AS

Physics

7407/2 - Paper 2

Mark scheme

June 2018

Version/Stage: 1.0 Final

Physics – Mark scheme instructions to examiners

1. General

The mark scheme for each question shows:

- the marks available for each part of the question
- the total marks available for the question
- the typical answer or answers which are expected
- extra information to help the Examiner make his or her judgement and help to delineate what is acceptable or not worthy of credit or, in discursive answers, to give an overview of the area in which a mark or marks may be awarded.

The extra information is aligned to the appropriate answer in the left-hand part of the mark scheme and should only be applied to that item in the mark scheme.

At the beginning of a part of a question a reminder may be given, for example: where consequential marking needs to be considered in a calculation; or the answer may be on the diagram or at a different place on the script.

In general the right-hand side of the mark scheme is there to provide those extra details which confuse the main part of the mark scheme yet may be helpful in ensuring that marking is straightforward and consistent.

2. Emboldening

2.1 In a list of acceptable answers where more than one mark is available 'any **two** from' is used, with the number of marks emboldened. Each of the following bullet points is a potential mark.
2.2 A bold **and** is used to indicate that both parts of the answer are required to award the mark.
2.3 Alternative answers acceptable for a mark are indicated by the use of **or**. Different terms in the mark scheme are shown by a / ; eg allow smooth / free movement.

3. Marking points

3.1 Marking of lists

This applies to questions requiring a set number of responses, but for which candidates have provided extra responses. The general principle to be followed in such a situation is that 'right + wrong = wrong'.

Each error / contradiction negates each correct response. So, if the number of errors / contradictions equals or exceeds the number of marks available for the question, no marks can be awarded.

However, responses considered to be neutral (often prefaced by 'Ignore' in the mark scheme) are not penalised.

3.2 Marking procedure for calculations

Full marks can usually be given for a correct numerical answer without working shown unless the question states 'Show your working'. However, if a correct numerical answer can be evaluated from incorrect physics then working will be required. The mark scheme will indicate both this and the credit (if any) that can be allowed for the incorrect approach.

However, if the answer is incorrect, mark(s) can usually be gained by correct substitution / working and this is shown in the ‘extra information’ column or by each stage of a longer calculation.

A calculation must be followed through to answer in decimal form. An answer in surd form is never acceptable for the final (evaluation) mark in a calculation and will therefore generally be denied one mark.

3.3 Interpretation of ‘it’

Answers using the word ‘it’ should be given credit only if it is clear that the ‘it’ refers to the correct subject.

3.4 Errors carried forward, consequential marking and arithmetic errors

Allowances for errors carried forward are likely to be restricted to calculation questions and should be shown by the abbreviation ECF or *conseq* in the marking scheme.

An arithmetic error should be penalised for one mark only unless otherwise amplified in the marking scheme. Arithmetic errors may arise from a slip in a calculation or from an incorrect transfer of a numerical value from data given in a question.

3.5 Phonetic spelling

The phonetic spelling of correct scientific terminology should be credited (eg fizix) **unless** there is a possible confusion (eg defraction/refraction) with another technical term.

3.6 Brackets

(…..) are used to indicate information which is not essential for the mark to be awarded but is included to help the examiner identify the sense of the answer required.

3.7 Ignore / Insufficient / Do <u>not</u> allow

‘Ignore’ or ‘insufficient’ is used when the information given is irrelevant to the question or not enough to gain the marking point. Any further correct amplification could gain the marking point.

‘Do **not** allow’ means that this is a wrong answer which, even if the correct answer is given, will still mean that the mark is not awarded.

3.8 Significant figure penalties

Answers to questions in the practical sections (7407/2 – Section A and 7408/3A) should display an appropriate number of significant figures. For non-practical sections, an A-level paper may contain up to 2 marks (1 mark for AS) that are contingent on the candidate quoting the **final** answer in a calculation to a specified number of significant figures (sf). This will generally be assessed to be the number of sf of the datum with the least number of sf from which the answer is determined. The mark scheme will give the range of sf that are acceptable but this will normally be the sf of the datum (or this sf -1).

An answer in surd form cannot gain the sf mark. An incorrect calculation **following some working** can gain the sf mark. For a question beginning with the command word ‘Show that…’, the answer should be quoted to **one more** sf than the sf quoted in the question eg ‘Show that X is equal to about 2.1 cm’ – answer should be quoted to 3 sf. An answer to 1 sf will not normally be acceptable, unless the answer is an integer eg a number of objects. In non-practical sections, the need for a consideration will be indicated in the question by the use of ‘Give your answer to an appropriate number of significant figures’.

