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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.

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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
01.1	Doubling of energy AND use of 1.6×10^{-19} (J) seen with answer 1.63×10^{-13} (J) (≥3 sf) ✓		1	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
01.2	Idea that excess energy is shared between the electron and the positron and the recoiling nucleus as kinetic energy✓ Maximum KE that is available to each of the electron and the positron is 0.23×10^{-13} (J) to 0.25×10^{-13} (J) ✓	Condone lack of reference to recoiling nucleus Accept answer of 0.47×10^{-13} (J) shared between electron and positron	2	AO1 × 1 AO2 × 1
Total			**3**	

Question	Answers	Additional comments/Guidelines	Mark	AO
02.1	It has magnitude and direction ✓	allow the product of a scalar / mass and a vector (velocity) is a vector	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
02.2	Calculates total initial momentum $-14.4\ \text{kg m s}^{-1}$ ✓ Idea that momentum is conserved in the collision✓ Truck **X** must be moving to the left so that total momentum after the collision is (also) to the left **OR** Truck **X** cannot be moving to the right otherwise net momentum would be to the right / momentum not conserved ✓	Max 2 if there is the assumption that X and Y move together after the collision Allow a clear indication of direction Allow if v is calculated there is a change in sign and a conclusion that the sign change shows change in direction	3	AO2
Total			**4**	

Question	Answers	Additional comments/Guidelines	Mark	AO
03.1	The gamma radiation is detected at a distance inside the detector OR The gamma radiation is emitted at a distance inside the source holder ✓ So the measured values of d will be shorter than the true value ✓	Ignore any random errors MP2 depends on MP1 If no other mark awarded allow 1 mark for the idea that the correct measurement is inside the gamma source to inside the detector	2	AO4

Question	Answers	Additional comments/Guidelines	Mark	AO
03.2	Subtract the background count rate ✓ Repeat and calculate a mean ✓	Allow increase time of measurements	2	AO4
Total			**4**	

Question	Answers	Additional comments/Guidelines	Mark	AO
04.1	Attempts to calculate the area under graph ✓ Distance = 0.046 to 0.049 ✓ Time = 19×10^{-3} to 19.5×10^{-3} **AND** Use of average speed = $\frac{\text{their distance from an area}}{\text{time}}$ ✓	Allow other correct methods Ignore POT in MP3 Their distance must be from a valid method expect to see 2.4 to $2.6\ \text{m s}^{-1}$	3	AO2 × 2 AO3 × 1

Question	Answers	Additional comments/Guidelines	Mark	AO
04.2	Determines a or uses $f = ma$ with their a ✓ $770\ \text{N}$ ✓	Expect to see $\frac{3.2}{2.3 \times 10^{-3}} = 1390\ \text{m s}^{-2}$ Accept answer in the range $690\ \text{N}$ to $870\ \text{N}$ consistent with read-offs for Δt of 2.0 to $2.5\ \text{ms}$ Do not penalise POT error if penalised in **04.1**	2	AO2 × 1 AO3 × 1
Total			**5**	

Question	Answers	Additional comments/Guidelines	Mark	AO
05.1	$^{99}_{42}\text{Mo} \rightarrow {}^{99\text{m}}_{43}\text{Tc} + {}^{0}_{-1}\beta^{-} + \overline{\nu_e}$ All numbers correct ✓ $\overline{\nu_{(e)}}$ ✓	Do not accept incorrect number on the neutrino for MP1 Do not accept 99m for Mo accept $\bar{\nu}$ but not ν	2	AO1 × 1 AO2 × 1

Question	Answers	Additional comments/Guidelines	Mark	AO
05.2	(Technetium) nucleus is in an excited state ✓ The idea that the resulting gamma emission is not immediate. ✓	Do not allow atom for nucleus Condone isotope or nuclide for nucleus allow excess energy in nucleus	2	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
05.3	Uses consecutive half-lives ✓ Determines number of half-lives to give time taken = 48 (hours) ✓	allow determination of λ and reference to $A = A_0 e^{-\lambda t}$ for MP1	2	AO2 × 1 AO3 × 1

