A-LEVEL
PHYSICS
7408/1

Paper 1

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 Assessment Writer.

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
01.1	Iodine-131 has 6 more neutrons (than iodine-125) ✓	Condone iodine-131 has 78 neutrons and iodine-125 has 72 neutrons. Condone "6 fewer/less neutrons than iodine-131" Do not credit nucleons. Suggestion of difference in number of protons loses the mark.	1
01.2	131 (nucleons) ✓	If more than one number is given, the nucleon number must be explicit.	1
01.3	The tellurium has 1 more neutron (than iodine-125) ✓ The tellurium has 1 fewer proton (than iodine-125) ✓	Accept reverse arguments. Accept tellurium has 73 neutrons Accept tellurium has 52 protons Condone "proton number". Condone "number of neutrons/protons have increased/decreased by one" Treat any nuclear reactions as neutral. Discussion of electrons in nucleus scores max 1. Accept answer in terms of quarks (one more down and one fewer up). Ignore references to nucleons/mass number.	2

01.4	**A** (*internal conversion*: only electron released); *beta-decay*: (electron and) anti-neutrino released; ✓ **B (both statements required for mark)** *internal conversion*: all electrons released will have similar/discrete energies/momenta *beta-decay*: electrons will have a range of energies/momenta ✓ **C** *(internal conversion*: no change in constituents of nucleus/element does not change) *beta-decay*: neutron converted to proton (allow in terms of quarks)/element changes (to one with (one) more p, different Z, different proton number/different atomic number)) ✓ **D** (*internal conversion*: orbital electron lost) *beta-decay*: electron comes from nucleus / no change in orbital electrons ✓ **E (both statements required for mark)** *internal conversion*: mediated by electromagnetic force / virtual photons *beta-decay*: mediated by weak interaction / W^- ✓	Any 3. Treat each difference, as delimited by the answer book, as a single independent mark. Contradiction within a difference cancels the mark for that difference (on list basis). For a contradiction between separate differences treat the incorrect difference as neutral. Allow: **F (both statements required for mark)** *Internal conversion:* may be accompanied by X-ray photon *Beta*-decay: may be accompanied by gamma photon ✓ Allow “shells” for “orbitals”. Do not award separate marks for force and exchange particle Condone “W boson” or “W particle” but not W^+ and W	3

Total			**7**

Question	Answers	Additional Comments/Guidelines	Mark
02.1	Ray enters (prism) along normal ✓	Allow normal explained eg at right angles <u>to surface</u> Accept “angle of incidence is 0”.	1
02.2	Treat each point independently. Prism material/it has/they have same refractive index / <u>optical</u> density as windscreen ✓ Prism fitted to windscreen without gaps ✓	 Condone ‘it has’ or ‘they have’ or just ‘same’ Allow “no change of speed between prism and windscreen” Allow “made from same material” Do not allow “same refractive index between them” Treat “monochromatic” as neutral Allow “contact between prism and windscreen is clean” etc. Allow “touching the windscreen” Condone suggestion that any bonding material has same refractive index (as prism and windscreen). Do not accept ‘no boundary’	2
02.3	C = arcsin $(1/1.52)$ = arcsin (0.66) = $41(.1)^{\circ}$ ✓ 45° > critical angle / 41.1° resulting in <u>total internal reflection / tir</u> (at each boundary) ✓	The first mark is for the calculation. The second is for the discussion but is contingent on obtaining a value for C. Ecf for any $C < 45^{\circ}$	2

		Accept clear reference to angle at point A in place of 45° statement. Do not allow "angle of incidence> critical angle" on its own.	
02.4	Calculation of critical angle at glass–water boundary (61.0^{o}) OR Calculation of possible *n* from glass to water (0.707) or absolute *n* for glass (1.88) OR Calculation of angle of refraction in water (53.9°) ✓ So total internal reflection no longer takes place **OR** some light escapes/refracts (into water) / less light reflects ✓ (Less light stays within windscreen so less light detected at sensor)	Do not allow suggestion that TIR occurs at critical angle/when angle of incidence=critical angle. Do not allow "ray/all the light escapes/refracts" or "no light reflects" or "less TIR". Do not condone "total internal refraction/diffraction"	2
02.5	Statement of effect of change in *n* on the path direction ✓ (Sensible reference to the variation of a few per cent) leads to the idea that change is unlikely to be significant ✓	Eg for MP1 • Light may change direction inside windscreen • Light may change direction at a windscreen boundary Eg for MP2 • Variation too small to deviate significantly within windscreen – internal effect • Variation too small to affect tir at A without	Max 2

		droplet – boundary effect • Variation too small to significantly affect transmission at A with droplet – boundary effect Allow discussions that *may* cause a difference, eg there is a summative effect from multiple reflections etc	

