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A LEVEL

Assessment story

PHYSICS A

H556

For first assessment in 2015

Exploring our question papers
Version 1.1

Version 1.1 (November 2024)

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Specifications are updated over time. Whilst every effort is made to check all documents, there may be contradictions between published resources and the specification, therefore, please use the information on the latest specification at all times. Where changes are made to specifications these will be indicated within the document, there will be a new version number indicated, and a summary of the changes. If you do notice a discrepancy between the specification and a resource please contact us at: resources.feedback@ocr.org.uk.

Contents

Introduction

We have produced this guide to help you prepare your students successfully. In this guide, we share the story of our assessment approach and explore our question papers with you.

Principles for our question papers:

- Keep presentation clear
- Keep the language of our questions simple (assessing understanding of the science rather than comprehension of complex sentences)
- Use clearly defined Command Words.

> *I like the PAG structure in OCR A-Levels, it allows me to slot appropriate practicals into my lessons, Julian Kennlyside, Head of Science.*

> *Exam questions are asked in an accessible way, Judy V.*

Specification content

The specification content determines the content that can be assessed. The A Level specification content is made up of six modules:

Module 1 – Development of practical skills in physics

1.1 Practical skills assessed in a written examination

1.2 Practical skills assessed in the practical endorsement

Module 2 – Foundations of physics

2.1 Physical quantities and units

2.2 Making measurements and analysing data

2.3 Nature of quantities

Module 3 – Forces and motion

3.1 Motion

3.2 Forces in action

3.3 Work, energy and power

3.4 Materials

3.5 Newton's laws of motion and momentum

Module 4 – Electrons, waves and photons

4.1 Charge and current

4.2 Energy, power and resistance

4.3 Electrical circuits

4.4 Waves

4.5 Quantum physics

Module 5 – Newtonian world and astrophysics

5.1 Thermal physics

5.2 Circular motion

5.3 Oscillations

5.4 Gravitational fields

5.5 Astrophysics and cosmology

Module 6 – Particles and medical physics

6.1 Capacitors

6.2 Electric fields

6.3 Electromagnetism

6.4 Nuclear and particle physics

6.5 Medical imaging

Modules 1 and 2 are the fundamental skills physicists require throughout the course.

Modules 3 and 4 are designed as the year 12 content.

Modules 5 and 6 are designed as the year 13 content.

All of the assessments are taken at the end of year 13 so the order of teaching can be flexible.

Navigating the specification content

The specification is your first port of call for finding out what needs to be taught. The examples below summarise the information available within the main content area of the specification:

Learning outcome. e.g. 3.1.2 (a) (i) This column tells you what needs to be covered in your teaching. E.g. 3.1.2 (a) (i).

The **Additional guidance** column helps clarify what can be tested and includes reference links to other areas of the specification and the skills in the specification appendices.

3.1.2 Linear motion

Learning outcomes	Additional guidance
Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a) **(i)** the equations of motion for constant acceleration in a straight line, including motion of bodies falling in a uniform gravitational field without air resistance $v = u + at$ $s = \frac{1}{2}(u + v)t$ $s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$	*M2.2, M2.4, M3.3* HSW9
(ii) techniques and procedures used to investigate the motion and collisions of objects	**PAG1** Apparatus may include trolleys, air-track gliders, ticker timers, light gates, data-loggers and video techniques. HSW4, 9, 10

Maths reference e.g. *M3.3*
Maths skills are listed in appendix 5e of the specification and help teachers identify mathematical skills for students to access the topic.

PAG reference e.g. PAG1
Highlights opportunities for practical activities for students to use the apparatus and techniques required by the Practical Endorsement listed in appendix 5g.

HSW reference e.g. HSW4
Highlights opportunities for integrating the 'How Science Works' principles throughout the course to help develop the wider science skills of benefit to students.

Assessment overview

A Level Physics A consists of three examined components (1, 2 and 3) and a Practical Endorsement component (see Appendix 5g in the specification).

Students must sit all three examined papers and complete the Practical Endorsement.

The qualification is marked out of a **total of 270 marks**. The performance of candidates on the examined papers determines their overall grade. An A Level qualification is awarded on the scale: A*, A, B, C, D, E, where A* is the highest grade. The result for the Practical Endorsement assessment is reported separately.