3.9 Unit penalties

An A-level paper may contain up to 2 marks (1 mark for AS) that are contingent on the candidate quoting the correct unit for the answer to a calculation. The need for a unit to be quoted will be indicated in the question by the use of ‘State an appropriate SI unit for your answer’. Unit answers will be expected to appear in the most commonly agreed form for the calculation concerned; strings of fundamental (base) units would not. For example, 1 tesla and 1 Wb m^{-2} would both be acceptable units for magnetic flux density but 1 kg m^2 s^{-2} A^{-1} would not.

3.10 Level of response marking instructions

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

Determining 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. i.e. if the response is predominantly level 2 with a small amount of level 3 material it would be placed in level 2.

The exemplar materials used during standardisation will help you to determine the appropriate level. 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	(u =)0.2(0) or 20 or 200 **and** (v =)0.25 or 25 or 250 $_1$✓; substitution of their u and v in $(a =)\dfrac{v-u}{t_3}$ $_2$✓ Where t_3 has been substituted must be $t_3 = 1.19$ (s) $a = 4.2 \times 10^{-2}$ (m s^{-2}) $_3$✓	**Both** velocities seen / allow seen in $(a =)\dfrac{v-u}{t_3}$ / condone (possible) powers of ten (POT) error for 1st mark and 2nd mark in their v and u and any substitution v and u into $(a =)\dfrac{v-u}{t_3}$ Where t_3 has been substituted must be $t_3 = 1.19$ (s) values for: u (0.20 (m s^{-1}) or 20 (cm s^{-1})200 (mm s^{-1})) **and** v (0.25 (m s^{-1}) or 25 (cm s^{-1}) or 250 (mm s^{-1})) correctly combined with t_3 (1.19) will earn 1st and 2nd marks Where u and v are not correct, they must be identifiable as their u and v (2nd mark is only mark available except where error is POT) Allow their $\frac{\Delta v}{1.19}$ (= a) where clear it is their Δv correct result for a will earn three marks; accept 420 mm s^{-2} or 42 cm s^{-2} if m s^{-2} has been replaced on the answer line 2 sf answer only	3
01.2	(set **B** because) it has a greater time / takes longer (to travel between gates) (hence distance between gates is larger) $_1$✓ (and) set **B**’s <u>average velocity</u> is greater / set **B**’s <u>velocity</u> at <u>gate 1</u> is greater / Set **B**’s <u>velocity</u> is greater at both gates	two calculations for gate separation s using either	2

<table>
<tr><td></td><td>OR
(and) set A's average velocity is smaller / set A's velocity at gate 1 is smaller/ Set A's velocity is smaller at both gates $_2$✓

Alternative Method
values of u and v are calculated (condone POT error) and corresponding values for each s determined; $_1$✓
a comparison of their distances leading to conclusion that set B produced when s is largest
OR
ratio ($t_3 \times \frac{t_1 + t_2}{t_1 \times t_2}$) is proportional to distance s and B's ratio is greater $_2$✓</td><td>$(s =)\left(\frac{u+v}{2}\right) \times t_3$ OR $(s) = \frac{v^2 - u^2}{2a}$; OR
$(s =)\, t_3 \times \frac{t_1 + t_2}{t_1 \times t_2}$

<table>
<tr><td></td><td>u/ms^{-1}</td><td>v/ms^{-1}</td><td>s/m</td><td>$v^2 - u^2$/ m^2s^{-2}</td></tr>
<tr><td>set A</td><td>0.164</td><td>0.238</td><td>0.356</td><td>0.0297</td></tr>
<tr><td>set B</td><td>0.181</td><td>0.270</td><td>0.476</td><td>0.0401</td></tr>
</table>

<table>
<tr><td></td><td>$t_3 \times \frac{t_1 + t_2}{t_1 \times t_2}$</td></tr>
<tr><td>set A</td><td>7.12</td></tr>
<tr><td>set B</td><td>9.54</td></tr>
</table>

