Name	Date started	Target end date

GCE AS / A LEVEL — PROJECTILE MOTION QUESTION PACK

Legacy PH1 · New spec Unit 1 Topic 2b · AS unit, 20% of A-level

REVISE
.wales

PHYSICS — UNIT 1 · PROJECTILE MOTION

PH1.2 Kinematics — projectiles & terminal velocity

Independence of horizontal and vertical motion under gravity, horizontal- and angle-launch problems, plus terminal velocity from balancing drag against weight.

NEW 2015 SPEC · UNIT 1 TOPIC 2B

Estimated time for entire question pack: ~2 h

Derived from the legacy PH1 paper's pace of 80 marks in 1¼ hours.

*You are advised to **not** attempt to complete all of this in one sitting.*

ABOUT THIS QUESTION PACK

This is a **comprehensive practice question pack**, not a single mock paper. It contains every question from the legacy WJEC PH1 papers (2008 modular spec) that maps onto new-spec Unit 1 Topic 2b (1.2).

Questions are ordered chronologically within each section.

INSTRUCTIONS

Use black ink or black ball-point pen. Answer all questions in the spaces provided.

The number of marks is given in brackets at the end of each question or part-question. A calculator is required. The Data Booklet is allowed.

For Examiner's use only

Q	Source	Max	Mark
16	PH1 Jun 09 Q7	13	
17	PH1 Jan 10 Q6	11	
18	PH1 Jun 10 Q6	12	
19	PH1 Jun 12 Q5	11	
20	PH1 Jun 12 Q7	17	
21	PH1 Jun 15 Q1	11	
22	PH1 Jun 16 Q2	11	
	Total	**86**	

Projectile Motion — what the new spec asks

WJEC GCE AS / A Level Physics (from 2015) · Unit 1: Motion, Energy & Matter · Topic 1.2.

Projectile principles A

- Independence of horizontal and vertical motion under gravity.
- Motion combining uniform horizontal velocity with uniform vertical acceleration.
- Horizontal launch: range R = ut, fall time t = $\sqrt{(2h/g)}$.
- Angled launch: resolve speed into ux = R cos θ and uy = R sin θ.

Terminal velocity A

- Describe motion of bodies falling with air resistance.
- Reaching terminal velocity when drag balances weight.
- Sketching v-t graphs for a falling body with drag.

Crib sheet »

Projectile Motion in one page

Quick-reference notes — revisit before each section.

Independence of motion

Horizontal motion: uniform velocity (no air resistance).

Vertical motion: uniform acceleration g.

Times are shared between the two analyses.

Horizontal launch

Fall time: $t = \sqrt{(2h/g)}$.

Range: $R = ut$.

Vertical impact speed: $v_y = gt$.

Resultant speed: $v = \sqrt{(u^2 + v_y^2)}$.

Angled launch

$u_x = R \cos \theta$, $u_y = R \sin \theta$.

Max height: $u_y^2/(2g)$.

Time of flight (level ground): $T = 2u_y/g$.

Horizontal range: $R_x = u_x \cdot T$.

Terminal velocity

Drag F_d grows with v until $F_d = W$.

Net force $\Rightarrow 0$, so $a \Rightarrow 0$.

v-t graph: rising curve flattening to terminal value.

Reading values

Take $g = 9.81$ m s^{-2} (unless told otherwise).

For dropped objects: $u = 0$, so $s = \frac{1}{2}gt^2$.

Convert km h^{-1} to m s^{-1} before substituting.

Common pitfalls

Don't average velocity for non-uniform a.

Always state sign convention up front.

