Pearson Edexcel

International A Level Science

Understanding Assessment and Improving Delivery Outcomes in International A Level Physics YPH11-25IF1

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Welcome to today's event

- Introduction to your trainer
- Housekeeping
- What's in your pack?
- How today's training is structured

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Getting to know you

- Who are you and which school do you teach at?
- How long have you been teaching the IAL Physics specification?
- Are you currently an examiner?

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Aims and objectives

During the day you will:

- Be introduced to an outline of how question papers are written
- Be introduced to the idea of assessment objectives: what are they and why they are used when writing examination papers
- Examine the role of command words in the specification and the examination papers
- Analyse recent question papers and learn which types of question match the different assessment objectives
- Examine various assessment objectives by reviewing student responses from past exams.
- Discuss strategies for teaching to try and make sure students can access questions targeting different assessment objectives
- Review the support Pearson offers for the qualification
- Network, discuss best practice and share ideas with other teachers.

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Agenda--- timings are approximate

- Introductions
- Session 1 including Activities 1 and 2
- BREAK
- Session 2 including Activities 3 and 4
- LUNCH
- Session 3 including Activities 5, 6 and 7
- BREAK
- Session 4 including Activity 8
- Common Mistakes/Support from Pearson/ feedback / depart

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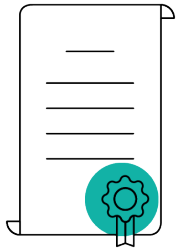

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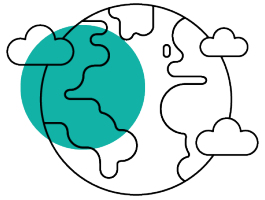

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Writing question papers and mark schemes

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How are question papers written?

- Content authors write papers
- Questions should sample across the specification
- Exam questions need to assess **skills**, not just knowledge
- Question papers must be consistent across series

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Accessibility of Questions

- Accessibility and language level are key factors when deciding upon final question wording.
- Ramping is used so that the difficulty increases progressively.
  - Ramping occurs in individual questions
  - Ramping also occurs across the whole paper.
- Ramping allows all students a chance of gaining marks throughout the paper.
- A language specialist works with the senior examiner team in the QPEC meeting at which final wording of questions is discussed.

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Command Words

- To help students understand how they should frame their answer, we use command words.
- The command words are used:
  - in the same way across all sciences
  - in the same way for A level as for GCSE.
- Command words always appear at the beginning of the sentence.
- Each command word signals a particular style of response, so candidates should be familiar with the style of response associated with each command word.

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Command words

- Questions in our exam papers are designed to use a specific command word to guide students
- The command words represent a range of skills:
  - simple recall (Give…., Name….)
  - using knowledge (Describe…)
  - giving reasons (Explain…)
  - provide more detailed analysis (Evaluate, Justify)
  - show particular skills (Calculate…., Plot….)

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ACTIVITY 1 - command words

- Go through papers 1 and 2 from the June 2024 series and identify the command words used.
- Keep a tally of how many times particular command words are used.
- What do you notice about the frequency of use?

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Frequently used command words

Common command words	Less common command words
Calculate	Determine
Explain	Complete
Give/State	Describe
Show that	Derive
Assess	Discuss
Deduce	Evaluate

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Explanation of Assessment Objectives (AO)

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Explanation of the Assessment Objectives

- What are the Assessment Objectives (AOs)?
- Why they are used
- Balance of AOs in the papers
- Activity 2: applying AOs to questions

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Why Assessment Objectives are used

- A range of skills tested on each unit examination
- Consistency between the different units of a specification
- Similar standard papers produced each year
- Same assessment objectives across all the sciences

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The Assessment Objectives

AO1	Demonstrate knowledge and understanding of science
AO2a	Application of knowledge and understanding of science in familiar and unfamiliar contexts
AO2b	Analysis and evaluation of scientific information to make judgements and reach conclusions.
AO3	Experimental skills in science, including analysis and evaluation of data and methods.

AO1, AO2a and AO2b will be assessed in units 1, 2, 4 & 5

AO3 will be assessed in units 3 & 6.

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AO1 Knowledge and understanding of Physics

Questions which target this AO focus on assessment of

- fundamental knowledge
- routine descriptions and explanations
- units
- equations

all from the specification----no need to link ideas from different sections

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AO1 Examples of AO1 questions in Unit 1 / Unit 2

- State the principle of conservation of momentum (or any law)
- Expressing the units of derived quantities in terms of base units
- Derive the equation for the resistance of two resistors in parallel (or any other derivations)
- Identify vector and scalar quantities
- Explanation of how a standing wave is formed
- Use of Huygens' construction to explain diffraction
- The wave model and the photon models of electromagnetic radiation
- *Recall the method of any of the 8 AS core practicals*

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AO1 Examples of AO1 questions in Unit 4 / Unit 5

- Use a vector diagram to derive the equations for centripetal acceleration
- Draw diagrams the describe radial and uniform electric fields
- State factors affecting the e.m.f. induced when there is relative motion between a coil and a magnet
- Describe the role of electric and magnetic fields in particle accelerators.
- Describe the processes of nuclear fusion and fission
- Explain how the amplitude of a forced oscillation changes around the natural frequency of a system
- Compare electric fields with gravitational fields
- Describe how trigonometric parallax is used to determine the distances to astronomical objects
- *Recall of the method of any of the 8 A2 core practicals*

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Typical AO1 questions from WPH11

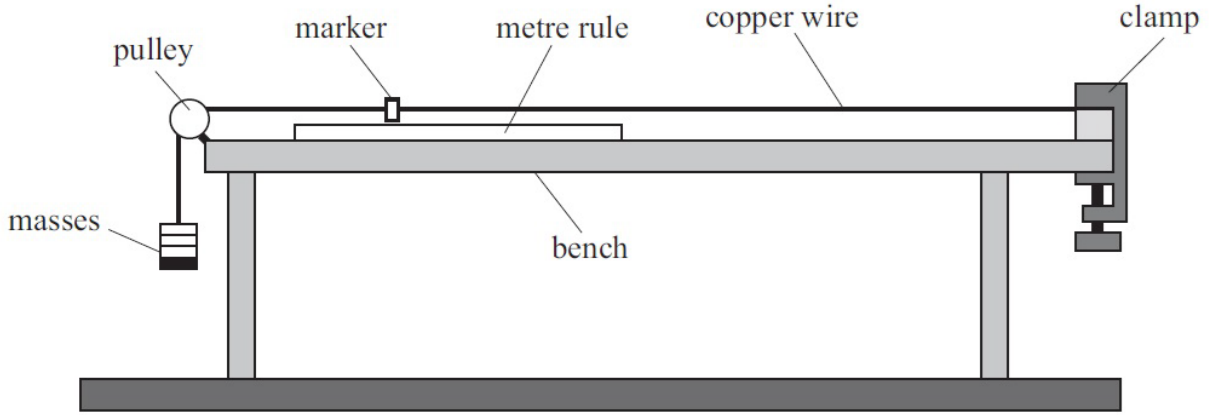
(c) Explain how the temperature of the water affects the terminal velocity of a grain of sand if Stokes' law does apply.

(2)

What makes these questions AO1?

*(a) The student clamped one end of a copper wire to the bench. The wire passed over a pulley and masses were added to the other end of the wire.

A metre rule was fixed to the bench and a marker fixed to the wire, as shown.



The student measured the diameter of the copper wire.

Describe the other measurements that need to be made using this apparatus and how they will be used to determine the Young modulus of copper.

You should define the meanings of any symbols you use.

(6)

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AO2a Application of knowledge and understanding of physics in familiar and unfamiliar contexts

Questions which target this AO focus on assessment of

the ability of students to apply their knowledge and understanding to different physics contexts

- which they are familiar with
- which are new to the student

AO2a questions require that the student to use information in the question, i.e. it is more than just the knowledge the student brings to the exam.

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AO2a Examples of AO2a questions

- Calculations
- Drawing scaled vector diagrams
- Context-based questions where students have to apply knowledge to a given situation (These are usually ‘explain’ questions)
- Interpretation of particle track diagrams
- Interpret charge or discharge curves for a resistor capacitor circuit
- Convert between MeV or MeV/c^2 and SI units
- Interpreting radiation curves for a black body radiator

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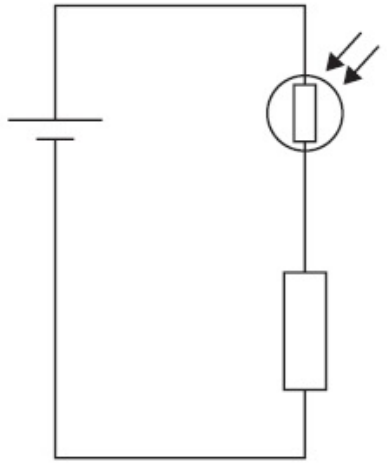
Typical AO2a question

What makes these questions AO2a?

16 A security lamp automatically switches on when the intensity of light incident on an LDR decreases.

Part of the electrical circuit in the security lamp is shown. The cell has negligible internal resistance.



(a) The light intensity incident on the LDR decreases.

Explain what happens to the potential difference across the fixed resistor.

(2)

(b) The security lamp switches on when the potential difference across the fixed resistor is 0.62 V.

When the lamp switches on, the ratio of the resistance of the LDR to the resistance of the fixed resistor is 3 : 2

The current in the circuit is 28 mA.

Calculate the resistance of the LDR when the security lamp switches on.

(3)

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AO2b

Questions which target this AO focus on assessment of

the student's ability to **analyse**

the student's ability to **interpret**

the student's ability to **evaluate**

} different forms of physics information

A question is AO2b if it requires the student to *make a conclusion* or *make a choice* or to *justify a statement*.

These questions usually require students to usual *carry out calculations to come to a conclusion.*

They *don't tell the students exactly what to calculate.*

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AO2b Examples of AO2b questions

Examples of AO2b questions

- Deduce whether Stokes' law applies to the bubble
- Assess the student's suggestion
- Deduce which string of the guitar was plucked.
- Deduce whether the collision was elastic
- Evaluate whether the luminosity of Ross-154 is less than 0.5% of the luminosity of the Sun

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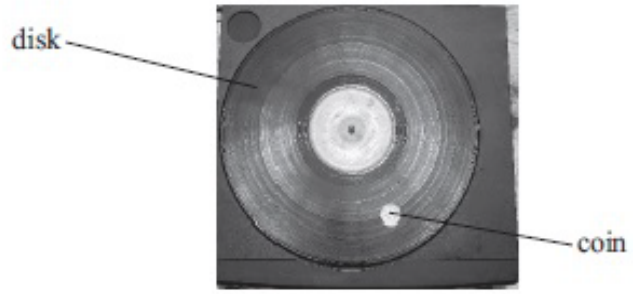
Typical AO2b question from WPH14

What makes part (ii) AO2b?

(b) The student placed the disk on a horizontal turntable and placed the coin on the disk, as shown below.



View from above

The disk rotated at 45 revolutions per minute.

(i) Calculate the angular velocity of the disk.

(2)

Angular velocity = ...

