AQA

AS
PHYSICS
7407/1

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 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	AO
01.1	126 ✓		1	AO1.1a

Question	Answers	Additional Comments/Guidance	Mark	AO
01.2	A neutron decays into a proton **Or** $n \rightarrow p + e^{(-)} + \bar{\nu}_e$ ✓ Proton number **increases by one** when Bi-210 decays and describes beta minus OR Bi-210 has **one fewer proton** (than Po-210) and describes beta minus in words OR Po-210 has **one more proton (**than Bi-210) and describes beta minus in words Or Proton number **increases from 83 to 84** and describes beta minus in words ✓	Allow a neutron changes to a proton. (owtte) Accept the decay equation of a neutron / bismuth • Statement that neutron converts to proton✓ • all numbers correct and context ✓ $^{210}_{83}Bi \rightarrow {}^{210}_{84}Po + {}^{0}_{-1}e + ({}^{0}_{0}\bar{\nu}_e)$ Condone missing (or incorrect) neutrino or symbol for bismuth Allow proton number increases where there is a clear statement that a neutron has decayed into a proton.	2	AO2.1b AO2.1a

Question	Answers	Additional Comments/Guidance	Mark	AO
01.3	(Missing) energy carried off by third particle Or (A third particle must be produced) for conservation of energy✓	Accept energy is converted into mass of third particle. Where third particle is named must be a neutrino or an antineutrino.	2	AO1.1a AO1.1a
	There is missing energy (When) a beta (particle) has less than $1.2\ \text{MeV}$ (of kinetic energy). Or The law of conservation of energy appears to be violated when beta (particle) has less than $1.2\ \text{MeV}$ ✓	Identify there is difference between $1.2\ \text{MeV}$ and E_k.		

Question	Answers	Additional Comments/Guidance	Mark	AO
01.4	(It must be an electron antineutrino to) conserve lepton number✓ An electron and (electron) antineutrino have lepton numbers of opposite signs. Or An electron and (electron) antineutrino have a (total) lepton number of zero. ✓ **Alternative:** Producing an (electron) neutrino wouldn't conserve lepton number✓ An electron and (electron) neutrino have lepton numbers of the same sign. Or An electron and (electron) neutrino have a (total) lepton number equal to 2. ✓	Alternative for 2nd Marking point: Appropriate particle equation seen annotated with correct lepton numbers. Alternative 2nd marking point: Appropriate particle equation seen annotated with correct lepton numbers.	2	AO1.1a AO2.1a

Question	Answers	Additional Comments/Guidance	Mark	AO
01.5	(**X** =) W-minus (boson) / W^- (boson) ✓ (**Y** =) neutron / n ✓		2	AO2.1a AO2.1a

Question	Answers	Additional Comments/Guidance	Mark	AO
01.6	Lepton (in the water molecule) is an electron ✓ and **Max 2** from annihilation ✓ gamma photon**s** are produced ✓ Two (gamma) photons are produced (that travel) in opposite directions. ✓	Must state that lepton (in the water) is an electron for all 3 marks Penalise answers that list other products in MP3 annd MP4	3	AO2.1a AO1.1a AO1.1a

Question	Answers	Additional Comments/Guidance	Mark	AO
01.7	**Max 3** The positron because: positron is charged and the (electron) antineutrino ($\bar{\nu}_{(e)}$) is neutral ✓ The antineutrino only interacts via the weak interaction / The positron interacts via the electromagnetic interaction (and weak interaction)✓ The antineutrino's (weak) interaction is shorter range / the antineutrino is less likely to get close enough to interact (with particles in the water so will travel further) / the antineutrino will interact with fewer particles✓ The positron's (electromagnetic) interaction has a longer range / the positron does not have to be so close to interact (with particles in the water so will travel a shorter distance) / the positron will interact with more particles✓	Must have the correct conclusion for 3 marks.	3	AO3.1a AO3.1a AO3.1a

Total			15

Question	Answers	Additional Comments/Guidance	Mark	AO
02.1	One wavelength✓	Accept λ	1	AO1.1a

Question	Answers	Additional Comments/Guidance	Mark	AO
02.2	Light from slits overlap / undergo diffraction✓ Path difference is a whole number of wavelengths **Or** Arrive at screen in phase / zero phase difference ✓ (Meet and) undergo superposition / waves superpose✓	If no other mark awarded allow **one** mark for: interfere constructively / Produces reinforcement / produces constructive interference	3	AO2.1c AO2.1c AO2.1c