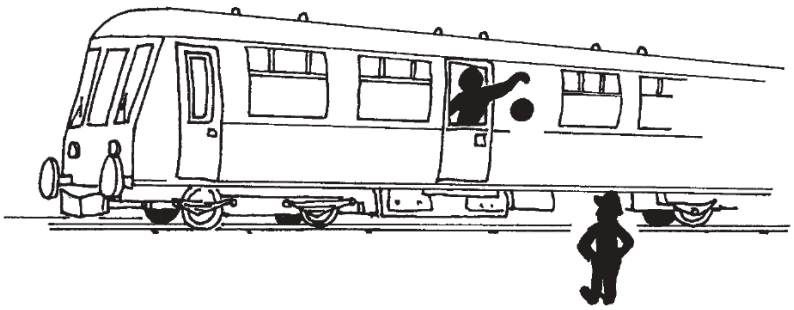
Symmetric trajectory only on level ground.

Section index

Use this index to jump straight to the section you need.

Examiner only

7. A passenger on a train, moving at constant speed, drops a ball out of a window as shown. A stationary observer is standing near the track and directly in front of the window when the ball is dropped.



(a) (i) If air resistance is neglected, describe and explain the horizontal motion of the ball as seen by the passenger.

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[2]

(ii) Describe the horizontal motion of the ball as seen by the observer.

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[1]

(b) If air resistance is now taken into account, how will your answers to (a) (i) and (ii) have to be modified?

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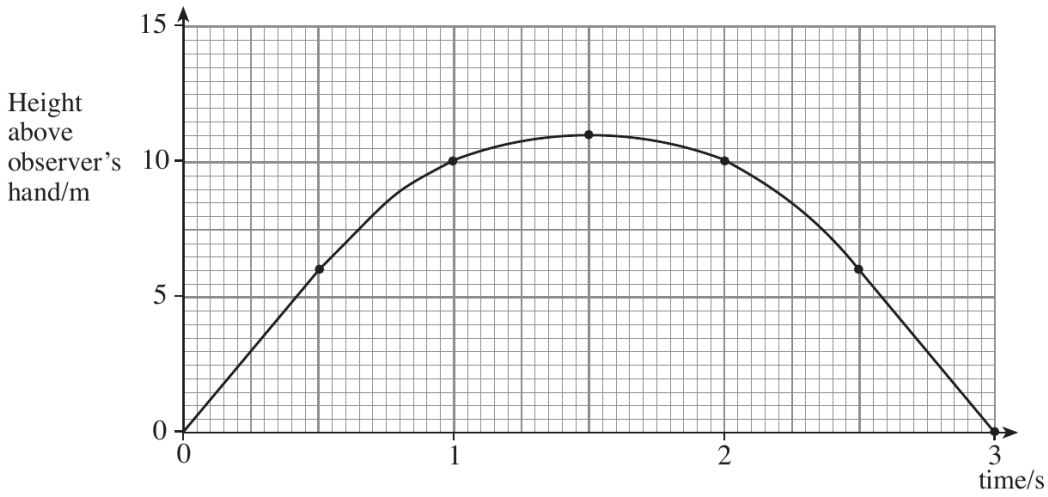
[3]

(c) The observer retrieves the ball and throws it vertically upwards, catching it on its return. A graph of height (from the observer's hand) against time is shown.



(i) How can you tell from the graph that the air resistance now acting on the ball is negligible?

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[1]

(ii) By considering the maximum height reached, determine the initial upward velocity of the ball.