(ii) When the student placed the coin near the centre of the disk, the coin remained in position and rotated with the disk.

When the student placed the coin at the edge of the disk, the coin slid off the rotating disk.

The student estimated that the closest the coin could be to the edge of the disk without sliding off was about 5 cm.

Deduce whether this was a suitable estimate.

You should assume that the maximum frictional force is 0.02 N.

(3)

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AO3

By carrying out the core practicals and other experiments students should be able to:

- Plan an experiment
- For a given experiment be able to comment on
    - experimental techniques,
    - measurements,
    - uncertainties,
    - significant figures
    - and anomalous results
- Analyse data by plotting a graph using correct units and sensible scales,
    - determine relationships or constants,
    - deal qualitatively and quantitatively with uncertainties,
    - make conclusions.

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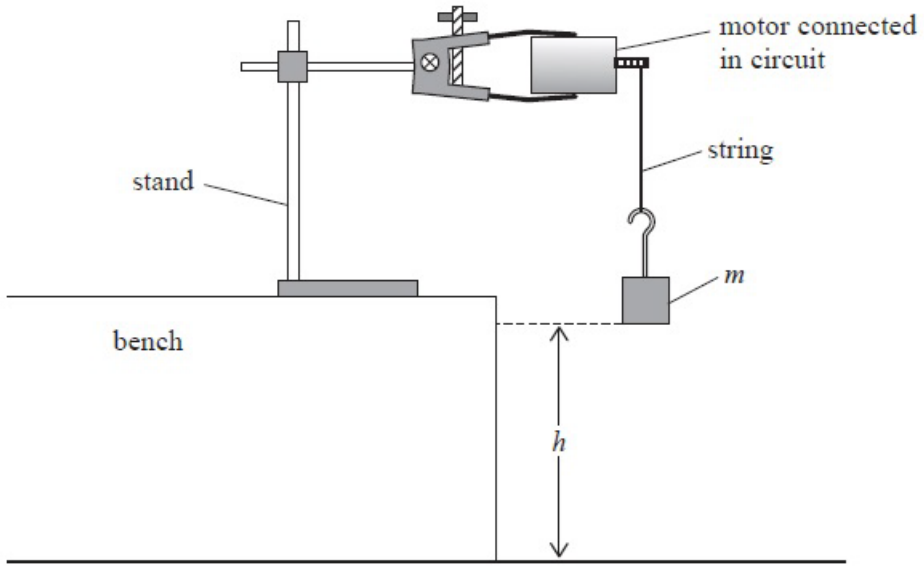
Typical AO3 question

(b) The student used the switch in position 1 to charge the capacitor.

The student changed the switch to position 2 to discharge the capacitor through the motor.

As the capacitor discharged, the motor raised a small mass m through a height h, as shown.



The student used a metre rule to measure h.

Describe an accurate method to determine a single value of h using a metre rule.

You may include additional apparatus.

(3)

(c) The student repeated the procedure in (b) several times. She recorded the following measurements.

h / m	0.246	0.239	0.243	0.241

(i) Calculate the mean value of h.

(1)

(ii) Determine the percentage uncertainty in the mean value of h.

(2)

(iii) Determine the efficiency of the electric motor.

maximum potential difference across capacitor = 6 V
capacitance of capacitor = 4700 μF
m = 20 g

(3)

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The border lines…

- The context of the question and the command word used are both important for assigning an AO
- For example, a question could require a calculation to be carried out:
    1. Calculate the resultant force acting on the car.
    2. Determine the specific heat capacity of copper.
    3. Deduce which wire was used.

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The border lines…all of these require a calculation

1. Calculate the resultant force acting on the car.

   Calculate would be one AO1 mark, and the rest would be AO2b. (In a "calculate" question all the values to be substituted are stated in the question part)

2. Determine the specific heat capacity of copper.

   Determine would be the AO2b, but a value would have to be obtained from elsewhere (e.g. a graph) to complete the calculation.

3. Deduce which wire was used.

   Deduce would be all AO2b marks.

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Balance of AOs in each section of the examination

		% in AS WPH11, WPH12, WPH13	% in IA2 WPH14, WPH15, WPH16	% in IAL
AO1	Demonstrate knowledge and understanding of science	34–36	29-31	32–34
AO2a	Application of knowledge and understanding of science in familiar and unfamiliar contexts	34–36	33-36	34–36
AO2b	Analysis and evaluation of scientific information to make judgements and reach conclusions	9–11	14-16	11–14
AO3	Experimental skills in science, including analysis and evaluation of data and methods	20	20	20

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Marks assigned to AOs in a typical WPH11or WPH12 paper

80-mark paper which counts for 40% of the AS award:

- 33 marks AO1
- 34 marks AO2a
- 13 marks AO2b

What is the implication for our students?
Recall is not enough-----its roughly only 40% of the marks
60% is **skills** based---calculate, determine, evaluate, assess, deduce etc
Just as you can practice recall, you can practice the skills----*and we, the teachers, must train these skills!*

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Relationship of assessment objectives to units for the International Advanced Level qualification

Unit number	AO1	AO2a	AO2b	AO3	% of the IAL exam
Unit 1	8.5-9.0	8.5-9.0	2.25-2.75	0	20
Unit 2	8.5-9.0	8.5-9.0	2.25-2.75	0	20
Unit 3	0	0	0	10	10
Unit 4	7.3-7.8	8.4-8.9	3.6-4.0	0	20
Unit 5	7.3-7.8	8.4-8.9	3.6-4.0	0	20
Unit 6	0	0	0	10	10
Totals for IAL	32-34	34-36	11-14	20	100

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ACTIVITY 2 – assigning AOs

Your pack contains Paper 1 and Paper 2 from the June 2024 IAL Physics series.

- Look at Q14, Q15 and Q16(a) in the WPH11 paper
- Look at Q12, Q13, and Q14 in the WPH12 paper
- Assign an A.O. to each question part

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ACTIVITY 2 – assigning AOs

WPH11 June 2024				
Item	Marks	AO		
		AO1	AO2a	AO2b
14(a)	1	1		
14(b)	3			3
14(c)	2	2		
15(a)	3	1	2	
15(b)	2	1	1	
15(c)	2	2		
16(a)	6	6		
16(b)	4	1	3	

WPH12 June 2024				
Item	Marks	AO		
		AO1	AO2a	AO2b
12(a)	2	2		
12(b)	2	1	1	
13(a)	3	1	2	
13(b)	2	2		
13(c)	2	2		
14(a)(i)	1	1		
14(a)(ii)	4	4		
14(b)	2	2		
14(c)	2	1	1	
14(d)	5			5

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Mark Schemes

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Mark scheme terminology

- ALLOW/ACCEPT
  - For a response that is not fully correct, but which scores the marks
- REJECT
  - For a response that is wrong (may indicate a misconception)
- IGNORE
  - For a response that can be treated as neutral
- UNDERLINING
  - Indicates a word that must be seen
- BRACKETS
  - Detail that does not need to be seen for the marks to be given

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Mark scheme from WPH11 June 2024

Mark schemes must answer the question, but some questions have multiple correct responses.

14 A grain of sand quickly reaches terminal velocity when it falls into water.

(a) State why the grain of sand reaches terminal velocity.

(1)

Question Number	Answer	Mark
14(a)	The weight of the grain is equal to the sum of the drag and upthrust acting on it **Or** Resultant force = 0 **Or** The sum of the upward forces is equal to the sum of the downward forces **Or** The (vector) sum of the forces is zero **(1)**	1

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ACTIVITY 3 – develop a mark scheme

- Your pack contains Q14a from the WPH12 June 2024 paper.
- Read the question and:
  - independently write a mark scheme
  - compare your suggested mark scheme with a colleague

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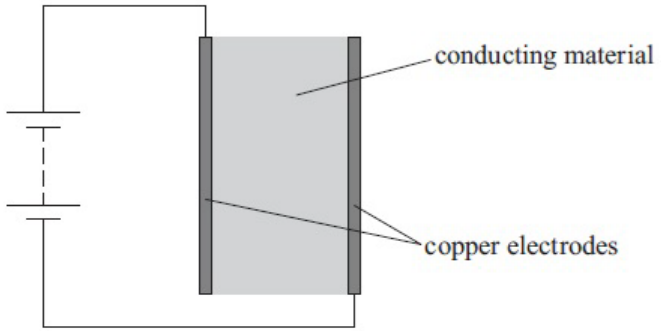
Q14(a) from WPH12 June 2024

14 An electrical heating system consists of heating panels.

Each panel is made from a thin sheet of conducting material attached to two copper electrodes. The electrodes are connected to a power supply, as shown.



(a) A student uses a sample of the conducting material to determine its resistivity.

(i) State what is meant by resistivity of a material.

(1)

(ii) Describe how the student could determine a value for the resistivity of the conducting material.

You do **not** need to draw a circuit diagram.

(4)

Question Number	Answer	Mark
14(a)(i)	The resistance of a sample of the material of unit cross-sectional area and unit length **Or** $\rho = \frac{RA}{l}$ with terms defined including cross-sectional area **Or** the resistance multiplied by cross-sectional area divided by length **(1)**	1
14(a)(ii)	Measure the length **and** width **(1)** Measure the thickness of the material using a micrometer **Or** Measure the thickness of the material using vernier callipers **(1)** Use an ammeter and voltmeter to determine the resistance using $R = \frac{V}{I}$ **Or** Use an ohmmeter to measure the resistance of the sample **(1)** Use $\rho = \frac{RA}{l}$ (to determine the resistivity) **(1)** **Or** valid description of a graph and gradient calculation to determine the resistivity	4

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” Areas to Target” Comments from the CE

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Areas to target comments from the Chief Examiner

I think that the key areas where centres can improve in the IAL assessment are

- the linkage questions which are mostly AO1
- the AO2b questions
  - deduce/compare/evaluate
- AO2a longer questions
  - trigonometry

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AO1 linkage questions

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Linkage questions

- These questions are always 6 marks.
- There will be 6 indicative content (IC) points.
- These points can be awarded a maximum of 4 marks.
- 2 more marks are available for linkage between the IC points and reasoning.
- Usually, these questions will require an explanation with linkage on knowledge from the specification. so likely to be AO1.
- Questions can be AO2a if some marks are for applying knowledge to a new situation.

Linkage questions may require:

- an explanation where there is a consequential change, e.g. the effect of temperature on the resistance of a conductor
- describing a change over time, e.g. evolution of a star.
- some sort of comparison

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Activity 4 marking IC questions

WPH15 Q19 June 2024

Main sequence stars evolve into red giant stars. Red giant stars eventually become white dwarf stars.

Explain this evolutionary sequence.

You should refer to the fusion processes occurring in the star.

Indicative content

IC1 Hydrogen fusion occurs in the core of the (main sequence) star

IC2 Hydrogen (in the core) runs out

IC3 The rate of fusion decreases and the star contracts

IC4 The temperature rises (in the core) and fusion of helium begins

IC5 The star expands (and cools) to form a red giant star

IC6 (Helium) fusion stops and the star collapses to a white dwarf star

OR *helium runs out and the star collapses to a white dwarf star*

Use the MS to mark the two examples of students work.

