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PHYSICS
PH01

Unit 1 Mechanics, materials and atoms

Mark scheme

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Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this mark scheme are available from oxfordaqaexams.org.uk

Level of response marking instructions

Level of response mark schemes are broken down into levels, each of which has a descriptor. The descriptor for the level shows the average performance for the level. There are marks in each level.

Before you apply the mark scheme to a student's answer read through the answer and annotate it (as instructed) to show the qualities that are being looked for. You can then apply the mark scheme.

Step 1 Determine a level

Start at the lowest level of the mark scheme and use it as a ladder to see whether the answer meets the descriptor for that level. The descriptor for the level indicates the different qualities that might be seen in the student's answer for that level. If it meets the lowest level then go to the next one and decide if it meets this level, and so on, until you have a match between the level descriptor and the answer. With practice and familiarity you will find that for better answers you will be able to quickly skip through the lower levels of the mark scheme.

When assigning a level you should look at the overall quality of the answer and not look to pick holes in small and specific parts of the answer where the student has not performed quite as well as the rest. If the answer covers different aspects of different levels of the mark scheme you should use a best fit approach for defining the level and then use the variability of the response to help decide the mark within the level, ie if the response is predominantly level 3 with a small amount of level 4 material it would be placed in level 3 but be awarded a mark near the top of the level because of the level 4 content.

Step 2 Determine a mark

Once you have assigned a level you need to decide on the mark. The descriptors on how to allocate marks can help with this. The exemplar materials used during standardisation will help. There will be an answer in the standardising materials which will correspond with each level of the mark scheme. This answer will have been awarded a mark by the Lead Examiner. You can compare the student's answer with the example to determine if it is the same standard, better or worse than the example. You can then use this to allocate a mark for the answer based on the Lead Examiner's mark on the example.

You may well need to read back through the answer as you apply the mark scheme to clarify points and assure yourself that the level and the mark are appropriate.

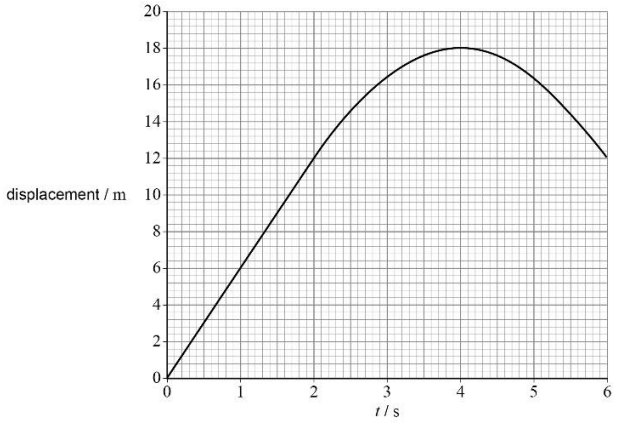
Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other valid points. Students do not have to cover all of the points mentioned in the Indicative content to reach the highest level of the mark scheme.

An answer which contains nothing of relevance to the question must be awarded no marks.

Question	Answers	Additional comments/Guidelines	Mark	AO
01	Kinetic energy increases (from zero), then decreases ✓ Idea that potential energy decreases, then increases ✓ <u>Elastic</u> potential energy decreases ✓ <u>Gravitational</u> potential energy increases (always) ✓	If no other mark given, allow 1 mark for a correct description of part of the movement (e.g. from **X** to **O**, or **O** to **Y**). Award MP2 if MP1, MP3 and MP4 given. For MP3 allow elastic PE increases if spring is described as compressing between **O** and **Y** Penalise contradictions within answer.	4	AO1 AO1 AO1 AO1
Total			**4**	

Question	Answers	Additional comments/Guidelines	Mark	AO
02.1	The system is isolated **OR** no external forces act ✓	Condone "closed" for isolated	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
02.2	Attempt to use conservation of total momentum **OR** a common impulse ✓ Correct substitution of values and velocities ✓ 0.063 (kg) ✓	 Correct signs required for MP2. E.g. $(0.050 \times 0.90) - (0.80\ m) = (0.050 \times -0.30) + (0.15\ m)$ **OR** $0.050 \times [0.30 - (-0.90)] = m[0.15 - (-0.80)]$ Expect to see $0.06 = 0.95m$ before answer	3	AO2 AO2 AO2
Total			**4**	

Question	Answers	Additional comments/Guidelines	Mark	AO
03	diagonal line to 2 s and smooth (symmetric) curve ending at 6 s ✓ turning point (of curve) at 4.0 s within ½ grid square ✓ displacements of 18 m at 4.0 s and 12 m at 6.0 s ✓ displacement of 16.5 m at 3.0 s and 5.0 s ✓	 Condone displacements within 1 grid square for MP4.	4	AO3 AO3 AO3 AO3
Total			**4**	

