AQA

AS
PHYSICS
7407/1

Paper 1

Mark scheme

June 2020

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206A7407/1/MS

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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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/Guidance	Mark	ID details
01.1	Lepton number = 0 **and** Strangeness = 0✓ charge = (+)1(e)✓	accept (+) 1.6 x 10^{-19} (C) condone lack of unit	2	AO2.1b AO2.1b
01.2	Proton / p / $^{1}_{1}\mathrm{H}$ ✓	Apply ECF to answers any particle other than a proton. The particle must be correct for the given L, S and Q. (clip with 2.1)	1	AO2.1b
01.3	Tick in first box only✓	(electron) antineutrino $\bar{\nu}_{(e)}$	1	AO1.1a

<table>
<tr><th>Question</th><th>Answers</th><th>Additional Comments/Guidance</th><th>Mark</th><th>ID details</th></tr>
<tr>
<td>01.4</td>
<td>
The marking scheme for this question includes an overall assessment for the quality of written communication (QWC). There are no discrete marks for the assessment of QWC but the candidate's QWC in this answer will be one of the criteria used to assign a level and award the marks for this question.
<table>
<tr><th>Mark</th><th>Criteria</th><th>QWC</th></tr>
<tr><td>6</td><td>All 3 areas A, B and C covered
Only allow minor omissions</td><td rowspan="2">The student presents the relevant information coherently, employing structure, style and SP&G to render meaning clear. The text is legible.</td></tr>
<tr><td>5</td><td>2 complete descriptions with one partial from A, B and C.</td></tr>
<tr><td>4</td><td>Full description of one area, with partial description of two other.
OR
Full description of two areas with very little on third or nothing at all.</td><td rowspan="2">The student presents relevant information in a way which assists the communication of meaning. The text is legible. SP&G are sufficiently accurate not to obscure meaning.</td></tr>
<tr><td>3</td><td>A full description of one area and a partial description of one area.
OR
A partial discussion of all three areas.</td></tr>
<tr><td>2</td><td>A full description of one area.
OR
A partial discussion of two areas.</td><td rowspan="2">The student presents some relevant information in a simple form. The text is usually legible. SP&G allow meaning to be derived although errors are sometimes obstructive.</td></tr>
<tr><td>1</td><td>Only one area covered, and that partially.</td></tr>
<tr><td>0</td><td>No relevant information</td><td></td></tr>
</table>
</td>
<td>
The following statements are likely to be present.

Area A
Hadrons properties:

Identifies hadrons as consisting of quarks
May interact via the strong nuclear force

Area B
General structure:

Two classes are mesons and baryons
quark-antiquark: meson
Quark, quark, quark: baryon

Area C
Stability of free hadron:

Only stable free baryon is proton
Example of decay of a free meson or baryon e.g. kaon decay into pions / states neutron decays into a proton

</td>
<td>6</td>
<td>AO1.1a
AO1.1a
AO1.1a
AO1.1a
AO1.1a
AO1.1a</td>
</tr>
</table>

Total			10	
Question	**Answers**	**Additional Comments/Guidance**	**Mark**	**ID details**
02.1	Use of $E_k = ½ mv^2$ ✓ (Kinetic energy =) 9.2×10^9 (J)✓ An answer to 2 significant figures (with some working)✓	Condone POT error on 1st MP Allow use where v where has been converted from 5.5 km h^{-1} Significant figure mark requires evidence of some relevant working.	3	AO1.1a AO2.1b AO1.1b

02.2	**Why force on the gas:** The gas's momentum is changing✓ This require a force according to **Newton's 2nd law** ✓ Or The gas is being accelerated✓ This require a force according to **Newton's 2nd law** ✓ **Why (resistive) force on system:** The gas exerts a force on the parachute (with an equal magnitude and opposite direction force) / there is air resistance (on the system) / there is drag (on the system) / there is a resistive force (on the system)✓ (because) the Parachute exerts a force on the gas according to **Newton's 3rd law** ✓ **Why system decelerates:** The resistive force is <u>greater than the weight</u> so there is a resultant force **Or** The **resultant** force is acting in the opposite direction (to its motion). ✓ acceleration in same direction as resultant force according to **Newton's 2nd law** ✓	**Max 3** for **why there is a force on the gas** and **why there is a resistive force on the system** Must have **why the system decelerates** to obtain all **4 marks**. The reason why the resultant force causes the deceleration rather than the acceleration. Allow statement that is equivalent to N1 / N2 / N3. Allow: air resistance (or drag) increases. Allow: there is an upward force must have a clear action-reaction pair for this **N3** mark. allow the **resultant** force is vertically upwards **Or** **Links** to violation for conditions of Newton's 1st law and therefore cannot continue at constant velocity.	4	AO2.1a AO2.1e AO2.1a AO2.1e