Consider how many IC marks you would give them.

Then consider the linkage marks.

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ACTIVITY 4

*(b) Main sequence stars evolve into red giant stars. Red giant stars eventually become white dwarf stars.

Explain this evolutionary sequence.

You should refer to the fusion processes occurring in the star.

(6)

- In the main sequence, the fusion of hydrogen occurs in the star's core
- When the hydrogen supply runs out, ~~fusion~~ fusion ceases and the star collapses due to gravitational forces
- Then, the star expands and is now a red giant
- The temperature in the red giants core is high enough for fusion of helium to occur
- When the helium supply runs out, the ~~star collapses again~~ fusion ceases ~~forever~~ and the star collapses again
- The star is now a white dwarf, a core remnant of a red giant which is very hot

(Total for Question 19 = 15 marks)

*(b) Main sequence stars evolve into red giant stars. Red giant stars eventually become white dwarf stars.

Explain this evolutionary sequence.

You should refer to the fusion processes occurring in the star.

(6)

Main sequence are stars that have an equal gravitational force and radiation pressure in order to remain with more thy or stable. The core of the star is hot enough for fast hydrogen fusion to occur. However hydrogen fusion ceases causing fusion to not happen as the core runs at of hydrogen which causes the main sequence star to contract due to stronger gravitational forces and then expand due to radiation pressure which allows it to become a red Giant Star. The core is not enough in a red giant star for helium fusion to occur as it runs at of helium and reactants, however once helium fusion ceases it causes the red giant star to collapse contract and ~~become~~ cool down causing it to become a white dwarf star. This evolutionary process only happens if main sequence star has less mass than the sun.

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ACTIVITY 4

***19(b)**

This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning. The following table shows how the marks should be awarded for indicative content.

IC points	IC mark	Max linkage mark	Max final mark
6	4	2	6
5	3	2	5
4	3	1	4
3	2	1	3
2	2	0	2
1	1	0	1
0	0	0	0

The following table shows how the marks should be awarded for structure and lines of reasoning.

	Number of marks awarded for structure of answer and sustained line of reasoning
Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2
Answer is partially structured with some linkages and lines of reasoning	1
Answer has no linkages between points and is unstructured	0

Indicative content

IC1 Hydrogen fusion occurs in the core of the (main sequence) star

[Allow "burn" for "fuse"]

IC2 Hydrogen (in the core) runs out

IC3 The rate of fusion decreases and the star contracts

[Allow ceases/stops for "decreases"]

IC4 The temperature rises (in the core) and fusion of helium begins

IC5 The star expands (and cools) to form a red giant star

IC6 (Helium) fusion stops and the star collapses to a white dwarf star
Or helium runs out and the star collapses to a white dwarf star
[Allow "star becomes smaller" for "star collapses"]

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ACTIVITY 4

*(b) Main sequence stars evolve into red giant stars. Red giant stars eventually become white dwarf stars.

Explain this evolutionary sequence.

You should refer to the fusion processes occurring in the star.

(6)

- In the main sequence, ~~to~~ fusion of hydrogen occurs in the star's core
- When the hydrogen supply runs out, ~~fusion~~ fusion ceases and the star collapses due to gravitational forces
- Then, the star expands and is now a red giant
- The temperature in the red giants core is high enough for fusion of helium to occur
- When the helium supply runs out, the ~~star collapses again~~ fusion ceases ~~forever~~ and the star collapses again
- The star is now a white dwarf, a core remnant of a red giant which is very hot

(Total for Question 19 = 15 marks)

*(b) Main sequence stars evolve into red giant stars. Red giant stars eventually become white dwarf stars.

Explain this evolutionary sequence.

You should refer to the fusion processes occurring in the star.

(6)

Main sequence are stars that have an equal gravitational force and radiation pressure in order to remain with near thy are stable. The core of the star is hot enough for fast hydrogen fusion to occur. However hydrogen fusion ceases causing fusion to not happen as the core runs out of hydrogen which causes the main sequence star to contract due to stronger gravitational forces and then expand due to radiation pressure which allows it to become a red Giant Star. The core is hot enough in a red giant star for helium fusion to occur however once helium fusion ceases as it runs out of helium and reactants, it causes the red giant star to ~~collapse~~ contract and ~~become~~ cool down causing it to become a white dwarf star. This evolutionary process only happens if main sequence star has less mass than the sun.

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Improving student's response to Linkage Questions

- Practice, Practice, Practice……there is a vast resource available from Past Papers which are accessible via Exam Wizard
- Teach how to answer!
  - Identifying the scaffolding used in the questions
  - Identifying key terminology
  - Writing each sentence on a new line
  - Not repeating the 'stem' of the question
  - Exam Technique…..1 mark/min (plus 5 or 10 mins to read over the paper and correct if necessary)

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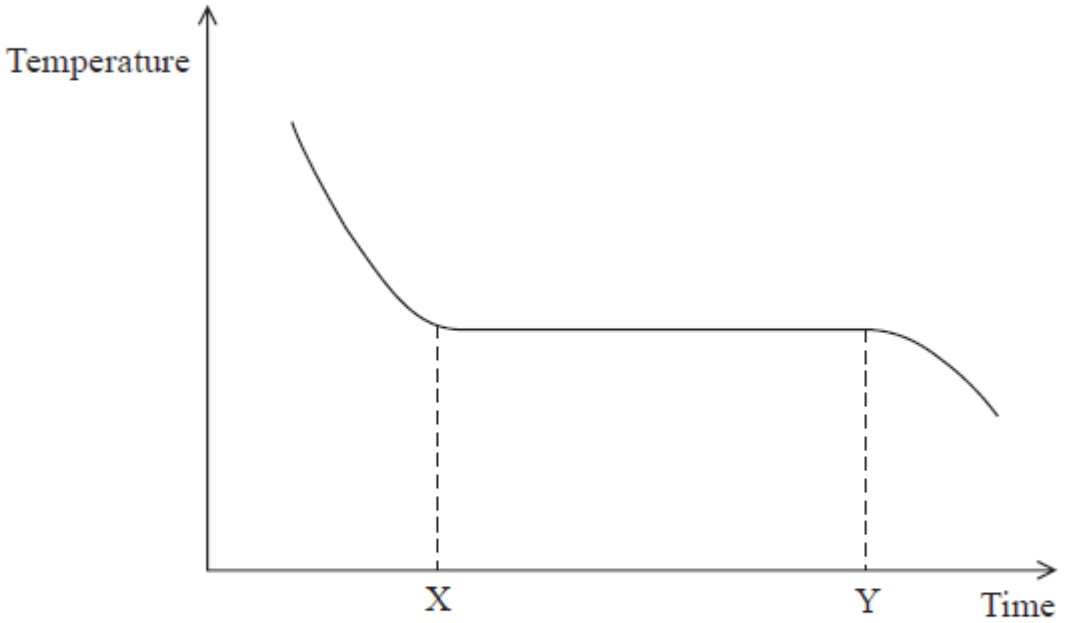
WPH15 2306 Q18

***18** Wax is heated until the temperature is above the melting point of the wax. The hot wax is poured into a bowl and allowed to cool.

The graph shows how the temperature of the wax varies with time as it cools.



Describe how the internal energy of the wax changes as the wax cools.

You should refer to the energy of the wax molecules as the liquid wax cools and becomes solid, and the solid wax cools.

Times X and Y have been included to help you refer to the graph.

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WPH15 2306 Q18

Indicative content

IC1 The internal energy of the wax decreases during cooling
Or The internal energy of the wax decreases as time passes

IC2 The internal energy of the wax is the sum of potential energy and kinetic energy of the molecules

IC3 As the temperature of the wax decreases, the (molecular) kinetic energy decreases

IC4 Between times X and Y the (liquid wax is solidifying and the molecular) potential energy decreases

IC5 Between times X and Y the temperature is constant and so there is no change in (molecular) kinetic energy

IC6 At time Y the wax has solidified

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Example A

Describe how the internal energy of the wax changes as the wax cools.

You should refer to the energy of the wax molecules as the liquid wax cools and becomes solid, and the solid wax cools.

Times X and Y have been included to help you refer to the graph.

As the temperature of liquid wax ~~cools~~ decreases, its internal energy decreases and the kinetic energy of ~~the~~ molecules is lost. Once it reaches time X, the ~~internal energy~~ temperature stops changing as the wax has reached its' melting temperature. ~~From~~ From time X to time Y, internal energy is not being used to change temperature, now its changing state, so particles are getting closer together. At time Y, all the energy to change state has been gathered and all the wax have the same internal energy to become solid. After becoming solid, the temperature is still decreasing and wax is still loosing energy

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Example A

Describe how the internal energy of the wax changes as the wax cools.

You should refer to the energy of the wax molecules as the liquid wax cools and becomes solid, and the solid wax cools.

Times X and Y have been included to help you refer to the graph.

≡ Cooling

(As the temperature of liquid wax ~~cools~~ decreases), its internal energy decreases and the Kinetic energy of molecules is lost. Once it reaches time X, the ~~internal energy~~ temperature stops changing as the wax has reached its melting temperature. From time X to time Y, internal energy is not being used to change temperature, now its changing state, so particles are getting closer together. At time Y, all the energy to change state has been gathered and all the wax have the same internal energy to become solid. After becoming solid, the temperature is still decreasing and wax is still loosing energy

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Example B…..
what has this student done?

Describe how the internal energy of the wax changes as the wax cools.

You should refer to the energy of the wax molecules as the liquid wax cools and becomes solid, and the solid wax cools.

Times X and Y have been included to help you refer to the graph.

* IE = Internal energy.

The wax is heated untill it is in a liquid state, the molecules move freely across the substance but the force between the bonds is reduced as the heat get greater, with high temperature comes high kinetic energy, internal energy is equal to kinetic plus potential energy so internal energy increases when the wax starts to cool down the substance starts to become solid increasing the strenght of the bonds and redueing the kinetic energy, which reduces the internal energy, between X and y the object is becoming solid again so the temperature and kinetic energy are constant, when completely solid temperature goes down and so does IE*

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Describe how the internal energy of the wax changes as the wax cools.

You should refer to the energy of the wax molecules as the liquid wax cools and becomes solid, and the solid wax cools.

Times X and Y have been included to help you refer to the graph.

* IE = Internal energy.

The wax is heated untill it is in a liquid state, the molecules move freely across the substance but the force between the bonds is reduced as the heat get greater, with high temperature comes high kinetic energy, internal energy is equal to kinetic plus potential energy so internal energy increases when the wax starts to cool down the substance starts to become solid increasing the strenght of the bonds and redueing the kinetic energy, which reduces the internal energy, between X and y the object is becoming solid again so the temperature and kinetic energy are constant, when completely solid temperature goes down and so does IE*

not referenced to the graph times X & Y

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Specification Points

128 Understand the concept of internal energy as the random distribution of potential and kinetic energy amongst molecules.

129 Understand the concept of absolute zero and how the average kinetic energy of the molecules is related to the absolute temperature.