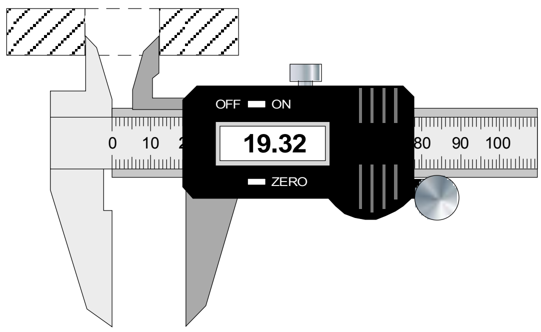
Allow ecf for acceleration where used to find s
Using a =0.042: s_A = 0.354 and s_B= 0.478
Treat a larger change in velocity as neutral</td><td></td></tr>
<tr><td>Question</td><td>Answers</td><td>Additional Comments/Guidelines</td><td>Mark</td></tr>
</table>

<table>
<tr><td>01.3</td><td>Continuous, ruled straight best fit line through 1st and last points $_1$✓

Gradient from $\frac{y\,\text{step}}{x\,\text{step}}$ seen
and
G= 0.045 range (0.042 to</td><td>n=4 point below and n=7 above, other points cut by line of best fit.
Line must not be thicker than half a square grid
Line must have no variation in thickness
Do not accept more than one line drawn, do not accept discontinuities

steps at least half the height and half the width of the grid; (at least 3 squares horizontally and at least 5 squares vertically)
allow $\frac{\text{change in y}}{\text{change in x}}$ where points are on line and are at least half drawn line apart ($\Delta x \geq 3$ and $\Delta y \geq 0.175$)</td><td>2</td></tr>
</table>

	0.053) 2✓	Ignore any units given for G Allow 1 sf answers of 0.04 or 0.05 where correct working is shown.	
01.4	$\frac{\text{their } G}{4.9}$ ✓ $(h = 9.2 \times 10^{-3}\text{ m})$	Ecf from part 1.3 **Expect 2 sf normally**. Penalise 3 or more sf. Condone 1 sf answers where correct working is shown in part 4.1 **and** where their *G* is quoted to 1sf. In this case, allow use of their rounded G or full carry value.	1
01.5	idea that the intercept can be found by calculating *a* – *Gn* where *a* and *n* are values read-off (from a point on the line) and *G* is the gradient ; intercept <u>compared</u> to 0, 0 (OWTTE in a general y=mx +c description) or Read-off points (of line of best fit for) x_1 and x_2 compare with corresponding y_1 and y_2 , <u>compares</u> the ratio of the x terms to the ratio of the y terms; if equal then directly proportional or Determine the constant of proportionality for at least two points (on line of best fit) and <u>compare</u>, where constant exists then directly proportional. ✓	simply explaining how to find the intercept does not fully answer the question and gets no credit must describe the <u>comparison</u> aspect; do not accept idea of extrapolation off the grid or re-plotting on axes that include (0, 0) Idea that *a* and *n* will share a common factorial increase.	1
Total			**9**

Question	Answers	Additional Comments/Guidelines	Mark
02.1	to reduce the impact of systematic error: tare [zero] the callipers before use **OR** take reading with callipers fully closed (at some stage) and subtract from readings $_1$✓ to reduce the impact of random error: take measurement several times for different diameters/directions and calculate mean **OR** take measurement several times for different diameters to check for anomalies $_2$✓		2
02.2	use of inside jaws on callipers required: must have a clear drawing with inside jaws in <u>contact</u> internal diameter$_1$✓	 A ***sectional*** view of the magnet must be given. Jaws must be inside cavity (as here).	1
02.3	Determines a cross-sectional area: (larger A=) 2.82 x 10^{-3} or (smaller area =) 2.932 x 10^{-4} **OR** states that the cross sectional area from Δ $A = \left(\frac{\pi D^2}{4} - \frac{\pi d^2}{4}\right)$ **OR** Calculates one volume correctly $_1$✓	allow POT error $_1$✓ and $_2$✓ where *r* is used must have an additional statement on how *r* relates to *D* (in the case where there is no correct substitution and no correct answer)	3

	substitution of $D = 59.90$, $d = 19.32$ and $t = 12.09$ into $V = \left(\frac{\pi D^2}{4} - \frac{\pi d^2}{4}\right) \times t$ **OR** $V = \text{their } \Delta A \times 12.09$ **OR** Correctly finds difference in ***their*** volumes $_2$✓ 3.1×10^{-5} / 3.05×10^{-5} / 3.053×10^{-5} (m^3) $_3$✓	Or equivalent Correct substitution into $V = \left(\frac{\pi D^2}{4} - \frac{\pi d^2}{4}\right) \times t$ receives the first two marks (allow POT) Expect values: $V_D = 3.41 \times 10^{-5}$ (m^3) $V_d = 3.54 \times 10^{-6}$ (m^3) no limit on maximum sf Correct answer scores 3. Allow 3rd sf round error where answer rounds to 3.1×10^{-5} when correct method seen	