Question	Answers	Additional Comments/Guidance	Mark	AO
02.3	Pointer **A** and CD ✓ (Smallest) angular spread for each order (θ_{min}) is given by sin $\theta_{(min)} = \frac{n\lambda}{d}$ OR Greatest number of maxima is given by $n_{max} = \frac{d}{\lambda}$ ✓	**Condone:** smallest wavelength and greatest slit spacing **Max 1 mark for**: An argument that links spacing to slit width and its effect on diffraction.	2	AO3.1b AO3.1b

Question	Answers	Additional Comments/Guidance	Mark	AO
02.4	use of $n\lambda = d \sin\theta$ ✓ use of $\tan\theta = r / 15$ or adds θ_2 and θ_1 and compares to $90°$ or adds θ_2 and θ_2 and compares to $90°$ or adds θ_1 and θ_1 and compares to $90°$ ✓ No, can see 4 (bright spots) ✓	For example, where: $n = 1$, $\lambda = 6.36 \times 10^{-7}$ m and $d = 1.6 \times 10^{-6}$ m $(\theta = 23°)$ or $n = 2$, $\lambda = 6.36 \times 10^{-7}$ m and $d = 1.6 \times 10^{-6}$ m $(\theta = 53°)$ Allow use of $\tan\theta = r / 15$ for any combination of θ, r and 15 where unknown has been made subject. $\theta = 45°$ and 3 bright spots therefore yes is a maximum of max 2 marks Allow use of $n = \frac{d}{\lambda}$ where they have reached a conclusion for 1 mark maximum.	3	AO3.1b AO3.1b AO3.1b

Total			9

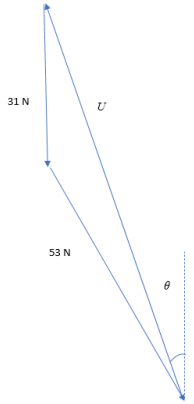
Question	Answers	Additional Comments/Guidance	Mark	AO
03.1	(Work done = lost KE = ½ mv^2 =) 0.019 (J) ✓		1	AO1.1b

Question	Answers	Additional Comments/Guidance	Mark	AO
03.2	Use of $W = Fs$✓ (F =) 0.66 (N) ✓	Condone POT error in substitution ECF from **03.1** **Alternative:** Use of an appropriate suvat equation **and** use of $F = ma$ ✓ ($t = 9.8 \times 10^{-6}$ s) ($a = 6.0 \times 10^{8}$ m s^{-2}) Condone POT error in substitution No ECF from 3.1 this route (F =) 0.66 (N) ✓	2	AO1.1a AO2.1b

Question	Answers	Additional Comments/Guidance	Mark	AO
03.3	Use of Volume = Thickness x area of cross-section✓ (Average density =) $\frac{50+5}{2} = 27.5$ ✓ Use of density = $\frac{\text{mass}}{\text{volume}}$✓ (mass =) 6.6×10^{-4} (kg) ✓ c.a.o **Alternative:** Use of Volume = Thickness x area of cross-section✓ Use of density = $\frac{\text{mass}}{\text{volume}}$ / (mass =) 1.2 x 10^{-3} or 1.2 x 10^{-4}✓ (Average mass =) $\frac{1.2\times10^{-3}+1.2\times10^{-4}}{2}$ ✓ $= 6.6 \times 10-4$ (kg) ✓ c.a.o **Alternative:** Condone POT errors apart from final answer Attempts to determine the area under the graph: Formula for area of a rectangle added to the formula for area of a triangle seen / formula for the area of trapezium seen✓ $5 \times 0.03 + \frac{(50-5)\times0.03}{2} = 0.825\ (kg\ m^{-2})$ ***or*** $\frac{50+5}{2} \times 0.03 = 0.825\ (kg\ m^{-2})$✓ Multiplies their area by 8 x 10^{-4}✓ Mass = 6.6×10^{-4} (kg) ✓ c.a.o	Condone POT errors apart from final answer $(V=)\ 8 \times 10^{-4} \times 0.03$ Or $(V=)\ 2.4 \times 10^{-5}$ Condone use of their density and volume Condone POT errors apart from final answer $(V=)\ 8 \times 10^{-4} \times 0.03$ Or $(V=)\ 2.4 \times 10^{-5}$ Condone use of their density and volume (50 kg m^{-3} =1.2 x 10^{-3}) (5 kg m^{-3} =1.2 x 10^{-4})	4	AO1.1a AO1.1b AO1.1b AO2.1b

