Starter

2008 Higher, Section A

Scan the code and answer these:

8 **10** **18**

Charged particles, a.c., semiconductors.

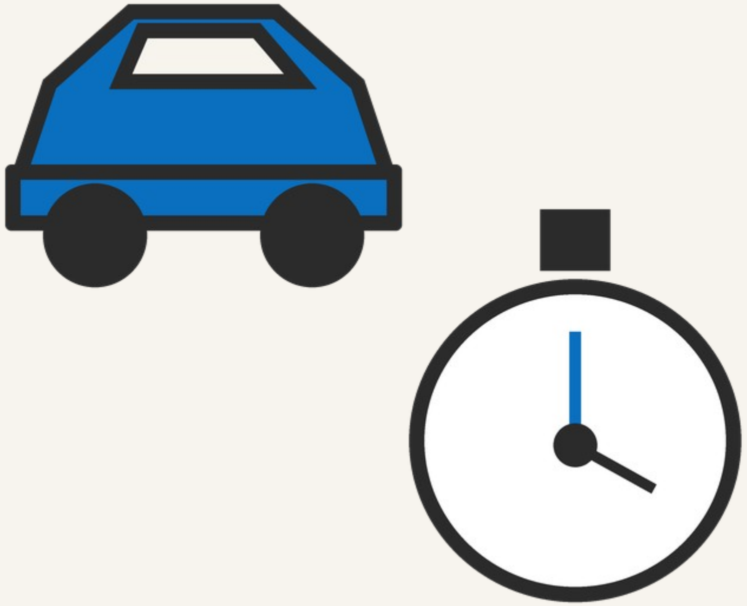
Show your working, not just the letter.

Scan for the paper

Marking scheme

HIGHER PHYSICS · OUR DYNAMIC UNIVERSE

Motion, graphs, projectiles



Six lessons on how things move — and on getting the working right.

Higher Physics

PART 1

Motion, as you know it

Everything at Higher is built on the N5 picture of motion. This part gets it back.

By the end of this part...

1. I can tell a scalar from a vector and give examples of each
2. I can find distance, displacement, speed and velocity for a journey
3. I can find acceleration and displacement from a velocity-time graph

What you already know

From National 5 — all of it is still true at Higher.

Quantity	Scalar or vector	How you find it
distance, d	scalar	the whole path travelled
displacement, s	vector	start to finish
speed, v	scalar	distance ÷ time
velocity, v	vector	displacement ÷ time
acceleration, a	vector	$(v - u) \div t$

Velocity-time graph: gradient is a, area under it is s.

N5 recap — boards up

SHOW ME BOARDS

More practice: Textbook p.4–12

1. Which of these are vectors: distance, displacement, speed, velocity, acceleration?
2. A car drives 300 m north, then 400 m east, in 30 s. What distance has it travelled?
3. For the same car, what is the size and direction of its displacement?
4. For the same car, work out the average speed and the average velocity.
5. A car goes from rest to $8.0\ \mathrm{m\,s^{-1}}$ in 4.0 s. Find a, then find s.

Starter

2011 Higher, Section A

Scan the code and answer these:

1 **8** **18**

Scalars and vectors, volts, n-type.

Show your working, not just the letter.

Scan for the paper

No marking scheme

PART 2

The equations of motion

Four equations cover every straight-line problem where the acceleration does not change.

By the end of this part…

1. I can pick the right equation of motion from what I am given
2. I can solve problems for objects with constant acceleration
3. I can lay my working out the way the marking instructions expect

Five symbols, and one condition

Only when the acceleration is constant and the motion is straight.

- u – the velocity at the start, in $\mathrm{m\,s^{-1}}$
- v – the velocity at the end, in $\mathrm{m\,s^{-1}}$
- a – the acceleration, in $\mathrm{m\,s^{-2}}$
- s – the displacement, in m
- t – the time taken, in s

Equation 1 — $v = u + at$

JOTTER NOTES

$$v = u + at$$

v ($m\ s^{-1}$) velocity at the end	**u ($m\ s^{-1}$)** velocity at the start	**a ($m\ s^{-2}$)** acceleration	**t (s)** time taken

The one with no s in it.

Past-paper example — $v = u + at$

A car and caravan climb a slope at 4.0 m s^{-1}, then speed up uniformly for 250 s to 9.5 m s^{-1}. Show that $a = 0.022 \text{ m s}^{-2}$.

$u = 4.0 \text{ m s}^{-1}$

$v = 9.5 \text{ m s}^{-1}$

$t = 250 \text{ s}$

$a = ?$

$v = u + at$

$a = (v - u)/t$

$a = 9.5 - 4.0/250$

$\underline{a = 0.022 \text{ m s}^{-2}}$

Equation 2 — $s = ut + \frac{1}{2}at^2$

JOTTER NOTES

$$s = ut + \tfrac{1}{2} a t^2$$

s (m)	**u (m s^{-1})**	**a (m s^{-2})**	**t (s)**
displacement	velocity at the start	acceleration	time taken

The one with no v in it.

Past-paper example — $s = ut + \frac{1}{2}at^2$

A car travelling at 12 $m\ s^{-1}$ accelerates uniformly at $-1.5\ m\ s^{-2}$ for 6.0 s. Calculate the distance travelled in that time.

$u = 12\ m\ s^{-1}$

$a = -1.5\ m\ s^{-2}$

$t = 6.0\ s$

$s = ?$

$$s = ut + \tfrac{1}{2} a t^2$$

$$s = (12 \times 6.0) + (\tfrac{1}{2} \times -1.5 \times 6.0^2)$$

$$s = 72 - 27$$

$$\underline{s = 45\ m}$$

Equation 3 — $v^2 = u^2 + 2as$

JOTTER NOTES

$$v^2 = u^2 + 2as$$

v ($m\ s^{-1}$) velocity at the end	**u ($m\ s^{-1}$)** velocity at the start	**a ($m\ s^{-2}$)** acceleration	**s (m)** displacement

The one with no t in it.

Past-paper example — $v^2 = u^2 + 2as$

A train accelerates uniformly from 5.0 m s^{-1} to 12.0 m s^{-1} while it travels 119 m along a straight track. Calculate its acceleration.

$u = 5.0 \text{ m s}^{-1}$

$v = 12.0 \text{ m s}^{-1}$

$s = 119 \text{ m}$

$a = ?$

$$v^2 = u^2 + 2as$$

$$a = (v^2 - u^2)/2s$$

$$a = (12.0^2 - 5.0^2)/2 \times 119$$

$$\underline{a = 0.50 \text{ m s}^{-2}}$$

Equation 4 — $s = \frac{1}{2}(u + v)t$

JOTTER NOTES

$$s = \tfrac{1}{2}(u + v)t$$

s (m)	u ($m\,s^{-1}$)	v ($m\,s^{-1}$)	t (s)
displacement	velocity at the start	velocity at the end	time taken

The one with no a in it.

Past-paper example — $s = \frac{1}{2}(u + v)t$

A car accelerates uniformly from rest and travels 18 m in 3.0 s.

Calculate the speed of the car at 3.0 s.

$u = 0\ \text{m s}^{-1}$

$s = 18\ \text{m}$

$t = 3.0\ \text{s}$

$v = ?$

$$s = \tfrac{1}{2}(u + v)t$$

$$18 = \tfrac{1}{2} \times (0 + v) \times 3.0$$

$$\underline{v = 12\ \text{m s}^{-1}}$$

Choosing the equation

List what you have and what you want, then pick the one that fits.

You have	You want	Use
u, a, t	v	$v = u + at$
u, a, t	s	$s = ut + \frac{1}{2}at^2$
u, a, s	v	$v^2 = u^2 + 2as$
u, v, t	s	$s = \frac{1}{2}(u + v)t$

Worked example — a lorry

A lorry accelerates from 21 m s^{-1} to 35 m s^{-1} while it covers 120 m.

Calculate its acceleration.

