy are still not understood.

TURN OVER

Key words, misconceptions, required practicals and Grade 7+ links are on the next page.

Knowledge organiser: key words, misconceptions, practicals

ELABORATION GRADE 4 GRADE 5 GRADE 7

KEY WORDS: LEARN THESE WORD FOR WORD (SAME AS SIDE 2 OF YOUR KNOWLEDGE ORGANISER)

Nebula: a cloud of dust and gas where stars form.
Main sequence star: a stable star: inward gravity balances the outward force from fusion energy.
Supernova: the explosion of a massive star; produces elements heavier than iron and distributes them through the universe.
Satellite: an object that orbits a larger body; moons are natural, others artificial.
Red-shift: an observed increase in the wavelength of light from most distant galaxies.
Big Bang theory: the universe began from a very small region that was extremely hot and dense.
Dark mass and dark energy: proposed to explain observations; not yet understood.

MISCONCEPTIONS: SPOT THE MISTAKE

× Common mistake	✓ What's actually true
× The Sun will become a black hole.	✓ It isn't massive enough: it becomes a white dwarf, then a black dwarf.
× Red-shift means the galaxy looks red.	✓ It means the wavelength of its light has increased.
× Satellites at constant speed aren't accelerating.	✓ Their direction changes, so velocity changes: they accelerate (Higher).

AIM FOR GRADE 7+

- Explain the life cycle of a star as a sequence of linked steps.
- Link red-shift to distance and speed, then to an expanding universe.
- Explain why orbiting objects accelerate at constant speed (Higher).

Extra practice

Retrieval · answers in the answer booklet

1 Grade 5 Where are elements heavier than iron made, and how do they spread through the universe? [2]

In supernovas (explosions of massive stars)

The explosion distributes the elements throughout the universe

2 Grade 5 Name the force that keeps a moon in orbit, and the type of object it orbits. [2]

Gravity

A planet

3 Grade 7+ Explain why scientists say there is still much about the universe that is not understood. [3]

Since 1998, observations of supernovae suggest distant galaxies are receding ever faster

This can't be explained by known matter/energy

Dark mass and dark energy have been suggested, but nobody knows what they are

4 Fill the gap: A cloud of dust and gas where stars form is called a _____. [1]

nebula. Gravity pulls it together into a protostar.

RETRIEVAL PRACTICE GRADE 4 GRADE 5

Order it: the life cycle of stars

Number the stages for each star in order.

Sun-sized: white dwarf · nebula · red giant · main sequence · black dwarf · protostar

Massive star: supernova · main sequence · neutron star or black hole · nebula · red super giant · protostar

Sun: nebula → protostar → main sequence → red giant → white dwarf → black dwarf

Massive: nebula → protostar → main sequence → red super giant → supernova → neutron star or black hole

RETRIEVAL PRACTICE GRADE 4 GRADE 5

Fill the gaps

Use the AQA key words. No word bank: that's the point.

1. Stars form from a cloud of dust and gas called a **nebula**.
2. In a main sequence star, gravity is balanced by the outward force from **fusion** energy.
3. Elements heavier than iron are produced in a **supernova**.
4. Moons are natural **satellites** that orbit planets.
5. An observed increase in the wavelength of light from distant galaxies is called **red-shift**.

ELABORATION GRADE 5

Odd one out

Circle the odd one out in each row and explain why.

1. planet · moon · dwarf planet · galaxy

Galaxy: it's not part of our solar system.

2. red giant · white dwarf · supernova · black dwarf

Supernova: only happens to stars much more massive than the Sun.

3. red-shift · expanding universe · Big Bang · steady state

Steady state: the others are evidence for / part of the Big Bang model.