The modules assessed in the component, marks, duration, and weightings for all components are shown below:

Components	Modules	Marks	Duration	Weighting
Paper 1: Modelling physics	1, 2, 3, 5	100	2 hours 15 minutes	37%
Paper 2: Exploring physics	1, 2, 4, 6	100	2 hours 15 minutes	37%
Paper 3: Unified physics	All	70	1 hour 30 minutes	26%
Practical Endorsement Non-exam assessment	1	Assessed internally through a minimum of 12 practical activities		Reported separately

Overview of content in our exams

All of the examined papers assess candidates' knowledge of practical skills (module 1) and foundational physics skills (module 2).

In our science A specifications we have split the content assessed in the first two papers. This reduces the cognitive load for candidates early in the assessment series and reduces exam anxiety.

The final paper assesses all of the content, so candidates can demonstrate their knowledge of the whole specification and the synoptic nature of physics.

Paper 1: Modelling Physics
This paper focuses on assessing content from module 3, Forces and motion, and module 5, Newtonian world and astrophysics. There is a natural progression from the mechanics of everyday scenarios to modelling the motion of the planets.

Paper 2: Exploring Physics
This paper focuses on assessing content from module 4, Electrons, waves and photons, and module 6, Particles and medical physics. Questions explore candidates' knowledge of electric charge and electric current, quantum physics and nuclear and particle physics. Contexts range from simple electrical circuits to the application of physics in medical imaging.

Paper 3: Unified Physics
This paper assesses content from all modules.

Assessment objectives

Every question must test one or more of the assessment objectives. Assessment objectives and their approximate weightings for science qualifications are defined by Ofqual.

	Assessment Objective elements	% Qualification weighting
AO1	**Demonstrate knowledge and understanding of:** • Scientific ideas and processes • Scientific techniques and procedures.	**31–34**
AO2	**Apply knowledge and understanding of scientific ideas, processes, techniques and procedures:** • in a theoretical context • in a practical context • when handling qualitative data • when handling quantitative data.	**40–43**
AO3	**Analyse, interpret and evaluate scientific information, ideas and evidence including in relation to issues to:** • make judgements and reach conclusions • develop and refine practical design and procedures.	**25–28**

Assessment objectives for each question paper

The approximate weighting for each assessment objective for each paper is shown below.

Paper	Approx. % weighting of paper		
	AO1	AO2	AO3
1	34–38	40–44	20–24
2	34–38	40–44	20–24
3	19–23	40–44	34–39

Paper 3 has a greater emphasis on analysing, interpreting and evaluating (AO3) and less emphasis on knowledge and understanding (AO1).

Ofqual has set a maximum limit of 10% of the qualification for marks that can be used to test *knowledge in isolation* as part of AO1.

Knowledge in isolation:

- is awarded solely for recalling facts or other knowledge that is part of the specification.
- is not awarded for selecting appropriate knowledge (for example, to evidence an argument), or for applying knowledge to a particular context.

Practical skills

It is an Ofqual requirement that an overall **minimum of 15%** of the marks in our science question papers involve assessment of practical skills.

Practical skills are assessed throughout the three written papers and the Practical Endorsement*.

The table below summarises the practical skills assessed within papers.

Practical skills assessed within papers
Planning
Designing experiments Identifying variables Evaluating that method meets expected outcomes
Implementing
Using apparatus and techniques Measuring with appropriate units Recording results in an appropriate format
Analysis
Processing, analysing and interpreting results Analysing quantitative data using mathematical skills Using appropriate significant figures Plotting and interpreting graphs from experimental results: • axes, scales, quantities and units • measurement of gradients and intercepts
Evaluation
Evaluating results and drawing conclusions Identifying anomalies in measurements Identifying limitations in procedures Assessing precision and accuracy, including uncertainties and percentage error Refining experimental design to improve procedure and apparatus

Further details are shown in Module 1.1 of the specification.

*** Practical Endorsement**

The experiments and skills required for the Practical Endorsement will allow learners to develop and practise their practical skills, preparing learners for the written examinations.