$u = 21 \text{ m s}^{-1}$

$v = 35 \text{ m s}^{-1}$

$s = 120 \text{ m}$

$a = ?$

$$v^2 = u^2 + 2as$$

$$a = (v^2 - u^2)/2s$$

$$a = (35^2 - 21^2)/2 \times 120$$

$\underline{a = 3.27 \text{ m s}^{-2}}$

Worked example — a cannon

A cannon ball starts from rest and accelerates at $150\ \mathrm{m\ s^{-2}}$ for 0.20 s. Calculate the length of the barrel.

$u = 0\ \mathrm{m\ s^{-1}}$

$a = 150\ \mathrm{m\ s^{-2}}$

$t = 0.20\ \mathrm{s}$

$s = ?$

$$s = ut + \tfrac{1}{2} a t^2$$

$$s = (0 \times 0.20) + (\tfrac{1}{2} \times 150 \times 0.20^2)$$

$\underline{s = 3.0\ \mathrm{m}}$

Worked example — the same cannon

The same ball accelerates from rest at $150\ \mathrm{m\ s^{-2}}$ for 0.20 s.

Calculate the velocity it leaves the barrel with.

$u = 0\ \mathrm{m\ s^{-1}}$

$a = 150\ \mathrm{m\ s^{-2}}$

$t = 0.20\ \mathrm{s}$

$v = ?$

$$v = u + at$$

$$v = 0 + (150 \times 0.20)$$

$$\underline{v = 30\ \mathrm{m\ s^{-1}}}$$

Equations of motion — boards up

SHOW ME BOARDS

1. A car speeds up from rest at 2.0 m s^{-2} for 6.0 s. What is its final velocity?
2. The same car – how far does it travel in those 6.0 s?
3. A train slows from 30 m s^{-1} to 12 m s^{-1} over 210 m. Find its acceleration.
4. A cyclist at 4.0 m s^{-1} accelerates at 0.50 m s^{-2} for 8.0 s. How far does she go?
5. Which equation would you use if you had u, v and t, and wanted s?

Your turn

Work through the equations-of-motion questions.
Set every answer out the way the worked examples do.

Textbook p.28 (1.3.2)

Starter

2013 Higher, Section A

Scan the code and answer these:

3 | 8 | 11

Q3 is this experiment — same apparatus.

Show your working, not just the letter.

Scan for the paper

Marking scheme

PART 3

Acceleration down a slope

An experiment the exam can ask you to describe, so it goes in the jotter in full.

By the end of this part…

1. I can describe an experiment to measure acceleration down a slope
2. I can explain why two light gates are needed, not one
3. I can calculate the acceleration from the light-gate readings

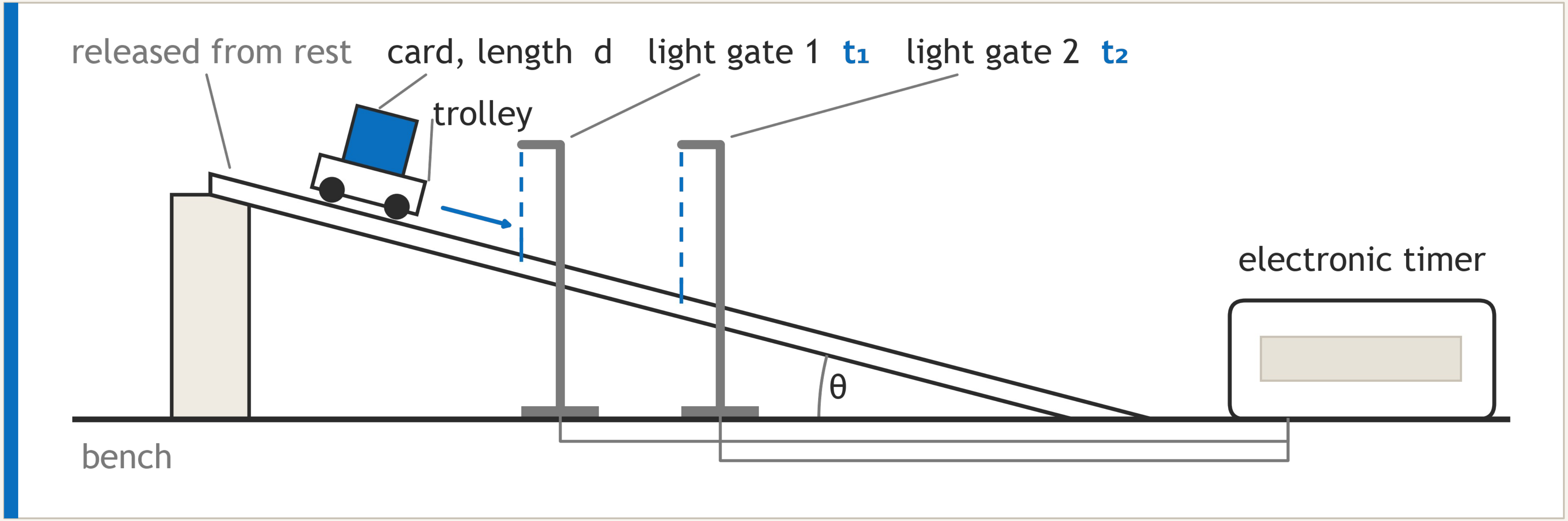
Why two light gates?

Acceleration is a change in velocity, so one velocity is never enough.

- A light gate times how long the card takes to cut the beam.
- Card length ÷ that time is the velocity at that gate.
- One gate gives one velocity — and no change to measure.
- Two gates give u and v; the timer gives the t between them.
- Use the same card at both gates, or the lengths differ.

JOTTER NOTES

Experiment: acceleration of a trolley down a slope



Draw this, label it, and keep it — the exam can ask you to describe the whole experiment.

JOTTER NOTES

The method, step by step

Measure the card length d with a ruler.

Release the trolley from rest, from the same point every run.

Gate 1 times the card cutting its beam: t_1.

Gate 2 times the same card: t_2.

The timer also gives t_3, the time between the gates.

Repeat and take the mean.

JOTTER NOTES

Working out the acceleration

$$u = d/t_1$$

$$v = d/t_2$$

$$a = (v - u)/t_3$$

Worked example — velocity at the first gate

A card 0.025 m long cuts the first light-gate beam for 0.050 s.

Calculate the velocity of the trolley at that gate.

$d = 0.025$ m

$t_1 = 0.050$ s

$u = ?$

$u = d/t_1$

$u = 0.025/0.050$

<u>$u = 0.50$ m s^{-1}</u>

Worked example — the acceleration

The same card cuts the second beam in 0.020 s, so $v = 1.25 \text{ m s}^{-1}$.
The timer reads 0.35 s between the gates. Find the acceleration.

$u = 0.50 \text{ m s}^{-1}$

$v = 1.25 \text{ m s}^{-1}$

$t = 0.35 \text{ s}$

$a = ?$

$a = (v - u)/t_3$

$a = 1.25 - 0.50/0.35$

$\underline{a = 2.1 \text{ m s}^{-2}}$

Past-paper example — the same experiment

2022 Higher, Paper 1 Q2 — one gate this time, and $v^2 = u^2 + 2as$.

A trolley is released from rest at P and runs down a ramp.
A card on it cuts a light gate at Q. Which statements are right?

The statement	Right?	Why
$u = 0\ \mathrm{m\ s^{-1}}$	yes	it starts from rest at P
s = length of the card	no	s is the distance from P to Q
v = PQ ÷ timer reading	no	the gate times the card, not PQ

The slope experiment — boards up

SHOW ME BOARDS

1. What is measured with a ruler in this experiment, and why?
2. Why is the trolley released from the same point every time?
3. Why does the card have to be the same at both gates?
4. A card of 0.020 m cuts the beam in 0.040 s. What is the velocity there?
5. Name one thing that would make your value of a too small, and say why.

Your turn

Set up the slope, the trolley and the two light gates.
Take three runs, find the mean acceleration, and write the experiment up.

Textbook p.20 (1.2.4)

Starter

2015 Higher, Section A

Scan the code and answer these:

1 | 8 | 10

Vectors, work on a charge, an a.c. kettle.

Show your working, not just the letter.

Scan for the paper

Marking scheme

PART 4

Straight up and back down

Once it has left your hand, gravity is the only thing acting — so the acceleration never changes.