Question	Answers	Additional Comments/Guidelines	Mark
02.4	***Procedure:*** **MAX 2** Take more measurement(s) of *h* for additional / different masses (of clay) ✓ Convert (total) mass into weight (and equal to the repulsive force of magnet **A** on magnet **B)** ✓ Describe method to measure *h* using ruler or set square ✓ ***Analysis***: Plot a graph of *F* against $1/h^3$ ✓ Should be a <u>straight line</u> of best fit ✓ ***Determination of k***: **MAX 1** Measure gradient and set equal to *k* ✓	More than one added mass, allow varies amount of clay condone $1/h^3$ against *F* or equivalent (in this case determination of *k* must be consistent with graph) This mark can be awarded if seen by drawing of straight line with positive gradient on sketch of graph. Allow one mark for plot of *F* against h^3 and statement that area under graph is *k*. Mark ***Procedure*** as scheme.	5

	Substitute (total) weight into formula and rearrange to find k ✓	Must be consistent with graph	

Total			**11**

Question	Answers	Additional Comments/Guidance	Mark
03.1	Mass of alpha particle = $\dfrac{2\times1.6\times10^{-19}}{4.81\times10^{7}}$ =$6.6(53)\times10^{-27}$ (kg) **OR** Correctly re-arranged k.e. equation (with v^2 or v as subject) with 8.1 x 10^{-13} (J) substituted correctly 1✓ 1.56×10^{7} seen 2✓	Allow mass = 2 × m_p + 2 × m_n = 6.696 × 10^{-27} kg Allow mass = 4 x 1.66 x10^{-27} kg = 6.64 × 10^{-27} kg Allow mass = 4 x 1.67 x10^{-27} kg = 6.68 × 10^{-27} kg Allow slight rounding on mass (must be correct to 2 sf) Condone **incorrect mass** in otherwise correct substitution **with *v* or v^2 recognisable** as subject . Alternative approaches are: $v=\sqrt{\dfrac{E_k\times\text{specific charge}}{e}}$ $v=\sqrt{\dfrac{2\times E_k}{m_\alpha}}$ Must see answer to at least 2 sf Must see attempt to use one of the alternative approaches to support correct answer.	2

03.2	Use of $W=Fs$, $F = 8.1 \times 10^{-13} \div 3.5 \times 10^{-2}$ 1✓ (F=) 2.3×10^{-11} (N) 2✓ **OR** Use of an appropriate equation of motion to find a **and** $F=ma$ *(allow their mass and their velocity in this sub)* 1✓ (F=) 2.3×10^{-11} (N) 2✓ **OR** Use of an appropriate equation of motion to find t **and** $F=\Delta mv/t$ *(allow their mass and their velocity in this sub)* 1✓ (F=) 2.3×10^{-11} (N) 2✓	Condone POT error Correct answers gets 2 marks Condone POT error Condone POT [answer is $\frac{(\text{their speed})^2 \times (\text{their } m_\alpha)}{0.070}$ Using 2 x 10^7 m s^{-1} yields(5.71 x 10^{15} x their $m_{\alpha)}$ – allow 1 sf answer in this case. Expect to see 3.8 x 10^{-11} (N) or 4 x 10^{-11} (N)]	2
03.3	(Number of ions formed over range =) $5.1 \times 10^4 \times 3.5$ seen **or** 1.785×10^5 (ions) seen Or 8.1 x 10^{-13} converted to eV seen 1✓	Condone POT error in first mark Ignore units	3