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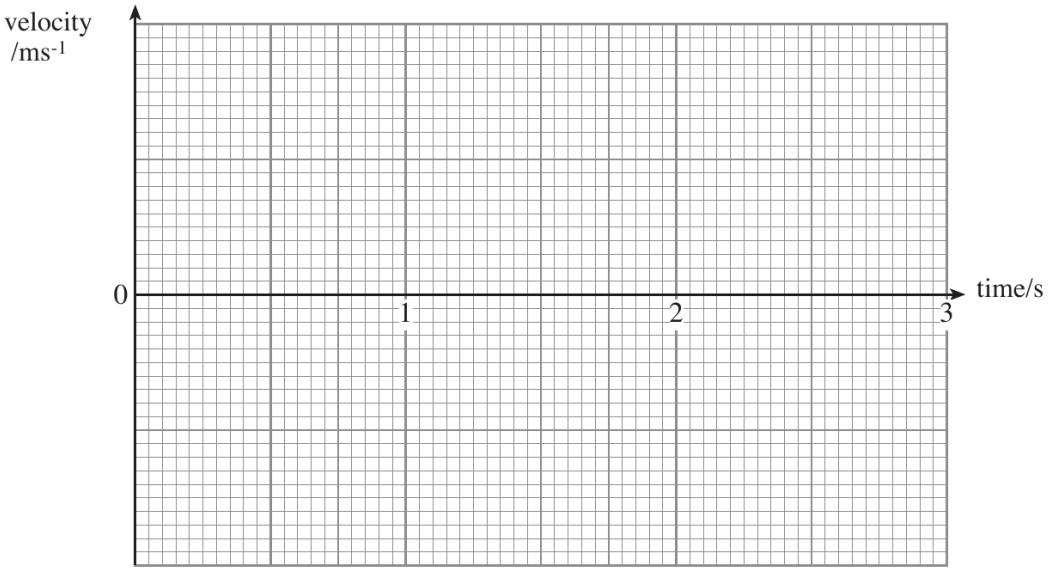
[3]

Examiner only

(iii) Use your answer to (c) (ii) and other data from the graph on the previous page to draw a velocity-time graph for the whole of the ball's flight. The time axis has been completed for you. [5]



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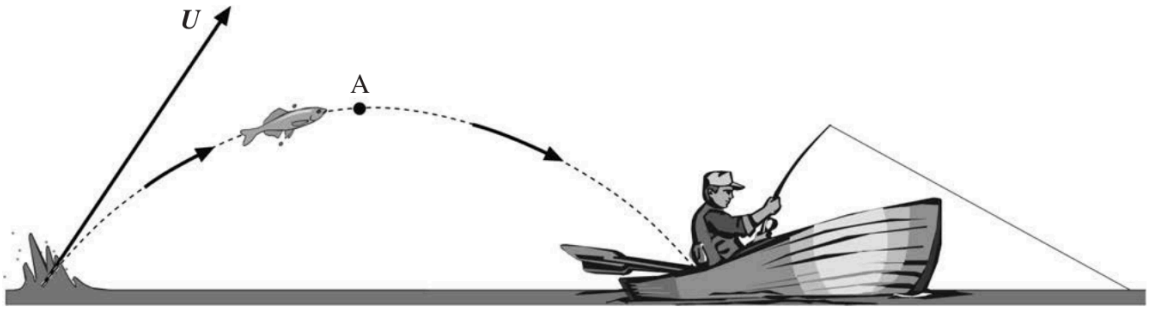
QUESTION 8 is on page 14

Examiner only

6. The Silver Carp is a fish which was accidentally introduced to the Mississippi river in the 1990s. It has since bred to such an extent that the river has become overpopulated with them. Many are seen to jump out of the water and they sometimes land in the boats of fishermen.
[Ignore air resistance throughout this question].



(a) The trajectory (flight path) of a Silver Carp is shown. Point **A** represents the highest point on the trajectory. Draw arrows at **A** to show

(i) the direction of motion of the Carp at this instant. (Label this arrow **D**);

(ii) the force (or forces) acting on the Carp at this instant. (Label this/these arrow(s) **F**). [2]

(b) A fisherman wishes to determine the velocity with which a Carp left the water (shown by the vector labelled ***U***). The fisherman makes the following estimations:

Horizontal distance travelled by the Carp = 4.50 m
Time of flight = 1.50 s
Maximum height = 2.75 m

Use this information to calculate:

(i) the horizontal component of the velocity of the Carp; [1]

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(ii) the initial vertical velocity of the Carp; [3]

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Examiner only

(iii) the magnitude of the velocity (***U***) with which the Carp left the water. [2]

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(c) Your answer to *(b)* (iii) can be checked by considering the energy changes that take place during the Carp's flight.