Feedback from the CE

- For this question, some students didn't refer to the graph at all, others just described the graph in very basic terms..
- In some responses internal (as well as kinetic) energy was associated with temperature, which led some to say that PE increases when KE decreases to keep total energy (internal energy) constant.
- Others said that internal energy did fall, but only before X and after Y, i.e. when the temperature was decreasing.

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AO2a & AO2b

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AO2a

These include:

- Questions involving calculations from data or a graph
- Questions involving explanations based on the context of the question.
- Often, but not always, AO2a calculations are short-—worth 2 or 3 marks.

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Marking an AO2a question

WPH15, Q16(a)
2406 series

16 The star ε-Eridani is one of the closest stars to the Sun. The intensity of ε-Eridani, as measured on the Earth, is 1.05×10^{-9} W m^{-2}.

(a) Calculate the wavelength, λ_{max}, corresponding to the peak intensity of emission of radiation from ε-Eridani.

distance of ε-Eridani from the Earth = 9.94×10^{16} m
radius of ε-Eridani = 5.12×10^{8} m

λ_{max} = ...

Question Number	Answer		Mark
16(a)	Use of $I = \frac{L}{4\pi d^2}$	(1)	
	Use of $L = \sigma A T^4$	(1)	
	Use of $A = 4\pi r^2$	(1)	
	Use of $\lambda_{max} T = 2.898 \times 10^{-3}$ m K	(1)	
	$\lambda_{max} = 5.64 \times 10^{-7}$ m	(1)	5
	Example of calculation $1.05 \times 10^{-9}\ \text{W m}^{-2} = \frac{L}{4\pi \times (9.94 \times 10^{16}\ \text{m})^2}$		
	$L = 4\pi \times (9.94 \times 10^{16}\ \text{m})^2 \times 1.05 \times 10^{-9}\ \text{W m}^{-2} = 1.30 \times 10^{26}\ \text{W}$		
	$A = 4\pi \times (5.12 \times 10^{8}\ \text{m})^2 = 3.29 \times 10^{18}\ \text{m}^2$		
	$1.30 \times 10^{26}\ \text{W} = 5.67 \times 10^{-8}\ \text{W m}^{-2}\text{K}^{-4} \times 3.29 \times 10^{18}\ \text{m}^2 \times T^4$		
	$T = \sqrt[4]{\frac{1.30 \times 10^{26}\ \text{W}}{5.67 \times 10^{-8}\ \text{W m}^{-2}\text{K}^{-4} \times 3.29 \times 10^{18}\ \text{m}^2}} = 5140\ \text{K}$		
	$\lambda_{max} = \frac{2.898 \times 10^{-3}\ \text{m K}}{5140\ \text{K}} = 5.64 \times 10^{-7}\ \text{m}$		

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working it through
equations are given, constants are given

Stefan-Boltzmann law $L = \sigma T^4 A$

Wien's law $\lambda_{max} T = 2.898 \times 10^{-3}\ \text{m K}$

Intensity of radiation $I = \frac{L}{4\pi d^2}$

Stefan-Boltzmann constant $\sigma = 5.67 \times 10^{-8}\ \text{W m}^{-2}\ \text{K}^{-4}$

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Example 1

- Activity 5 marking AO2a
- There are 3 in the pack

16 The star ε-Eridani is one of the closest stars to the Sun. The intensity of ε-Eridani, as measured on the Earth, is $1.05 \times 10^{-9}\ \text{W m}^{-2}$.

(a) Calculate the wavelength, λ_{max}, corresponding to the peak intensity of emission of radiation from ε-Eridani.

distance of ε-Eridani from the Earth = 9.94×10^{16} m
radius of ε-Eridani = 5.12×10^{8} m

(5)

$1.05\times10^{-9} = \frac{L}{4\pi(9.94\times10^{16})^2}$

$L = 1.3\times10^{26}\ \text{W}$

$1.3\times10^{26} = 5.67\times10^{-8} \times T^4 \times 4\pi(5.12\times10^{8})^2$

$T^4 = 6.92\times10^{14}$

$T = 5139.9\ \text{K}$

$\lambda_{max} \times T = k$

$A = 4\pi r^2$

$\lambda_{max} \times 5139.9 = 2.898\times10^{-3}$

$\lambda_{max} = 5.6\times10^{-7}\ \text{m}$

$= 5.64\times10^{-7}\ \text{m}$

$\lambda_{max} = 5.64\times10^{-7}\ \text{m}$

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Example 2

16 The star ε-Eridani is one of the closest stars to the Sun. The intensity of ε-Eridani, as measured on the Earth, is $1.05 \times 10^{-9}\ \text{W m}^{-2}$.

(a) Calculate the wavelength, λ_{max}, corresponding to the peak intensity of emission of radiation from ε-Eridani.

distance of ε-Eridani from the Earth = 9.94×10^{16} m
radius of ε-Eridani = 5.12×10^{8} m

(5)

$I = \frac{L}{4\pi d^2}$

$1.05 \times 10^{-9} = \frac{x}{4\pi (9.94 \times 10^{16})^2}$

$x = 1.05 \times 10^{-9} \times 4\pi (9.94 \times 10^{16})^2$

$= 1.3 \times 10^{26}$

$L = 6 A T^4$

$1.31 \times 10^{9} = (5.67 \times 10^{-8})(4\pi (5.12 \times 10^{8})^2) T^4$

$T^4 = \sqrt[4]{\frac{1.31 \times 10^{9}}{(5.67 \times 10^{-8})(4\pi (5.12 \times 10^{8})^2)}}$

$T = 5139.96\ \text{K}$

$T \times \lambda_{max} = 2.898 \times 10^{-3}$

$\lambda_{max} = 2.2 \times 10^{-29}$

$\lambda_{max} = 2.2 \times 10^{-29}$ m

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Example 3

16 The star ε-Eridani is one of the closest stars to the Sun. The intensity of ε-Eridani, as measured on the Earth, is $1.05 \times 10^{-9}\,\mathrm{W\,m^{-2}}$.

(a) Calculate the wavelength, λ_{max}, corresponding to the peak intensity of emission of radiation from ε-Eridani.

distance of ε-Eridani from the Earth = $9.94 \times 10^{16}\,\mathrm{m}$
radius of ε-Eridani = $5.12 \times 10^{8}\,\mathrm{m}$

(5)

$I = 1.05 \times 10^{-9}\ Wm^{-2}$ ~~$d = 9.94 \times 10^{16} + 5.12 \times 10^{8} = 9.94 \times 10^{16}$~~

$I = \frac{L}{4\pi d^2}$ $L = I \cdot 4\pi d^2 = 1.05 \times 10^{-9} \cdot 4\pi \cdot 9.94 \times 10^{16} + 5.12 \times 10^{8}$

$= 1.31 \times 10^{9}$

$L = \sigma A T^4$ $1.31 \times 10^{9} = 5.67 \times 10^{-8} \cdot \pi \cdot (5.12 \times 10^{8})^2 \cdot T^4$

$T = 0.41$

$\lambda T = 2.898 \times 10^{-3}$ $\lambda = 7.08 \times 10^{-3}$

$\lambda_{max} = 7.08 \times 10^{-3}$

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AO2b

These questions require students to evaluate information, sometimes do a calculation and *always write a conclusion*.

Feedback from the CE

The command words, **assess, deduce, evaluate** tend to be used, and all suggest the need for a conclusion.

A conclusion is a judgement backed up with reasoning, and we usually require a *comparison* of a calculated value with a value given in the question as the reasoning. Candidates often miss this out.

Another pointer is to encourage candidates to work towards obtaining a value for the quantity mentioned in the command sentence.

Some candidates adopt a haphazard approach of starting in a random place and calculating something that it's hard for them to use in a comparison

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WPH11, Q14(b) 2406 series

Activity 6, marking AO2b questions

(b) A spherical grain of sand has a weight of 4.3×10^{-5} N. The grain of sand displaces water with a weight of 1.5×10^{-5} N.

The terminal velocity of the grain of sand as it falls through the water is about $0.050\ \text{m s}^{-1}$.

Deduce whether Stokes' law applies to the grain of sand as it falls at terminal velocity.

viscosity of water = 1.2×10^{-3} Pa s
diameter of grain of sand = 1.5×10^{-3} m

(3)

14(b)	Use of weight = upthrust + drag	**(1)**	
	Use of viscous drag = $6\pi\eta rv$	**(1)**	
	$v = 1.7$ m s^{-1} **and** comparison with 0.050 m s^{-1} **and** consistent conclusion. (allow correctly calculated values for other quantities given in the question, with consistent conclusion)	**(1)**	**3**
	Example of calculation Drag $= 4.3 \times 10^{-5}\text{N} - 1.5 \times 10^{-5}\text{N} = 2.8 \times 10^{-5}\text{N}$ $v = \dfrac{2.8 \times 10^{-5}\ \text{N}}{6 \times \pi \times 1.2 \times 10^{-3}\ \text{Pa s} \times \left(\dfrac{1.5 \times 10^{-3}\ \text{m}}{2}\right)} = 1.65\ \text{m s}^{-1}$ 1.65 ≠ 0.05 so Stokes' law does not apply		

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Example 1

(b) A spherical grain of sand has a weight of 4.3×10^{-5} N. The grain of sand displaces water with a weight of 1.5×10^{-5} N.

The terminal velocity of the grain of sand as it falls through the water is about $0.050\,m\,s^{-1}$.

Deduce whether Stokes' law applies to the grain of sand as it falls at terminal velocity.

viscosity of water = 1.2×10^{-3} Pas
diameter of grain of sand = 1.5×10^{-3} m

(3)

Drag = ~~4.3~~ W − V = $4.3 \times 10^{-5} - 1.5 \times 10^{-5} = 2.8 \times 10^{-5}$ N

$F = 6\pi\eta rv$ $\quad v = \frac{F}{6\pi\eta r} = \frac{2.8 \times 10^{-5}}{6 \times \pi \times 1.2 \times 10^{-3} \times 0.75 \times 10^{-3}} = 1.65\,ms^{-1}$

$1.65\,ms^{-1} \pm 0.05\,ms^{-1}$

thus ~~Stokes'~~ Stokes' law ~~does~~ doesn't apply to the grain of sand as it falls at terminal velocity

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Example 2

(b) A spherical grain of sand has a weight of 4.3×10^{-5} N. The grain of sand displaces water with a weight of 1.5×10^{-5} N.

The terminal velocity of the grain of sand as it falls through the water is about $0.050\,m\,s^{-1}$.

Deduce whether Stokes' law applies to the grain of sand as it falls at terminal velocity.

viscosity of water = 1.2×10^{-3} Pas
diameter of grain of sand = 1.5×10^{-3} m

D + U = W

(3)

According to stoke's law,

$F = 6\pi\eta rv$

$= 6\pi\, 7.5\times10^{-4} \times 1.2\times10^{-3} \times 0.050$

$= 8.48\times10^{-7}$.

Drag $= W - U$

$= 4.3\times10^{-5} - 1.5\times10^{-5}$

$= 2.8\times10^{-5}$.

$\therefore 8.48\times10^{-7} \neq 2.8\times10^{-5}$.