Question	Answers	Additional Comments/Guidance	Mark	AO
03.4	**Q** has a larger volume (for the same mass and KE) / **Q** has a larger surface area (for the same mass and KE) ✓ **Q** will experience a greater resistive force (at any given speed) / **Q** will displace more matter per unit distance✓ **Q** will do more work per unit distance / **Q** will transfer more of its kinetic energy per unit distance / **Q** will experience a greater deceleration✓	Must have **Q** will travel a shorter distance for all 3 marks.	3	AO3.1a AO3.1a AO3.1a

Total			**10**

Question	Answers	Additional Comments/Guidance	Mark	AO
04.1	Closed triangle of forces drawn ✓ Appropriate scale ✓ $\theta = 23$ to 27 (°) ✓ $U = 77$ to 81 (N) ✓	Accept scale where 10 N is represented by at least 1 cm.  Treat each marking point independently. Do not accept answers for U and θ without a scale diagram. Maximum of 3 marks for a free-body diagram where forces have been drawn to scale. (Check figure 8)	4	AO1.1a AO1.1b AO1.1b AO1.1b

Question	Answers	Additional Comments/Guidance	Mark	AO
04.2	V is vertical / Force at **Y** is now vertical / V does not have a horizontal component / $V = S + 31$ / V is perpendicular to the pole / V is of greater magnitude than U / Force at **Y** has increased in magnitude✓ (Because) S and weight (or mg) are both vertical (in **Fig 9**)✓ (Because) greater moment of weight (about **Y**) in **Fig 9** / smaller moment of weight (about **Y**) in **Fig 7** / (Because) S is larger in magnitude than D (to produce a greater moment (about **Y** because they are equal distances from Y)✓		3	AO3.1a AO3.1a AO3.1a

Total			7

Question	Answers	Additional Comments/Guidance	Mark	AO
05.1	Use of $p = mv$ **or** estimates walking speed = 1 or 2 m/s✓ Accept any answer in range 2×10^6 to 10×10^6 (kg) ✓	Allow use of where m has been made the subject and p has been substituted. Range on answer: (Using speeds in range 0.5 ms^{-1} to 2.5 ms^{-1}) Accept 1 significant figure answer	2	AO1.1a AO2.1a

Question	Answers	Additional Comments/Guidance	Mark	AO
05.2	**Max 4** There is a force on the water (from the propeller) and this produces an equal force on the propeller (from the water in the opposite direction) ✓ Correctly links to Newton's 3rd law ✓ This force on the ship equals the drag force on the ship✓ Correctly links to Newton's 1st law✓ Force is needed to change the water's momentum✓ Correctly links to Newton's 2nd law✓	Must link correct law to at least one correct statement for all 4 marks	4	AO2.1a

Question	Answers	Additional Comments/Guidance	Mark	AO
05.3	(When system is enabled,) drag decreases by more than thrust **Or** (When system is enabled,) decrease in work done (per second) against drag (at any speed) is greater than the decrease in the work done by the propeller (at any rotational speed)✓ To maintain constant momentum then drag must equal thrust✓ Propeller can operate at lower rotational speed so that thrust again equals drag **Or** Engine does less work (and less fuel needs burnt) ✓	Work done (per second) by drag decreases and work done (per second) by propeller decreases (at any rotational speed) ✓ 3rd MP: Accept answer in terms of power $= Fv$	3	AO3.1b AO3.1b AO3.1b

Total			9

Question	Answers	Additional Comments/Guidance	Mark	AO
06.1	The amount of energy is transferred from **chemical energy** to **electrical energy** (for every coulomb of charge)✓ 5.30 J of energy per coulomb of charge✓	Alternative first mark: The work done in moving (1 coulomb of) charge **<u>whole</u>** way round circuit	2	AO1.1a AO1.1a

Question	Answers	Additional Comments/Guidance	Mark	AO
06.2	$5.30 - 1.05 = 4.25$ (V) seen or 4.25 V across 640 Ω resistor seen or use of $V = IR$✓	Allow use of $V=IR$ to find the current in the 320 Ω resistor. $(I = 3.28 \times 10^{-3}\ (A))$	2	AO2.1d AO2.1d
	$(I = \frac{4.25}{640} =) 6.6(4) \times 10^{-3}$ (A) seen✓	Where candidates assume voltmeter has resistance 320 Ω , their answer = 6.56×10^{-3} A. Do not credit this.		

