GCSE

WJEC GCSE
The Sciences (Double Award)

Approved by Qualifications Wales

Sample Assessment Materials

Unit 3: Physics - Forces, Motion and the Universe
Higher Tier

Teaching from 2026
For award from 2028

This Qualifications Wales regulated qualification is not available to centres in England.

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Ready for the world.

WJEC would like to thank the students and teachers of Fitzalan High School, Cardiff and Llanwern High School, Newport for their participation in the creation of these covers.

Contents

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Surname	Centre number	Candidate number
First name(s)		0

GCSE

3455UC

The Sciences (Double Award) – Unit 3 Physics: Forces, Motion and the Universe

HIGHER TIER
1 hour 15 minutes
SAMPLE ASSESSMENT MATERIALS

Additional materials

A calculator and ruler are permitted.

Instructions to candidates

Use black ink or black ball-point pen. Do **not** use gel pen or correction fluid.

You may use a pencil for graphs and diagrams only.

Write your name, centre number and candidate number in the spaces provided at the top of this page.

Answer **all** questions.

For examiner's use only		
Question	**Maximum mark**	**Mark awarded**
1.	**14**	
2.	**11**	
3.	**10**	
4.	**11**	
5.	**10**	
Total	**56**	

Write your answers in the spaces in this booklet. If you need more space, use the additional page(s) at the back of this booklet. Number the question(s) correctly.

Information for candidates

The number of marks is given in brackets at the end of each question or part-question.

The total number of marks available is **56.**

You should think carefully about how you use your time.

Your responses must be clear, accurate and well presented.

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Equations

Speed = $\frac{\text{distance}}{\text{time}}$	
acceleration [or deceleration] = $\frac{\text{change in speed}}{\text{time}}$	
weight = mass × gravitational field strength	W = mg
efficiency = $\frac{\text{useful energy transferred}}{\text{input energy}}$ x 100 OR efficiency = $\frac{\text{useful power output}}{\text{input power}}$ x 100	
power = $\frac{\text{energy transfer}}{\text{time}}$	$P = \frac{E}{T}$
units used (kWh) = power (kW) × time (hours) cost = units used × cost per unit	
frequency = $\frac{1}{\text{period}}$	$f = \frac{1}{T}$
wave speed = frequency × wavelength	$v = f\lambda$
force = mass × acceleration	F = ma

SI multipliers

Prefix	Symbol	Conversion factor	Multiplier
pico	p	divide by 1 000 000 000 000	1×10^{-12}
nano	n	divide by 1 000 000 000	1×10^{-9}
micro	μ	divide by 1 000 000	1×10^{-6}
milli	m	divide by 1000	1×10^{-3}
centi	c	divide by 100	1×10^{-2}

kilo	k	multiply by 1000	1×10^{3}
mega	M	multiply by 1 000 000	1×10^{6}
giga	G	multiply by 1 000 000 000	1×10^{9}
tera	T	multiply by 1 000 000 000 000	1×10^{12}

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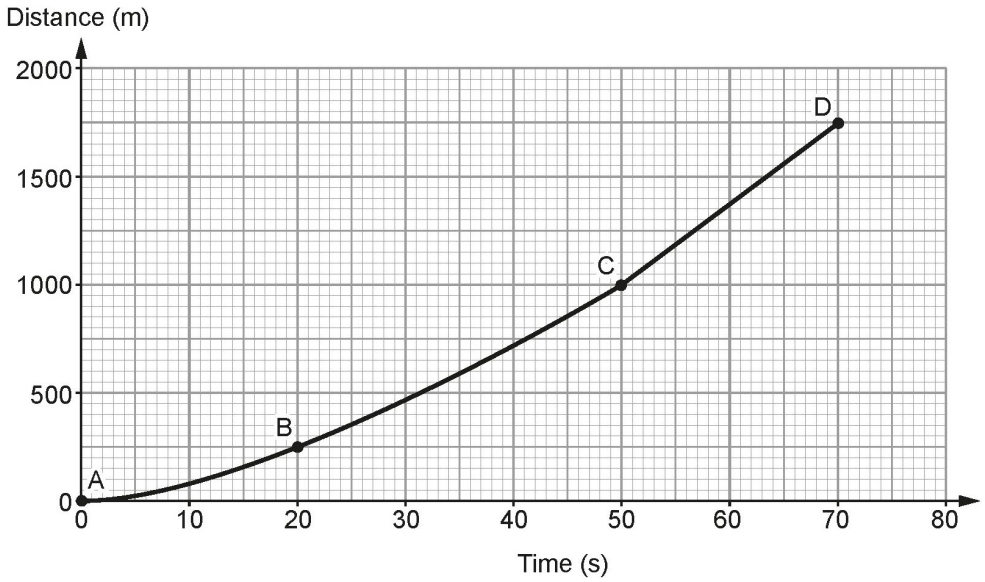
Answer **all** questions