$\therefore$ stoke's law is not applied

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Example 3

(b) A spherical grain of sand has a weight of 4.3×10^{-5} N. The grain of sand displaces water with a weight of 1.5×10^{-5} N.

The terminal velocity of the grain of sand as it falls through the water is about $0.050\,m\,s^{-1}$.

Deduce whether Stokes' law applies to the grain of sand as it falls at terminal velocity.

viscosity of water = 1.2×10^{-3} Pas
diameter of grain of sand = 1.5×10^{-3} m

(3)

$F = m_s g \times \frac{4}{3}\pi r^3 \times \rho_s g$

$8.48\times10^{-7} = 4.3\times10^{-5} \times 9.81 \times \frac{4}{3}\pi \times (7.5\times10^{-4})^3 \times \rho_s \times 9.81$

$8.48\times10^{-7} = 9.75\times10^{-9} \times \rho_s$

$\rho_s = \frac{8.48\times10^{-7}}{9.75\times10^{-9}}$

$= 86.9 \approx 87\ kg\,m^{-3}$

Yes it does.

$F = 6\pi r \eta v$

$= 6\pi \times 7.5\times10^{-4} \times 1.2\times10^{-3} \times 0.050$

$= 8.48\times10^{-7}$

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Trigonometry questions!

There is *always* a question which requires

SOH CAH TOA

Practice makes perfect…..use of whiteboards to check who is unsure

- Activity 7 marking AO2b trigonometry questions

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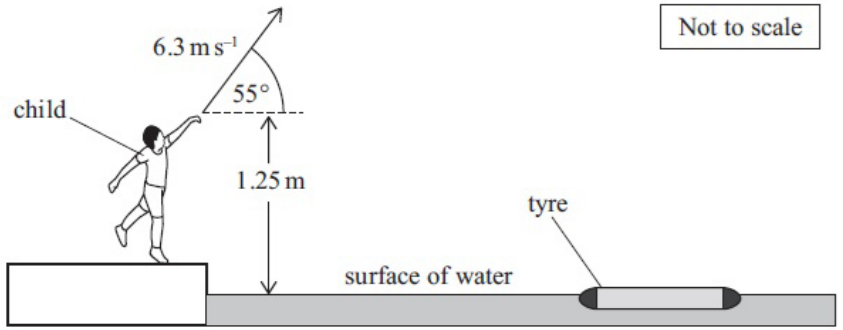
WPH11, Q17(a) - (b)

17 A child is playing a game. The child is trying to get stones to land inside an old tyre floating on the water.

The child throws a stone at a speed of $6.3\,m\,s^{-1}$ and at an angle of 55° to the horizontal.

The stone leaves the child's hand at a height of 1.25 m above the surface of the water, as shown.



(a) Show that the vertical component of the stone's initial velocity is about $5\,m\,s^{-1}$ and that the horizontal component is about $4\,m\,s^{-1}$.

(2)

(b) Show that the greatest height above the surface of the water reached by the stone is about 3 m.

(3)

Question Number	Answer		Mark
17(a)	Use of trigonometry to show $u_v = 5.2$ (m s^{-1})	(1)	
	Use of trigonometry to show $u_h = 3.6$ (m s^{-1})	(1)	2
	Example of calculation $u_v = 6.3\text{ m s}^{-1} \times \sin 55° = 5.16\text{ m s}^{-1}$ $u_h = 6.3\text{ m s}^{-1} \times \cos 55° = 3.61\text{ m s}^{-1}$		
17(b)	Use of $v^2 = u^2 + 2as$ with $a = -g$ and $u = u_v$	(1)	
	Adds 1.25 m to height gained	(1)	
	Greatest height = 2.6 (m) (allow ecf from 17(a))	(1)	3
	Example of calculation $0 = (5.16\text{ m s}^{-1})^2 - 2 \times 9.81\text{ m s}^{-2} \times s$ $s = \frac{26.6\text{ m}^2\text{ s}^{-2}}{19.6\text{ m s}^{-2}} = 1.36\text{ m}$ $1.36 + 1.25 = 2.61$ m		

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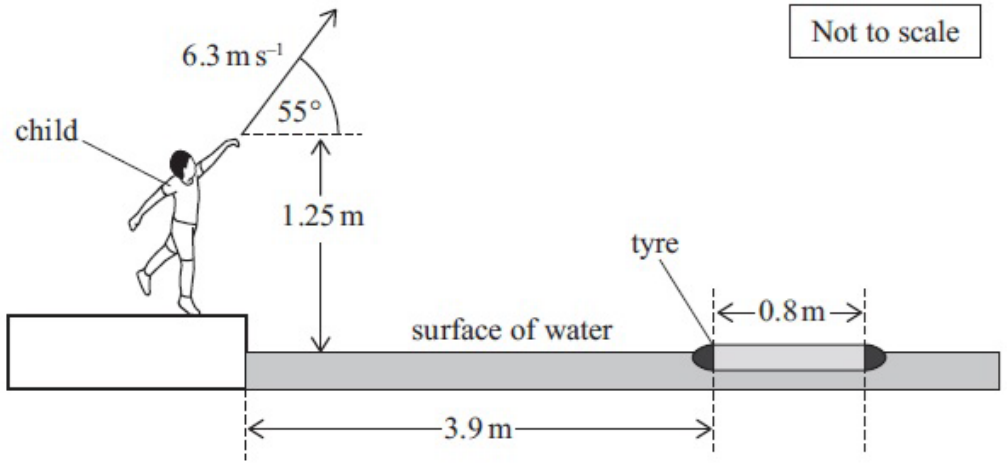
WPH11, Q17(c)

(c) The inside of the tyre is 0.8 m in diameter and is 3.9 m from the side of the water, as shown.



Deduce whether the stone thrown by the child lands inside the tyre.

(4)

17(c)	**EITHER**		
	Uses valid suvat equation(s) to determine time taken for stone to land in water	(1)	
	Uses valid suvat equation(s) to determine horizontal distance travelled by stone	(1)	
	Horizontal distance travelled before landing = 4.5m (ecf from 17(a) and/or 17(b))	(1)	
	Comparison of horizontal distance travelled with 3.9 (m) and 4.7 (m) **and** consistent conclusion	(1)	
	OR		
	Uses valid suvat equation(s) to determine time taken for stone to reach front or back of ring	(1)	
	Uses valid suvat equation(s) to determine height of stone above front or back of ring	(1)	
	Height at front of ring = 1.10m **and** height at back of ring = -0.33 m (ecf from 17(a) and/or 17(b))	(1)	
	Comparison of height at front of ring and height at back of ring with 0 **and** consistent conclusion	(1)	**4**
	<u>Example of calculation</u> Vertically $v^2 = (5.16\ \text{m s}^{-1})^2 + 2 \times (-9.81\ \text{m s}^{-2}) \times (-1.25\ \text{m})$ $v = -7.15\ \text{m s}^{-1}$ $-7.15\ \text{m s}^{-1} = 5.16 - 9.81\ \text{m s}^{-2} \times t$ $t = 1.25\ s$ Horizontally $s = 3.61\ \text{m s}^{-1} \times 1.25\ \text{s} = 4.51\ \text{m}$ $3.9\ \text{m} < 4.5\ \text{m} < 4.7\ \text{m}$, so the stone will land in the tyre		
	Total for question 17		**9**

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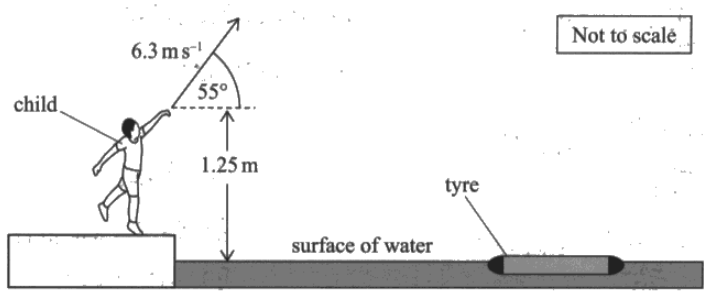
Example 1

7 A child is playing a game. The child is trying to get stones to land inside an old tyre floating on the water.

The child throws a stone at a speed of $6.3\,m\,s^{-1}$ and at an angle of 55° to the horizontal.

The stone leaves the child's hand at a height of 1.25 m above the surface of the water, as shown.



(a) Show that the vertical component of the stone's initial velocity is about $5\,m\,s^{-1}$ and that the horizontal component is about $4\,m\,s^{-1}$.

(2)

$V_x = 6.3 \times \cos 55 = 3.6\ m\,s^{-1}$

$V_y = 6.3 \times \sin 55 = 5.16\ m\,s^{-1}$

(b) Show that the greatest height above the surface of the water reached by the stone is about 3 m.

(3)

$V = 0 \quad u = 5.16 \quad a = -g = -9.81 \quad s = ?$

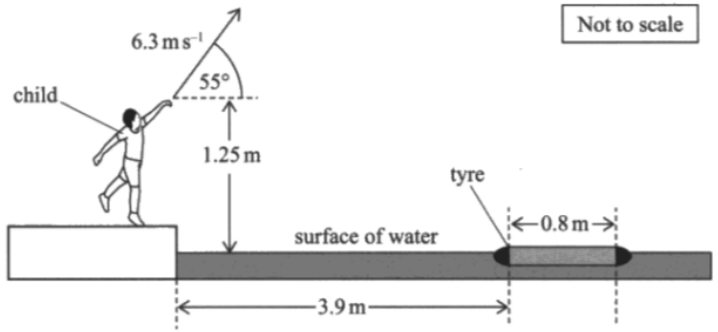
$V^2 - u^2 = 2as$

$0^2 - 5.16^2 = 2 \times (-9.81)s$

$s = 1.357\ m$

$1.357 + 1.25 = 2.607\ m$

(c) The inside of the tyre is 0.8 m in diameter and is 3.9 m from the side of the water, as shown.



Deduce whether the stone thrown by the child lands inside the tyre.

(4)

$u = 5.16 \quad a = -9.81 \quad s = 1.357 \quad t = ?$

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

$5.16t - 4.905t^2 = 1.357$

$t = 0.529\ s$

$0.529 \times 2 \times 3.6 = 3.808\ m$

$3.9 > 2.808$

The child not inside the tyre.

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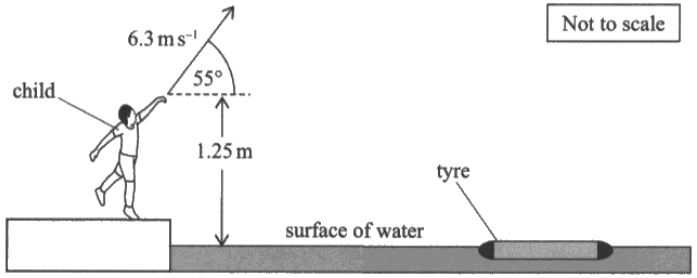
Example 2

17 A child is playing a game. The child is trying to get stones to land inside an old tyre floating on the water.

The child throws a stone at a speed of $6.3\,m\,s^{-1}$ and at an angle of 55° to the horizontal.

The stone leaves the child's hand at a height of 1.25 m above the surface of the water, as shown.