Extra practice

Retrieval · answers in the answer booklet

1 Grade 5 Describe the life cycle of a star about the same size as the Sun. [4]

Nebula: a cloud of dust and gas pulled together by gravity

Protostar: gets hotter until fusion starts

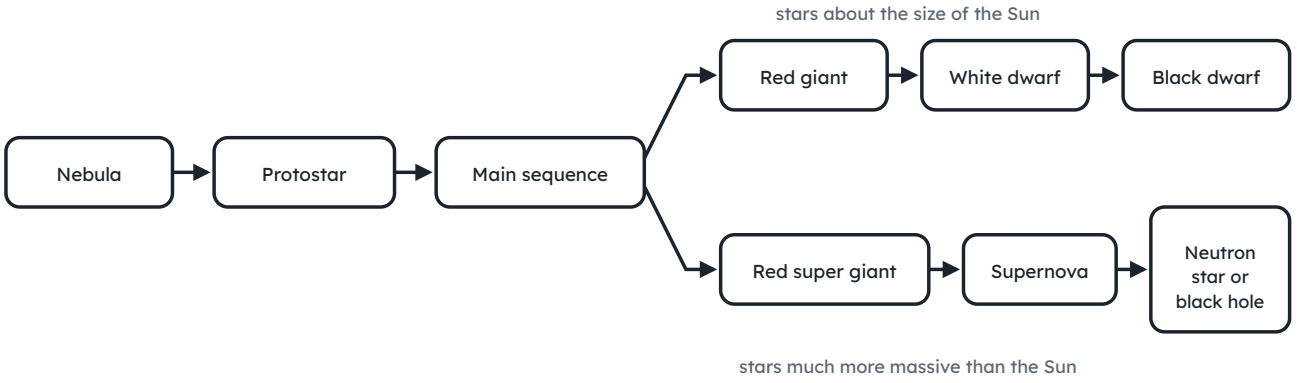
Main sequence star (stable for billions of years)

Red giant → white dwarf → black dwarf

Picture it

DUAL CODING GRADE 4

Life cycle of stars



a What force pulls a nebula together? [1]

Gravity

b What decides which path a star takes after the main sequence? [1]

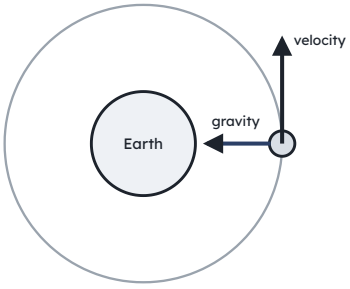
Its size (mass)

c Where are elements heavier than iron made? [1]

In a supernova

DUAL CODING GRADE 5 GRADE 7

Orbits



Gravity provides the force towards the centre, so speed stays the same but direction (velocity) changes: the satellite is accelerating (Higher)

Smaller orbit → must move faster to stay in orbit (stable orbit: if speed changes, radius changes)

a What provides the force that keeps a satellite in orbit? [1]

Gravity

b Explain why a satellite moving at constant speed in a circle is accelerating. (Higher) [3]

Velocity includes direction;

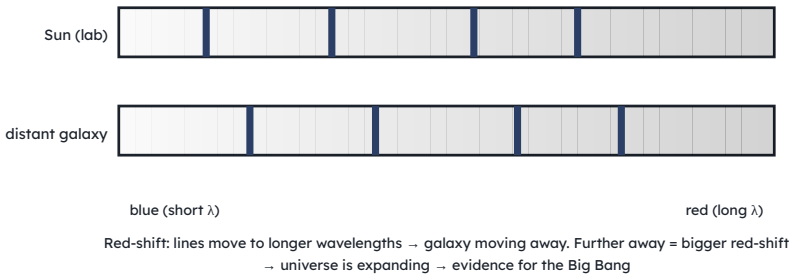
the direction keeps changing, so the velocity changes;

a change in velocity is an acceleration.

Picture it (continued)

DUAL CODING GRADE 4 GRADE 5

Red-shift



Red-shift: lines move to longer wavelengths → galaxy moving away. Further away = bigger red-shift → universe is expanding → evidence for the Big Bang

a Describe how the lines in the galaxy's spectrum differ from the Sun's. [2]

They are shifted towards the red end,

to longer wavelengths.

b What does this tell us about the galaxy? [1]

It is moving away from us.

Extra practice

Retrieval · answers in the answer booklet

1 Grade 5 Explain why a main sequence star stays the same size for billions of years. [3]

Fusion in the core releases energy, creating an outward pressure

Gravity pulls inwards

These forces are balanced, so the star is in equilibrium

2 Grade 7+ Explain how red-shift provides evidence for the Big Bang theory. [3]

Most distant galaxies show red-shift, so they are moving away from us

The further away, the faster they recede, so the universe is expanding

Running time backwards, the universe began from a very small, extremely hot and dense region

3 Grade 7+ Galaxy A shows a larger red-shift than galaxy B. What can you conclude, and what does this suggest about the universe? [3]

Galaxy A is moving away from us faster

Galaxy A is further away

More distant galaxies receding faster suggests the universe is expanding (supporting the Big

Bang)

4 Grade 5 Where are elements up to iron made, and where are heavier elements made? [2]

Elements up to iron: fusion in stars

Elements heavier than iron: in a supernova

WORKED EXAMPLES GRADE 4 GRADE 5

Explaining a stable star

I do (worked example)

Why is a main sequence star stable?