Examiner only

1. In January 2024 Welsh duo Adele Nicoll and Kya Placide won gold in the women's bobsleigh at the Europe Cup in Switzerland.

The graph below shows their journey from the start at A to the finish line, D.



(a) Use information from the graph to calculate the distance from B to C. [2]

distance = ... m

(b) A spectator stated that the bobsleigh had the highest speed between B and C.

Use information from the graph to explain whether you agree. [2]

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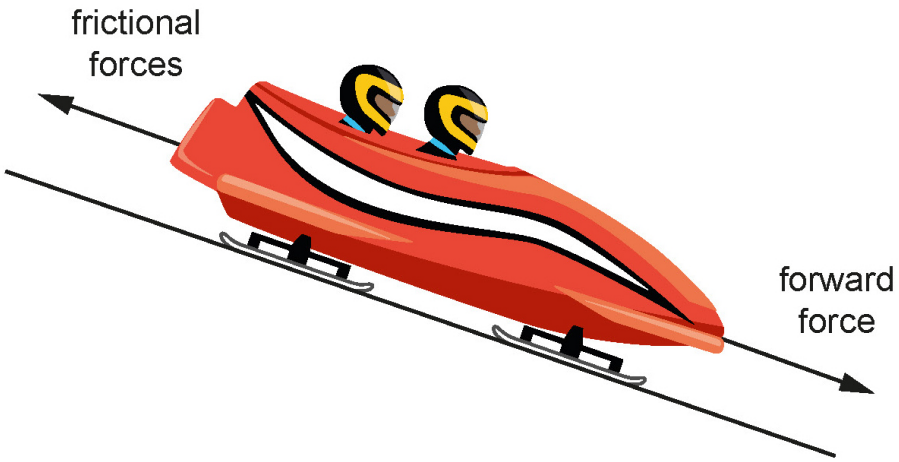
(c) They achieved a maximum terminal speed of 38 m/s.



(i) Explain, in terms of forces, why the bobsleigh reaches its terminal speed. [2]

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.....

To reach their highest speed the crew crouch as low as possible in the bobsleigh with only the driver sitting upright to see the track.

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(ii) Explain how crouching down as low as possible improves the maximum terminal speed the bobsleigh can achieve. [2]

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……

(d) At the start of the course, they accelerated from rest to 13 m/s in 5.6 s.

(i) Use the equation:

$$\text{acceleration} = \frac{\text{change in speed}}{\text{time}}$$

to calculate their mean acceleration at the start. [2]

acceleration = ……. m/s^2

(ii) The mass of the bobsleigh and crew is 330 kg.
Use an equation from page 2 to calculate the resultant force at the start. [2]

resultant force = ……. N

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(e) The maximum allowed mass for the bobsleigh is 330 kg.

Delyth states that having more mass means that the bobsleigh will accelerate faster during the push start.

Explain whether she is correct. [2]

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14

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2. Scientists at a university use ultrasound waves to study fish populations.

(a) One of the scientists suggests that both ultraviolet and ultrasound waves are transverse waves because the vibrations are in the same direction in both.