By the end of this part…

1. I can explain why the acceleration is the same all the way up and all the way down
2. I can choose a direction as positive and stay with it
3. I can solve problems for objects moving vertically

A ball thrown straight up

Ignore air resistance: gravity is the only force on it.

- On the way up it is still moving up, but slowing down.
- At the very top the velocity is zero — the acceleration is not.
- On the way down it speeds up again, at the same rate.
- Slowing down going up is the same as speeding up going down.
- So the acceleration is $9.8\ \mathrm{m\ s^{-2}}$ towards the ground, throughout.

JOTTER NOTES

Vertical motion — the sign convention

Choose one direction as positive and keep it for the whole question.

Taking up as positive, $a = -9.8\ \mathrm{m\ s^{-2}}$ for the whole flight.

The minus sign says the acceleration points down, not that the object does.

At the highest point $v = 0$, but a is still $-9.8\ \mathrm{m\ s^{-2}}$.

A displacement back at the starting height is $s = 0$, not $2h$.

Watch out — signs in vertical motion

THE MISTAKE

- Using $+9.8$ going up and -9.8 coming down
- Writing $s = 0$ as the height reached
- Reading $v = 0$ at the top as $a = 0$

THE CORRECT ANSWER

- One convention for the whole question
- s is the displacement, not the distance flown
- a is $-9.8\ \mathrm{m\ s^{-2}}$ at every instant, top included

Markers read every line of your working

Vertical motion is where signs decide the mark.

IMPORTANT — MARKS

Qualifications Scotland markers check the whole of your working, not only the final line.

A + or − in the wrong place is one of the commonest ways to lose marks here, even when the arithmetic is right.

Write down which direction is positive, then keep every substitution consistent with it.

Worked example — how high?

A stone is thrown straight up, leaving the hand at $10\ \mathrm{m\,s^{-1}}$.
Calculate the maximum height it reaches.

$u = 10\ \mathrm{m\,s^{-1}}$

$v = 0\ \mathrm{m\,s^{-1}}$

$a = -9.8\ \mathrm{m\,s^{-2}}$

$s = ?$

$$v^2 = u^2 + 2as$$

$$s = (v^2 - u^2)/2a$$

$$s = (0 - 10^2)/2 \times -9.8$$

$\underline{s = 5.1\ \mathrm{m}}$

Worked example — how long?

The same stone leaves the hand at $10\ \mathrm{m\ s^{-1}}$ going straight up. Calculate the time until it is back at the height it started.

$u = 10\ \mathrm{m\ s^{-1}}$

$v = 0\ \mathrm{m\ s^{-1}}$

$a = -9.8\ \mathrm{m\ s^{-2}}$

$t = ?$

$v = u + at$

$t = (v - u)/a$

$t = 0 - 10/-9.8$

$t = 1.02$ s to the top

<u>total time = $2 \times 1.02 = 2.0$ s</u>

Vertical motion — boards up

SHOW ME BOARDS

1. A ball is thrown up at $12\ \mathrm{m\,s^{-1}}$. What is its velocity at the highest point?
2. What is its acceleration at that highest point?
3. How long does that ball take to reach the top?
4. A stone is dropped from rest down a well and falls for 2.0 s. How fast is it going?
5. Why is the displacement zero when a ball lands back in your hand?

Your turn

Vertical-motion questions from the textbook. Then plan the free-fall experiment: at least five different heights, four repeats each, table and graph in Excel, and a full write-up.

Textbook p.30 (1.3.3)
Experiment: g by free fall

Starter

2014 Revised Higher, Section A

Scan the code and answer these:

2 | 9 | 19

Equations of motion, magnetism, p-n.

Show your working, not just the letter.

Scan for the paper

Marking scheme

PART 5

Projectiles

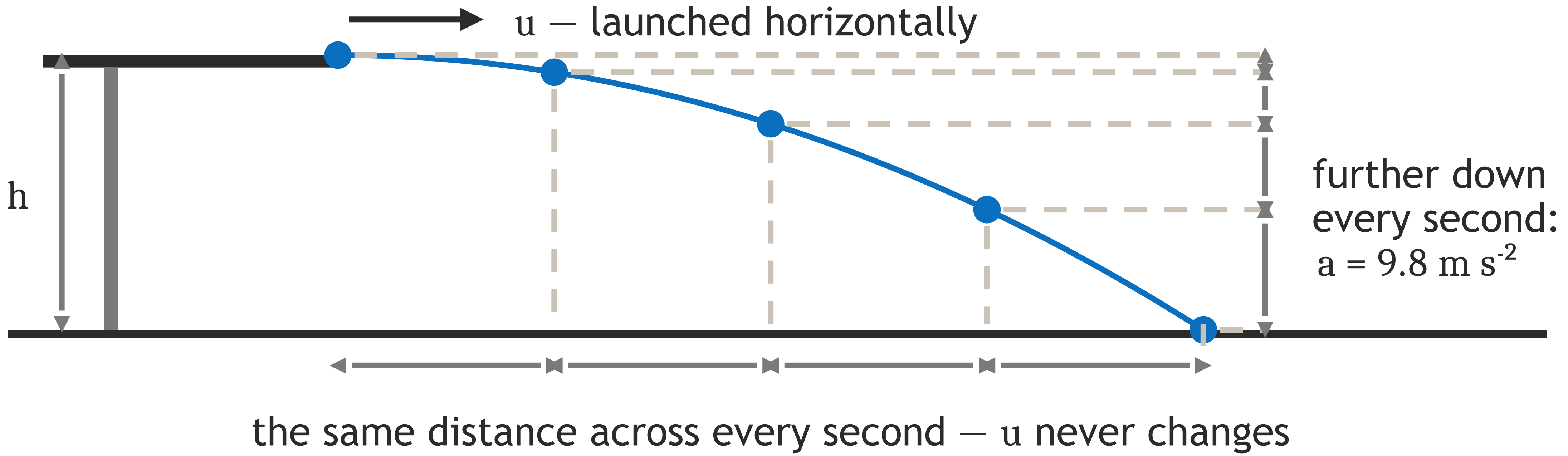
Two motions at once, and they take no notice of each other.

By the end of this part…

1. I can explain why horizontal and vertical motion are independent
2. I can resolve a launch velocity into its two components
3. I can solve problems for a projectile launched at an angle

Projectiles at National 5 — launched horizontally

Constant velocity across, constant acceleration down.



JOTTER NOTES

Projectiles — the two motions are independent

Horizontal and vertical motion do not affect each other.

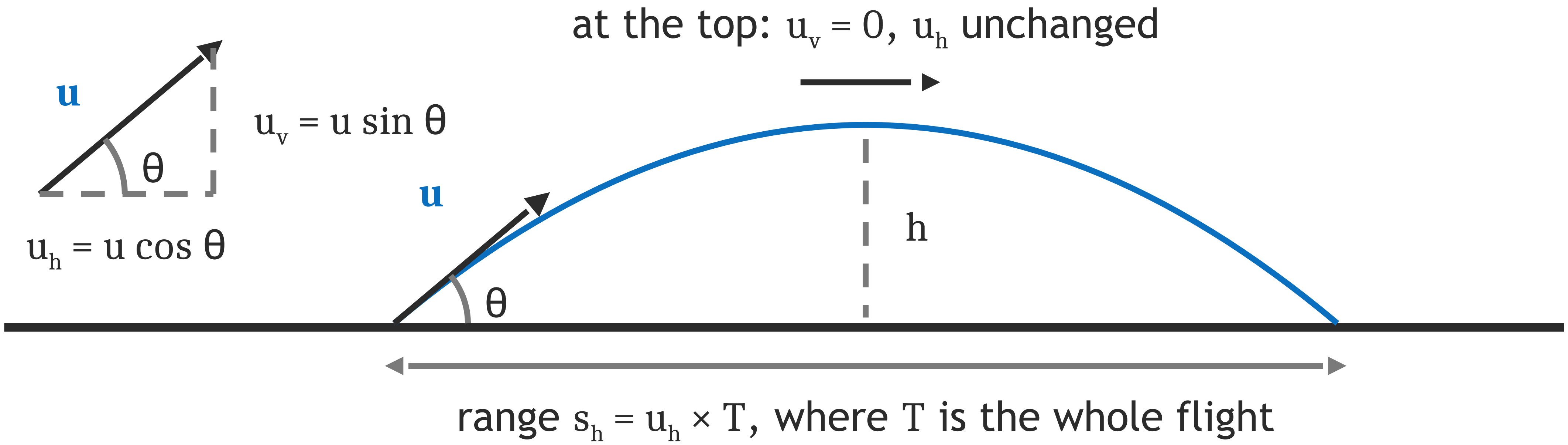
Horizontal: constant velocity, so $s_h = u_h\ t$.