(i) Calculate the **total** energy possessed by the Carp at point **A**. [Assume the Carp has mass 6.0 kg] [3]

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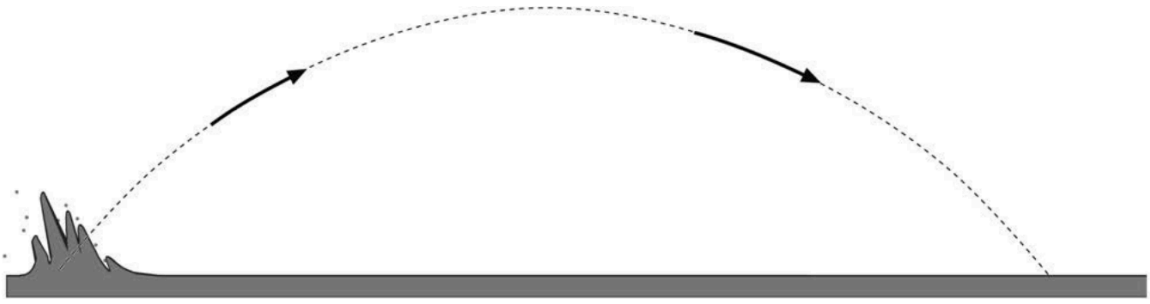
(ii) Below is a sketch of the Carp's trajectory but this time without the boat included. Mark on the diagram **two** points where the Carp will have its greatest kinetic energy. [Label both points with a letter **K**]. [1]



(iii) Use your answer to *(c)* (i) to show that the Carp's initial velocity (***U***) is the same as that calculated in *(b)* (iii). [2]

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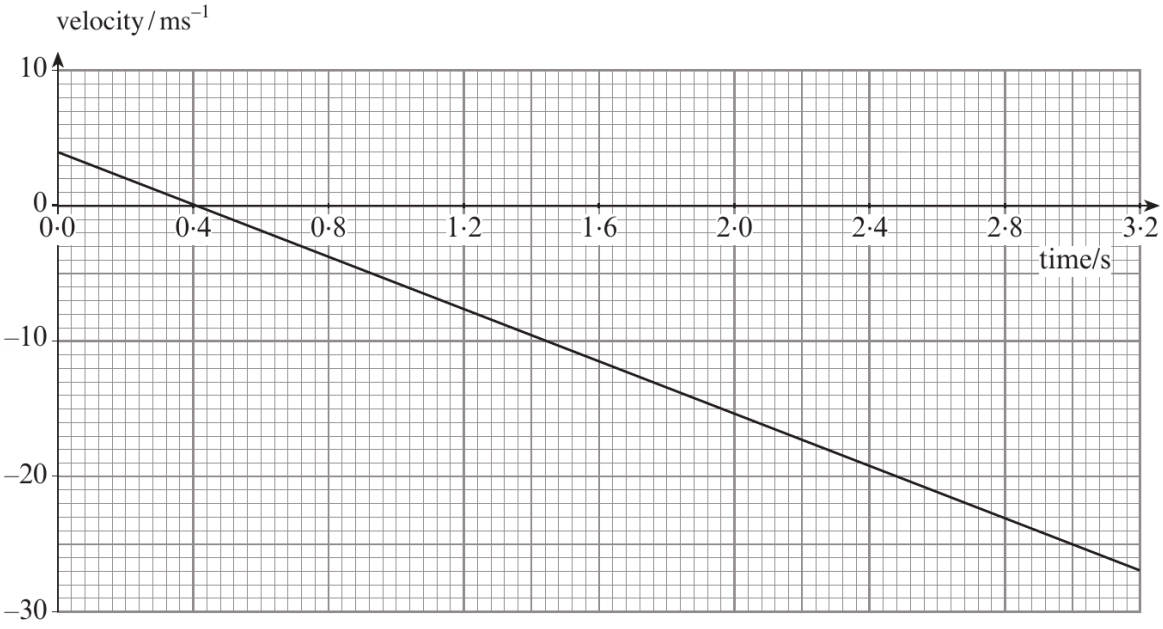
Examiner only