Explain whether you agree. [3]

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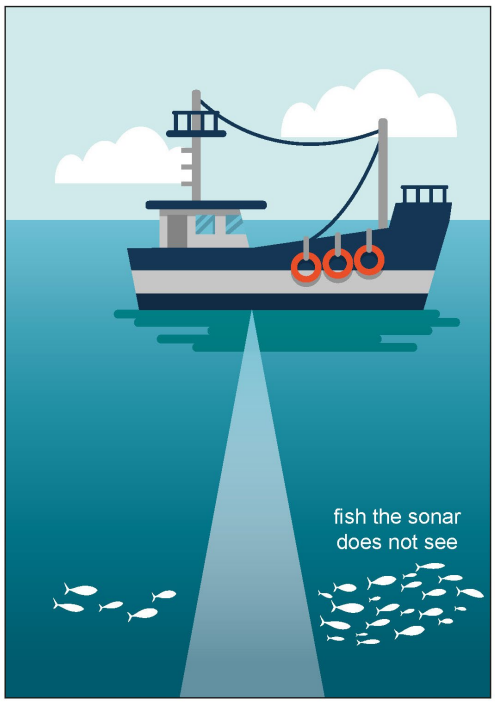
(b) The ultrasound waves travel at 1.5 km/s in water.



The ultrasound is sent out from the boat.
The echo is received back at the boat 0.15 seconds later.

Use an equation from page 2 to calculate the depth of the fish below the surface.

Give your answer in metres. [4]

depth = ... m

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(c) The ultrasound waves are used to detect the fish have frequency 200 kHz (200 000 Hz).

(i) State the meaning of the term frequency. [1]

……...

……...

(ii) Information about the speed and wavelength of ultrasound waves travelling in different mediums is given in the table below.

Medium	Wavelength (mm)	Wave speed (m/s)	Frequency (Hz)
water	7.5	1500	2.0×10^5
air	1.5	300	2.0×10^5
metal	30	6000	2.0×10^5

Tick (✓) the boxes for the three correct conclusions that you can make about this data. [3]

The frequency increases as the wavelength decreases. ☐

When the wave speed increases by a factor of 5, the wavelength is 5 × smaller ☐

Wavelength is inversely proportional to wave speed ☐

Wavelength is smallest in air ☐

Wavelength is proportional to wave speed ☐

When the wave speed increases by a factor of 20, the wavelength is 20 × bigger ☐

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3. (a) (i) Spica is a high mass star.
It is currently on the main sequence.
Explain, in terms of named forces, why Spica is stable. [2]

……...

……...

……...

……...

(ii) Explain, in terms of forces and fusion, the next observable stage in Spica's life cycle. [4]

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(b) The table below gives some information about different stars.

Star	Mass of star (compared to the Sun)	Temperature of star (°C)
Sun	1.0	6 040
A	0.8	4 970
B	11.4	25 600
C	1.1	6 180

Explain which star A, B or C is most likely to be Spica. [2]

……..……..

……..……..

……..……..

……..……..

(c) Astronomers study stars like Spica using space-based telescopes.

State one advantage and one disadvantage of using a space-based telescope compared to a ground-based telescope. [2]

Advantage

……..……..

……..……..

Disadvantage

……..……..

……..……..

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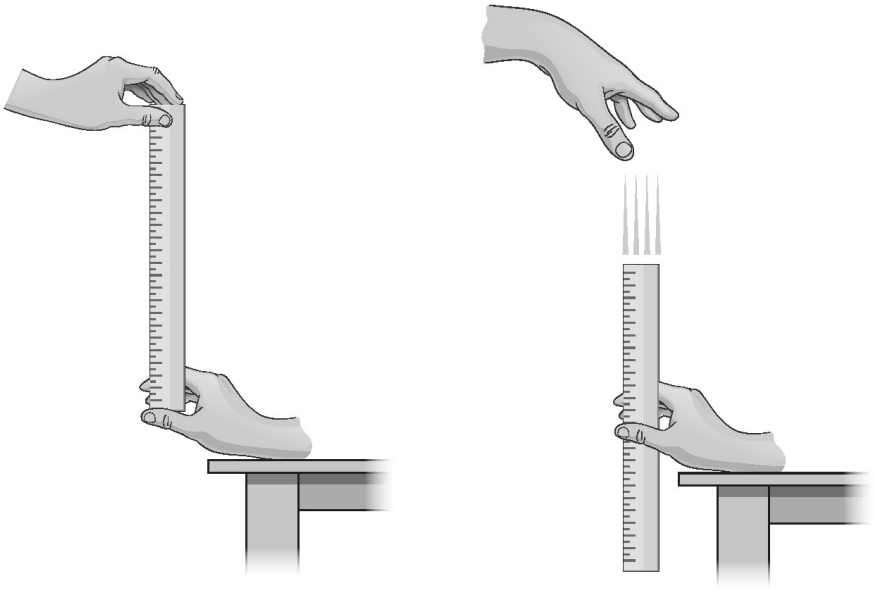
4. Emrys and Jo are studying road safety and are investigating thinking time.