Vertical: constant acceleration $-9.8\ \mathrm{m\ s^{-2}}$, so use the equations of motion.

Time is the only quantity the two motions share.

A satellite is a projectile that never lands — it is in free fall around the planet.

Higher — launched at an angle



Resolve first: u becomes $u \cos\theta$ across and $u \sin\theta$ up. After that it is an ordinary projectile.

JOTTER NOTES

Resolving the launch velocity

$$u_h = u\cos\theta$$

$$u_v = u\sin\theta$$

Then: u_h never changes, and u_v is the u of a vertical problem.

Time of flight is worked out from the vertical motion only.

JOTTER NOTES

Setting out a projectile: two columns, every time

Rule one page in two: VERTICAL on the left, HORIZONTAL on the right.

VERTICAL is a $u\ v\ a\ s\ t$ problem — the equations of motion, with $a = -9.8\ \mathrm{m\ s^{-2}}$.

HORIZONTAL is a constant-speed problem — only $s = v\,t$.

The time t is the one entry that appears in BOTH columns.

Fill the columns in before you choose an equation.

Worked example — resolving

A ball is launched at $20\ \mathrm{m\ s^{-1}}$, at 35° to the horizontal.

Calculate the horizontal and vertical components of that velocity.

VERTICAL

u v a s t

u = ?

$a = -9.8\ \mathrm{m\ s^{-2}}$

HORIZONTAL

s = v t

v = ?

$u_h = u\cos\theta$

$u_h = 20\cos 35° = 16.4\ \mathrm{m\ s^{-1}}$

$u_v = u\sin\theta$

$\underline{u_v = 20\sin 35° = 11.5\ \mathrm{m\ s^{-1}}}$

Worked example — a golf ball (1 of 3)

A golf ball is struck at $30\ \mathrm{m\ s^{-1}}$, at 25° to the horizontal.

Calculate the horizontal and vertical components of its velocity.

VERTICAL

u v a s t

u = ?

$a = -9.8\ \mathrm{m\ s^{-2}}$

HORIZONTAL

s = v t

v = ?

$u_h = u \cos\theta$

$u_h = 30 \cos 25^{\circ} = 27.2\ \mathrm{m\ s^{-1}}$

$u_v = u \sin\theta$

$\underline{u_v = 30 \sin 25^{\circ} = 12.7\ \mathrm{m\ s^{-1}}}$

Worked example — a golf ball (2 of 3)

The ball leaves the tee with $u_v = 12.7\ \mathrm{m\ s^{-1}}$ upwards.

Calculate the maximum height it reaches.

VERTICAL

u v a s t

$u = 12.7\ \mathrm{m\ s^{-1}}$

$v = 0\ \mathrm{m\ s^{-1}}$

$a = -9.8\ \mathrm{m\ s^{-2}}$

$s = ?$

HORIZONTAL

$s = v\,t$

$v = 27.2\ \mathrm{m\ s^{-1}}$

$$v^2 = u^2 + 2as$$

$$0 = 12.7^2 + (2 \times -9.8 \times s)$$

$$\underline{s = 8.2\ \mathrm{m}}$$

Worked example — a golf ball (3 of 3)

The ball lands at the height it was struck from, so it returns at $-12.7\ \text{m s}^{-1}$. Find the time of flight, then the range.

VERTICAL

u v a s t

$u = 12.7\ \text{m s}^{-1}$

$v = -12.7\ \text{m s}^{-1}$

$a = -9.8\ \text{m s}^{-2}$

$t = ?$

HORIZONTAL

s = v t

$v = 27.2\ \text{m s}^{-1}$

$t = ?$

$s = ?$

$$v = u + at$$

$$-12.7 = 12.7 + (-9.8 \times t)$$

$$t = 2.59\ \text{s}$$

$$\underline{s_h = 27.2 \times 2.59 = 70.4\ \text{m}}$$

Past-paper example — the crossbar challenge (1 of 2)

A football is kicked at 17.0 m s^{-1}, at 24.0° to the horizontal.

Calculate the horizontal and vertical components of that velocity.

VERTICAL

u v a s t

$u = ?$

$a = -9.8 \text{ m s}^{-2}$

HORIZONTAL

s = v t

$v = ?$

$s = 11 \text{ m}$

$$u_h = u \cos \theta$$

$$u_h = 17.0 \cos 24.0° = 15.5 \text{ m s}^{-1}$$

$$u_v = u \sin \theta$$

$$\underline{u_v = 17.0 \sin 24.0° = 6.91 \text{ m s}^{-1}}$$

Past-paper example — the crossbar challenge (2 of 2)

The crossbar is 11 m away, and the ball is at the top of its flight as it hits. Find the time to the bar, then the height it hits at.

VERTICAL

u v a s t

$u = 6.91\ \mathrm{m\ s^{-1}}$

$v = 0\ \mathrm{m\ s^{-1}}$

$a = -9.8\ \mathrm{m\ s^{-2}}$

$s = ?$

HORIZONTAL

s = v t

$v = 15.5\ \mathrm{m\ s^{-1}}$

$s = 11\ \mathrm{m}$

$t = ?$

$t = 11 / 15.5 = 0.71\ \mathrm{s}$

$$v^2 = u^2 + 2as$$

$$s = (0 - 6.91^2)/2 \times -9.8$$

$\underline{s = 2.44\ \mathrm{m}}$

Investigation — which angle goes furthest?

Use the launcher to fire at the same speed but different angles.
Measure the range each time and put the results in a table.
How does the launch angle change the range, and which angle is best?

Write it up in your jotter

Projectiles — boards up

SHOW ME BOARDS

1. A ball is thrown horizontally off a cliff. What is its horizontal acceleration?
2. Two identical balls: one dropped, one thrown horizontally. Which lands first?
3. A shell is fired at $40\ \mathrm{m\ s^{-1}}$ at 30°. What is its horizontal component?
4. For that shell, what is its vertical component?
5. Why are astronauts on the space station weightless if gravity still acts on them?

Your turn

Projectile questions, including launches at an angle.
Draw the triangle first on every one — components before anything else.

Textbook p.92 (4.2.1)

Starter

2012 Higher, Section A

Scan the code and answer these:

8 **9** **11**

Internal resistance, resistors, farads.

Show your working, not just the letter.