Papers 1 to 3 will all test candidates' understanding of practical skills and the use of apparatus and techniques from the specification in a wide range of practical contexts. The contexts are not limited to OCR's suggested practical activities.

The Practical Skills Handbook has a lot of useful guidance on practical skills for teachers and students.

Mathematical requirements

Across all papers, at least 40% of the marks assess mathematical skills in the context of physics.

This includes:

- application and understanding, requiring choice of data or of equation to be used
- problem solving involving skills from different areas of maths and decisions about direction to proceed
- questions involving use of A Level mathematical content, e.g. use of logarithmic equations.

Mathematical skills will always be tested in a physics context, and questions testing mathematical skills can test any of the three assessment objectives, AO1 to AO3. A question testing mathematical skills could also be testing, for instance, understanding of practical skills.

The subject content section of the specification indicates where there are opportunities to incorporate the maths skills requirements into teaching and where there are content specific mathematical learning outcomes.

The key mathematical requirements (with examples of skills) are shown below. Further details are shown in Appendix 5e of the Physics A specification.

- M0 – Arithmetic and numerical computation
- M1 – Handling data
- M2 – Algebra
- M3 – Graphs
- M4 – Geometry and trigonometry

Synoptic assessment

Synoptic assessment involves the drawing together of knowledge, understanding and skills learned in different parts of the A Level course. All papers within Physics A will have questions containing an element of synoptic assessment.

A synoptic question will require candidates to construct their answer, using knowledge, skills and understanding from a number of parts of the specification.

For example, by:

- applying knowledge and understanding of more than one area to a particular situation or context
- using knowledge and understanding of principles and concepts in planning experimental and investigative work and in the analysis and evaluation of data
- bringing together, and applying, scientific knowledge and understanding from different areas of the subject.

Level of difficulty

Our aim is to ensure that all students can access all question papers.

We estimate the level of difficulty of each mark as being low (L), medium (M) or high (H) demand. There are approximately equal amounts of each demand type (L, M and H). About one-third of the high demand questions are classified as being 'stretch and challenge', i.e. targeting A* grade standard.

Our question papers

Candidates are required to respond to a variety of question types in the examined papers.

Paper 1 and Paper 2 – 100 marks each paper

Both papers have a similar format and are divided into two sections, A and B. Both components have a maximum mark of 100 each. Candidates answer all questions.

Section A: Multiple choice questions (MCQs) 15 marks

There are 15 MCQs, 1 mark each. MCQs allow assessment of a wide range of content, whilst keeping the overall assessments as short as possible. MCQs are in a separate section of the paper. Research shows that candidates find MCQs more accessible when they are grouped together in this way.

We recommend that candidates spend no more than 30 minutes on Section A. Only AO1 and AO2 are tested in MCQs. questions

Section B: 85 marks

Short answer response questions – these consist of structured questions featuring problem-solving, calculations, and practical skills. These types of question are marked by a points-based mark scheme.

Extended response questions – a smaller number of questions requiring longer responses, generally worth 3–6 marks. These questions are marked using a points-based mark scheme.

Two 6 mark level of response (LoR) questions
These questions are flagged with an asterisk* in the question paper. A LoR question tests the ability of the candidate to construct and develop a sustained line of reasoning which is coherent, relevant, substantiated and logically structured. A level of response mark scheme is used.

Paper 3: 70 marks

Candidates should answer all questions. Candidates will be assessed across all modules of the specification by a combination of question types. There are no multiple choice questions in paper 3.

The question types are:

Short answer response questions
Extended response questions
Two 6-mark level of response (LoR) questions

Command words

The most frequently used command words used in our examination papers are listed below. **It is not an exhaustive list.** The definitions provide guidance to teachers and students about what is expected when these words are used in exams.

