A-level

PHYSICS

7408/1

Paper 1

Mark scheme

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236A7408/1/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.

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

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. ie 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	AO
01.1	uds ✓	Do not accept D for d. Penalise extra particles	1	AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
01.2	weak (interaction / force)✓ strangeness changes (in this decay)✓ (from -1 to 0 and strangeness can only change in a weak interaction)	MP2: Reject negative arguments (eg 'strangeness is conserved in a strong interaction') Reject the idea that strangeness **always** changes in a weak interaction. General statement of strangeness conservation in the weak interaction on its own is insufficient. Accept "strangeness is not conserved (in this decay)". Condone "strangeness is lost".	2	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
01.3	anti-neutron ✓	Accept $\bar{n}$ Reject ambiguous answers unless supported by other evidence. Do not accept answer solely in terms of quarks	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
01.4	$1.1(1) \times 10^3$ (MeV) ✓	Reject incorrectly rounded answers. Accept: 1100 MeV (2sf) / 1110 MeV (3sf) / 1115 MeV (4sf) etc Calculator value: 1114.66875 MeV	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
01.5	Any **one** from ✓ (teams must be large and international) because: • research is expensive / requires funding from many countries • both scientists and engineers are required (because the machines used for research are complex/large pieces of civil engineering) • research is multi-faceted / multi-disciplinary (because computation/theory/ etc. is required) • research is round-the-clock (so teams are large to work on shift basis) • they are needed to process the large amounts of data produced	Treat idea of peer review as neutral (this argues for independent teams). Do not accept idea that it ‘avoids bias’ or ‘reproducibility’.	1	AO1
Total			**6**	

Question	Answers	Additional comments/Guidelines	Mark	AO
02.1	Conversion of $1230\ \text{km h}^{-1}$ to m s^{-1} OR Calculates time for $343\ \text{m s}^{-1}$ run OR Calculates total time (using total distance, $3.22\ \text{km}$, and speed record) OR Calculates unknown speed ✓ Answer that rounds to 4.73 (s) ✓	Expect to see $342\ \text{m s}^{-1}$ (341.7) Expect to see $4.69\ \text{s}$ Expect to see $9.42\ \text{s}$ Expect to see $340.3\ \text{m s}^{-1}$ Do not accept 2sf for final answer.	2	AO1 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
02.2	speed from graph: $450\ \text{m s}^{-1}$ ✓ Use of their speed and KE equation to give consistent answer ✓	Accept 445 – 455 m s^{-1} Expect to see 6.6×10^{8} (J)	2	AO3 AO2

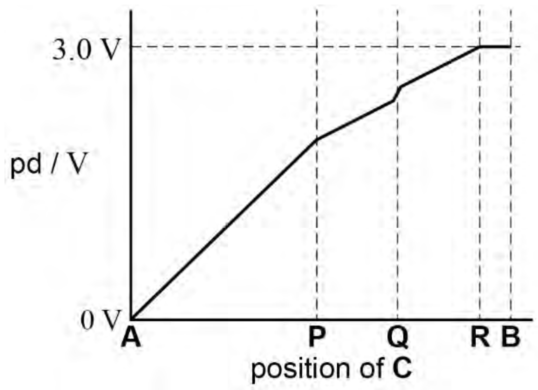
Question	Answers	Additional comments/Guidelines	Mark	AO
02.3	**MAX three** from: ✓✓✓ • Use of graph to determine gradient • Uses (their) speed and (their) gradient to give acceleration • Use of $F = m \times$ (their a) to give resultant force • Use of $P =$ (their F) $\times$ (their speed) Final answer between 16% and 17%✓	Expect to see $450\ \text{m s}^{-1}$ for their speed Evidence for gradient may be on figure Allow ECF from **02.2** • $\frac{450}{5600} = 0.080(4)$ • Expect to see $450 \times 0.08 = 36(.2)\ \text{m s}^{-2}$ • Expect to see 2.35×10^5 N • Expect to see $450 \times 2.35 \times 10^5 = 106$ MW Reject power that is calculated assuming a constant speed.	4	AO1 AO2 2× AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
02.4	Identifies distance decelerating **AND** max velocity = (470 ± 5) m s^{-1} ✓ Uses *suvat* equation(s) to get a = (−) 15 m s^{-2} which is less than $3g$ (so yes). ✓	allow 7000 m to 7600 m allow answer consistent with their distance that rounds to 15 or 16 give full credit to calculations that show that an acceleration of $3g$ would stop the car in a (much) shorter distance, with a statement that this means that the actual acceleration must be (much) less than $3g$. For MP2 allow calculation of gradient × average speed to give a = (−) 15 m s^{-2} which is less than $3g$ (so yes)	2	AO3
Total			**10**	