Question	Answers	Additional comments/Guidelines	Mark	AO
05.4	Max 2 from: ✓ ✓ Half-life which is long enough for the patient to be examined Half-life which is short enough that it doesn't remain active in the patient for a long time and damage the body Emits gamma so is detectable Not harmful to patients because (low-energy) gamma emitted (no beta or alpha)	Allow weak beta emitted Accept low toxicity argument	2	AO1
Total			**8**	

Question	Answers	Additional comments/Guidelines	Mark	AO
06.1	There is no resultant moment (about any point) ✓ There is no resultant force ✓		2	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
06.2	Uses $W = mg$ to determine weight of skateboard (47 N) ✓ Adds to the weight of the child and halves to give 204 (N) ✓	Allow 200 (N) (2sf) but not 203 (N)	2	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.3	$F_A = 30$ (N) or $F_B = 330$ (N) ✓ Takes moments about **P** ACW moment = $330\ x$ ✓ CW moment = $(4.8 \times 9.81)\ 32.5\cos 15 + (30 \times 53\cos 15)$ ✓ Uses POM to give $x = 9.1$ (cm) ✓	Allow mp2 and mp3 to be combined Allow mp2 and mp3 in terms of F_A and/or F_B Accept answer in m if unit correct	4	AO2 × 2 AO3 × 2
Total			**8**	

Question	Answers	Additional comments/Guidelines	Mark	AO
07.1	Both act on the same object **OR** are different types of force ✓		1	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
07.2	Drag increases with speed ✓ Resultant force decreases (since drag increases and thrust is constant) ✓ When drag = thrust, resultant force is zero (so constant speed) and correct reference to Newton's 1st or 2nd law ✓	Ignore references to friction Accept air resistance for drag Accept driving force for thrust Condone engine force Accept balanced force for resultant force is zero	3	AO1 × 2 AO2 × 1

Question	Answers	Additional comments/Guidelines	Mark	AO
07.3	(Effective surface area decreases) which decreases drag ✓ Idea that there is a resultant force acting which causes the car to accelerate **OR** Idea that resultant force zero at greater terminal velocity ✓	Accept air resistance for drag MP2 must follow from correct ideas about the forces	2	AO3
Total			**6**	

Question	Answers	Additional comments/Guidelines	Mark	AO
08.1	v = (15 sin 38 =) 9.2 (9.23) (m s^{-1}) ✓		1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
08.2	Correct substitution into equation of uniform motion or conservation of energy✓ 4.31 (≥3 sf) (m) ✓	Expect to see $\frac{(0)-9.2^2}{2\times-9.81}$ MP2 dependent on MP1 Condone v = 9.2 and a = + 9.81 4.34 if 9.23 used allow ecf from **08.1** for MP1 only	2	AO1 × 1 AO2 × 1

Question	Answers	Additional comments/Guidelines	Mark	AO
08.3	Correct use of an equation of uniform motion ✓ 0.937 (≥3 sf) (s) ✓	ecf incorrect value from **08.1** or **08.2** MP2 dependent on MP1 Do not allow u and a to have the same sign 0.941 if 4.34 used	2	AO1 × 1 AO2 × 1

Question	Answers	Additional comments/Guidelines	Mark	AO
08.4	Correct use of equation of uniform motion $s = ut + \frac{1}{2}at^2$ ✓ Calculates time to fall from max height to $2.56\ \text{m}$ = 0.60 (0.602) s ✓ 1.5 (1.54) (s) ✓	Use of $s = ut + \frac{1}{2}at^2$ and solving for t can gain full marks	3	AO1 × 1 AO2 × 1 AO3 × 1

Question	Answers	Additional comments/Guidelines	Mark	AO
08.5	Finds horizontal component of velocity **OR** uses $d = 1.5 \times u$ ✓ 18 (m) ✓	ecf incorrect value from **08.4**	2	AO1 × 1 AO2 × 1