They conduct an experiment to measure the thinking time.

Emrys drops a ruler and Jo catches it as quickly as possible.

They measure the distance the ruler falls and uses this to calculate the thinking time.



(a) State what is meant by the term thinking time. [1]

……..……...

……..……...

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(b) Jo practises catching the ruler 5 times.

Their results are shown below.

Distance dropped by the ruler (cm)					
Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Mean
29	53	25	23	27	26

Jo states that the mean should be 31 cm but Emrys states that it is 26 cm.

Explain whether you agree with Jo or Emrys. [2]

……..……...

……..……...

……..……...

……..……...

(c) Thinking time can be calculated using the following equation

$$\text{thinking time} = 0.045 \times \sqrt{\text{distance the ruler dropped (cm)}}$$

(i) Calculate Jo's thinking time when the ruler is dropped 29 cm. [2]

thinking time = ... s

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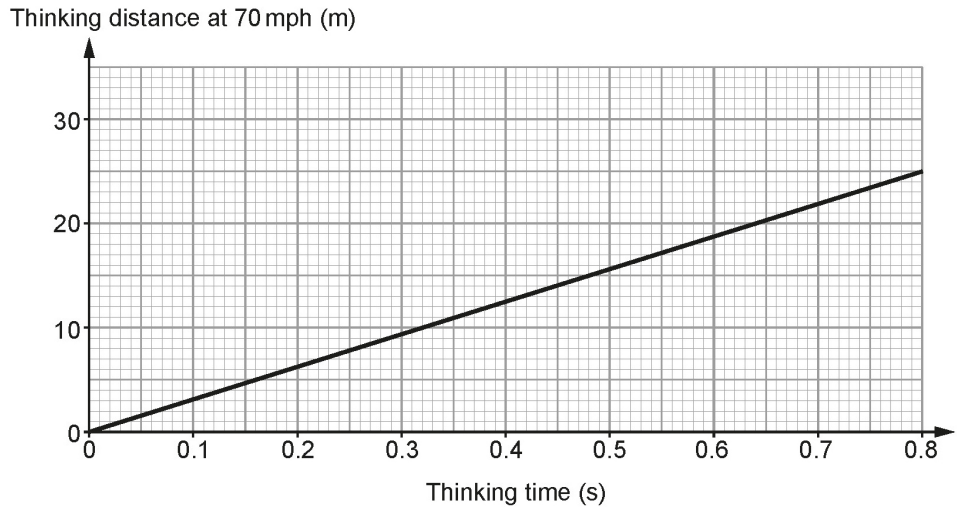
(ii) The graph below shows the thinking distances at 70 mph for different thinking times.



Describe the relationship between the thinking time and the thinking distances at 70 mph. [2]

……

……

……

……

(iii) Use your answer to (i) and the graph to state Jo's thinking distance at 70 mph. [1]

thinking distance = ... m

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(d) A car manufacturer conducts tests to investigate the thinking distances and stopping distances under different conditions.

The conditions for the tests are shown in the table below.

Test number	Speed (mph)	Driver condition	Road Conditions	Tyre condition
1	50	Alert	Wet	New
2	50	Alert	Dry	New
3	50	Tired	Dry	New
4	30	Alert	Dry	New
5	50	Tired	Dry	Worn

The results of the tests are shown below.

Place the correct number **1-5** in the table below to show which results are due to each set of test conditions.

One has been completed for you.

[3]

Thinking distance (m)	Braking distance (m)	Test number
15	38	2
9	14	.....
30	76	.....
30	38	.....
15	64	.....