Question	Answers	Additional comments/Guidelines	Mark	AO
03.1	(1 C of) the charge gains ε J on passing through cell OR energy transferred (by 1 C) in R_1 is V_1 (J) OR energy transferred (by 1 C) in R_2 is V_2 (J) OR energy transferred (by 1 C) in r is Ir (J) ✓ (for conservation of energy) $\varepsilon = IR_1 + IR_2 + Ir$ ✓	If no other mark awarded, allow one mark for definition of emf in terms of energy transfer. accept: ‘dissipated’ accept ‘lost volts’ for Ir but reject ‘voltage across r’ accept ‘work done’ for ‘energy transferred’ Alternative for MP2 $\varepsilon = V_1 + V_2 + Ir$ provided that MP1 is awarded.	2	AO1

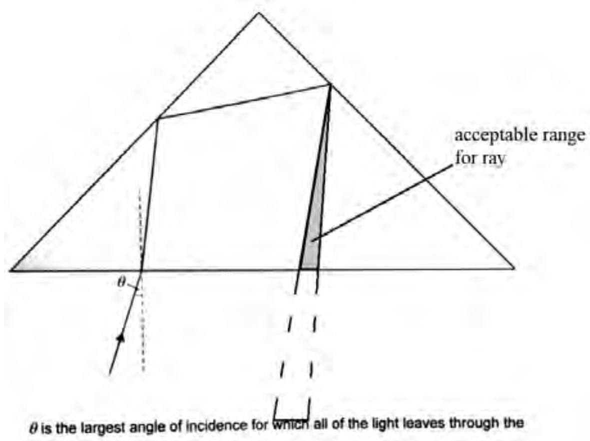
Question	Answers	Additional comments/Guidelines	Mark	AO
03.2	Equates emf to $Ir + 2.89$ in some form✓$_1$ Calculates I from $2.89 \div 125$ (=0.02312 A) ✓$_2$ Giving $r = 4.76$ (Ω) ✓$_3$	If no other mark awarded, award one mark for use of emf value in MP2. Allow in MP1 (their current/A) ×125Ω for 2.89 V Allow alternative routes for ✓$_1$ and ✓$_2$. E.g. 'Lost volts'= 0.11 V ✓$_1$ Applies potential-divider equation e.g. $0.11 \div 2.89 = r \div 125$ ✓$_2$ OR $3 \div (125 + r) = 2.89 \div 125$✓$_1$✓$_2$ Must see at least 3 sf answer Answer must round to 4.76(Ω)	3	AO2 × 3

Question	Answers	Additional comments/Guidelines	Mark	AO
03.3	(Resistance splits $25\ \Omega$ and $104.8\ \Omega$) Applies potential divider formula eg $\frac{V}{3.00} = \frac{25}{129.8}$ ✓ $V = 0.58$ (V) ✓	Accept other routes for MP1 e.g. using $V = IR$, with $25\ \Omega$ and their current, for example from • $I = 0.023$ A (from Q03.2) • $I = \frac{\text{emf}}{\text{total resistance}} = \frac{3}{125 + r}$ • $I = \frac{terminal\ pd}{125}$ **OR** using $V = \frac{2.89}{5}$ with an identification of 2.89 V as the terminal pd. If no other mark awarded, allow one mark for using $29.8\ \Omega$ instead of $129.8\ \Omega$ for total resistance giving 2.5(2) V.	2	AO2× 2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.4	Any **four** from: Straight line 0 V **A** to **P** $_1$✓ Less steep non-zero gradient from **P** to **Q** $_2$✓ Short steep increase at **Q** $_3$✓ **Q** to **R** about same non-zero gradient as **P** to **Q** $_4$✓ Horizontal line from **R** to **B** at 3.0 V $_5$✓	 For $_3$✓ allow range no greater than width of "**Q**" label on horizontal axis. If graph sketched from 3 V (at **A**) to 0V (at **B**) award **max 2** (based on $_2$✓ and $_4$✓). If a single diagonal straight line from 0 V (at A) to B, award $_1$✓only. If a single diagonal straight line from 0 V (at A) to R and then horizontal to B, award only $_1$✓ **and** $_5$✓ if scored (**ie max 2**).	Max 4	AO3 × 4
Total			**11**	