Examiner only

6. A stone is released from the basket of a hot-air balloon that is moving upwards.
The velocity-time graph describes the vertical motion of the stone from the moment it is released to the time it lands on the ground at 3.2 s. Ignore air resistance throughout this question.



(a) Calculate the gradient of the graph and explain its significance. [2]

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(b) State the velocity at which the balloon was ascending at the moment the stone was released. [1]

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(c) Describe the motion of the stone between 0.0 s and 0.8 s. [3]

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Examiner only

(d) (i) Shade the part of the graph which represents the height of the stone above the ground at the moment of release. [1]

(ii) Hence, or otherwise, calculate the height of the stone above the ground at the moment of release. [2]

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(e) The balloon is also moving **horizontally** at a steady velocity when the stone is released. State whether the stone will land on the ground behind, directly beneath or in front of the moving basket. Explain your answer. [3]

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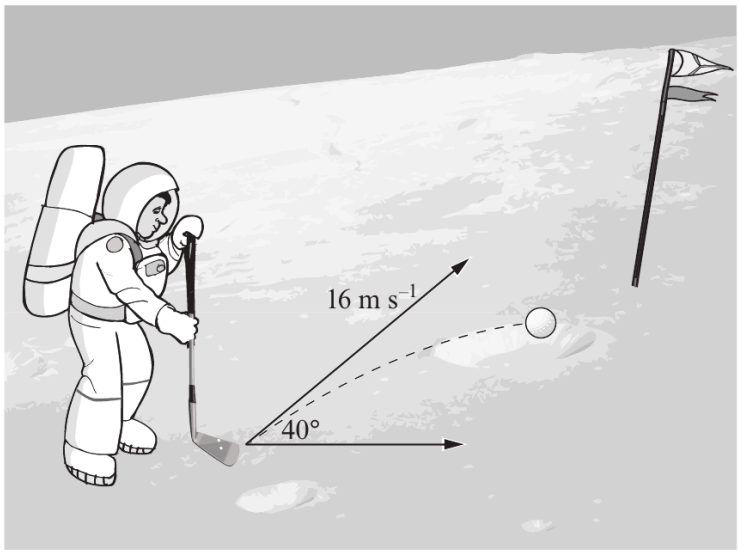
Examiner only

5. The astronauts of Apollo 14 played golf on the Moon. They struck a number of shots such as the one shown below.



(a) (i) Calculate the horizontal and vertical components of velocity of the golf ball at the instant it was struck. [2]

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(ii) Describe the essential difference between the horizontal and vertical components of velocity during the flight of the ball. [1]

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Examiner only

(b) The acceleration due to gravity on the Moon is 1.6 m s^{-2}. Assuming the shot is played on horizontal ground, calculate

(i) the total time of flight, [3]

(ii) the horizontal distance the ball travels, [1]

(iii) the maximum height reached. [2]

(c) A similar golf shot is played on Earth. Give two reasons why your answer to *(b)*(iii) would be different. [2]

1.

2.