Scan for the paper

Marking scheme

PART 6

Graphs of motion

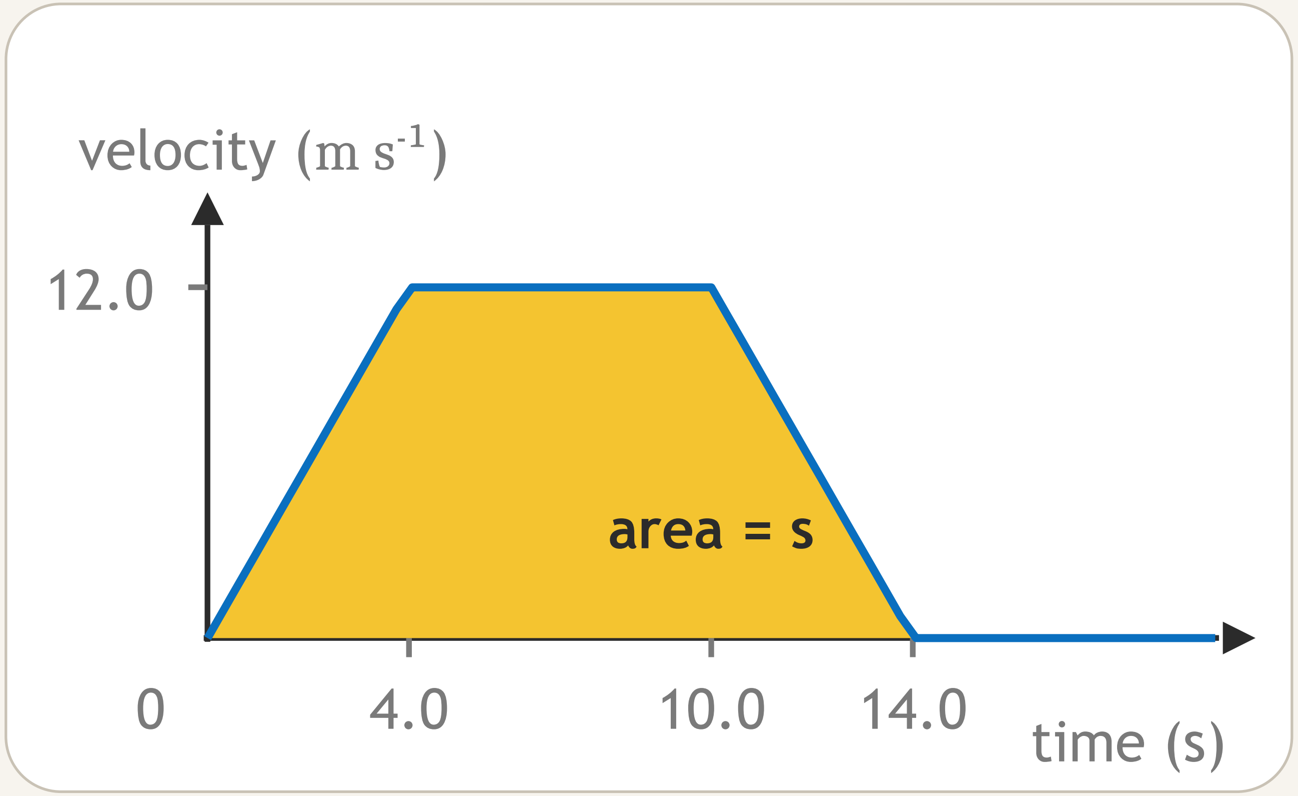
Three graphs of the same journey — and each one tells you what the next one looks like.

By the end of this part...

1. I can find velocity, acceleration and displacement from a motion-time graph
2. I can change between displacement-time, velocity-time and acceleration-time graphs
3. I can sketch the graphs for a ball thrown up and for a bouncing ball

Velocity-time graphs

Gradient is the acceleration; area under the line is displacement.



Speeding up: the line rises.

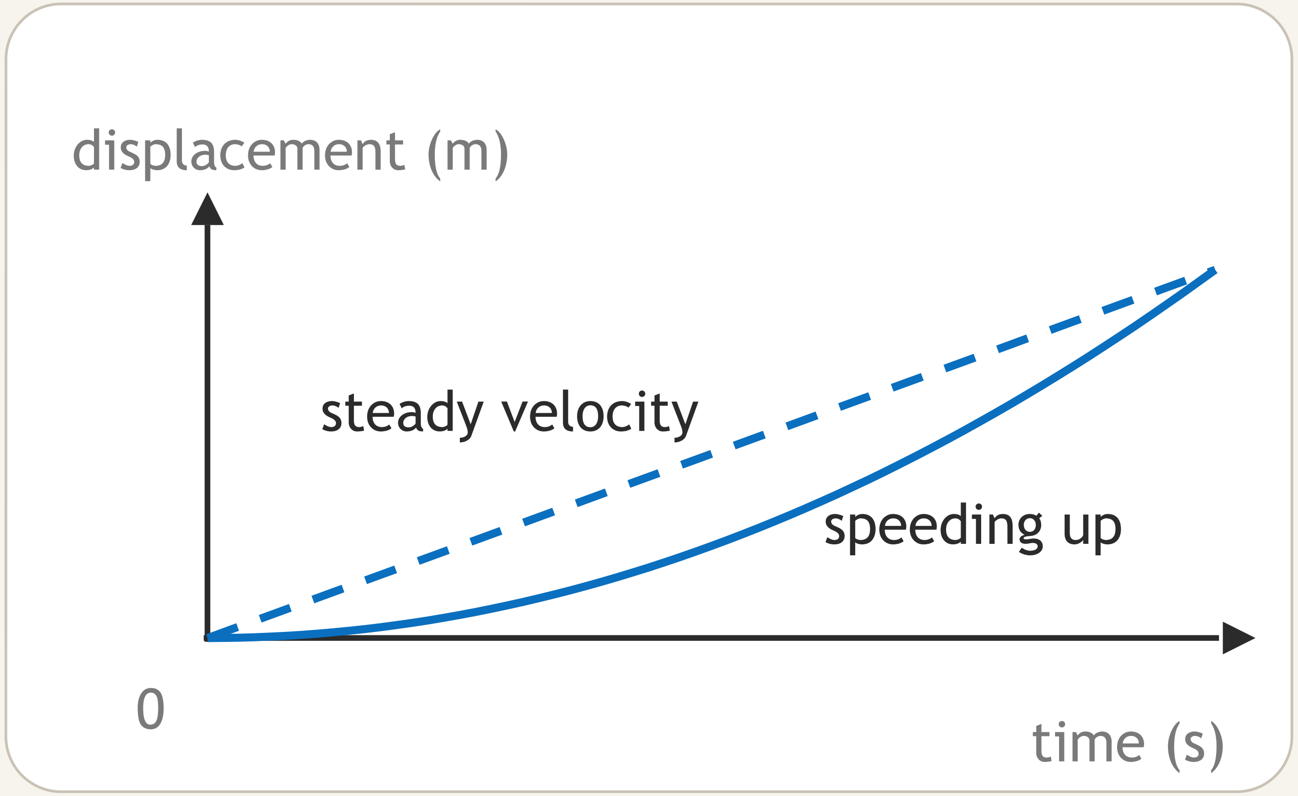
Steady speed: it is flat.

Slowing down: it falls.

The steeper the line, the bigger the acceleration.

Displacement-time graphs

Gradient is the velocity — there is no area to read on this one.



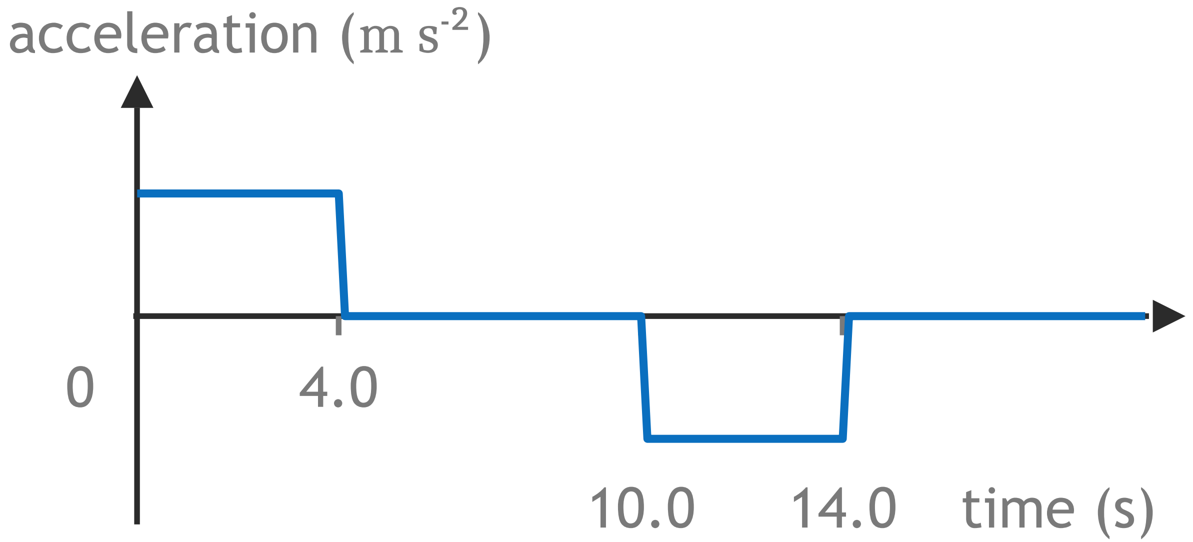
A straight line is a constant velocity.