Question	Answers	Additional comments/Guidelines	Mark	AO
04.1	Uses $\sin c = \frac{1}{n}$ to get 1.51 ✓	Must see relevant work to award the mark. Minimum 3 sf must be seen	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
04.2	(Each) angle of incidence is 45° (at 2nd and 3rd surfaces) AND total internal reflection occurs / which is greater than the critical angle. ✓ Angle of incidence as ray leaves block is 0° OR The ray leaves along the normal (and so the ray emerges parallel to the incident ray). ✓		2	AO1 AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
04.3	Only (totally internally) reflected ray seen at 2nd reflecting boundary ✓ Reflected ray parallel to first refracted ray (by eye)✓ Ray leaves parallel to initial ray (by eye) ✓	For MP2:  	3	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
04.4	Angle of incidence at 2nd reflecting boundary = 41.5° ✓ Angle of reflection at 1st reflecting boundary = 48.5° ✓ Angle of refraction at entry = (90° – 45° – 41.5°) = 3.5° ✓ Use of n = 1.5 and Snell's law to give 5.3° to at least 2 sf ✓	MP1 is an identification of angle at 2nd reflecting boundary MP2 is (90°- their angle at 2nd reflecting boundary) MP3 is (45° - their angle at 2nd reflecting boundary) Accept answer that rounds to 5.3° The identification of their angles can be inferred from their working or diagram. Simply writing 90° – 41.5° = 48.5° does not get a mark on its own.	4	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
04.5	Using 60° prism (Fig 9) does not work because: • light would not leave the prism at the original angle ✓ • idea that light will escape from second reflection ✓ A smaller n (Fig 10) does not work because: • larger critical angle ✓ • which would reduce the value of θ ✓	Suggestion that the design would work limits the mark to Max 1 for that design. Alternative for MP2 Light would no longer be totally internally reflected at second reflection OR angle of incidence at second reflection is now less than the critical angle	4	AO3
Total			**14**	

Question	Answers	Additional comments/Guidelines	Mark	AO
05.1	Evidence of appropriate use of Figure 11 e.g. $105 \times 10^{6} \div 7.5 \times 10^{-4}$ leading to an answer in the range 1.38 to 1.42×10^{11} Pa ✓	Some evidence that Figure 11 is used: calculation based on a point on line between 75 MPa and 125 MPa OR calculation from point on straight line extended OR Use of triangle from more than half of the linear section. Allow 2 sf answer 1.4×10^{11} (Pa).	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
05.2	Idea that wire undergoes only (very) small (increase in) strain beyond the linear section before fracture ✓	Reject idea that there is **no** increase in strain. Condone ‘extension’ or ‘(plastic) deformation’ for ‘strain’. Condone ‘shortly after’ for ‘beyond’ Accept: does not show 'necking' before fracture Accept: fracture occurs very near the limit of proportionality (condone ‘elastic limit’). Accept references to a particular value of strain e.g. 9×10^{-4} to 12.7×10^{-4}	1	AO1 × 1

Question	Answers	Additional comments/Guidelines	Mark	AO
05.3	Evidence of determination of total load or load on one wire ✓ (halves load) Use of $E = \frac{(\text{their } F) \times L}{A \times \Delta L}$ ✓ $\Delta L = 1.1(4) \times 10^{-3}$ (m) ✓	Total load = $(4.4 + 16.0) \times 9.8(1) = 200(.1)$ N Allow 'g' for 9.8(1) Expect to see F =100 N and $A = 5.03 \times 10^{-7}$ m^2. Condone use of d in calculation of cross-sectional area A in MP2. Or separate calculations using $\sigma = F \div A$, $E = \sigma \div$strain, strain = $\Delta L \div L$ Condone POT error in MP2.	3	AO1× 1 AO2× 2

Question	Answers	Additional comments/Guidelines	Mark	AO
05.4	Evidence of extension/strain in each wire is the same 1✓ Substitutes data leading to $F_a = 1.33\ F_s$ 2✓ Calculates F_s or F_a 3✓ Evidence of an attempt at a moment equation 4✓ Distance = 1.18 m ✓5	$\Delta L = \{FL \div AE\}$ steel = $\{FL \div AE\}$ aluminium $\{F \div d^2E\}$ steel = $\{F \div d^2E\}$ aluminium 1✓ $\frac{F_s}{0.8^2 \times 210} = \frac{F_a}{1.6^2 \times 70}$ $F_a = 1.33\ F_s$ OR $F_s = 0.752\ F_a$ 2✓ $1.33\ F_s + F_s = 200$ N $F_s = 86$ N, $F_a = 114$ N 3✓ Attempt to take moments about A or B or other suitable point, expect to see $16.0gx = 228 - 4.4g$ ✓4 Note that an answer of 1.14 m comes from not taking into account the weight of the beam Award **max 4** for this approach. ECF for MP2 and MP3 in MP4	5	AO3× 5
Total			**10**	