Examiner only

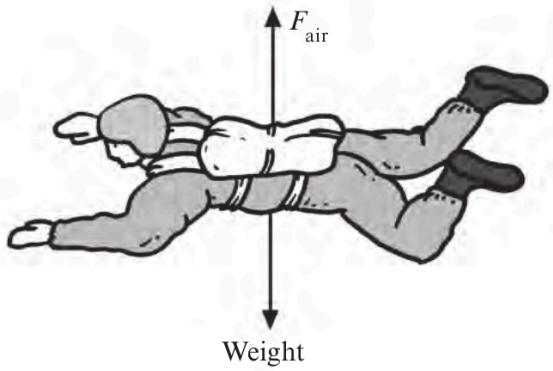
7. The force due to air resistance F_{air} exerted on a skydiver due to her motion through the air is given by

$$F_{air} = \frac{\rho D v^2}{2}$$

where ρ is the density of air, v is the speed of the skydiver and D is a constant called the drag factor.

(a) Show that the SI unit of D is **metre^2**. [4]

(b) The diagram shows two of the main forces acting on the skydiver during her descent.



(i) Newton's third law concerns pairs of forces. State the law. [1]

(ii) Give **one** reason why the forces in the diagram are **not** a pair of Newton 3rd law forces. [1]

Examiner only

(c) The table gives data for the first 16.0 seconds of the jump.

Time / s	0.0	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0
Acceleration / $m\,s^{-2}$	9.8	8.8	6.6	4.3	2.5	1.4	0.8	0.4	0.2

(i) The mass of the skydiver is 60 kg. Calculate her weight. [1]

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(ii) Using your answer to *(c)*(i) and the information in the table, calculate the force due to air resistance acting on the skydiver at t = 10.0 s. [3]

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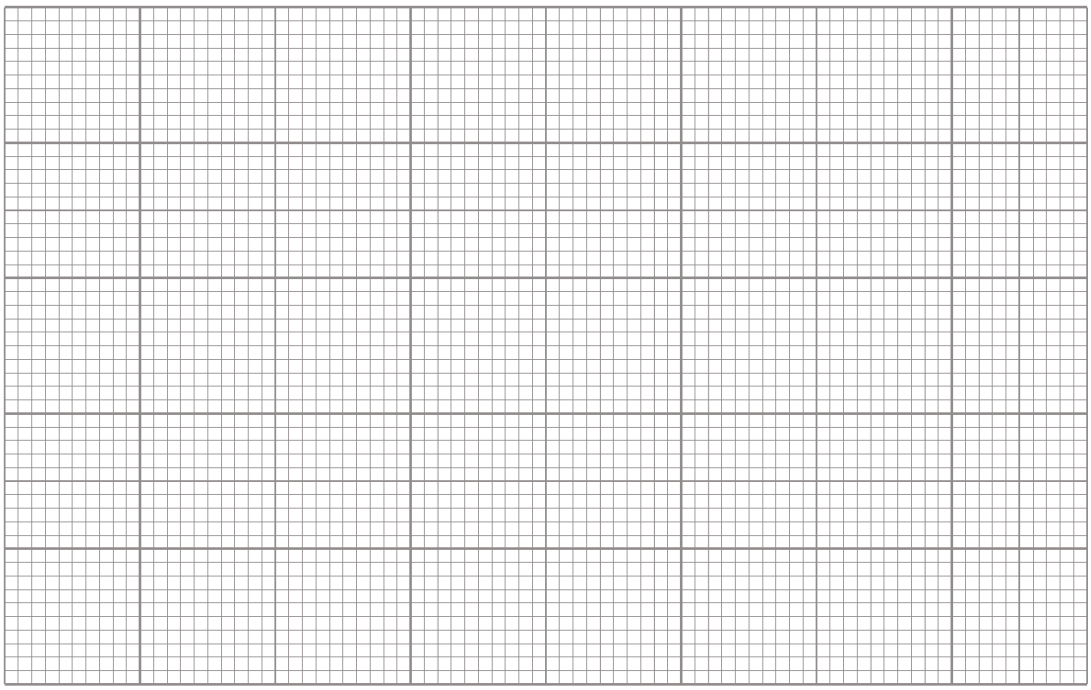
(d) (i) Draw a graph of acceleration (y-axis) against time (x-axis) for the skydiver. [3]



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(ii) Use your graph to estimate the velocity of the skydiver at $t = 10.0\,\text{s}$. [2]

(iii) Using your answers to *(c)*(ii), *(d)*(ii) and the equation given at the start of the question, calculate a value for the drag factor, D. Assume $\rho = 1.2\,\text{kg m}^{-3}$ [2]

THERE ARE NO MORE QUESTIONS IN THE EXAMINATION.