(a) Show that the vertical component of the stone's initial velocity is about $5\,m\,s^{-1}$ and that the horizontal component is about $4\,m\,s^{-1}$.

(2)

$V \rightarrow 6.3 \times \sin 55 = 5.16\,ms^{-1}$

$H \rightarrow 6.3 \times \cos 55 = 3.61\,ms^{-1}$

(b) Show that the greatest height above the surface of the water reached by the stone is about 3 m.

(3)

$s = ?$ $\quad v^2 = u^2 + 2as$

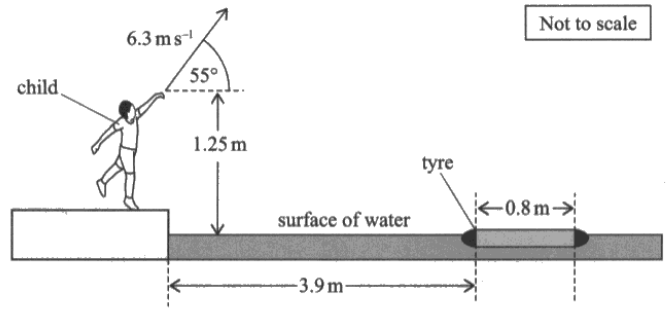
$u = 5.16$ $\quad u^2 = 2as$

$v = 0$ $\quad 5.16^2 = 2 \times 9.81 \times s$

$a = -9.81$ $\quad s = 1.36\,m$

$1.36 + 1.25 = 2.61\,m$

(c) The inside of the tyre is 0.8 m in diameter and is 3.9 m from the side of the water, as shown.



Deduce whether the stone thrown by the child lands inside the tyre.

(4)

$s = -1.25$ $\quad s = ut + \frac{1}{2}at^2$

$u = 6.3 \times \sin 55$ $\quad -1.25 = 5.16t - \frac{9.81}{2}t^2$

$v =$ $\quad t = 1.255$ or -0.203

$a = -9.81$

$t = ?$

$s = ?$ $\quad s = ut + \frac{1}{2}at^2$ $\quad a = 0$

$u = 6.3 \times \cos 55$ $\quad s = ut$

$v =$ $\quad s = 3.61 \times 1.255 = 4.53$

$a = 0$ $\quad 4.53 - 3.9 = 0.63\,m$

$t = 1.255$ $\quad 0.63\,m < 0.8\,m$

So, yes it will land inside

(Total for Question 17 = 9 marks)

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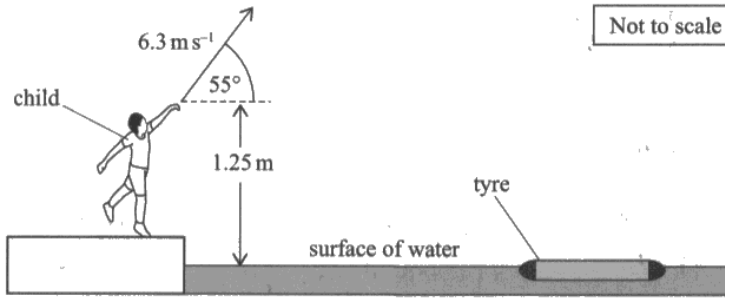
Example 3

17 A child is playing a game. The child is trying to get stones to land inside an old tyre floating on the water.

The child throws a stone at a speed of $6.3\,m\,s^{-1}$ and at an angle of 55° to the horizonta

The stone leaves the child's hand at a height of 1.25 m above the surface of the water, as shown.



(a) Show that the vertical component of the stone's initial velocity is about $5\,m\,s^{-1}$ and that the horizontal component is about $4\,m\,s^{-1}$.

Vertical component: $6.3\sin 55 = 5.2\,ms^{-1}$

Horizontal component: $6.3\cos 55 = 3.6\,ms^{-1}$

(b) Show that the greatest height above the surface of the water reached by the stone is about 3 m.

$v = 0$

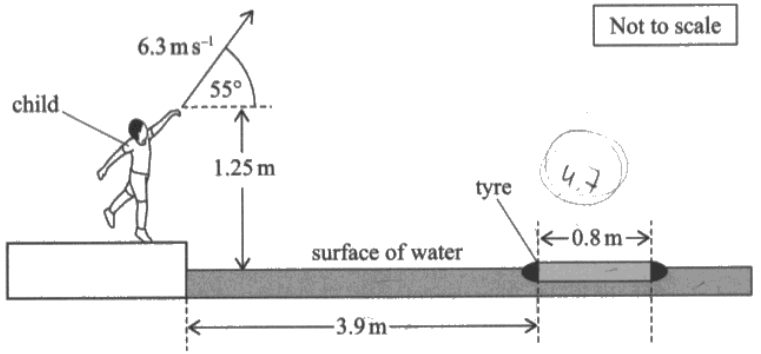
$v^2 = u^2 + 2as$

$0^2 = (5.2)^2 + 2(-9.81)s$

$s = \frac{-(5.2)^2}{2(-9.81)} = 1.4\,m$ (AG)

greatest height $= 1.4 + 1.25 = 2.7\,m$ (4)

(c) The inside of the tyre is 0.8 m in diameter and is 3.9 m from the side of the water, as shown.



Deduce whether the stone thrown by the child lands inside the tyre. (4)

Vertically

$s = -2.7 = 5.2t - 4.9t^2$

$4.9t^2 - 5.2t - 2.7$

$t = 1.44_5$

Horizontally

$s = \frac{D}{t}$

$D = s \times t = 3.6 \times 1.44$

$= 5.2\,m$

0.225

∴ the stone does not land inside the tyre since total of horizontal distance is 4.7 m which is less than 5.2 m

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Points to consider for our students

- ✓ Don't give up.....even if you get the calculation wrong, you can get the last mark for making a consistent comparison
- ✓ Make it legible.....if we can't read it, we can't mark it.....including making it tiny.....don't assume we understand your abbreviations such as pt, ht, ↑
- ✓ Use consistent equals ....the quantities on each side must be the same
- ✓ Say what you are doing in a calculation, e. finding 'r'
- ✓ Learn to use your calculator!.....e.g. can you take $\sqrt[4]{}$ when doing Stephan-Boltzmann calculations?
- ✓ Write down intermediate steps.....don't just carry all the stages on your calculator
- ✓ Work to 1or 2 more DP than in the question
- ✓ UNITS!!!!!
- ✓ Read the question carefully

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AO3

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AO3 assessment of practical skills

WPH13

Students are expected to develop experimental skills, and a knowledge and understanding of experimental techniques, by carrying out a range of practical experiments and investigations while they study Units 1 and 2.

This unit will assess students' knowledge and understanding of experimental procedures and techniques that were developed in Units 1 and 2.

WPH16

Students are expected to further develop the experimental skills and the knowledge and understanding of experimental techniques that they acquired in Units 1 and 2 by carrying out a range of practical experiments and investigations while they study Units 4 and 5.

This unit will assess students' knowledge and understanding of the experimental procedures and techniques that were developed in Units 4 and 5.

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WPH13, Q3b with MS

3(b)	Calculates time t = number of divisions × time per division	**(1)**	
	Use of $v = \frac{s}{t}$	**(1)**	
	Uses $2 \times s$ **Or** Uses $\frac{1}{2} \times t$	**(1)**	
	$v = 331$ (m s^{-1})	**(1)**	**4**
	Example of calculation $t = 6$ divisions × 0.5 ms per division = 3 ms $v = \frac{s}{t} = \frac{2 \times 0.497\ \text{m}}{3 \times 10^{-3}\ \text{s}} = 331.3\ \text{m s}^{-1}$		

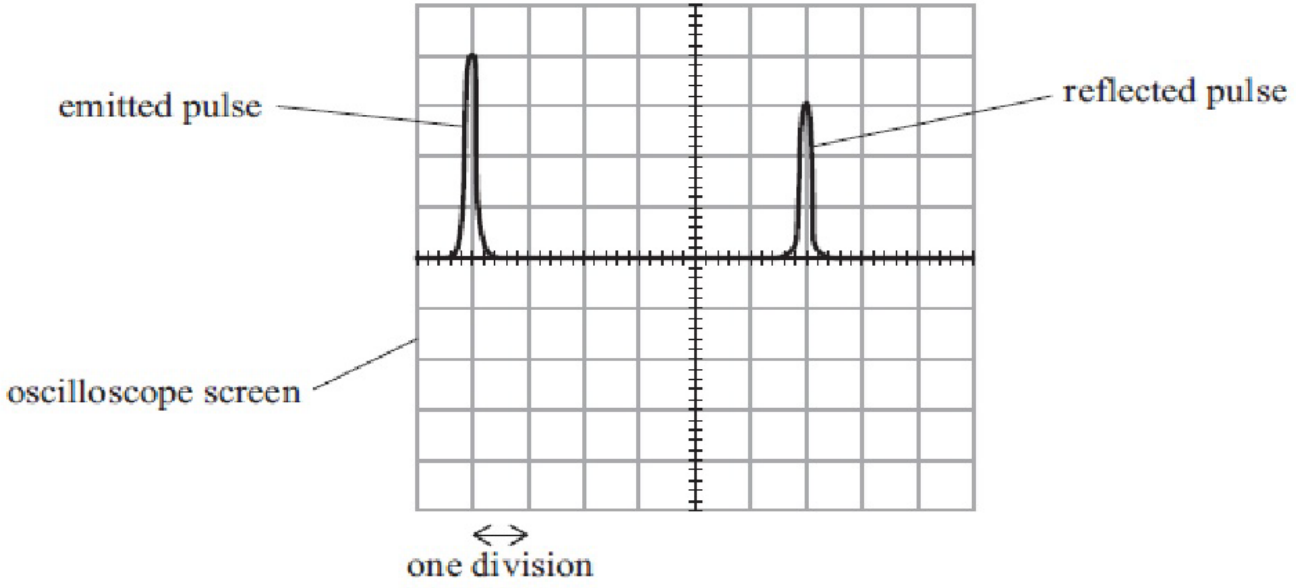
3 A student determined the speed of ultrasound in air using an ultrasound transducer.

(b) The ultrasonic transducer emitted pulses of ultrasound.

The emitted pulses were reflected at the water surface and then detected when they returned to the ultrasonic transducer.

The student connected an oscilloscope to the transducer, to determine the time between an emitted pulse and the reflected pulse.

The oscilloscope screen is shown below.



The horizontal axis represents time.

The time scale was set to 0.5 ms per division.