Question	Answers	Additional Comments/Guidance	Mark	ID details
02.3	Attempt at determining difference = $3.3\ (\times 10^5) - 2.2\ (\times 10^5)$ or difference = 1.1 (x 10^5)✓ Use of $E_p = mgh$✓ (g =) 3.7 (m s^{-2}) ✓	1st mark: Credit an application of conservation of energy (allow written statement, or equation without substitution) Ignore signs on difference and answer. MP2 allow their energy in a substitution that is, otherwise correct. Condone an answer = 18.4 (m s^{-2}) is worth 2 marks. Condone mgh = ½ mv^2 where rearranged to make g subject. Condone 610 x g x 49 = t**heir energy** Alternative: • Attempt to use appropriate equations of motion to determine acceleration $v^2=u^2+2as$ rearranged to make a the subject (condone use of their values for v and u and / or g = a) • Attempt to use W=Fs to determine the air resistance F_D (or F_D= 6734(.7) (N) seen) • Attempt to determine g from the deceleration of the system $g = \frac{F_D - ma}{m}$	3	AO2.1f AO1.1a AO2.1b

02.4	More mass to **displace** / more particles to **collide with** / more gas / dust to displace ✓ (at any given speed) Greater (rate of) change of momentum / More work done (per unit distance) / Greater (resistive) force / more kinetic energy transferred (per unit distance) ✓ Greater **resultant** force **on** the system (therefore greater deceleration) / greater loss of velocity per second (therefore greater deceleration) ✓	Must have some interaction with parachute-spacecraft. N/E to say there are more particles / gas / dust /mass 3rd MP for greater resultant force: allow the idea that the difference between the drag and weight has increased 3rd MP Allow clear statement that links: • rate of change of momentum of gas / dust to rate of change of momentum of system • rate of work done on gas / dust to rate of work done by system	3	AO3.1b AO3.1b AO3.1b

Total			**13**

Question	Answers	Additional Comments/Guidance	Mark	ID details
03.1	Use of an appropriate equation of motion✓ (v =) 0.35 (ms^{-1}) ✓	Where $v^2 = u^2 + 2as$ is correctly stated, condone one error in substitution e.g. sign of a Where other equations are used it must be clear that v can be determined. Must see v as subject and an attempt to determine t. Allow more than 2 sf where correct.	2	AO1.1a AO2.1b
03.2	Use of tan 35 = u_v / 8.8 Or Use of u cos 35 = 8.8 and u_v = u sin 35 and 6.2 or 6.16 with supporting a calculation✓	Alternative: credit use of sine rule Must see answer to at least two significant figures	1	AO2.1b

03.3	Use of an appropriate equation of motion✓ ECF (t=) 0.63 (s) ✓ ECF		Condone their incorrect value of u in this substitution. Condone errors in signs in substitution Where other equations are used it must be clear how t can be determined. Must see t as subject and an attempt to determine s. 0.61 (s) for use of $u = 6\ \text{m s}^{-1}$ For MP2, where their value of u is used, the answer must be consistent with this value. **Only** allow this use where their value of u, to 1 significant figure, = (5<u<7) m s^{-1} Condone 1 significant figure answer where U is 1 sig fig.	2	AO1.1a AO2.1b

Question	Answers	Additional Comments/Guidance	Mark	ID details
03.4	Use of an appropriate equation of motion ✓ ECF (h =) 1.9 (m) ✓ ECF	Where equation is correctly stated, condone one error in substitution e.g. **one error on sign** of a substituted value **or** one incorrect value substituted (of course, ecf is acceptable) h = 1.83 m for use of u = 6 m s^{-1} allow ecf on t (check 3.3) For MP2, where their value of u is used, the answer must be consistent with this value. **Only** allow this use where their value of u, to 1 significant figure, = (5<u<7) m s^{-1} allow reverse calculation where u=0 and v = 6 m s^{-1}	2	AO1.1a AO2.1b

03.5	Smooth curve with maximum turning point seen, curve starts at the ball and finishes at **X**✓	Curve should be approximately parabolic in shape. Curve must start below the label 'golf ball' and ends within 5mm of the ball or the label **X**. Curve must have a maximum turning point.	1	AO3.1b

03.6	(Increase the angle to horizontal so) the ball must go higher (and increases its time in the air) **Or** (Increase the angle to horizontal so) the ball must have a greater (initial) vertical velocity ✓ (Covers the same horizontal distance over) a longer time in the air (so has a smaller horizontal velocity)✓ Alternative: Increased angle (to horizontal of projection) so smaller horizontal velocity✓ must be falling towards ground to land at **X**✓	(Increase the angle to horizontal so that) the vertical velocity greater than the horizontal / increase the vertical decreases the horizontal	2	AO3.1b AO3.1b