GCE PHYSICS
TAG FFISEG
Advanced Level / Safon Uwch

Data Booklet

A clean copy of this booklet should be issued to candidates for their use during each GCE Physics examination.

Centres are asked to issue this booklet to candidates at the start of the GCE Physics course to enable them to become familiar with its contents and layout.

Values and Conversions

Avogadro constant	N_A	$= 6{\cdot}02 \times 10^{23}\ \text{mol}^{-1}$
Fundamental electronic charge	e	$= 1{\cdot}60 \times 10^{-19}\ \text{C}$
Mass of an electron	m_e	$= 9{\cdot}11 \times 10^{-31}\ \text{kg}$
Molar gas constant	R	$= 8{\cdot}31\ \text{J mol}^{-1}\ \text{K}^{-1}$
Acceleration due to gravity at sea level	g	$= 9{\cdot}81\ \text{m s}^{-2}$
Gravitational field strength at sea level	g	$= 9{\cdot}81\ \text{N kg}^{-1}$
Universal constant of gravitation	G	$= 6{\cdot}67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2}$
Planck constant	h	$= 6{\cdot}63 \times 10^{-34}\ \text{J s}$
Boltzmann constant	k	$= 1{\cdot}38 \times 10^{-23}\ \text{J K}^{-1}$
Speed of light *in vacuo*	c	$= 3{\cdot}00 \times 10^{8}\ \text{m s}^{-1}$
Permittivity of free space	ε_o	$= 8{\cdot}85 \times 10^{-12}\ \text{F m}^{-1}$
Permeability of free space	μ_o	$= 4\pi \times 10^{-7}\ \text{H m}^{-1}$
Stefan constant	σ	$= 5{\cdot}67 \times 10^{-8}\ \text{W m}^{-2}\ \text{K}^{-4}$
Wien constant	W	$= 2{\cdot}90 \times 10^{-3}\ \text{m K}$

$T/\text{K} = \theta/°\text{C} + 273{\cdot}15$

$1\ \text{u} = 1{\cdot}66 \times 10^{-27}\ \text{kg}$

Examiner only

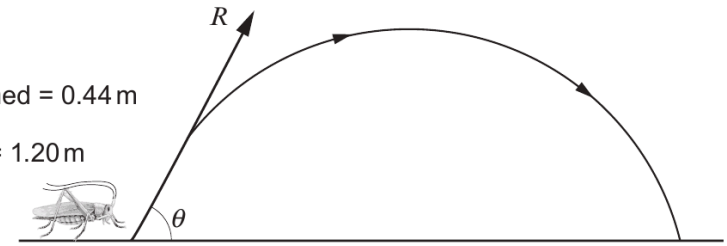
Answer **all** *questions.*

1. A science student is investigating the jump characteristics of a grasshopper. She makes the following observations when analysing one particular jump.

Maximum vertical height obtained = 0.44 m

Maximum horizontal distance = 1.20 m

Time of flight = 0.60 s



Air resistance can be ignored for parts *(a)* to *(c)*.

(a) Use the information to calculate:

(i) the horizontal component of the velocity of the grasshopper; [1]

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(ii) the initial vertical component of the velocity of the grasshopper. [2]

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(b) Hence calculate:

(i) the magnitude of the velocity at take-off, marked R in the diagram; [2]

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(ii) the angle of take-off, marked θ in the diagram. [1]

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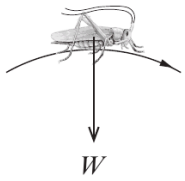
Examiner only

(c) The diagram below shows the grasshopper of mass 3.0×10^{-5} kg at the instant when it is at its maximum height above the ground.