Show that, for this example, the speed v of ultrasound in air was about 330 m s^{-1}.

length of air column s = 49.7 cm

Activity 8, marking AO3 questions

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WPH13, Q3b – example 1

Show that, for this example, the speed v of ultrasound in air was about $330\,m\,s^{-1}$.

length of air column $s = 49.7\,cm$

(4)

$v = \frac{s}{t}$

$v = \frac{2 \times (49.7 \times 10^{-2})}{0.5 \times 6 \times 10^{-3}} = 331.3\ m/s \approx 330\ m/s$

time $= 6 \times (0.5 \times 10^{-3})$

distance $= 2 \times s$ (in order to travel and be reflected back)

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WPH13, Q3b – example 2

Show that, for this example, the speed v of ultrasound in air was about $330\,m\,s^{-1}$.

length of air column $s = 49.7\,cm$

(4)

~~0.5ms x 10 = 5ms~~ $\frac{49.7cm}{100} = 0.497m$ $\frac{0.5ms}{1000} = 5\times10^{-4}s$

$5\times10^{-4}s \times 10 = 5\times10^{-3}s$ $2s = 0.994m$ $\therefore \frac{0.994}{2.5\times10^{-3}} = 397.6ms^{-1}$

$5\times10^{-3} \times \frac{1}{2}$ since time should be halved since wave is reflected.

length is doubled since the wave is reflected.

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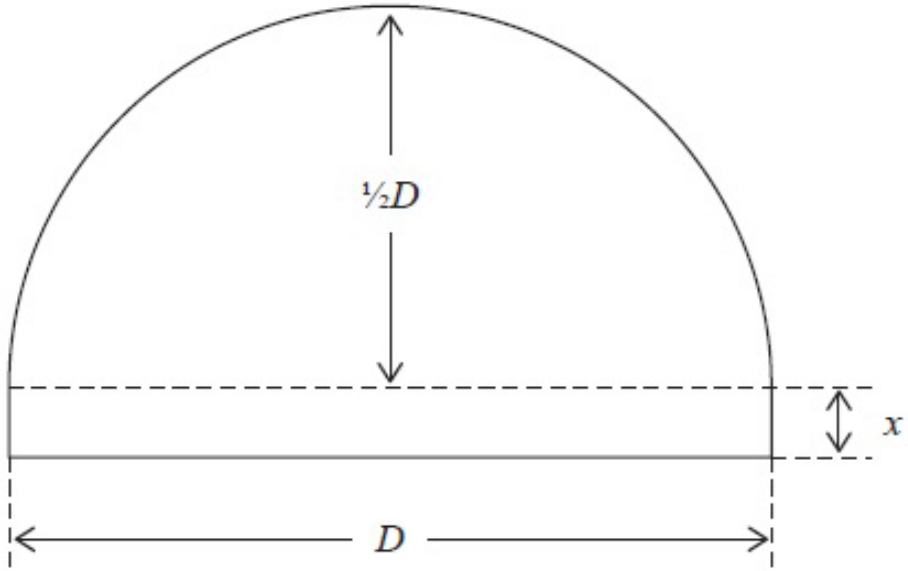
WPH16, Q4b

(b) The student determined the volume V of the plastic protractor from the measurements shown.



The student recorded the following measurements.

$D = 10.10\,\text{cm} \pm 0.05\,\text{cm}$
$x = 4.5\,\text{mm} \pm 0.1\,\text{mm}$
$t = 1.40\,\text{mm} \pm 0.02\,\text{mm}$

(i) Show that V is about $6.2\,\text{cm}^3$.

(2)

(ii) Show that the uncertainty in V is about $0.2\,\text{cm}^3$.

(4)

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WPH16, Q4b MS

4(b)(i)	Uses V = (area of semicircle + area of rectangle) × thickness	**(1)**	
	$V = 6.24$ (cm^3)	**(1)**	**2**
	Example of calculation		
	Volume of semicircle = $\frac{\pi D^2 t}{8} = \frac{\pi \times (10.1\text{cm})^2 \times 0.14\text{ cm}}{8} = 5.608$ cm^3		
	Volume of rectangle = 10.1 cm × 0.45 cm × 0.14 cm = 0.636 cm^3		
	$V = 5.608$ cm^3 + 0.636 cm^3 = 6.24 cm^3		
4(b)(ii)	**EITHER**		
	Doubles %U in D Accept doubles $\frac{\Delta D}{D}$	**(1)**	
	Correct calculation of %U in $\frac{\pi D^2 t}{8}$ **Or** Correct calculation of %U in Dxt	**(1)**	
	Calculation of U in $\frac{\pi D^2 t}{8}$ **and** U in Dxt	**(1)**	
	U = 0.16 (cm^3)	**(1)**	
	Example of calculation		
	%U in D = 0.5%		
	%U in x = 2.2%		
	%U in t = = 1.4%		
	%U in $\frac{\pi D^2 t}{8}$ = (2 × 0.5%) + 1.4 % = 2.4 %		
	%U in Dxt = 0.5 % + 2.2 % + 1.4 % = 4.1 %		
	U in V = (5.61 cm^3 × 2.4 %) + (0.64 cm^3 × 4.1%) = 0.135 cm^3 + 0.026 cm^3		
	= 0.16 (cm^3)		
	OR		
	Uses maximum values to calculate maximum V **Or** Uses minimum values to calculate minimum V	**(1)**	
	Maximum $V = 6.40$ (cm^3) **Or** minimum $V = 6.08$ (cm^3)	**(1)**	
	Correct calculation of half range	**(1)**	**4**
	U = 0.16 (cm^3)		
	Example of calculation		
	Maximum $V = \frac{\pi \times (10.15\text{cm})^2 \times 0.142\text{cm}}{8} + 10.15\text{cm} \times 0.46\text{cm} \times 0.142\text{cm}$		
	= 5.74 cm^3 + 0.66 cm^3 = 6.40 (cm^3)		
	Minimum $V = \frac{\pi \times (10.05\text{cm})^2 \times 0.138\text{cm}}{8} + 10.05\text{cm} \times 0.44\text{cm} \times 0.138\text{cm}$		
	= 5.47 cm^3 + 0.61 cm^3 = 6.08 (cm^3)		
	U in $V = \frac{(6.40 - 6.08)\text{cm}^3}{2} = 0.16$ (cm^3)		

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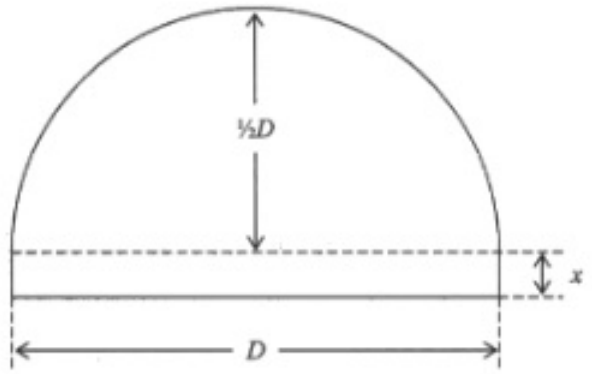
WPH16, Q4b – example 1

(b) The student determined the volume V of the plastic protractor from the measurements shown.



The student recorded the following measurements.

$D = 10.10\,\text{cm} \pm 0.05\,\text{cm}$
$x = 4.5\,\text{mm} \pm 0.1\,\text{mm}$
$t = 1.40\,\text{mm} \pm 0.02\,\text{mm}$

(i) Show that V is about $6.2\,\text{cm}^3$.

(2)

$4.5 \div 10 = 0.45\text{cm}$ $1.4 \div 10 = 0.14\text{cm}$ $10.10 \div 2 = 5.05\text{cm}$

$V = 0.5 \times \pi \times (5.05)^2 \times 0.14 + 0.45 \times 10.10 \times 0.14 = \boxed{6.24\text{cm}^3}$

(ii) Show that the uncertainty in V is about $0.2\,\text{cm}^3$.

(4)

$V = \frac{1}{8} \times D^2 t + Dxt$

$\frac{0.05}{10.10} \times 100 = 0.495\%$ $\frac{0.02}{1.4} \times 100 = 1.4\%$

$2 \times 0.495 + 1.4 = 2.42\%$ ~~$0.242 \times 0.25 \times x \times 10.10^2 =$~~

~~$0.0242 \times 0.5 \times x \times (5.05)^2 \times 0.14 = 0.135$~~

$0.0242 \times \frac{1}{8} \times \pi \times (10.10)^2 \times 0.14 = 0.136$ $\frac{0.1}{4.5} \times 100 = 2.22\%$

$2.22 + 1.4 + 0.495 = 4.15\%$. $0.0415 \times 0.45 \times 10.10 \times 0.14 = 0.02638$

$0.02638 + 0.136 = \boxed{0.16\text{cm}^3}$

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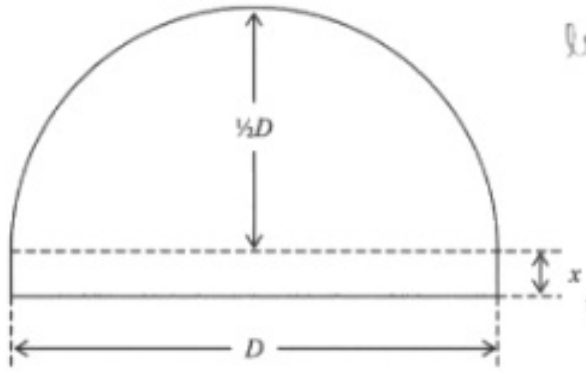
WPH16, Q4b – example 2

(b) The student determined the volume V of the plastic protractor from the measurements shown.



The student recorded the following measurements.

$D = 10.10\,\text{cm} \pm 0.05\,\text{cm}$
$x = 4.5\,\text{mm} \pm 0.1\,\text{mm}$
$t = 1.40\,\text{mm} \pm 0.02\,\text{mm}$

(i) Show that V is about $6.2\,\text{cm}^3$.

(2)

$A = \pi r^2 = \pi \times (5.05)^2 \times 0.5 = 40.06\text{cm}^2$ } 44.605 cm^2
$A = Dx = 10.1\text{cm} \times 0.45\text{cm} = 4.545\text{cm}^2$ }
$V = 44.605\text{cm}^2 \times 0.14\text{cm} = 6.2447 = 6.2\text{cm}^3$

lower limit = $6.09\,\text{cm}^3$
$A = 44.122\text{cm}^2$
$\pi r^2 = 39.7\text{cm}^2$
$Dx = 4.422\text{cm}^2$
0.158
10.05
0.44

(ii) Show that the uncertainty in V is about $0.2\,\text{cm}^3$.

(4)

upper limit = D: 10.15cm t: 0.142cm
x: 0.46cm
$\frac{1}{2}\pi r^2 = 40.5$ $Dx = 4.669$ $A = 45.169\text{cm}^2$
$45.169\,\text{cm}^2 \times 0.46\text{cm} = 6.414\text{cm}^3$
lower limit = D: 10.05cm t: 0.138cm
x: 0.44cm
uncertainity = 0.16cm³
$\frac{1}{2}\pi r^2 = 39.7\text{cm}^2$ $Dx = 4.422\text{cm}^2$ $A = 44.122\text{cm}^2$
$44.122\text{cm}^2 \times 0.138\text{cm} = 6.09\,\text{cm}^3$ $\frac{6.414 - 6.09}{2} = 0.16\text{cm}^3$

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Common mistakes (and how to avoid them)

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Common mistakes

1. When answering an AO2b question candidates sometimes forget to make a conclusion.
2. Some candidates do not pay sufficient attention to the command words used in the question.
3. Some candidates miss out on a final answer mark in a question because they omit units.
4. Some responses just repeat previous mark scheme answers.
5. The conclusion must include a comparison of the calculated answer and a value given in the question.
6. Candidates should learn the difference between ’describe’ and 'explain’ so the correct level of detail is included.
7. Units are required for all calculated final answers (including AO3 questions) unless it is a ‘show that’ question.
8. A ‘standard’ answer (as seen in a previous MS) is only fine if it is iven in response to a standard question.