Total			**10**

Question	Answers	Additional Comments/Guidance	Mark	ID details
04.1	(mass of ion =) 1.8(4) × 10^{-26} (kg) ✓		1	AO2.1b
04.2	(Mass of ion divided by mass of nucleon=) 10.6 or 10.8✓ ECF (number of nucleons=) 11 ✓ **ECF**	allow 1 mark for 10 seen as final answer whole number not in standard form	2	AO2.1b AO2.1b
04.3	Same number of protons✓ **X** has more neutrons (than **Y**) Or **Y** has fewer neutrons (than **X**)✓	Allow 'same proton number' but **not** same 'atomic number' Allow: isotopes have same number of protons Condone any mention of electrons ' X has more nucleons' or 'Y has fewer nucleons' insufficient	2	AO1.1a AO2.1a

Question	Answers	Additional Comments/Guidance	Mark	ID details
04.4	Specific charge on ion **X** is less than specific charge on **Y** Or Specific charge on ion **Y** is greater than specific charge on **X** ✓ Specific charge is inversely proportional to mass (for the same charge) ✓	Or words to that effect Where equation is stated, the symbols must be defined or standard symbols must be used.	2	AO2.1a AO2.1a

04.5	Specific charge of sample determined correctly✓ Specific charge of each sample determined correctly ✓ Sample 2 has a greater percentage **because** it has a higher specific charge ✓ **Or** Mean mass of a nucleon in a sample determined correctly✓ Mean mass of a nucleon in each sample determined correctly✓ Sample 2 has a greater percentage **because** the nucleons have a lower mean mass. ✓ Or Mean mass of a nucleon in a sample determined correctly✓ Multiples by this average by number of nuclei in the other sample✓ Sample 2 has a greater percentage **because** the nucleons in sample 2 have a lower average mass. Or Sample 2 because it has a lower mass if both samples had the same number of ions✓ **Or** 10^9 times smaller in number but more than 10^9 times smaller mass ✓ (Therefore) sample 2 must have a lower mean mass (than sample 1)✓ Sample 2 has a greater percentage of **Y because Y** has less mass than X ✓	Mean mass of a nucleon sample 1= 1.8×10^{-26} kg Mean mass of a nucleon sample 2 = 1.77×10^{-26} kg Specific charge of sample 1 = 8.8×10^6 (C kg^{-1}) Specific charge of sample 2 = 9.0×10^6 (C kg^{-1}) Conclusion must be supported by at least one relevant, correct calculation Condone one power of ten error in one calculation. Accept converse statements. Condone incorrect units	3	AO3.1a AO3.1a AO3.1a

Total			**10**

Question	Answers	Additional Comments/Guidance	Mark	ID details
05.1	Work done in moving 1 C of charge through the cell✓ 1.5 J of work is done in moving 1 C of charge through the cell ✓ OR Amount of energy converted from other forms to electrical energy per 1 C of charge ✓ 1.5 J of energy converted from other forms to electrical energy per unit charge (passing across the emf) ✓ OR Work done in moving 1 C of charge (whole way) round circuit✓ 1.5 J of work is done in moving 1 C of charge the (whole way) round circuit ✓	2nd marking point obtains both marks **Max 1 mark** available for the following: The emf is the terminal pd when there is no current in the cell (and this equals 1.5 V) 1.5 J of energy per 1 C of charge. Allow a statement of Kirchhoff's 2nd law for 1 mark. Where the law is in symbol form, the meaning of the symbols must be stated. Need a clear communication of internal and external resistances.	2	AO1.1a AO2.1f
05.2	P= VI **And** (P) = 0.465 (W) ✓	Seen to more than 2 sf with supporting equation with subject seen in working	1	AO2.1b

05.3	Use of appropriate power equation to determine wasted power **or** power dissipated in **R** = total power – their wasted power ✓ $(P =)$ 0.40 W ✓	Alternative for 1 mark: Use of $I = \frac{\varepsilon}{R+r}$ **Or** pd across R = 1.5 – 0.65 x 0.31 or pd across R = 1.2985 (V) or total resistance = 1.5/ 0.31 or total resistance = 4.839 (Ω) or R = 4.2 (Ω) **or** $P = I^2$ x their R **or** P = $\frac{V^2}{R}$ using their V and R✓	2	AO1.1a AO2.1b

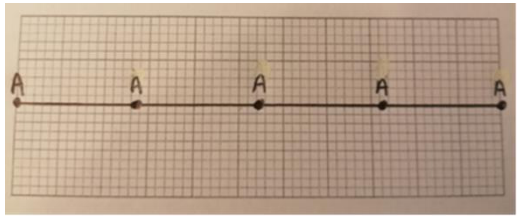
Question	Answers	Additional Comments/Guidance	Mark	ID details
05.4	Use of $E = P\,t$ *or* $E = VI\,t$ *Or* $E = QV$ ***and*** $Q = It$✓ (t =) 3.0(1) x 10^4 (s) ✓	Allow use of the equation with their values. An answer of 3.5 x 10^4 is worth 1 mark	2	AO1.1a AO2.1b