Question	Answers	Additional comments/Guidelines	Mark	AO
04.1	3 correct = 2 marks ✓ ✓ 2 correct = 1 mark ✓ proton / p / p^+ electron / beta-minus particle / e^- / β^- (electron) antineutrino / $\bar{\upsilon}$	Reference to any decay other than of a free neutron is talk out and gets zero marks.	2	AO1 AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
04.2	Method B is more precise than method A with some quantitative comparison ✓	Comparison of absolute uncertainties or calculation of percentage uncertainties: A = 0.25%; B = 0.09% Allow that the absolute uncertainty of B is smaller than that of A, if there's a comment that the values for t_n are similar.	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
04.3	When the experiment is repeated by another person, or by another method, the same result is obtained (OWTTE) ✓		1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
04.4	Max 2 from: ✓ ✓ Methods A and B do not produce a reproducible value (for t_n) because ranges don't overlap Calculations to show ranges don't overlap Discussion that A or B could be reproducible given further measurements	 Accept statement that the ranges do not overlap so data do not show that A and B are reproducible	2	AO3
Total			**6**	

Question	Answers	Additional comments/Guidelines	Mark	AO
05.1	47 ✓		1	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
05.2	Use of $\frac{\text{charge}}{\text{mass}}$ ✓ $\frac{77 \times 1.60 \times 10^{-19}}{197 \times 1.67 \times 10^{-27}}$ ✓ 3.7×10^{7} (C kg^{-1}) ✓	Allow other values for m and Q for MP2 if e and m_n used. Treat electron masses as neutral. Allow MP2 for either correct top line or correct bottom line of fraction	3	AO1 AO3 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
05.3	2 antiprotons ✓ 2 antineutrons ✓	Allow 1 mark for antiprotons and antineutrons. Allow symbols. Penalise reference to positrons. Use list principle.	2	AO1 AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
05.4	Both produce gamma radiation/photons or two identical photons ✓ Antihelium annihilation produces higher energy/frequency or shorter wavelength radiation ✓ (Because) antihelium/helium has greater rest energy/mass (than antihydrogen/hydrogen/proton) ✓	Allow γ for "gamma". Give full credit for discussion in terms of pairs of photons. Condone mass for rest mass	3	AO2 AO2 AO2
Total			**9**	

Question	Answers	Additional comments/Guidelines	Mark	AO
06.1	0.029 (N) ✓		1	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
06.2	Couple consists of (a pair of equal) forces acting in opposite directions (and along different lines) ✓ So no, as forces act in same direction, or do no act in opposite directions ✓	Allow credit for discussion of not being a couple in terms of moments.	2	AO1 AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
06.3	(sum of) clockwise moments equals (sum of) anticlockwise moments ✓ (resultant moment or sum of moments is zero) for a system in equilibrium ✓		2	AO1 AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
06.4	Calculates one moment eg $0.002\ \text{g} \times 5$ ✓ States horizontal component of distance = $0.10\cos\theta$ **OR** perpendicular component of weight = $0.004g\cos\theta$ ✓ 76° ✓	Allow mass instead of weight eg 2×5; Allow mass in g and d in cm. Allow other methods.	3	AO3 AO2 AO2
Total			**8**	

Question	Answers	Additional comments/Guidelines	Mark	AO
07.1	Max 2 from : ✓ ✓ Reads the width – $12.17\ \text{cm}$ Divides their width by 3 to get diameter (expect $4.06\ \text{cm}$) or 6 to get radius (expect $2.03\ \text{cm}$) Substitutes their *r* or *d* into $A = \pi r^2$ or $A = \pi \frac{d^2}{4}$ and multiplies by 7 $9.05 \times 10^{-3}\ \text{m}^2$ ✓	Needs to be a convincing conversion of cm to m for full marks. Need to see a subject for the area of circle $9.06 \times 10^{-3}\ \text{m}^2$ if $2.03\ \text{cm}$ used for radius	3	AO3 AO1 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
07.2	Calculates mass of one rope: $9.0 \times 10^{-3} \times 520 \times 4.7 \times 10^{3}$ ✓ Multiplies by 4 to get $8.8 \times 10^{4}\ \text{kg}$ ✓	For full marks, a subject (e.g. m, ρ, V) must be shown for at least one part of the solution.	2	AO1 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
07.3	Calculates total tension (5.6×10^6 N) ✓ Subtracts weight from tension **OR** $F = T - W$ seen ✓ Uses $F = ma$ ✓ 0.56 (m s^{-2}) ✓	Allow 2.2×10^4 g, 8.8×10^4 g, 4.5×10^5 g or 5.4×10^5 g for weight. Expect $W = 5.3 \times 10^6$ N. Allow answers that round to 0.6 m s^{-2} to account for different rope masses.	4	AO2 AO2 AO2 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
07.4	Uses $\sigma = \frac{F}{A}$ to get σ (160 MPa) **OR** to get breaking force for one rope (8.0×10^6 N) ✓ Compares 8.0×10^6 N to $5 \times 1.4 \times 10^6$ N, with correct conclusion **OR** compares 5×160 MPa to 890 MPa, with correct conclusion ✓	Comparisons are: 1.6×10^6 N with 1.4×10^6 N or 8.0×10^6 N with 7.0×10^6 N, or 160 MPa with 178 MPa, or 780 MPa with 890 MPa, so conclusion is that they are safe.	2	AO3 AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
07.5	Uses $mg\Delta h$ for mass ($4.5 \times 10^5 \times 9.81 \times 520 = 2.3 \times 10^9$ J or 0.64 MW h) ✓	$W = 4.4 \times 10^6$ N	4	AO2
	Uses $mg\Delta h$ with 260 m for ropes ($9 \times 10^4 \times 9.81 \times 260 = 2.3 \times 10^8$ J or 0.064 MW h) ✓	$W = 8.8 \times 10^5$ N		
	Shows 4 MW h = $4 \times 10^6 \times 3600 = 1.4 \times 10^{10}$ J **OR** converts their energy to MW h ✓	1 MW h = 3.6×10^9 J		
	Claim is incorrect because 2.6×10^9 J < 1.4×10^{10} **OR** 0.72 MW h < 4 MW h ✓	Allow MP4 if mass of ropes not included ($2.3 \times 10^9 < 1.4 \times 10^{10}$) **OR** if mass of ropes included with Δh = 520 m ($2.7 \times 10^9 < 1.4 \times 10^{10}$). Allow ≠ for < or >		
Total			**15**	