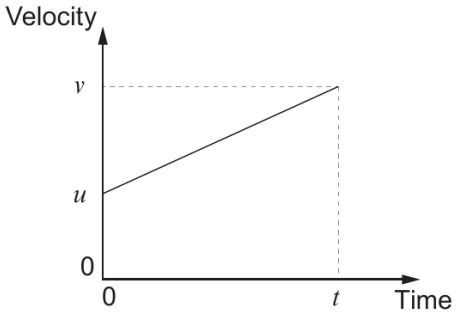
(i) The arrow labelled W represents the force of gravity on the grasshopper due to the Earth. Identify the Newton third law 'equal and opposite' force to W. [1]

(ii) Calculate the magnitude of the force you identified in *(c)*(i). [1]

(d) Assume air resistance does act. **Circle the arrow** which correctly shows the direction of the force due to air resistance on the grasshopper at the instant it is at its maximum height. [1]

Examiner only

2. *(a)* A velocity-time graph is given for a body which is accelerating.



Using the symbols given on the graph, show that:

$$v = u + at$$ [2]

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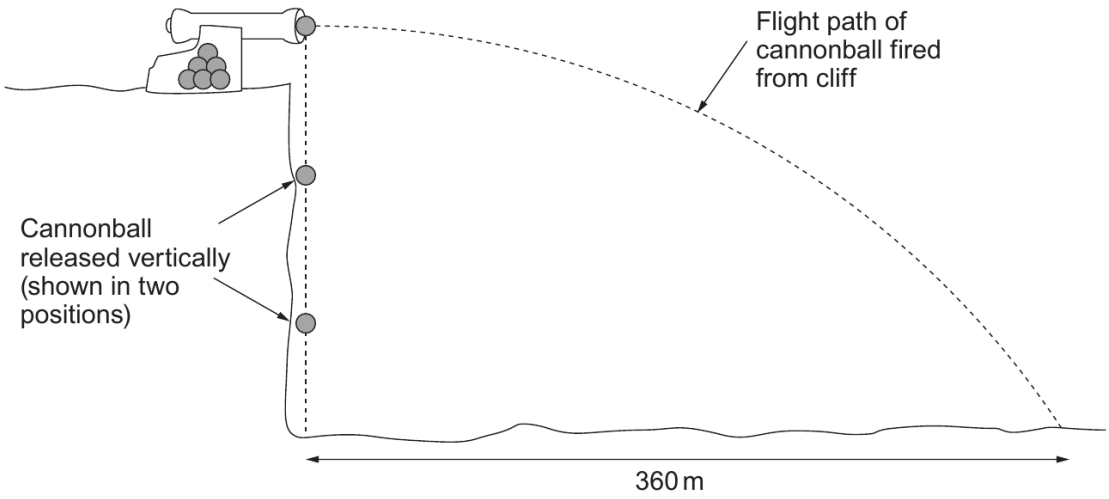
(b) The flight path for a cannonball fired horizontally from the top of a cliff is shown. **At the same instant**, a second cannonball is released and falls vertically from the same initial height. The second cannonball is shown at two positions during its descent.



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(i) Draw on the diagram the expected positions of the fired cannonball at the same instants as **each** of the positions indicated by the dropped cannonball. Explain your reasoning. Ignore air resistance. [3]

(ii) The cannonball fired from the cannon impacts with the ground 3.20 s after being fired.

I. Calculate the height from which the cannonball was fired. [2]

II. Calculate the velocity with which the **fired** cannonball impacts with the ground. [4]

END OF QUESTION PACK

7 questions · 86 marks · ~2 h
Source: WJEC PH1 (2008 modular spec)
Curated for WJEC Physics 2015 spec AS Unit 1 — Topic 2b (1.2)