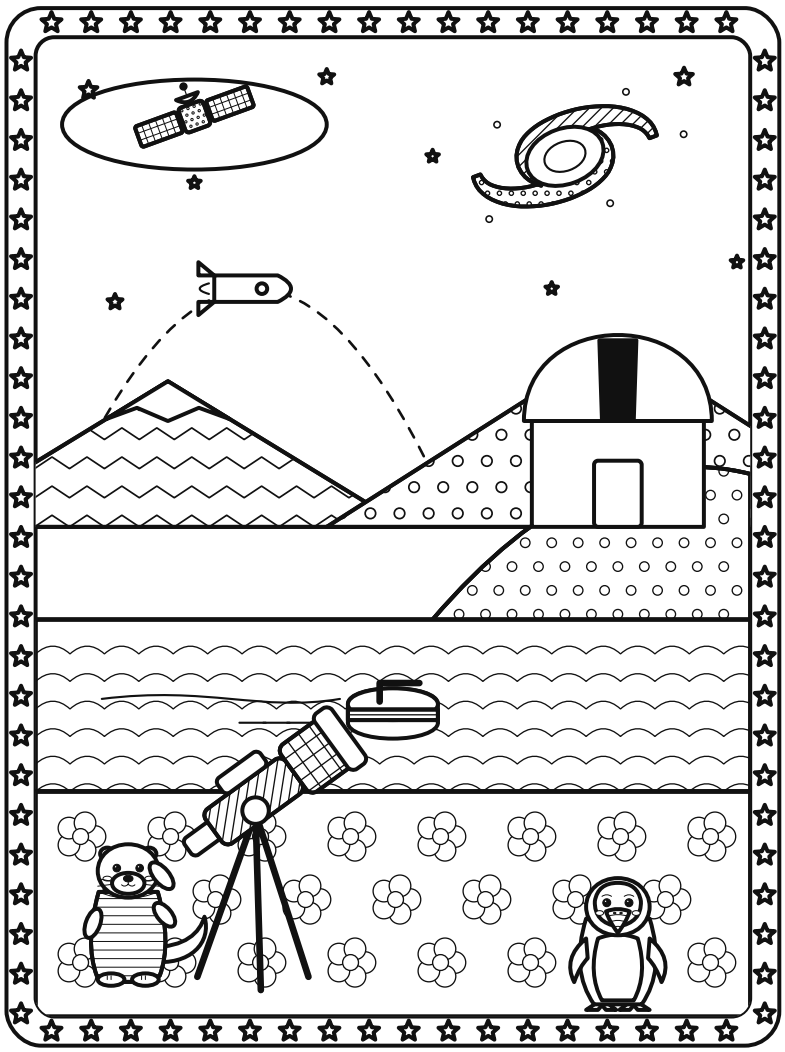
REAL-LIFE PHYSICS

Our Dynamic Universe

Workbook for Higher Physics

Unit: Our Dynamic Universe



C. Blewis

Blewis LEARNING

Contents

GETTING STARTED

	How to use this book	4

MOTION, FORCES AND COLLISIONS

Topic 1	Motion: equations and graphs	6
Topic 2	Forces, energy and power	15
Topic 3	Collisions, explosions and impulse	24

GRAVITATION, SPACE AND TIME

Topic 4	Projectiles and gravitation	33
Topic 5	Special relativity	42
Topic 6	The expanding Universe	51

AT THE BACK

	My progress tracker	60
	My practical skills	61

How to use this book

This book covers Our Dynamic Universe for Higher Physics: equations of motion, forces and energy, collisions and impulse, projectiles and gravitation, special relativity, and the expanding universe and big bang. Each topic follows the same pattern, so you always know what comes next.

EACH TOPIC HAS

Opener	the story for the topic, what you will learn and the key words
Learn pages	short explanations with diagrams, and questions to try
Practical	You plan the investigation yourself, carry it out safely, take repeat readings, draw a graph and evaluate your method.
Brain break	a calm puzzle or colouring page
Check-up	a few questions to show what you know, and a checklist

PRACTICAL WORK: STAY SAFE

- Only start a practical when an adult says it is OK.
- Read the whole method and the Stay safe table first.
- Tell your teacher about anything that might affect you, like asthma or an allergy.
- Stop and tell an adult if you feel unwell or something goes wrong.

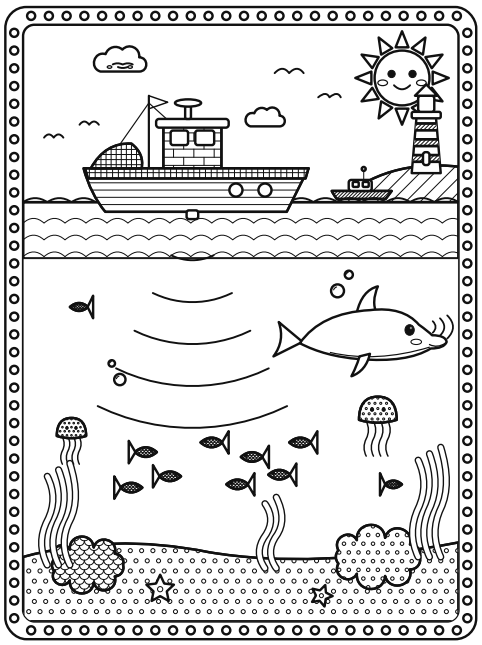
NO LAB TODAY?