11

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5. A school in South Wales intends to reduce its carbon footprint.

They decide the best solution is to install a wind turbine on the school grounds.

(a) The school uses the turbine to replace some of the energy they use from the National Grid.

The turbine parts are made overseas and shipped to the UK before being delivered by road to the site.

Assembling the turbine requires the use of 150 tonnes of concrete and the use of machinery including cranes.

The school claims the wind turbine will reduce its carbon footprint.

Suggest what other information is required to check that the school's claim is correct. [2]

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……

(b) The wind turbine manufacturer states that the turbine will have an average output power of 12 kW for 2500 hours per year and costs £70 000.

Use equations from page 2 to calculate the payback time for this turbine. [5]

The cost of 1 unit of energy is 25 p.

payback time = ... years

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(c) The manufacturer makes the following statements about the turbine

- The average wind power in the area per m^2 = 400 W/m^2
- The efficiency of the wind turbine converting wind power to electrical power = 35%

Calculate the area required to produce 12 kW of electrical power. [3]

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10

Area required = ……m^2

END OF PAPER

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Question number	Additional page, if required. Write the question number(s) in the left-hand margin.
	…… ……

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THE SCIENCES (DOUBLE AWARD)
UNIT 3

Physics: Forces, Motion and the Universe

HIGHER TIER

MARK SCHEME

Guidance for examiners

Generic marking principles

- Marks awarded are always whole marks (not half marks, or other fractions).
- Answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.
- Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).
- Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

Positive marking

It should be remembered that candidates are writing under examination conditions and credit should be given for what the candidate writes, rather than adopting the approach of penalising candidates for any omissions. It should be possible for a very good response to achieve full marks and a very poor one to achieve zero marks. Marks should not be deducted for a less than perfect answer if it satisfies the criteria of the mark scheme.

For questions that are objective or points-based, the mark scheme should be applied precisely. Marks should be awarded as indicated and no further subdivision made.

Mark schemes often list points which may be included in candidates' answers. The list is not exhaustive. The inclusion of *'Credit any other valid response.*' (or similar instruction) within mark schemes allows for the possible variation in candidates' responses. Credit will be given for correct and relevant alternative responses which are not recorded in the mark scheme. Credit should be given according to the accuracy and relevance of candidates' answers.

Appropriate terminology is reflected in exemplar responses in mark schemes. However, unless there is a specific requirement within a question, candidates may be awarded marks where the answer is accurate but expressed in their own words.

Marking abbreviations

The following may be used in marking schemes or in the marking of scripts to indicate reasons for the marks awarded.

ecf = error carried forward
bod = benefit of doubt

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HIGHER TIER

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Enquiry Skills
1.	(a)		1000 – 250 (1) = 750 [m] (1)		2		2	1	2
	(b)		The bobsleigh travels further in less time between C and D (1) So faster between C and D so disagree (1) **OR** The line is steepest between C and D (1) So faster between C and D so disagree (1)			2	2		2
	(c)	(i)	Air resistance / friction increases as the speed increases (1) Until they balance the forward force pulling the bobsleigh down the hill (1)	2			2		
		(ii)	[Crouching lower] reduces air resistance (1) Which means that the bobsleigh will travel faster before the forces balance (1)		2		2		
	(d)	(i)	Acceleration = $\frac{13}{5.6}$ (1) = 2.3 [m/s^2] (1)		2		2	2	
		(ii)	Force = 330 $\times$ 2.3 **ecf** (1) = 759 [N] (1)	1	1		2	2	

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	(e)	The same force from the athletes pushing (1) On a greater mass means a smaller acceleration so Delyth is incorrect (1)			2	2		
		Question 1 total	**3**	**7**	**4**	**14**	**5**	**4**