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Common mistakes

9. Some responses to unstructured calculations are poorly set out.
10. If candidates set their work out haphazardly, they may miss out on full marks for their response as it may not be clear what method they have used.
11. Definition and derivation questions are often poorly answered.
12. Linkage questions tend to miss out on essential detail required for indicative content credit to be given.
13. Candidates should set out their work so that the logic of the solution can be seen. It may help to divide the answer space into two columns so that candidates do not run out of space.
14. Candidates should be encouraged to learn standard definitions and derivations.
15. Candidates should be encouraged to plan the key points that they want to make before they start to write in the answer space.

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Support and resources

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Free Resources and support	Planning, teaching and learning	Exam preparation and assessment	Results support
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Training Events (Face-to-Face & Online)	✓		
Subject Advisor Support	✓	✓	✓
Community Forums	✓	✓	✓
Schemes of Work	✓		
Skills Mapping	✓		
Sample Assessment Materials	✓	✓	
Examiner Reports	✓	✓	✓
Exemplar Marked Responses		✓	
Past Papers		✓	
examWizard		✓	
Mark Schemes		✓	
ResultsPlus Mock Exam Analysis		✓	
Results Plus		✓	✓
Access to Scripts Service (ATS)			✓

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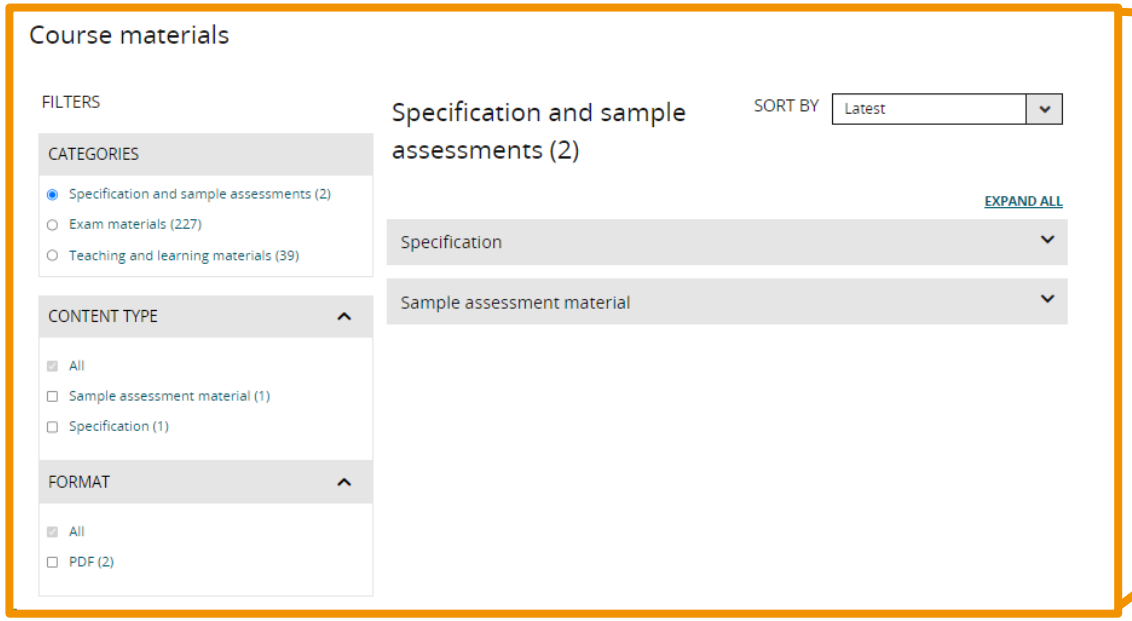
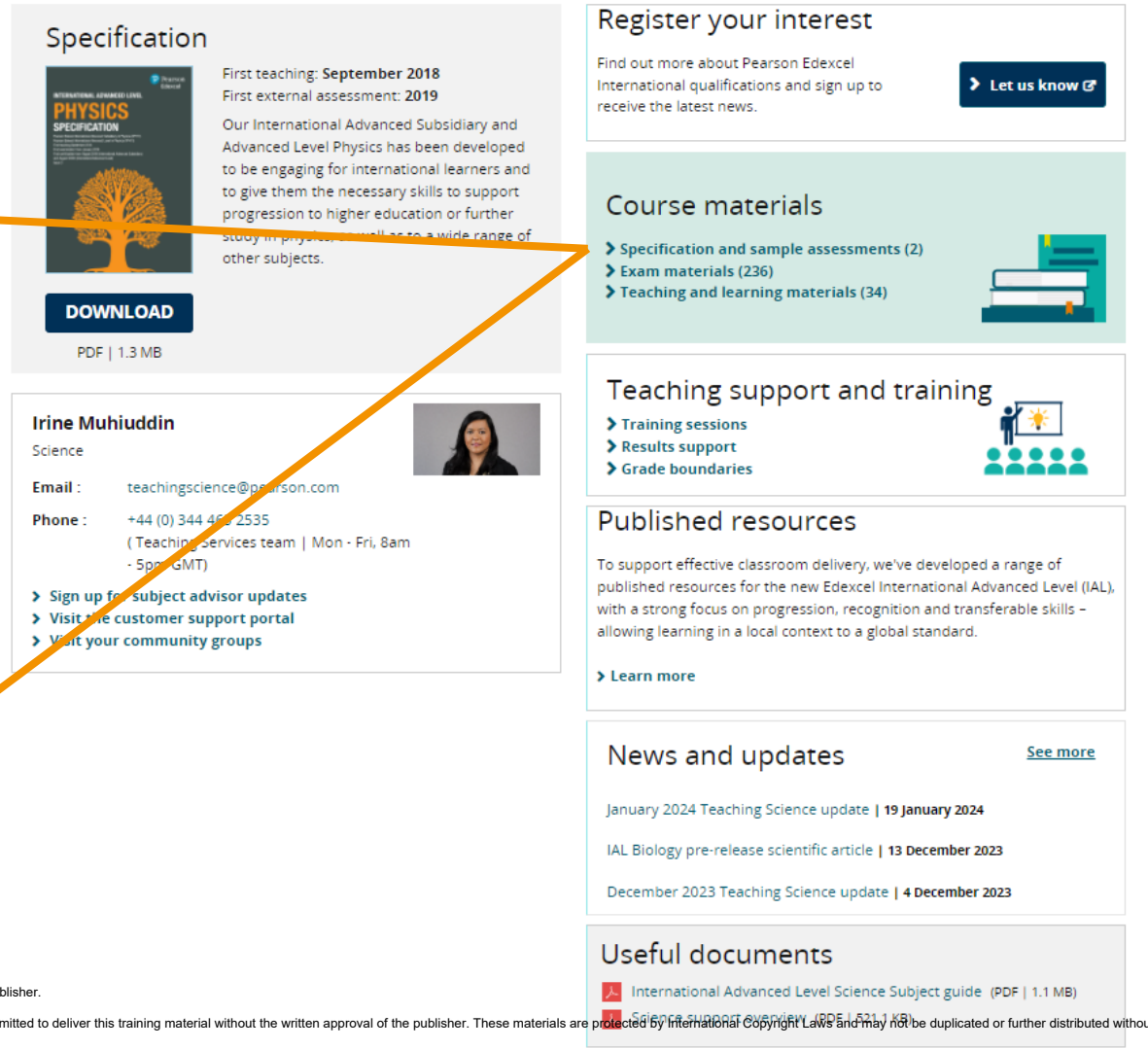
Teaching and Learning Materials online





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ResultsPlus

1. Student takes exam on paper

2. Exam papers scanned

3. Examiners mark papers online

4. Performance reports shared

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Provides enhanced transparency and

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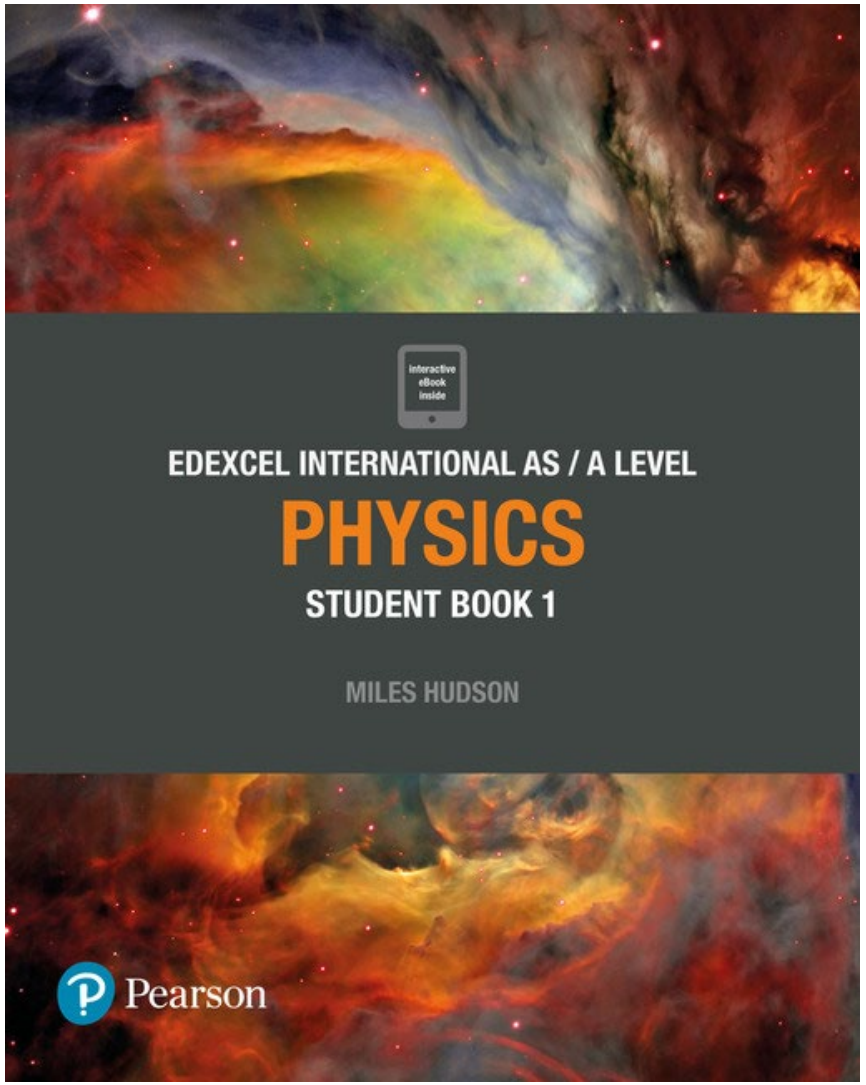
Resources

Developed for the latest International A Level Science specifications, these resources are specifically designed for international students, with a strong focus on progression, recognition and transferable skills, allowing learning in a local context to a global standard.

Student Book



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