1. Gravity pulls inwards
2. Fusion releases energy → outward force
3. The forces are balanced
4. **So the star is in equilibrium**

We do (finish it)

How does a protostar become a star?

1. Gravity pulls ___ inwards **the cloud**
2. It gets denser and ___ **hotter**
3. ___ starts **Fusion of hydrogen**
4. A ___ star forms **main sequence**

You do

Why does a red giant form?

Hydrogen in the core runs out

The forces are no longer balanced

The star expands

and cools, so it looks red

WORKED EXAMPLES GRADE 5 GRADE 7

Explaining evidence for the Big Bang

I do (worked example)

What does red-shift show?

1. Light from distant galaxies is red-shifted
2. So they are moving away
3. Further galaxies: bigger red-shift, moving faster
4. **Universe is expanding → Big Bang**

We do (finish it)

Galaxy A has more red-shift than B.

1. A is moving ___ **away faster**
2. A is ___ away **further**
3. This supports ___ **an expanding universe**

You do

What can't scientists explain yet?

Since 1998: distant galaxies receding faster and faster

Known matter/energy can't explain it

Dark mass and dark energy suggested

but not understood

ELABORATION GRADE 5

Spot the mistake

Each student has made one mistake. Find it and correct it.

1 Jay: "The Sun will end its life as a black hole." [1]

The Sun isn't massive enough: it will become a white dwarf, then a black dwarf.

2 Kim: "A satellite in a circular orbit at constant speed has no acceleration." [2]

Its direction changes, so its velocity changes: it is accelerating (Higher).

3 Lou: "Red-shift means galaxies are moving towards us." [1]

Red-shift means they are moving away from us.

Extra practice

Retrieval · answers in the answer booklet

1 Grade 7+ Explain why the Sun will never become a black hole. [3]

The Sun is not massive enough

Only stars much more massive than the Sun go supernova and can become black holes

The Sun will become a red giant, then a white dwarf (then a black dwarf)

2 Grade 5 Name, in order, the stages a star much bigger than the Sun goes through after the main sequence. [3]

Red super giant

Supernova

Neutron star (or black hole if massive enough)

ELABORATION GRADE 4 GRADE 5 GRADE 7

Build an explanation

Answer each question in two steps. Use the starter, then push yourself with the Grade 7+ extension.

1 Explain how the elements found on Earth were made.

Grade 4–5 starter: "Fusion in stars joins light nuclei to make…"

Fusion in stars joins light nuclei to make heavier elements,

up to iron.

Grade 7+ extension: "Link to supernovas and how the elements spread:…"

Elements heavier than iron are made in supernovas,

which distribute them through the universe, where they form new stars and planets.

2 Explain why a satellite in a lower orbit must travel faster. (Higher)

Grade 4–5 starter: "Closer to the Earth, the force of gravity is…"

Closer to the Earth, the gravitational force is stronger,

so the satellite must move faster to stay in orbit.

Grade 7+ extension: "Link speed and radius for a stable orbit:…"

For a stable orbit, if the speed changes the radius must change;

a smaller orbit needs a higher speed.

3 Explain why scientists accept the Big Bang theory.

Grade 4–5 starter: "It explains the observed red-shift of…"

It explains why light from most distant galaxies is red-shifted,

showing the universe is expanding.

Grade 7+ extension: "Talk about how theories change with new evidence:…"

Theories are accepted when they explain the evidence;

they can be changed if new evidence (e.g. dark energy) is found.

ELABORATION GRADE 5

True or false? Justify it.

Saying why is worth more marks than saying true or false.

4 "All galaxies show the same red-shift." [1]

False: more distant galaxies show bigger red-shift.