Question	Answers	Additional Comments/Guidance	Mark	ID details
05.5	**MAX 3 from (1 to 4) or (5 to 8)** It is suitable, because: (1) Current required in lamp = 0.62 A or use of I=$\frac{P}{V}$ seen (2) Resistance of lamp = 2.11 Ω or use of R= $\frac{V^2}{P}$ *seen* ✓ (3) current in each cell = 0.31 A✓ (4) lost volts = 0.2 V or lost volts = 0.65 x 0.31✓ **Conclusion: yes,** terminal pd = **1.5 – 0.2** seen or terminal pd= 1.5 – 0.65 x 0.4 /1.3✓ **OR** (5) total internal resistance = 0.325 Ω ✓ (6) total resistance in circuit = 2.44 Ω✓ (7) Resistance of lamp = 2.11 Ω✓ (8) pd splits in ratio of 0.325:2.11 ✓ **Conclusion:** yes, pd **across lamp is** $\frac{2.11 \times 1.5}{2.44}$ **(= 1.3 V) seen** ✓	Check **Figure 7** Must have the **correct conclusion to award 4 marks.** Allow max 3 from a combination of two route [(2) and (7) worth total of 1 mark]	4	AO3.1a AO3.1a AO3.1a AO3.1b

Question		Answers		Additional
5.6	(Cells must be added) in parallel ✓ Because: more energy stored in the bank of cells / less power from each cell✓ without increasing the voltage across the bulb (above 1.5 V) **or** without increasing the terminal pd (above 1.5V)✓	Must link the cells being added in parallel to one or both reason to gain three marks. Alternative: • In parallel • Current shared by cells • Takes longer to convert the energy stored in each cell. Alternative: • In parallel • Less internal resistance • Less power / energy wasted Cells in series statement means no marks can be obtained.	3	AO3.1a AO3.1a AO2.1g
Total			**14**	

Question	Answers	Additional Comments/Guidance	Mark	ID details
06.1	**Max 2** Antiphase / completely out of phase / π radian out of phase✓ Similar amplitudes (of vibration) **or** similar (magnitudes of) displacement (at any instant in time) ✓ Same period **or** same frequency✓ Move with the same speed✓	Allow ½ cycle or 180° out of phase Condone: 'Move in opposite directions' 'Displaced in opposite directions' 'when P is at its peak then Q is at its trough' for loose descriptions of antiphase 'Opposite amplitudes' too vague (treat as neutral) 'When P is positive Q is negative' too vague Allow same amplitude / same (magnitude of) displacement	2	AO1.1b AO1.1b

06.2	Use of $v = f\lambda$ or determines the wavelength = $0.275\ \text{m}$✓ (v =) 69 m s^{-1} ✓	Condone use of wavelength = 0.55 m or 0.1375 m in substitution for 1st MP Condone Power of ten errors on wavelength for 1st MP Two errors forfeit 1st mark: Allow wavelength in range 0.27 to 0.28 m Allow answers in range 67.5 to 70.0 m s^{-1}	2	AO1.1a AO2.1h
06.3	Same speed ✓ Moving in opposite directions✓ same wavelength / same frequency/ similar amplitudes ✓	The following are insufficient: Progressive / transverse / transfer energy Allow same amplitudes	3	AO1.1a AO1.1a AO1.1a

Question	Answers	Additional Comments/Guidance	Mark	ID details
06.4	Horizontal line drawn from **P** to **Q** ✓		1	AO2.1g
06.5	Marks an A at each end of the string ✓ Marks all 5 As (evenly spaced by eye) on a horizontal line✓ **cao**	Condone other incorrect antinodes or nodes drawn (1st MP) Penalise incorrect number A or poorly positioned A (2nd MP) 	2	AO2.1g AO2.1g

06.6	Third harmonic / third harmonic drawn in **Figure 13**✓ Frequency for first harmonic has reduced to 1/3 of previous or f = $\frac{1}{3} \times \frac{1}{2L}\sqrt{\frac{T}{\mu}}$ or speed reduces to 1/3 of previous ✓ String being driven at three times this frequency✓	Must be a clear statement that this is 3rd harmonic / accept 3 symmetrical loops drawn in **Figure 13** Where no other mark has been scored allow **1 mark** for: • Speed decreases • Fundamental frequency is lower/ frequency of 1st harmonic is lower • use of f = $\frac{1}{2L}\sqrt{\frac{T}{\mu}}$ where 9μ has been substituted correctly (accept in any correct rearrangement)	3	AO3.1a AO3.1a AO3.1a

Total			**13**