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Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Enquiry Skills
2.	(a)			Ultrasound waves have vibrations that are parallel (1) to the direction of the energy transfer / wave travel (1) Ultraviolet waves have vibrations at 90° so disagree (1)			3	3		2
	(b)			Substitution: 1.5 km/s = $\frac{\text{distance}}{0.15}$ (1) rearranging 1.5 x 0.15 = 0.225 [km] (1) Depth = $\frac{0.225\ \mathbf{ecf}}{2}$ = 0.1125 [km] (1) Depth = 112.5 [m] conversion (1)	1	1 1 1		4	3	3
	(c)	(i)		Number of waves per second	1			1		
		(ii)		Ticks in boxes 4, 5 and 6 i.e. • -Wavelength is smallest in air • -Wavelength is proportional to wave speed • -When the waves speed increases by a factor of 20, the wavelength is 20 × bigger			3	3	3	
				Question 2 total	**2**	**3**	**6**	**11**	**6**	**5**

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Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Enquiry Skills
3.	(a)	(i)	Inward gravitational force (1) is balanced by the outwards pressure force (1)	2			2		
		(ii)	Hydrogen fusion stops and helium fusion begins (1) The outward force becomes bigger than the inwards force (1) So the star expands (1) to become a red supergiant (1)	1 1	 1 1 		4		
	(b)		B (1) Spica is a high mass star so will have a much greater mass than the sun (1)		2		2		
	(c)		View not obstructed by the atmosphere / light pollution / no atmospheric distortion / able to detect regions of spectrum that are absorbed by the atmosphere (1) but they are more expensive (1)	2			2		
			Question 3 total	**6**	**4**	**0**	**10**	**0**	**0**

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Question			Marking details	Marks Available					
				AO1	AO2	AO3	Total	Maths	Enquiry Skills
4.	(a)		It is the time delay between seeing an incident and making a response or WTTE.	1			1		1
	(b)		29 + 25 + 23 + 27 = 104 $\frac{104}{4}$ = 26 [cm] (1) So 26 cm is correct because they should not include the anomalous result (1) agree with Emrys **Alternative** 29 + 53 + 25 + 23 + 27 = 157 $\frac{157}{5}$ = 31[.4] (1) But this does include the anomalous result so is incorrect (1) agree with Emrys			2	2		2
	(c)	(i)	$0.045 \times \sqrt{29}$ (1) = 0.24 [s] (1)	1	1		2		2
		(ii)	As the thinking time increases the thinking distance increases (1) At a constant rate (1) **Alternative** Thinking time is directly proportional to thinking distance (2)		2		2		2
		(iii)	7 [m] read from graph **ecf** from c(i)		1		1	1	1

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<table>
<tr>
<td></td>
<td>(d)</td>
<td>4 correct = 3 marks
2 or 3 correct = 2 marks
1 correct = 1 mark
<table>
<tr><th>Thinking distance (m)</th><th>Braking distance (m)</th><th>Test number</th></tr>
<tr><td>15</td><td>38</td><td>2</td></tr>
<tr><td>9</td><td>14</td><td>4</td></tr>
<tr><td>30</td><td>76</td><td>5</td></tr>
<tr><td>30</td><td>38</td><td></td></tr>
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<td>1</td>
<td>8</td>
</tr>
</table>

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Question		Marking details	Marks Available					
			AO1	AO2	AO3	Total	Maths	Enquiry Skills
5.	(a)	**Any 2 × (1) from:** • how much less CO_2 is produced from reducing the power from the national grid • how much carbon dioxide is produced in {producing / transporting} [parts of] the turbine • how much carbon dioxide produced due to installation and construction			2	2		
	(b)	12 × 2500 (1) = 30 000 [kWh] (1) 30 000 × 0.25 (1 – conversion) = £7 500 (1) $\frac{70\,000}{7500}$ = 9.3 [years] (1)	1	1 1 1 1		5	5	
	(c)	Output per m^2 = 400 × $\frac{35}{100}$ = 140 [W/m^2] (1) Total area required = $\frac{12}{0.14}$ (1 – substitution and conversion) = 85.7 [m^2] (1)		3		3	3	
		Question 5 total	**1**	**7**	**2**	**10**	**8**	**0**

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SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	TOTAL MARK	MATHS	Enquiry Skills
1	3	7	4	14	5	4
2	2	3	6	11	6	5
3	6	4	0	10	0	0
4	2	7	2	11	1	8
5	1	7	2	10	8	0
TOTAL	**14**	**28**	**14**	**56**	**20**	**17**

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