5 "Gravity provides the force that keeps the Moon in orbit around the Earth." [1]

True

Extra practice

Retrieval · answers in the answer booklet

1 True or false? Galaxies further away from us show less red-shift. Explain. [2]

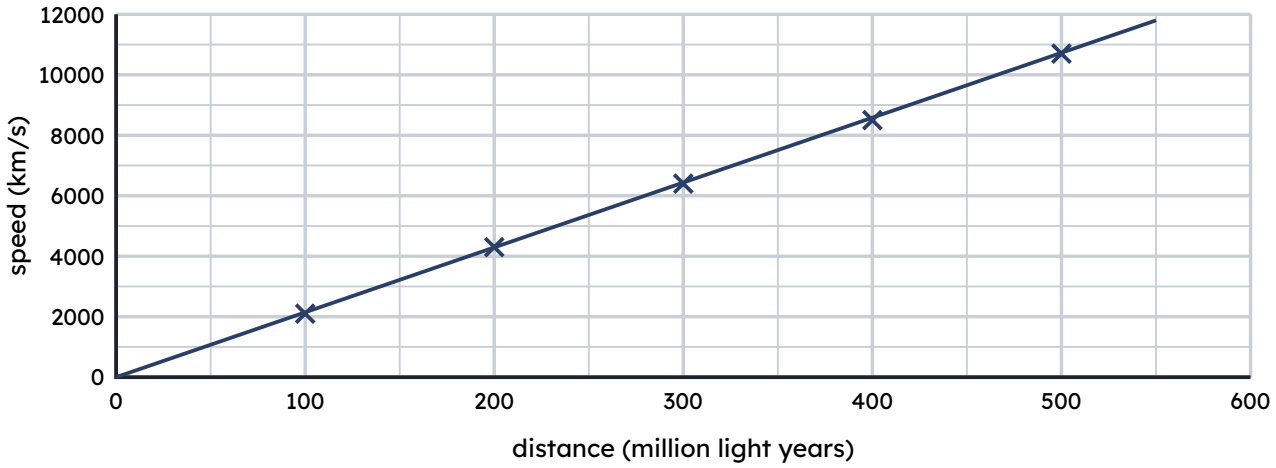
False. Further galaxies show more red-shift, so they're moving away faster.

DUAL CODING | ELABORATION | GRADE 5 | GRADE 7

Analyse galaxy data

Astronomers measure how far away galaxies are and how fast they are moving away.

Galaxy	A	B	C	D	E
Distance (million light years)	100	200	300	400	500
Speed moving away (km/s)	2100	4300	6400	8500	10 700



a Plot the data and draw a line of best fit. [3]

Points plotted; straight line through the origin.

b Describe the relationship. [2]

Speed is directly proportional to distance:

the further away the galaxy, the faster it moves away.

c Explain how this supports the Big Bang theory. [2]

All galaxies are moving away, faster the further they are,

so the universe is expanding from a single small, hot, dense region.

d Predict the speed of a galaxy 600 million light years away. [1]

About 12 800 km/s (≈ 21 km/s per million light years)

Extra practice

Retrieval · answers in the answer booklet

1 Grade 7+ Describe the role of gravity at each stage of a Sun-sized star's life. [4]

Gravity pulls the dust and gas of a nebula together to form a protostar

Gravitational collapse heats the core until fusion starts

In a main sequence star, gravity is balanced by the outward force from fusion (equilibrium)

When fusion slows, the balance changes; at the end, gravity squeezes the core into a white

dwarf

Exam practice

GRADE RADE 4

Secure the basics

1 Name the force that pulls a nebula together to form a star. [1]

Gravity

2 Name the galaxy that contains our solar system. [1]

The Milky Way

3 What will a star like the Sun become after it is a red giant? [1]

A white dwarf

4 Give an example of a natural satellite. [1]

The Moon

5 State what red-shift tells us about distant galaxies. [1]

They are moving away from us.

GRADE RADE 5

Apply and rearrange

6 Explain why a main sequence star is stable. [2]

Inward gravity is balanced by the outward force from fusion energy,

so it's in equilibrium.

7 Describe what happens to a star much more massive than the Sun after the main sequence. [3]

Becomes a red super giant

Explodes as a supernova

Leaves a neutron star, or a black hole if massive enough

8 Explain why the Big Bang theory is still incomplete. [2]

Observations (since 1998) suggest distant galaxies are receding faster and faster;

this is explained by dark energy, which is not understood.

Extra practice

Retrieval · answers in the answer booklet

1 Grade 7+ Light from galaxy A shows a smaller red-shift than light from galaxy B. Compare the two galaxies, and explain what this suggests about the universe. [3]

Galaxy B is moving away faster than galaxy A

So galaxy B is further away

Further galaxies receding faster suggests the universe is expanding (supporting the Big Bang

theory)

GRADE RADE 7+

Stretch

9 Galaxy X shows twice the red-shift of galaxy Y. Compare the two galaxies and explain what this tells us about the universe. [3]

Galaxy X is moving away faster

and is further away;

more distant galaxies receding faster means the universe is expanding.