Every practical has a set of example results. If you could not do the experiment, use these to finish the results, graph and conclusion.

DOODLE CORNERS

Some pages have a doodle corner. Colour it or doodle in it when you need a short break.

Motion: equations and graphs



A rescue flare is fired straight up from a lifeboat. How high does it go, and when should the crew look for it?

Theme: Port Arrin lifeboat station. Mhairi volunteers at the Port Arrin lifeboat station. She is learning how flares, boats and winch lines move, so that she can predict exactly where and when things will be.

IN THIS TOPIC YOU WILL LEARN TO

Skill 1	use the equations of motion, with a sign convention
Skill 2	use gradients and areas of motion graphs
Skill 3	measure g with a light gate, with uncertainties

KEY WORDS

Displacement	distance in a stated direction (m)
Acceleration	change in velocity per second (m/s²)
Sign convention	choosing one direction as positive
Gradient	rise ÷ run of a graph
Area under v–t	the displacement

❶ The equations of motion

For motion in a straight line with **constant acceleration**, five quantities link together: s, u, v, a and t. Each equation uses four of them. List the three you know and the one you want, then choose the equation that leaves out the one you do not need.

RELATIONSHIPS

$$v = u + a\,t \qquad s = u\,t + \tfrac{1}{2}\,a\,t^2$$

$$v^2 = u^2 + 2\,a\,s \qquad s = \tfrac{1}{2}\,(u + v)\,t$$

s	displacement in metres (m)
u, v	initial and final velocity in m/s
a	acceleration in m/s²
t	time in seconds (s)

WORKED EXAMPLE

A lifeboat accelerates uniformly from 4.0 m/s at 2.5 m/s² for 6.0 s. Find its final velocity and the distance it travels.

Values u = 4.0 m/s, a = 2.5 m/s², t = 6.0 s

Velocity v = u + a t = 4.0 + 2.5 × 6.0 = **19 m/s**

Distance s = u t + ½ a t² = 24 + 45 = **69 m**

1 A ferry slows uniformly from 6.0 m/s to rest in 40 s as it comes into the pier. Calculate its acceleration and the distance it travels while slowing.

Acceleration

Distance

2 A stone is dropped from rest down a well and hits the water 1.8 s later. Calculate the depth of the well and the speed of the stone as it hits the water.

Depth

Speed

3 A skier speeds up uniformly from 2.0 m/s to 12.0 m/s over 70 m of slope. **Show that** her acceleration is 1.0 m/s².

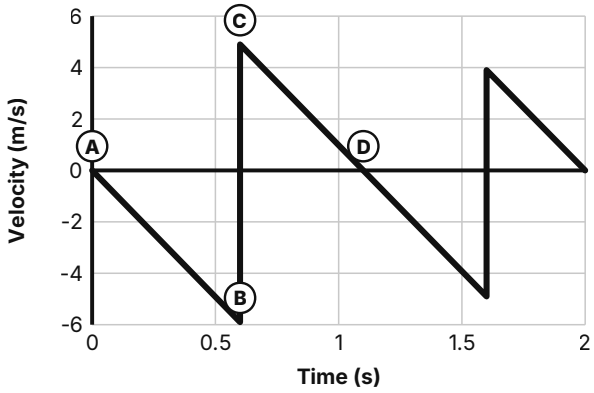
Relationship

Substitute

Answer

❷ Motion graphs

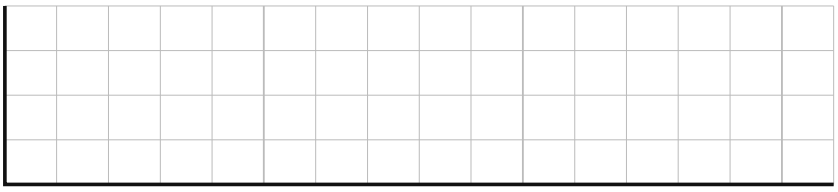
The **gradient** of a displacement–time graph is the velocity. The **gradient** of a velocity–time graph is the acceleration, and the **area** under it is the displacement. The area under an acceleration–time graph is the change in velocity. Areas below the time axis count as negative.



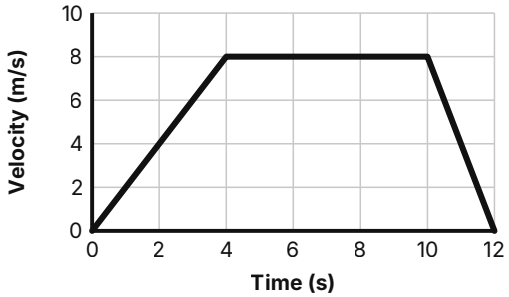
A BOUNCING BALL (UP IS POSITIVE)

A to B: falling and speeding up, so the velocity is negative. B to C: the bounce reverses the velocity almost at once. C to D: rising and slowing. Every sloping line has the same gradient, −9.8 m/s².