Command word	Meaning …
Calculate	Work out the numerical value. Show your working when asked to.
Compare	Give an account of the similarities and/or differences between two (or more) items or situations, referring to both (all) of them throughout.
Complete	Add words, numbers, labels or plots to complete a sentence, table, diagram graph, equation, etc.
Define	Use your knowledge to state the meaning of a given term.
Describe	Give an account using relevant concepts, processes, characteristics and, if necessary, examples.
Draw	Produce a diagram/drawing/graph with sufficient detail/annotation and labels to illustrate the answer.
Estimate	Assign an approximate value.
Evaluate	Make qualitative, or quantitative, judgements and/or reasoning conclusions.
Explain	Use relevant knowledge and/or evidence and/or ideas to demonstrate understanding why something is the case or how something happens.
Name	Provide appropriate word(s) or term(s).
Outline	Provide a description setting out the main characteristics/points.
Plot	Mark points accurately for a given range of values, using labelled axes.
Show that	Write down sufficient details, structured steps or calculations to prove a fact or answer.
Sketch	Produce a simple, freehand drawing to illustrate the general point(s) being conveyed, using annotations as required.
State	Express clearly and briefly.
Suggest	There is often no single correct answer. Candidates will be given credit for sensible reasoning based on correct physics.

Accessibility principles

We believe that candidates should be fairly rewarded for what they know and can do. Our aim is to ensure that no student is disadvantaged by not being able to access questions or tasks in an assessment.

We've developed accessibility principles that we use to write our assessment materials and develop new qualifications. We continually review our principles to ensure they meet the latest research and feedback.

Look and feel of the paper

Students can engage quickly and accurately with our assessment materials.

To ensure our assessment material is easy to read we:

- avoid visual overloading by providing adequate white space
- write questions in plain English and avoid jargon and complicated language
- left-align text, diagrams and tables to align with our modified papers to help with a range of visual impairments.

Assessment approach

Students are assessed by a consistent and research proven approach to assessment.

To ensure our materials are as accessible as possible we:

- use command words clearly and consistently
- use short sentences, often bulleted or numbered for ease of reference
- use emboldening for key words or instructions
- avoid the use of confusing contexts in questions
- minimise the use of names or gendered pronouns.

Scientific conventions

Students are supported by presenting scientific information based on accepted conventions, consistent with our specifications.

To ensure students can confidently interpret scientific terminology we:

- present units in a consistent, conventional form, without use of a solidus, e.g. $m\ s^{-1}$
- separate units from the name of the physical quantity in tables and graphs with a solidus, e.g. time / s
- use alternative formatting (e.g. italics for physical quantities) only where scientifically justified
- are consistent in our use of the language of measurement
- use accepted conventions for symbols for circuit diagrams
- provide a Data, Formulae and Relationships booklet so the exam assesses the application of physics, rather than the recall of facts and relationships.

Mark schemes

In all Physics A papers, marks are awarded using the MACB scheme. The meaning of each letter is provided in all mark schemes, and is summarised below.

M marks	These are **method** marks upon which **A**-marks later depend. For an **M**-mark to be scored, the point to which it refers must be seen in the candidate's answers. If a candidate fails to score a particular **M**-mark, then none of the dependent **A**-marks can be scored.
A marks	These are **accuracy** or **answer** marks, which either depend on an **M**-mark, or allow a **C**-mark to be scored.
C marks	These are **compensatory** method marks. These can be scored even if the points to which they refer are not written down by the candidate, providing subsequent working gives evidence that they must have known it. For example, if an equation carries a **C**-mark and the candidate completes a calculation without writing down the actual equation then the **C**-mark is given.
B marks	These are awarded as **independent** marks, which do not depend on other marks. For a **B**-mark to be scored, the point to which it refers must be seen specifically in the candidate's answers.

The MACB categorisation of marks will be explained in this Section by using examples from past Physics A papers.

Question type examples and comments

All examples have been chosen for the past Physics A papers, available from the OCR website.

Multiple choice questions (MCQs)

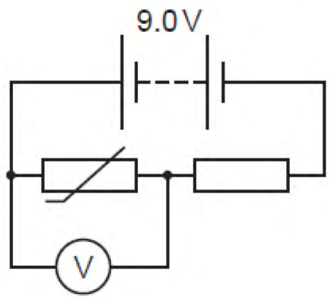
In papers 1 and 2, Section A comprises 15 multiple choice questions.

- All questions will contain four answer options, **A**, **B**, **C** and **D**.
- A small number of 'multiple completion' questions will contain three statements, with one, two or three of the statements being correct.
- All options will be covered by the specification (or will be covered by learning from a previous Key Stage).
- MCQs may check for common misconceptions or for common errors.
- Options will always be in alphabetical/numerical order unless doing so prompts the correct option.
- MCQs **do not** test AO3.
- There is a box at the end of the options for candidates to indicate their answer.