Question	Answers	Additional comments/Guidelines	Mark	AO
08.6	Max 2 from: Reaches lower maximum height ✓ Reaches maximum height at an earlier time ✓ The ball will pass under the crossbar or hit the crossbar lower ✓	Condone horizontal distance would be less for MP3	2	AO2 × 1 AO3 × 1
Total			**12**	

Question	Answers	Additional comments/Guidelines	Mark	AO
09.1	Uses gradient of the graph to determine the Young modulus ($188\ \text{GPa}$) including clear manipulation of powers of 10 ✓	Condone use of a single point (eg 0.0032, 600×10^{6})	1	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
09.2	Rotate the turnbuckle so that the screws move closer together which will increase the extension of /strain in the cable ✓		1	AO4

Question	Answers	Additional comments/Guidelines	Mark	AO
09.3	Determines pitch $\left(\frac{1.3}{2}\right)$ and calculates ratio ✓	Expect to see 22 or 21.5	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
09.4	Determines initial strain = 0.00105 to 0.00115 ✓	allow a calculation using the Young modulus and stress	1	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
09.5	Determines additional strain = 0.0058 ✓ strain = 0.0068 to 0.0069 ✓	expect to see $\frac{8\times1.3\times10^{-3}}{1.8}$	2	AO1 × 1 AO3 × 1

Question	Answers	Additional comments/Guidelines	Mark	AO
09.6	Use of stress = $\frac{F}{A}$ **OR** $E = \frac{\sigma}{\varepsilon}$ ✓ Determines the stress as candidate's **09.5** × 1.9×10^{11} ✓ T = 4.0×10^4 to 5.1×10^4 (N) ✓	No credit for answers based on 210 MPa Allow a value of stress read from graph consistent with their **09.5** Expect 1.28×10^9 (Pa) allow ecf from **09.5**	3	AO1 × 1 AO2 × 2
Total			**9**	

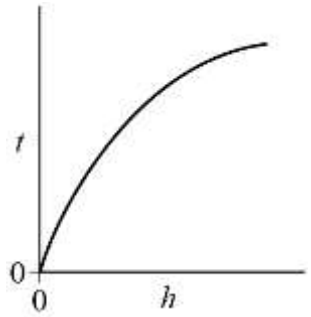
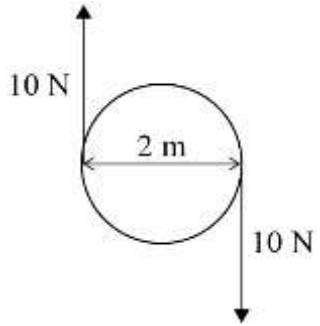
Question	Answers	Additional comments/Guidelines	Mark	AO
10.1	Calculates mean value of d **OR** half range ✓ Calculates mean value of d **AND** half range to get 2% ✓	expect to see 80/80.2 and/or 1.5 Condone 1.9% to 2 sf	2	AO2 × 2

Question	Answers	Additional comments/Guidelines	Mark	AO
10.2	Best-fit line ✓		1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
10.3	Uses $E_p = F \times d$ to show $x^2 = \frac{2\mu mgd}{k}$ ✓		1	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
10.4	Use of large triangle to find gradient ✓ Correct use of formula ✓ $\mu = 0.29$ to 0.31 ✓	the minimum length of horizontal side is 7.0×10^{-2} Penalise POT error in mp3 only	3	AO3 × 2 AO2 × 1
Total			**7**	

Question	Key	Answer	AO
11	**A**	$m(gs - \frac{v^2}{2})$	AO3
12	**C**	4.18×10^7 C kg^{-1}	AO3
13	**D**	$m(a + g) + D$	AO3
14	**D**		AO2
15	**C**		AO3
16	**D**	10%	AO3

17	**B**	$\Delta p \propto F$ $\Delta E_k \propto F^2$	AO1
18	**B**	α, β^-, β^-	AO1
19	**C**	24 m	AO1
20	**D**	kg m^2 s^{-3}	AO3
21	**C**	4500 N	AO2
22	**C**	Very few of the alpha particles were deflected through a large angle.	AO1
23	**A**		AO2
24	**A**		AO1

Total 14 marks