02.6	**More sensitive because…** more likely to encounter/detect water drop OR will encounter more water drops ✓ bigger decrease in light intensity, so more sensitive to rain ✓ **Less sensitive because…** more likely to encounter imperfections in glass/on surface of glass /dirt on surface of glass ✓ any curvature effects will be greater so may not hit detector ✓ light intensity reduced without presence of water / greater absorption in windscreen due to greater path length ✓	Allow any 2 comments taken from list . There must be a sense of whether the comment relates to an improvement or decrease in sensitivity. Treat as list; mark 1 and 2 independently. Allow idea of larger area Do not allow a response that discusses travel time of ray.	Max 2

Total			**11**

Question	Answers	Additional Comments/Guidelines	Mark
03.1	Central maximum with lower intensity maxima (either side) ✓ Central maximum is twice as wide/wider than other maxima ✓	MP1 is for comparison of intensity. Condone references to brightness/dimness. MP2 is for comparison of width Award credit for a drawn answer eg on Fig 3. Suggestion that pattern due to white light = max 1 Reference to Young's slit or equation = max 1 If only a single maximum is referred to MP2=0 but MP1 can score for description of intensity variation.	2
03.2	Wider (central) maxima (maximum) ✓ (Subsequent) maxima further apart ✓	'The pattern is wider/more spread out' gets 1 mark if no other marks given. Not "larger pattern". Condone "larger" distances between maxima. Condone 'maxima more spaced out' Reference to Young's slit or equation = max 1 Ignore comments related to change in wavelength	2
03.3	$d = 1 \times 10^{-3}/500$ $(= 2 \times 10^{-6})$ ✓ $(\sin\theta = n\lambda/d = 6.5 \times 10^{-7} / 2 \times 10^{-6} = 0.33)$	Allow POT error for d for MP1 May be seen in diffraction grating equation.	2

	$\theta = 19^{o}$ ✓	Allow max 1 for use of grating constant rather than *d* to give 7.45 x 10^{-11} ° if no other credit available.	

03.4	Any two from: ✓ ✓ (Range of wavelengths results in): Central maximum unchanged in width Broader maxima/range of angles for each maximum/order Gradually getting broader/more spread out for greater order maxima Part of third order maximum suppressed at long wavelengths (for $\theta >$ 90°)	Give credit for answer shown in diagram Evidence for these marks may be seen in calculations Treat intensity variation as neutral.	Max 2

Total			**8**

Question	Answers	Additional Comments/Guidelines	Mark
04.1	The centre of mass of the beam and box is at the pivot ✓ Idea that moments balance / sum of the moments is zero at this position ✓ **OR** The anticlockwise moment (of weight of the beam) = clockwise moment (of weight of the box) ✓ Links pivot position to a consideration of moments ✓	Accept one route or the other, do not accept points from both. Allow max 1 for "the pivot is to the right of the centre (of mass) of the beam" 'pivot' on its own does not get the first mark Award 2 for 1.25 x weight of beam = 1.5 x weight of empty box Confusion of moments with eg work done/forces = max 1	2
04.2	Clockwise moment = $610 \times 9.81 \times 1.5$ (= 8976 N m) ✓ Anticlockwise moment = $250 \times 4 + T \sin 50 \times 4.0$ (N m)✓ Use of clockwise = anticlockwise✓ Use of $T \sin 50^{o}$ seen / relates vertical component to tension✓ T (= 1994/sin 50^{o}) = 2600 (N)✓	Credit any evidence to work out a moment with one mark Condone cos 50 in MP2. Allow ecf for clockwise moment Allow ecf for anticlockwise moment Use of g = 10 N kg^{-1} gives 2990 N Omission of 4.0 m (g = 9.8) gives 10410 N. Use of cos 50 (g = 9.8) gives 3100 N	5

		Allow max 4 for use of g = 10 N kg^{-1}.	

04.3	$7.5 = ½\ g\ t^2$ ✓ (t = 1.2 s) (calculate distance) s (= ut = 18 × 1.2) = 22 (m)✓	Allow ecf from incorrect t for MP2	2

04.4	**(Range will be greater:)** component of velocity upwards ✓ rock will spend longer in the air ✓ greater *t* ✓ ***therefore*** the range is greater ✓ **OR** **(Range will be smaller)** Counterweight will fall less far before projectile released ✓ Less energy transferred to rock ✓ Initial speed of rock less/horizontal velocity reduced ✓ ***therefore*** the range is smaller ✓ **OR** (balanced arguments) ***therefore*** the range is unchanged / answer is indeterminate✓	Candidates can argue from both lists to reach a balanced view suggesting that there is no change. Full credit can be obtained from 2 deductions from one list ✓✓+ consistent conclusion✓ 1 deduction from each list ✓✓+ consistent conclusion ✓ Do not allow an unsupported conclusion. Conclusion must be consistent with **correct** statements. Treat incorrect statements as neutral. Do not reward arguments based on a longer time of flight.	Max 3
Total			12