All examples have been chosen from past exam papers, available from Teach Cambridge.

Example 1

A potential divider circuit is shown below.



The battery has electromotive force (e.m.f.) 9.0 V and negligible internal resistance.
At room temperature the potential difference (p.d.) across the thermistor is 4.5 V.
The temperature of the thermistor is increased and its resistance decreases by 20% from its previous value.

What is the p.d. across the thermistor now?

A 3.6 V

B 4.0 V

C 5.0 V

D 5.4 V

Your answer [1]

> The correct answer is **B**.
>
> The question tests maths skills and AO2 for the context of a potential divider.
>
> The level of demand is hard.
>
> The four values are in increasing numerical order.
>
> The correct answer is known as the **key**. All other answers are referred to as the **distractors.**
>
> The distractors correspond to common errors or misconceptions.

Example 2

A pendulum is oscillating in air and experiences damping.

Which of the following statements is/are correct for the damping force acting on the pendulum?

1 It is always opposite in direction to acceleration.
2 It is always opposite in direction to velocity.
3 It is maximum when the displacement is zero.

A Only 1 and 2

B Only 2 and 3

C Only 3

D 1, 2 and 3

Your answer [1]

> The correct answer (key) is **B**.
>
> The candidate needs to demonstrate knowledge and understanding of scientific processes, techniques and procedures (AO1).
>
> This is a medium-demand question.

Short answer questions

These question types can assess any Assessment objectives (AO1, AO2 and AO3) and will include:

- 1, 2 or 3 mark free-response questions
- 1, 2 or 3 mark calculations.

We use short answer questions because they allow broad coverage of the specification, while keeping the length of the examination manageable.

Example 1

17 (a) State **one** S.I. base quantity other than length, mass and time.

.... **[1]**

We embolden words in the question to help candidates. Only **one** example is required here.

The number of answer lines given is often a good indication of the depth of the answer required. Here, only a single line is necessary for the one-word answer.

This is a low demand question testing AO1.

Example 2

23 (a) A planet of mass *m* is in a circular orbit around a star of mass *M*.

Use the equation for Newton's law of gravitation and your knowledge of circular motion to show that the relationship between the orbital period *T* of the planet and its orbital radius *r* is $T^2 \propto r^3$.

The command words here are 'Use…..to show' for this medium demand question. The answer is given so all steps leading to the answer from the equation referenced need to be shown by the candidate.

[3]

Mark scheme

Question		Answer	Marks	Guidance
23	a	$\frac{GMm}{r^2} = \frac{mv^2}{r}$ **or** $\frac{GMm}{r^2} = mr\omega^2$	M1	Note the A1 mark can only be scored if the preceding M1 marks upon which it depends have been shown.
		$v = \frac{2\pi r}{T}$ **or** $\omega = \frac{2\pi}{T}$	M1	
		Substitution and manipulation to give $T^2 = \frac{4\pi^2}{GM} r^3$ (with $\frac{4\pi^2}{GM}$ is constant)	A1	**Allow** any subject

Longer answer / extended response questions

We usually classify longer answer / extended response questions in science as anything over 3 marks. We use these questions to assess across all three Assessment Objectives (AO1, AO2 and AO3).

These question types often include:

- open-ended questions
- synoptic questions linking concepts from across the specification
- data interpretation questions
- questions on experimental design
- questions assessing the application of knowledge in novel contexts
- multi-step calculations.

Example 3

(c) The Universe evolved from the Big Bang.

Describe the evolution of the Universe up to the formation of the first nuclei.

....

....

....

....

....

....

....

....

....

....

....

.... **[4]**

This question requires a descriptive answer, the command word is 'Describe'. The question assesses Assessment Objective AO1 - demonstrate knowledge and understanding of scientific ideas.

Lined answer space is provided, which together with the mark allocation **[4]** are good indicators of the expected length of the required response.

Calculation questions

Where there is a calculation, we will always leave space for candidates to show their working.