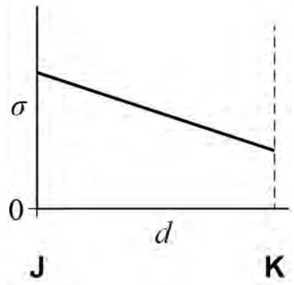
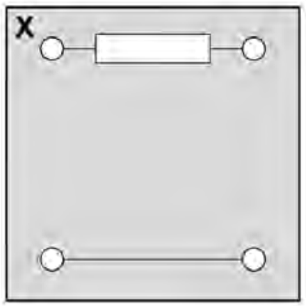
Question	Answers	Additional comments/Guidelines	Mark	AO
06.1	Equates resultant force to *ma* and shows a proportional to y, as $A\rho mg$ are all constant✓ Minus sign included and explained: (restoring) force/acceleration directed to centre of oscillation ✓ (hence SHM)	In MP1: Condone upthrust/buoyancy force for resultant force $F = ma = -A\rho yg$ $a = -\frac{A\rho yg}{m}$ Condone missing minus signs in MP1. In MP2: Minus because force/acceleration is in opposite direction to y OWTTE	2	AO1× 1 AO2× 1

Question	Answers	Additional comments/Guidelines	Mark	AO
06.2	($T = 2\pi/\omega$) so $\omega = \sqrt{\frac{g}{l}}$ ✓ (= 10.74 rad s^{-1}) ($a_{max} = -\omega^2 y_{max} = \frac{g}{l} \times y_{max} = (9.81 \div 0.085) \times 0.005$) 0.58 (m s^{-2}) ✓ from some correct working	Alternative for MP1: calculates time (0.58(5) s) AND then uses ω from this time MP2 for correct calculation of acceleration.	2	AO1 × 1 AO2 × 1

Question	Answers	Additional comments/Guidelines	Mark	AO
06.3	Idea that (at resonance) frequency of forced vibrations equals natural/resonant frequency $_1$✓ Idea that amplitude (of vibrations/oscillations) is at a maximum $_2$✓	Accept fully labelled graph of amplitude vs driving frequency with resonance frequency clearly labelled$_1$✓ and an amplitude peak. $_2$✓ Condone 'wave frequency' for 'driving frequency' Ignore references to phase	2	AO1 × 2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.4	stopped: wave frequency (= $\frac{v}{\lambda}$)= 0.12 Hz ₁✓ moving: when ship continues at $8\ \mathrm{m\ s^{-1}}$, forcing frequency will be further from resonant frequency ₂✓ Moving option is better with reason, eg for stopped option wave/forcing frequency very close to natural frequency, (so amplitude of oscillations will be high) **OR** for moving option resonance does not occur ₃✓	₁✓is for calculation of (driving) frequency when stopped. Condone reference to 'frequency of waves'. If no reference to ship being stopped, evidence can come from the substitution. Reject simple "0.12 (Hz)" ₂✓ is for a relevant comment about the moving situation OR calculation of forcing frequency with the ship moving (giving 0.05 Hz) For ₂✓ accept incorrect calculation from adding speeds provided comment that this frequency is further from resonant frequency. ₃✓ is for statement of why moving is the better option Allow answer for ₃✓ that mentions that damping will be highly likely, so amplitudes may not reach high enough values to prevent operation	3	AO3× 3
Total			**9**	

Question	Key	Answer
07	A	$10\ \mu m\ s^{-1}$ $100\ s$
08	B	$4\ m\ s^{-1}$
09	B	8 7
10	D	They decay into electrons.
11	B	down quark up quark β^-
12	C	$2.8 \times 10^5\ m\ s^{-1}$
13	A	decreasing the kinetic energy of the electrons
14	C	1.2 0.17
15	B	They have a constant phase relationship.
16	A	$0.22s$ 0.66λ
17	C	decreases increases
18	C	45 m
19	D	force mass × displacement
20	C	displacement and momentum
21	B	A current in it causes no heating effect.
22	B	B

23	A	$\frac{mg}{k}$
24	C	The acceleration is unchanged.
25	C	7.50 m s^{-1}
26	D	
27	D	
28	A	19

29	B	36
30	D	$\frac{v^2}{rg}$
31	B	the kinetic energy of the mass