A curve getting steeper means speeding up.

A flat line means it is not moving.

Acceleration-time graphs

The area under the line is the change in velocity.



Constant acceleration is a flat line above the axis.

Steady speed is a flat line on the axis.

Slowing down is a flat line below it.

JOTTER NOTES

How the three graphs are related

Gradient of a displacement-time graph = velocity.

Gradient of a velocity-time graph = acceleration.

Area under a velocity-time graph = displacement.

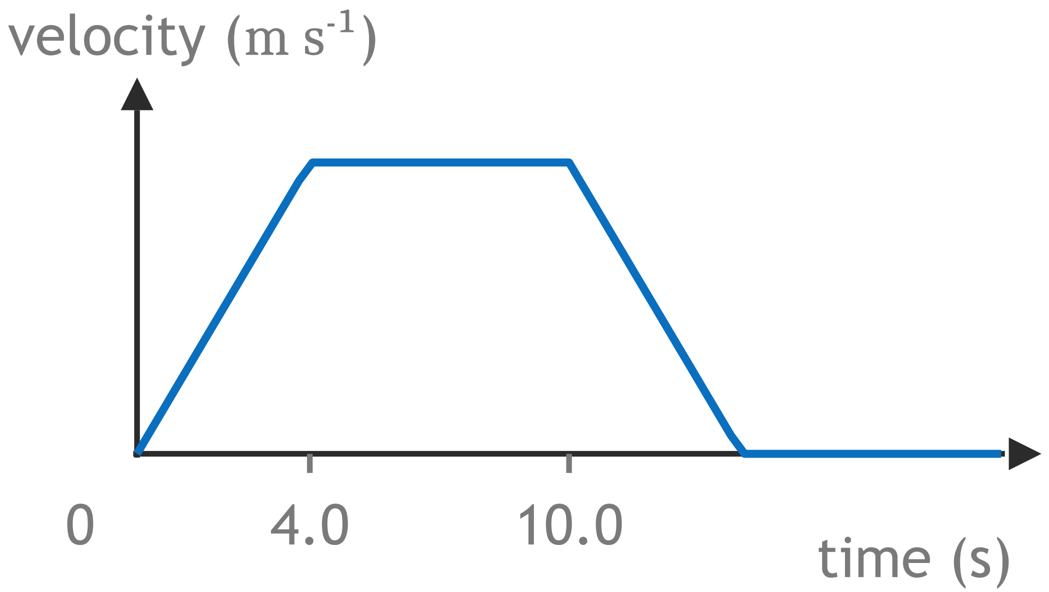
Area under an acceleration-time graph = change in velocity.

Go down the list with gradients; come back up it with areas.

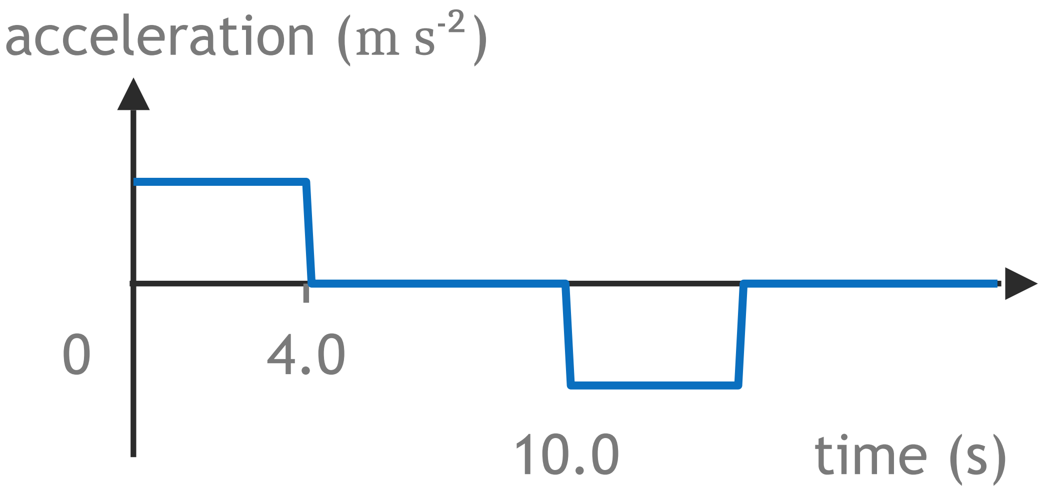
Changing between graphs — to acceleration-time

Read the gradient of each straight section and plot it as a flat line.

velocity-time



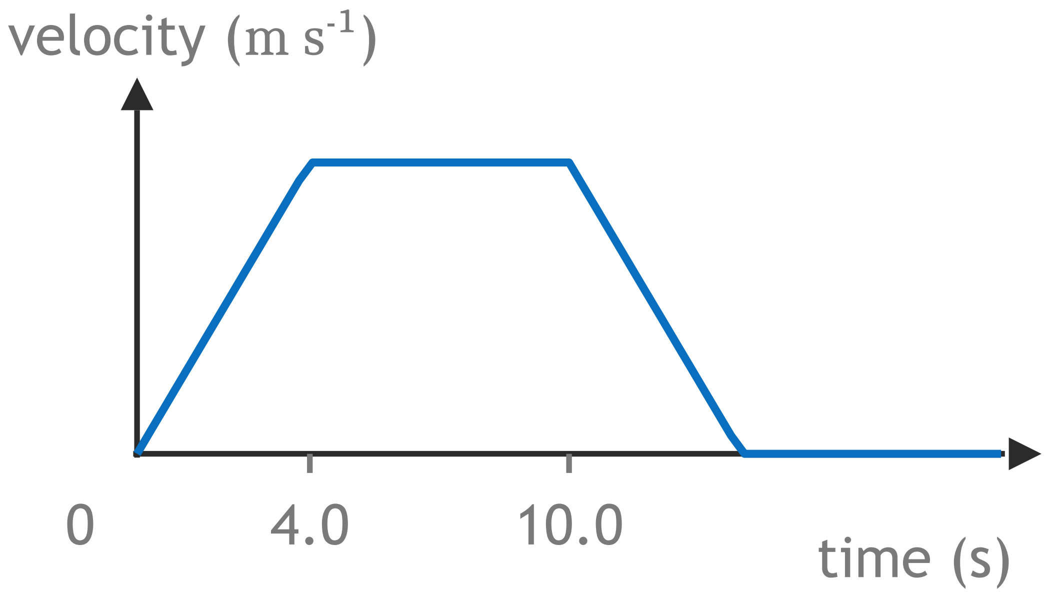
acceleration-time



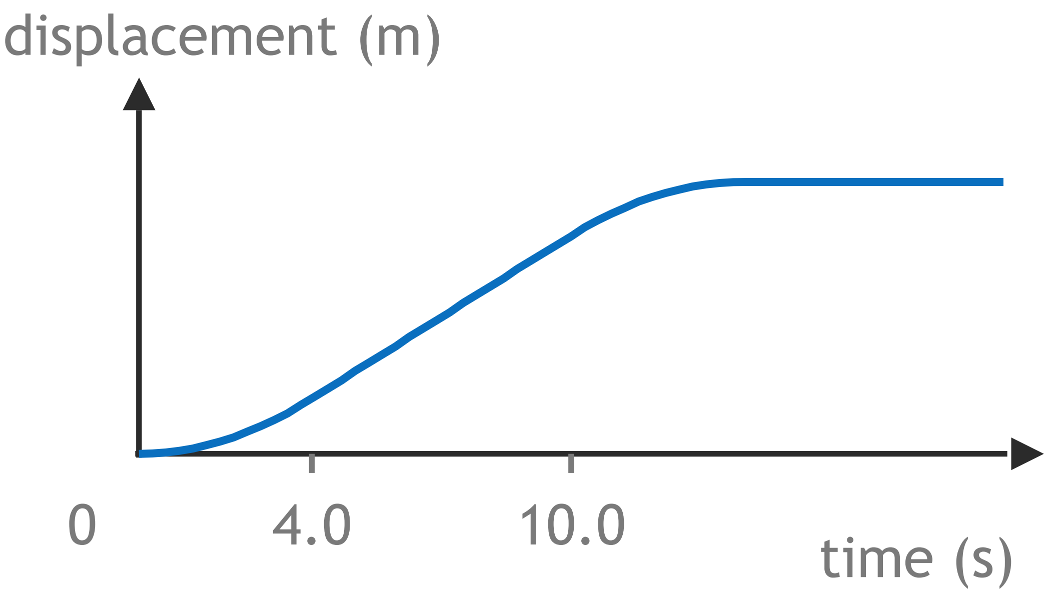
Changing between graphs — to displacement-time

Add the area up as you go: rising, then straight, then flattening off.

velocity-time



displacement-time



Worked example — reading a velocity-time graph

A car speeds up steadily from rest to $12\ \mathrm{m\ s^{-1}}$ in 4.0 s.