10 Describe the life cycle of a star the same size as the Sun, from its formation to its end. Explain why it is stable for most of its life. [6]

A nebula (cloud of dust and gas) is pulled together by gravity.

It becomes denser and hotter, forming a protostar.

When hot enough, fusion of hydrogen starts: main sequence star.

It is stable because gravity is balanced by the outward force from fusion energy.

When the hydrogen runs out, it expands into a red giant,

then becomes a white dwarf, which cools to a black dwarf.

Total: _____ / 21

RETRIEVAL PRACTICE SPACED PRACTICE GRADE 4

Quick-fire retrieval: Space physics

Cover everything. Answer in under 3 minutes. Redo it on your next spaced session.

1 Number of planets in our solar system?

Eight

2 Where do stars form?

Nebula

3 Elements made in normal stars?

Up to iron

4 What keeps planets in orbit?

Gravity

5 Evidence universe is expanding?

Red-shift of distant galaxies

6 Unknowns in cosmology?

Dark mass and dark energy

Extra practice

Retrieval · answers in the answer booklet

1 Grade 5 Give one example of a natural satellite and one of an artificial satellite. [2]

Natural: the Moon (a moon orbiting a planet)

Artificial: a communications / weather / GPS satellite, or the ISS

Reflect and plan

METACOGNITION

Re-rate yourself

Go back to the checklist at the start of this topic and fill in the 'After' column.

METACOGNITION GRADE 4 GRADE 5 GRADE 7

Exam wrapper: why did I drop marks?

After marking the exam practice, write the question numbers you got wrong in the right row.

Reason I lost marks	Question numbers	What to do next
I didn't know or remember it (knowledge gap)		Flashcards and brain dumps
I knew it but misread the question or command word		Underline command words
Maths slip: units, rearranging, standard form		Redo the "we do / you do" pages
I ran out of time or didn't finish		Timed practice: 1 mark per minute

METACOGNITION

Two things I'm now confident about

METACOGNITION

One thing I still need to work on, and how I'll fix it

e.g. 'Rearranging equations → redo the Grade 7+ questions and use the website's Aim higher section.'

SPACED PRACTICE

Book my next spaced sessions

Write the dates in the planner at the front: +2 days, +1 week, +3 weeks.

Extra practice

Retrieval · answers in the answer booklet

1 True or false? All galaxies show blue-shift. Explain. [2]

False. Most distant galaxies show red-shift: they're moving away.

Interleaved retrieval quiz

Do this a week after finishing a topic

INTERLEAVING · RETRIEVAL PRACTICE · GRADE 4 · GRADE 5 · GRADE 7

Mixed Paper 2 questions (plus Paper 1 links)

The questions are mixed up on purpose. First decide which topic each one is from, then answer it. Paper 2 can test ideas from Paper 1 too, like energy in a moving car.

1 (?) Calculate the weight of a 4 kg mass. (g = 9.8 N/kg) [2]

W = mg = 4 × 9.8 = 39.2 N

2 (?) A wave has f = 25 Hz and λ = 0.2 m. Calculate its speed. [2]

v = fλ = 25 × 0.2 = 5 m/s

3 (?) What will happen to a star much more massive than the Sun after it is a red super giant? [1]

It explodes as a supernova.

4 (?) Give one way to increase the strength of an electromagnet. [1]

More turns / bigger current / iron core

5 (?) Explain what is meant by terminal velocity. [2]

The constant velocity reached when the resultant force is zero (drag = weight).

6 (?) Which EM wave is used for medical imaging of bones? [1]

X-rays

7 (?) Calculate the force on 0.4 m of wire carrying 5 A in a 0.1 T field. (Higher) [2]

F = BIl = 0.1 × 5 × 0.4 = 0.2 N

8 (?) Explain why a satellite in orbit is accelerating. (Higher) [2]

Its direction keeps changing, so its velocity changes.

9 (?) A 1000 kg car moves at 20 m/s. Calculate its kinetic energy. (Energy) [2]

Ek = ½ × 1000 × 20² = 200 000 J

10 (?) Which wire in a plug is brown? (Electricity) [1]

Live

Q	1	2	3	4	5	6	7	8	9	10
Topic	Forces	Waves	Space	Magnetism	Forces	Waves	Magnetism	Space	Paper 1 link	Paper 1 link

Extra practice

Retrieval · answers in the answer booklet

1 Define **scalar**. [1]

A quantity with size only, e.g. speed, mass, energy.