Question	Answers	Additional comments/Guidelines	Mark	AO
08.1	To determine the mean background count (during the investigation) **OR** To make sure it hasn't changed or to account for random variations ✓		1	AO4

Question	Answers	Additional comments/Guidelines	Mark	AO
08.2	99 ✓		1	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
08.3	Correct values (0.204, 0.233, 0.260) ✓		1	AO4

Question	Answers	Additional comments/Guidelines	Mark	AO
08.4	Correct plotting of their values ✓	Allow ± half a grid square Allow ecf from **08.3**	1	AO4

Question	Answers	Additional comments/Guidelines	Mark	AO
08.5	Line of best fit with equal number of crosses either side of line ✓	Expect line to be above 1st, 2nd and 6th points, and below 3rd to 5th.	1	AO4

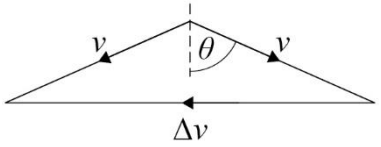
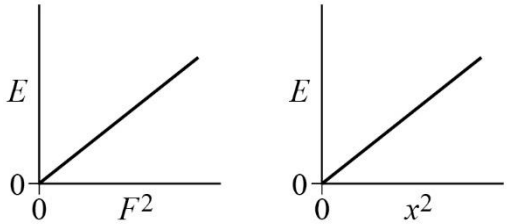
Question	Answers	Additional comments/Guidelines	Mark	AO
08.6	MP1 is for a comment about linearity ✓	E.g. Supports the law because the line is straight (and it should be)	2	AO4
	MP2 is for a comment about intercept ✓	E.g. Doesn't support the law because line doesn't pass through origin (and it should) **OR** line doesn't have to pass through origin with reason given as zero error or end correction		
Total			**7**	

Question	Answers	Additional comments/Guidelines	Mark	AO
09.1	$450.\cos 32^{o} + T_{Y}.\cos 14^{o} = 0$ **OR** $450.\cos 32^{o} = T_{Y}.\cos 14^{o}$ seen ✓ Recognisable T_{Y} as subject **AND** answer of 393 (N) seen ✓		2	AO1 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
09.2	(Scaled) free-body diagram or vector triangle ✓ Correct directions of arrows for free-body diagram or vector triangle ✓ Answers in the range 320 to 350 (N) ✓	Angles must be annotated. Allow use of trig <u>only</u> to check answer from a diagram.	3	AO3 AO3 AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
09.3	Use of graph to find gradient / YM = 120 (GPa) ✓ Use of Young modulus equation: $\Delta L = (450 \times 75)/(6.7 \times 10^{-6} \times 120 \times 10^{9})$ ✓ 0.041 (m) ✓	Must use at least one half of an axis within linear section. Allow calculation of stress for MP1 (67 MPa) Ignore powers of 10 omissions. Allow ecf for their gradient / YM for MP2 Allow 0.042 m.	3	AO1 AO2 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
09.4	tension in **X** decreases <u>and</u> tension in **Y** increases ✓		1	AO2
Total			**9**	

Question	Key	Answer	AO
10	**B**	14 kJ	AO2
11	**B**	acceleration speed time	AO1
12	**B**	$mgvt$	AO2
13	**A**	12 W	AO2
14	**A**	$-usin\theta$	AO2
15	**D**	$33\ \text{m s}^{-1}$	AO2
16	**D**	**R** hits the floor with the greatest speed.	AO3
17	**C**		AO3
18	**D**	2 7 10	AO1
19	**D**		AO1
20	**C**	**Y X**	AO2

21	**C**	equal to the magnitude of F.	AO2
22	**B**	6.6×10^{-6} W	AO2
23	**C**	has the same proton number as the original nuclide.	AO2