1 Sketch the acceleration–time graph for the bouncing ball from A to D. Label the value of the acceleration.



2 A winch pulls a casualty up to a helicopter. The velocity–time graph is shown. Calculate (a) the acceleration in the first 4 s, (b) the acceleration in the last 2 s, and (c) the total displacement.



(a) .....

(b) .....

(c) .....

3 Explain why the displacement–time graph for a ball thrown straight up is a curve, not a straight line.

Answer: .....

.....

PRACTICAL 1

Plan it: measuring g with a light gate

AIM To find the **ACCELERATION DUE TO GRAVITY**, g, by dropping a card through a light gate from different **HEIGHTS** and plotting v^2 against h.

1 Variables

I will change the independent variable	
I will measure the dependent variable(s)	
I will keep the same controlled variables (give two)	

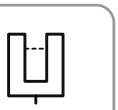
2 Prediction and theory

Using $v^2 = u^2 + 2as$ with $u = 0$, a graph of v^2 against h should be .....

with a gradient equal to .....

3 Equipment

Tick the equipment you need. Not everything here is useful.


☐ Light gate



☐ Timer


☐ Card


☐ Clamp stand

☐ Metre stick


☐ Catch box


☐ Thermo-meter

4 Stay safe

The first row is done for you. Add two more hazards.

Hazard What could cause harm?	**Risk** What could happen?	**Control** How will I stay safe?
Falling card and mass	It lands on feet or hands	Drop it into a padded catch box on the floor; keep hands clear below.

Method and results

5 Write your method

1. How will you hold the light gate and measure the drop height to the gate?

2. How will you release the card so it starts from rest and falls straight?

3. How many heights and repeats? How will you find the mean time and v?

4. What will you plot, and how will you get g from the graph?

6 Results

Complete the headings, including units.

				Mean time	v	v^2

NO LAB TODAY? USE THESE RESULTS

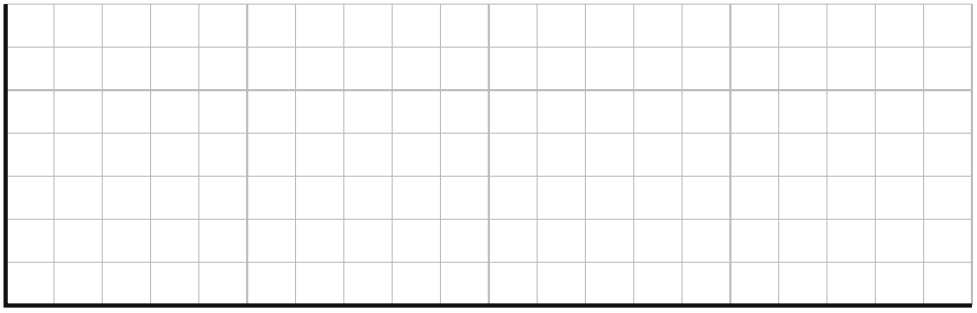
Height (m)	Time 1 (s)	Time 2 (s)	Time 3 (s)	Mean time (s)	v (m/s)	v^2 (m^2/s^2)
0.200	0.0256	0.0253	0.0254			
0.400	0.0180	0.0179	0.0178			
0.600	0.0146	0.0147	0.0146			
0.800	0.0126	0.0127	0.0127			
1.000	0.0114	0.0113	0.0113			

Card length 5.00 cm (measured with vernier callipers to ± 0.01 cm). The card is released from rest each time. Work out the rest yourself.

Analyse and evaluate

7 Draw a graph

Plot v^2 against height. Choose your scales, label both axes with units, and draw a best-fit straight line. Find the gradient.



Gradient =

So g = gradient $\times$ 2

UNCERTAINTIES

Random uncertainty = (largest − smallest) ÷ number of readings. Scale-reading uncertainty: ± half the smallest division (analogue) or ± 1 in the last digit (digital). Percentage uncertainty = $\frac{\text{uncertainty}}{\text{value}} \times 100$. The largest percentage uncertainty is the one that matters most in the final answer. Here the card length is 5.00 ± 0.01 cm (0.2%) and the timer reads to ± 0.0001 s, which is about 0.9% of 0.0113 s.

a Work out the random uncertainty in the mean time at 1.000 m, and its percentage uncertainty.

Answer:

8 Conclusion and evaluation

b Compare your value of g with 9.8 m/s². Give the percentage difference.

Answer:

c Suggest one systematic error that would make g too small, and one change that would make the result more precise.

Answer:

ASSIGNMENT LINK

Compare your g with a published value and give a full reference for the source.

FREE SAMPLE

Our Dynamic Universe (Higher Physics)

This sample shows a few pages. The full printed workbook is available from Amazon.

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