Calculate its acceleration over that 4.0 s.

$u = 0\ \mathrm{m\ s^{-1}}$

$v = 12\ \mathrm{m\ s^{-1}}$

$t = 4.0\ \mathrm{s}$

$a = ?$

$v = u + at$

$a = (v - u)/t$

$a = 12 - 0/4.0$

$\underline{a = 3.0\ \mathrm{m\ s^{-2}}}$

Worked example — the area under the graph

The same car holds $12\ \mathrm{m\ s^{-1}}$ until 10.0 s, then slows to rest at 14.0 s. Calculate the total distance travelled.

speeding up: 0 to 4.0 s

steady: 4.0 to 10.0 s

slowing: 10.0 to 14.0 s

distance = ?

area 1 = $\frac{1}{2} \times 4.0 \times 12 = 24$ m

area 2 = $6.0 \times 12 = 72$ m

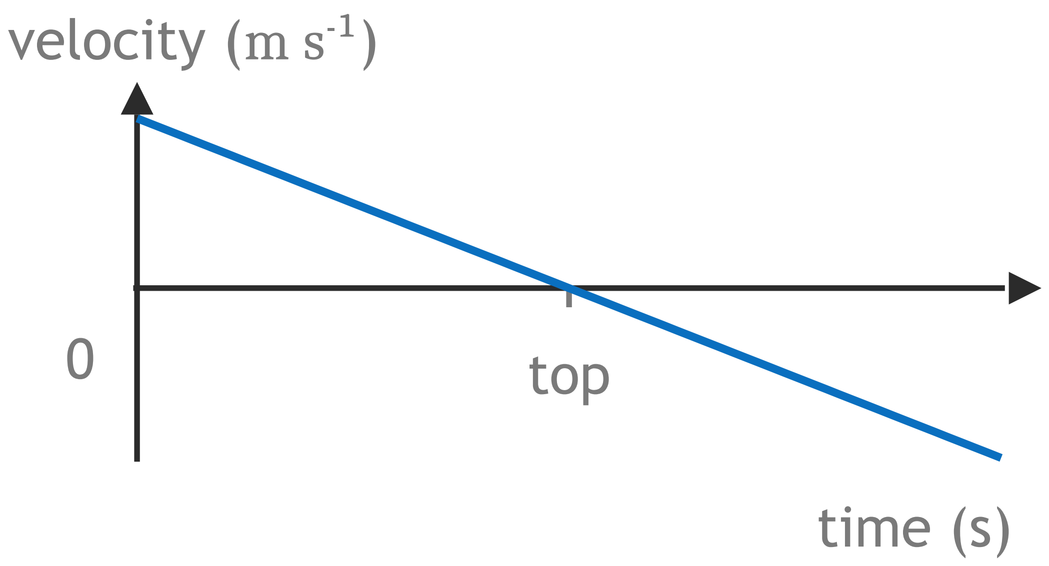
area 3 = $\frac{1}{2} \times 4.0 \times 12 = 24$ m

<u>distance = 24 + 72 + 24 = 120 m</u>

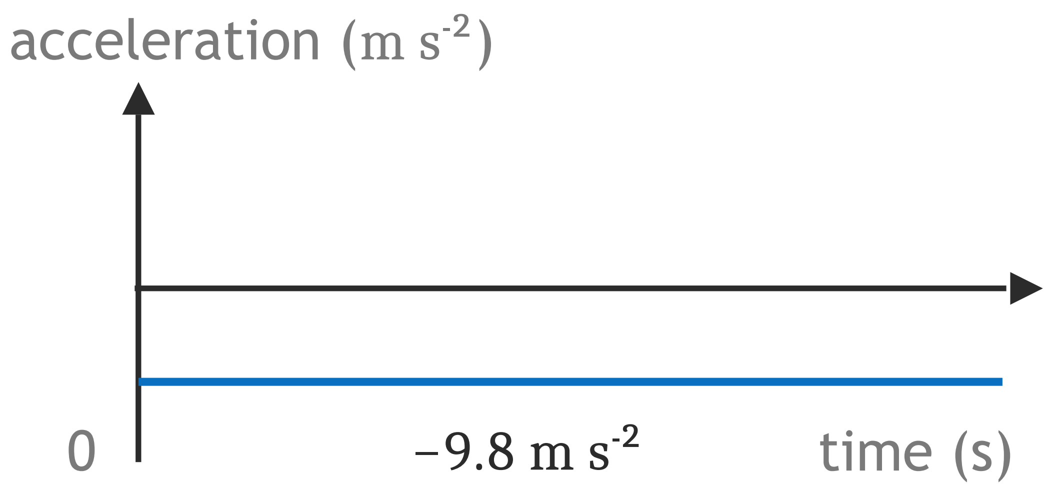
A ball thrown straight up

Up is positive, so the velocity passes through zero.

velocity-time

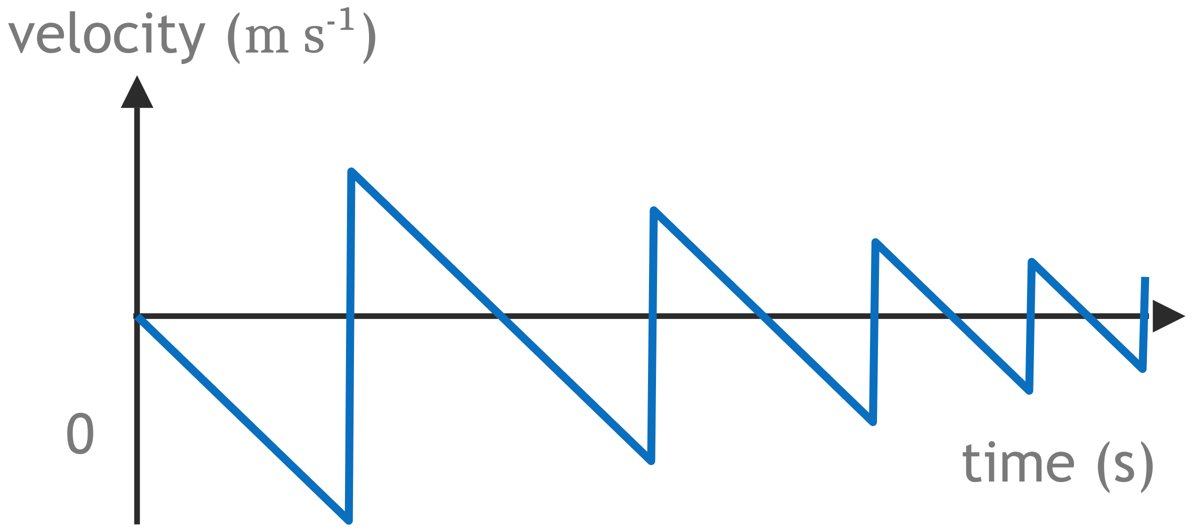


acceleration-time



A bouncing ball

Down is negative. Each bounce flips the velocity and shrinks it.