Question	Answers	Additional Comments/Guidelines	Mark
05.1	Conversion of $110\ \text{km h}^{-1}$ to $31\ \text{m s}^{-1}$ ✓ = ½ × 1.5×10^3 × *their conversion*^{2} with a consistent answer✓ (= $7(.2) \times 10^5$)	Allow ecf for incorrect or failure to carry out speed conversion Expect answer to be calculated correctly and to 2+ sf. Accept 700 kJ as 2 sf	2
05.2	Component of velocity = $31 \times \cos(20)$ **OR** evidence of using momentum = mass × velocity (eg 1.5×10^3 x a velocity) ✓ = 4.4×10^4 ✓ For unit <u>only</u> accept kg m s^{-1} **OR** N s ✓	Allow ecf for speed from 05.1 Accept 4.65×10^4 kg m s^{-1} for max 2 Use of 30.6 m s^{-1} gives 43 kN s	3
05.3	(KE before collision = 700 kJ) Speed (parallel to barrier) after (= $31 \times \cos 20$) = $28.7\ \text{m s}^{-1}$ ✓ KE after(= ½ × $1.5 \times 10^3 \times 28.7^2$) = 618 kJ ✓ Change = 700 – 618 ✓ (= 82 kJ) **OR**	Allow ecf for speed from 05.1 Use of KE = $p^2/2m$ can gain full credit. Allow ecf for momentum in 05.2 Final answer depends on extent to which candidate has rounded in earlier parts. Allow correctly evaluated solutions for full credit.	3

	~~Speed (perpendicular to barrier) after = $31 \times \sin 20$ (= $10.5\ \text{m s}^{-1}$)~~ ✓ Loss of KE (= ½ × $1.5 \times 10^3 \times 10.5^2$) = 82 kJ ✓ Justification that total KE = KE due to speed parallel to barrier + KE due to speed perpendicular to barrier ✓	~~In this question, do not insist~~ on final answer to 2+ sf. If there is a suggestion that KE is a vector or can be resolved, do not award MP3.	

05.4	Evidence of work done = force × distance Eg Force = 82 000 / 1.5 **OR** *their value for 05.3*÷1.5✓ = 5.5×10^4 N✓ This is less than braking force – so yes. ✓ **OR** energy approach • work done by barrier = 60 kN x 1.5 m✓ • 90 kJ ✓ • which is > E_k of vehicle, so yes ✓ **OR** impulse argument • evaluate time taken to stop, 0.26 s ✓ • impulse value leading to distance or force✓ • conclusion consistent with correct method of calculation ✓ **OR** use of *F=ma* and *suvat* : • F= ma leading to *a* = (-)40 m s^{-2}✓ • *suvat* leads to 1.37 m✓ • which is <1.5 m, so yes ✓	Allow 80 kJ for energy General scheme for alternatives and reverse arguments is: • first step calculation • subsequent calculation(s) leading to comparative value. Allow ecf for error in first step. • conclusion consistent with correct method of calculation Alternative suvat method: • uses suvat to get a = 36.5 m s^{-2} • uses F=ma • which is <60 kN, so yes	3

05.5	~~(Steel barrier is better because)~~ Increase time of contact as material deforms ✓ Reference to impulse (= change in momentum = Ft) implies smaller force (on dummy) ✓ **OR** Increasing stopping distance as material deforms ✓ Reference to work done (= Fs) implies smaller force (on dummy) ✓	Allow correct discussion leading to concrete barrier is worse. Alternative second mark for either alternative can be awarded for correct reference to F=ma	2

Total			**13**

Question	Answers	Additional Comments/Guidelines	Mark
06.1	1.5 (ms) ✓		1
06.2	A = 4.2 (mm) read from graph ✓ T = 2.0 (ms) read from graph ✓ (a_{max} = $4.2 \times 10^{-3} \times (2 \times \pi / (2 \times 10^{-3}))^2$ $4.1(5) \times 10^4$ (m s^{-2}) ✓ (Do not allow 4.2)	Condone power of ten error in A and/or T but not in final answer. Evidence for T might be seen in equation, as 500 (f). Only allowed ecf for max 2 is use of 4.1 mm for A, giving 4.0×10^4 (m s^{-2})	3
06.3	longitudinal (they) oscillate along direction of energy transfer ✓	Both required for 1 mark Condone "vibrate" for oscillate. Condone 'travel' for transfer	1
Total			**5**

Question	Answers	Additional Comments/Guidelines	Mark
07.1	Mention of increase in lost volts/ pd across internal resistance (in cell)✓ (because) current has increased **OR** internal resistance is a larger proportion of total resistance **OR** ratio of internal: external resistance is larger ✓	Accept reverse arguments Do not accept terminal pd has decreased Treat comments about resistance of lamp as neutral	2
07.2	Lost volts reduced (current remains the same, V2 > V1) **OR** Effective internal resistance is a smaller proportion of total resistance / ratio of internal: external resistance is smaller ✓ (because) two cells in parallel behave as a single cell (with the same emf) but with half the internal resistance / reduced internal resistance ✓ ***Alternative:*** Current through each cell is less than cell on its own ✓ Decreased current through cell decreases lost volts / pd dropped across internal resistance ✓		2

Total			**4**

Keys to Objective Test Questions (each correct answer is worth 1 mark)											
8	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**

A	D	C	C	C	A	B	D	D	B	C	C	

20	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**
D	B	D	D	B	B	A	C	C	D	C	A	D