Question	Answers	Additional Comments/Guidance	Mark	AO
06.3	Use of $V = IR$ seen (finds total resistance of circuit) Or Use of $V = IR$ for parallel section seen ✓ Use of $R_T = R_1 + R_2$ **or** $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$ seen (finds resistance of voltmeter)✓ (R =) 312.6 (Ω) or 313 (Ω) or 310 (Ω) seen ✓ Alternatively: Use of $V = IR$ seen (finds current in 320 Ω resistor)✓ Use of $I_T = I_1 + I_2$ seen (finds current in voltmeter)✓ (R =) 312.6 (Ω) or 313 (Ω) or 310 (Ω) seen ✓	R_T = 798 (Ω) (expect to see 757 (7 mA) or 803 (6.6 mA) or 807 (6.56 mA) Allow their R_T or their total resistance of the parallel section $I = 3.28 \times 10^{-3}$ (A) (evidence for this may be seen in 6.2) Allow their I_T and their current in the 320 Ω resistor. Answer is: 316 Ω where I = 6.6 mA 282 Ω where I = 7 mA 320 Ω where I = 6.56 mA **Must see working to support their answer.** **No workings = zero marks.**	3	AO2.1h AO2.1h AO2.1h

Question	Answers	Additional Comments/Guidance	Mark	AO
06.4	Use of $P = V^2 / R$ ✓ $(P =)$ 0.090 (W)✓	Allow their V along with R from **part 6.3** Allow V=5.3 with their R Alternative 1st MP Use of $V = IR$ **and** $P = I^2R$ **or** $V = IR$ **and** $P = VI$ ✓ Answer = 0.094 (W) where $R = 300\ \Omega$ Condone 1 sf answer where $R = 300\ \Omega$ is used.	2	AO2.1h AO2.1h

Question	Answers	Additional Comments/Guidance	Mark	AO
06.5	Current in circuit changes (as voltmeter position changes) / ratio of the voltage dropped across each resistor changes as voltmeter position changes. ✓ Because resistance in the circuit decrease / changes✓	Allow maximum of 1 mark for the reading will only be the emf if the voltmeter is across both resistors. ✓	2	AO2.1c AO2.1c

Total			11

Question	Answers	Additional Comments/Guidance	Mark	AO
07.1	Spreading of pulse / parts of a pulse take different times to travel through the fibre / pulse broadening✓ Due to different paths through the optical fibre / due to entering the optical fibre at different angles ✓	Do not credit material dispersion. owtte Accept a diagram showing different paths. .	2	AO1.1a AO1.1a

Question	Answers	Additional Comments/Guidance	Mark	AO
07.2	speed $(= \frac{distance}{time}) = \frac{10 \times 10^3}{5.225 \times 10^{-5}}$ ✓ (= 1.91 x 10^8)		1	AO1.1a

Question	Answers	Additional Comments/Guidance	Mark	AO
07.3	Reads off Sin $\theta_R = 0.3391$ or use of $n_1 \sin\theta_1 = n_2 \sin\theta_2$ ✓ Use of $n = \frac{c}{c_s}$ seen ✓ $c_s = 2.03 \times 10^8$ ✓ Alternative: Reads off Sin $\theta_R = 0.3391$ or $\theta = 19.8°$ ✓ $c_s \cos 19.8 = 1.9 \times 10^8$ ✓ $c_s = 2.03 \times 10^8$ ✓	 With their Sin θ_R (Refractive index of core = 1.47) Allow use of their refractive index where c_s is the subject of the formula Allow finding θ_R for their read off Allow use of their θ_R	3	AO1.1a AO2.1b AO2.1b

Question	Answers	Additional Comments/Guidance	Mark	AO
07.4	The refractive index of core for blue light is greater than the refractive index for red / The refractive index of core for red light is less than the refractive index for blue✓ The speed of the blue light is less than the speed of the red light and travel the same distance / The speed of the red light is greater than the speed of the blue light and travel the same distance✓	Max 1 mark for stating that the refractive indices are different because their speeds are different MP1 can come from graph or prior knowledge	2	AO1.1b AO2.1a

Question	Answers	Additional Comments/Guidance	Mark	AO
07.5	the blue now travels a shorter distance than the red light (compared to **07.4**)✓ **or** the red light now travels a greater distance than the blue light (compared to **07.4**)✓ **or** the difference between the blue's velocity parallel to the central axis and the red's velocity (parallel to the central axis) has decreased (compared to **07.4**).✓ **or** the difference between the horizontal velocity of the red light and the horizontal velocity of the blue light has decreased (compared to **07.4**).✓	Allow: now travel different distances whereas previously travelled the same distance.	1	AO2.1a

Total			**9**