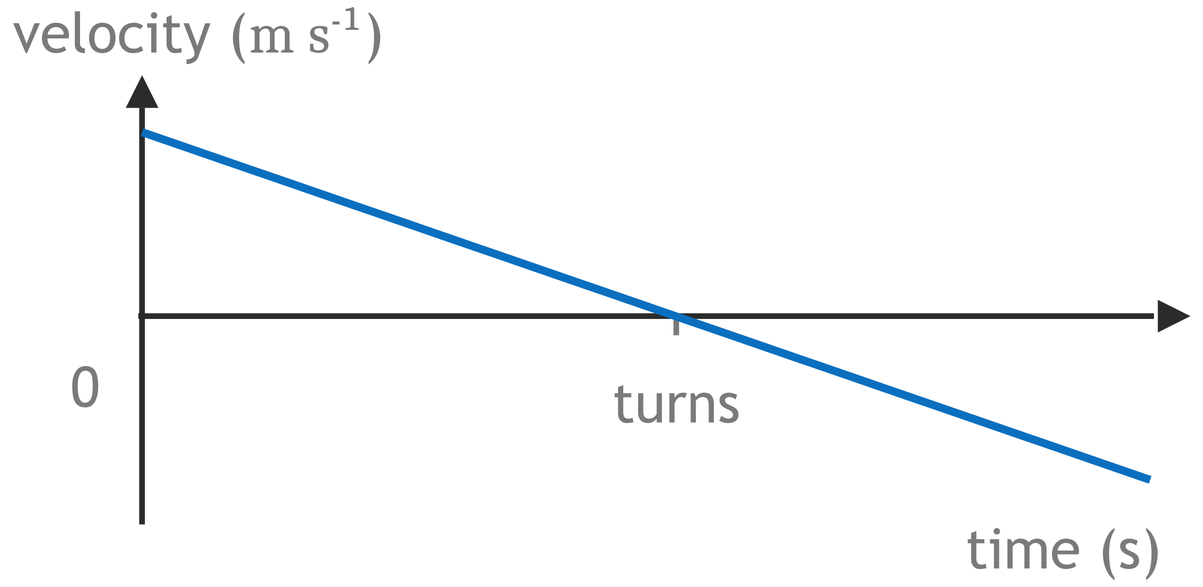
Every sloped line has the same gradient: a is always $-9.8\ \mathrm{m\ s^{-2}}$.

Each jump is a bounce.

The peaks shrink because energy is lost.

A car that changes direction

Below the axis is not slowing down — it is going the other way.



Area above the axis is displacement one way.

Area below it is displacement the other way.

Keep the signs for displacement; drop them for distance.

Sketch the graph — boards up

SHOW ME BOARDS

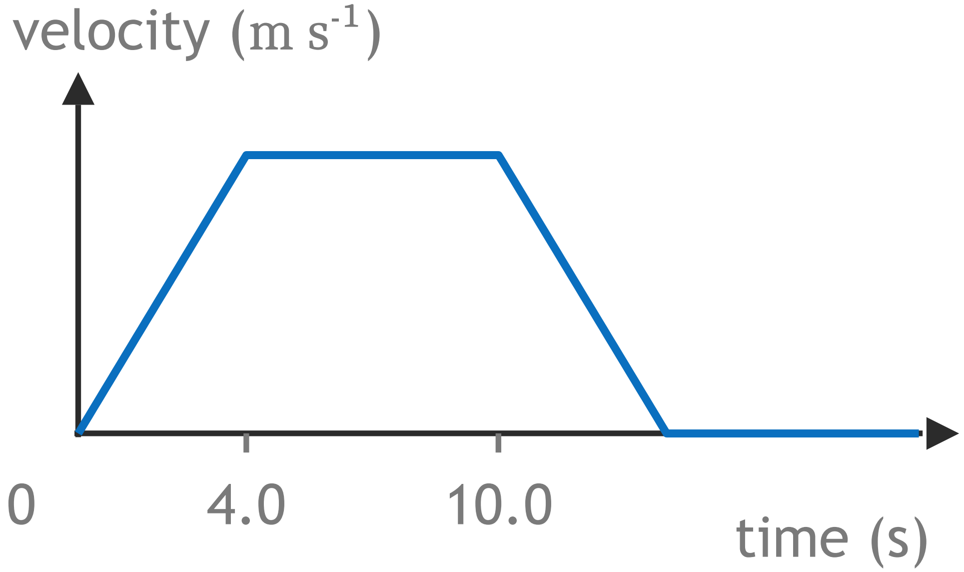
Axes labelled, units on, origin marked — every time.

1. A car speeds up from rest to $12\ \mathrm{m\ s^{-1}}$ in $4.0\ \mathrm{s}$, then holds it for $6.0\ \mathrm{s}$. Sketch the v-t graph.
2. Sketch the a-t graph for that same journey.
3. A ball is dropped and bounces twice. Sketch its v-t graph, taking down as negative.
4. Sketch the d-t graph of a car parked at the side of the road.
5. Sketch a v-t graph for a car that drives forwards, stops, then reverses.

Change this graph — boards up

SHOW ME BOARDS

Read the graph on the screen, then draw the other two.



1. Find the acceleration in the first 4.0 s.
2. Sketch the a-t graph for this journey.
3. Find the displacement in the first 4.0 s.
4. Sketch the d-t graph for this journey.

Graphs of motion — boards up

SHOW ME BOARDS

1. What does the gradient of a displacement-time graph tell you?
2. What does the area under a velocity-time graph tell you?
3. A velocity-time graph is flat and above the axis. What is the acceleration?
4. Sketch the acceleration-time graph for a ball thrown straight up.
5. On a velocity-time graph, how can you tell the object has turned round?

Your turn

Graph questions from the textbook.
Sketch every graph in your jotter — axes labelled, with units, and the origin marked.

Textbook p.17 (Leckie and Leckie)

Checkpoint

1. A ball is thrown up and caught again. What is its displacement, and why?
2. Why can you use the equations of motion for a projectile's vertical motion but not its horizontal motion?
3. Two gates and a card measure acceleration. What happens to your answer if the card at the second gate is longer, and why?

Exam practice

Open the paper on your phone — nothing is reproduced here.

Paper	Question	What it asks
2010 Higher	21	horizontal projectile
2016 Higher	Paper 2, 1	graphs and equations
2003 Higher	21	motion under gravity

LOOKING AHEAD

Forces, energy and power

You can describe how things move. Next: what makes them move that way.

Plenary

1. Name two vectors and two scalars from this lesson.
2. Which equation of motion has no t in it?
3. Describe how you would measure the acceleration of a trolley down a slope.
4. A ball is launched at $25\ \mathrm{m\ s^{-1}}$ at 40°. How would you start?
5. What does the area under an acceleration-time graph give you?

Extension

1. Show that a projectile launched at $45°$ on level ground goes furthest, for a fixed launch speed.
2. A ball is thrown down at $5.0\ \mathrm{m\ s^{-1}}$ from 30 m. How long until it lands, and how does that compare with dropping it?
3. A trolley runs down a slope and a student's value of a is too small every time. Give two possible reasons and say how to test them.

Course specification — 1 of 3

Our dynamic Universe · Motion — equations and graphs

- Use of appropriate relationships to solve problems involving distance, displacement, speed, velocity, and acceleration for objects moving with constant acceleration in a straight line.
- Interpretation and drawing of motion-time graphs for motion with constant acceleration in a straight line, including graphs for bouncing objects and objects thrown vertically upwards.
- Knowledge of the interrelationship of displacement-time, velocity-time and acceleration-time graphs.

Course specification — 2 of 3

Our dynamic Universe · Motion — equations and graphs, continued

- Calculation of distance, displacement, speed, velocity, and acceleration from appropriate graphs (graphs restricted to constant acceleration in one dimension, inclusive of change of direction).
- Description of an experiment to measure the acceleration of an object down a slope.

Course specification — 3 of 3

Our dynamic Universe · Gravitation — the projectile bullets, taught here

- Knowledge that the horizontal motion and the vertical motion of a projectile are independent of each other.
- Knowledge that satellites are in free fall around a planet/star.
- Resolution of the initial velocity of a projectile into horizontal and vertical components and their use in calculations.
- Use of resolution of vectors, vector addition, and appropriate relationships to solve problems involving projectiles.