	$8.1 \times 10^{-13} \div 1.785 \times 10^{5}$ **Or** $5.06 \times 10^{6} \div 1.785 \times 10^{5}$ seen $_2$✓ 28 (.4) (eV) $_3$✓	$8.1 \times 10^{-13} \div (5.1 \times 10^{4} \times 3.5)$ is worth 1^{st} and 2^{nd} marks Condone POT errors in second mark Correct answer obtains 3 marks 99(.3) (eV) scores 1 mark	
03.4	$(Q =)\ 0.85 \times 10^{-3} \times 1.2 \times 10^{-9} = 1.02 \times 10^{-12}$ **OR** $n =$ (their Q) $\div\ 1.6 \times 10^{-19}$ $_1$✓ $n = 6.4 \times 10^{6}$ (c.a.o.) $_2$✓	Condone one POT error for one mark.	2
03.5	At 3.5 cm the pd drops / the current begins **OR** When the source is 10 cm away no ionisation occurs in the air gap (because the alpha particles have insufficient range to reach the air gap) **OR** When the radioactive source is <u>close enough</u> (approx. 5 cm) ionisation occurs ✓ OR When beyond 3.5 cm no change in pd / current equals zero <u>When ionisation occurs / charge carriers are liberated in the air gap</u>: resistance has decreased **OR** current increases (from zero) **OR** the potential difference decreases (with a maximum current) (to its minimum value) (across the air gap)✓	Must be sense of abrupt change MAX 3 Allow more ionisation for second mark	3

	From 10 cm separation until 5 cm (approx) separation nothing changes / appreciates that pd is 4500 V / pd across gap = 4500 V until ionisation occurs ✓ Current is produced: the pd across 5 MΩ resistor is 4250 V / most pd is across the 5 MΩ resistor / small pd across air gap ✓ Current is produced and the pd across the air gap is 250 V✓ Current is produced and the pd across the air gap is 250 V✓		

Question	Answers	Additional Comments/Guidance	Mark
04.1	Use of $n_A = \frac{c}{c_A}$ to make c_A the subject of the equation or speed in glass **A** = $2.05(2)\times 10^8\ \text{ms}^{-1}$ $_1$✓ Speed in glass **B**= $1.985(3)\times 10^8$ or their speed in glass **A** $\times 0.96748$ (*or equivalent*) $_2$✓ or Alternative 1st and 2nd marks Use of $n_A/n_B = c_B/c_A$ by substitution for n_A $_1$✓ Use of $n_A/n_B = c_B/c_A$ by substitution for n_A and $c_B = c_A \times 0.96748$ $_2$✓ Or n_B = 1.461 / 0.96748 $_1$✓$_2$✓	Condone truncation without appropriate rounding mid-calculation. Condone use of c= $3\text{x}10^8$ But must see answer to 4 sf answer Values obtained using c= $3\text{x}10^8$: • speed in glass A= $2.05(3)\times 10^8\ \text{ms}^{-1}$ • speed in glass B = $1.98(7)\times 10^8$ • n= 1.510 watch for maths errors: dividing by 1.03252 ≠ multiplying by 0.96748	3

	1.510 cao to 4 sf only 3✓	multiplying by 1.03252 ≠ dividing by 0.96748 Correct answer to 4 sf obtains all 3 marks. Penalise any unit on final answer.	

04.2	**Relationship**: Increase in tension (or stress) in cable produces increase in strain resulting in increase in λ_R **Or** Decrease in tension (or stress) causes decrease in strain resulting in decrease in λ_R. 1✓ **Variation due to motion**: As the lift accelerates downwards, (the tension is less than the weight in the cable, a decrease in tension results) in λ_R decreasing 2✓ At constant velocity (the tension again equals the weight and) λ_R returns to the initial, at rest value 3✓	Allow a correct comment on the directional relationship between tension, strain and λ_R independent of the motion of the lift for first mark	3

04.3	**P** because it will produce a larger increase in λ_R for the (same) <u>increase</u> in strain **Or** **P** because it has a larger gradient (must be a sense of larger increase in λ_R for the (same) <u>increase</u> in strain) ✓ Hence <u>smaller accelerations</u> (which produce small changes in strain) can produce <u>measurable changes in λ_R</u> **Or** Hence gauge **P** will have a higher resolution ✓	Selecting Q gains zero marks Linking steeper gradient to being able to withstand a larger force negates this mark. Allow more accurate measurement of <u>acceleration</u> Allow more readings of <u>acceleration</u> can be taken (over the range) More sensitive treat as neutral	2

Total			**8**

	Keys to Objective Test Questions (each correct answer is worth 1 mark)												
Q	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
A	B	C	B	C	C	D	D	C	B	D	D	A	D
Q	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
A	C	A	C	C	B	B	D	A	D	A	A	D	C
Q	**31**	**32**	**33**	**34**									
A	A	A	B	B									