For calculation questions, in general, if the answer on the answer line is correct, full marks will be awarded (unless the question specifically requires working to be shown).

It is good practice to show working. Candidates who show their working may be less likely to make a mistake, and may easily spot and correct a mistake themselves. Marks can be given for correct working, even when the final value is incorrect.

Example 4

The table shows some data on the planet Venus.

Mass / kg	4.87×10^{24}
Radius / km	6050
Density of atmosphere at surface / kg m^{-3}	65
Period of rotation about its axis / hours	5830

(a) Calculate the magnitude of the gravitational field strength g at the surface of Venus.

Give your answer to **3** significant figures.

There is a clear indication that the answer must be given to **3** significant figures.

The unit is given at the end of the answer line for calculation questions, unless the unit is requested in the question.

g = ... N kg^{-1} **[3]**

Mark Scheme

Question			Answer	Marks	Guidance
1	(a)		$g = GM/r^2$	C1	**Allow** m for M **Allow** d or D or x or X or R for r
			$g = \dfrac{6.67 \times 10^{-11} \times 4.87 \times 10^{24}}{(6\,050 \times 10^{3})^{2}}$	C1	Full substitution needed **Allow** r = 6 050 for this C1 mark
			g = 8.87 (N kg^{-1})	A1	**Allow** a negative answer Answer must be to exactly 3sf for the A1 mark. Do not use the **SF** penalty for the paper here

An answer of 8.87, without working shown, implies that the preceding C1 marks (compensatory method marks) have also been gained and full marks are awarded. However, it is recommended working is always shown.

The A1 mark is awarded for the correct answer given to **3** significant figures (as clearly indicated in the question).

Level of Response (LoR) questions

We use the term *Level of Response* (often abbreviated to LoR by teachers and examiners) to cover a specific extended response question that tests a candidate's ability to form and develop a sustained line of reasoning which is coherent, relevant, substantiated and logically presented. A LoR question tests both the substance and organisation of the response and is marked using a level of response mark scheme.

In a question paper, LoR questions are flagged with an asterisk* so the candidate is made clear about how the question is being assessed. There are 6 marks for each LoR question. A LoR question can assess any of the assessment objectives (AO1, AO2 and AO3) and can be on:

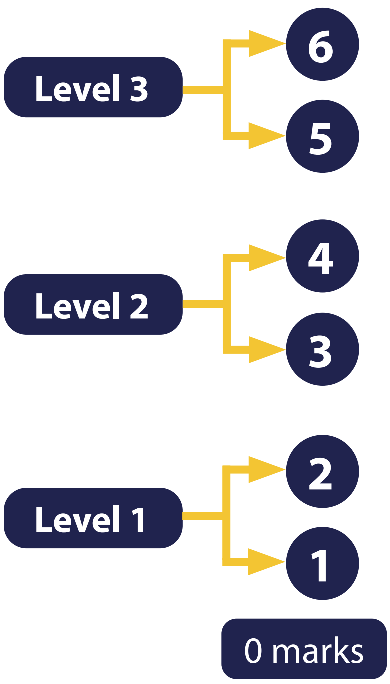
- synopticity
- practical skills
- analysis and evaluation skills
- mathematical skills.

Marking approach for Level of Response questions

Level of response questions are always marked in the same basic way, see below, with the six marks split into three bands and the generic communication descriptors in italics.

Indicative scientific content decides which level an answer is in, based on the level descriptors in the mark scheme.

The higher mark in the level is awarded when all aspects of the communication statement (in italics) are met.



There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.

There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.

There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.

No response or no response worthy of credit.

In summary:

- The skills and science content determine the level.
- The communication statement determines the mark within a level.

Example 5

The asterisk* indicates this question is assessed through level of response (LoR).

(d)* The speed v of surface water waves in shallow water of depth d is given by the equation $v = \sqrt{gd}$, where g is the acceleration of free fall.

The speed v is about $1\,m\,s^{-1}$ for a depth of about 10 cm.

You are provided with a rectangular plastic tray, supply of water and other equipment available in the laboratory.

Describe how an experiment can be conducted in the laboratory to test the validity of the equation above and how the data can be analysed to determine a value for g. **[6]**

The question requires a description of a suitable experiment and how the data can be analysed to determine g. Most of the marks available here are testing AO3. There is normally a range in the demand targeted for the marks in LoR questions, so that all candidates have an opportunity to make a good attempt at the question.

Mark scheme

Marking descriptors for each level of response.

These are 'indicative points' for the examiners.

(d)*	**Level 3 (5–6 marks)** Clear description **and** clear analysis *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Clear description **or** Clear analysis **or** Some description **and** some analysis *There is a line of reasoning presented with some structure. The information presented is in the most part relevant and supported by some evidence.* **Level 1 (1–2 marks)** Limited description **or** Limited analysis *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** *No response or no response worthy of credit.*	**B1× 6**	Use level of response annotations in RM Assessor **Indicative scientific points may include:** **Description** • Method for creating wave / pulse, e.g. lifting and releasing tray, dropping a ball into the water, ripple-tank arrangement, etc. (Details not expected) • speed = distance ÷ time **or** $v = x \div t$ **or** $v = f\lambda$ • Measure distance travelled using a ruler • Use a stopwatch / timer/ video technique / strobe to measure time / frequency • Measure the depth of water using a ruler etc • Record / measure / determine v for different d • Repeat to find average v **Analysis** • Plotting a graph, e.g. v against $\sqrt{d}$ **or** v^2 against d **or** lg$v$ against lg$d$ etc. • Correct determination of g from straight-line graph **or** • Table with v and $\sqrt{d}$ **or** v^2 and d • Correct calculation of average value of g from the table

We can see from the mark scheme above that the Level 3 descriptor for 5-6 marks requires candidates to provide a clear description and clear analysis. All the indicative points do not have to be met to gain Level 3. The higher mark in the level is awarded if the communication statement in italics is met.

Question 4 (b) (ii)

***(ii)** A student models water droplets falling through air using small solid spheres in a liquid.

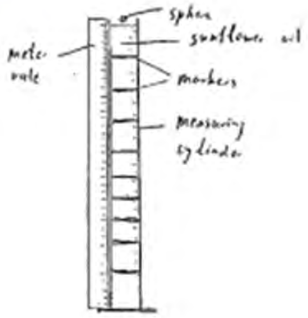
The table shows properties of the materials available to the student.

Material	Solid density, ρ_s / kg m^{-3}	Liquid density, ρ_f / kg m^{-3}	Approximate value of η / 10^{-3} kg m^{-1} s^{-1}
Water (liquid)		1000	1
Sunflower oil (liquid)		920	50
Steel (solid sphere)	7800		
Lead (solid sphere)	11300		

Describe an experiment to verify the expression given in **(i)** as accurately as possible.
As part of your answer, estimate the **lowest** terminal velocity if the student uses a solid sphere of diameter = 1 mm.

Exemplar 1

6 marks



Taken from June 2023 Paper 3 Question 4 (b) (ii). This response would have scored full marks.

· Measure the diameter of the sphere with a micrometer. Divide the diameter by 2 to calculate its radius. ~~R~~ Take measurements in 5 different directions and calculate the mean.
· Set up the apparatus as shown in the diagram. ~~Sunflower oil is used not water because η of water is too small and it may be very hard to calculate find the terminal velocity accurately.~~ Water is not used since it has a very small η value.
· Set up a camera pointing the cylinder and put a timer next to the cylinder. Drop the sphere just above the surface of the oil, and start the camera and the timer at the same time.
· The velocity of the sphere between each two markers **[6]** can be found using $v = \frac{x}{t}$, where x is the distance between markers and t is the time interval. The terminal velocity is reached if v is not changing.
· Repeat with spheres with the same size but different materials.
· Plot a graph of v against $\rho_s - \rho_f$. A straight line of best fit through the origin is expected.
· lowest terminal velocity:

~~$v = \frac{2g(1\times10^{-3} \div 2)^2 \times (7800 - 1000)}{9\times10^{-3}} = 3.706 \text{ ms}^{-1}$~~

$v = \frac{2g(1\times10^{-3} \div 2)^2 \times (7800 - 920)}{9 \times 50\times10^{-3}}$ = ~~0.0745~~ 0.075 ms^{-1}

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