Version 1.0: 0309

ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Physics 1451

Specification A

PHYA2 Mechanics, Materials and Waves

Mark Scheme

2009 examination - January series

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation meeting attended by all examiners and is the scheme which was used by them in this examination. The standardisation meeting ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for the standardisation meeting each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed at the meeting and legislated for. If, after this meeting, examiners encounter unusual answers which have not been discussed at the meeting they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' 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 to download from the AQA Website: www.aqa.org.uk

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Dr Michael Cresswell Director General

Instructions to Examiners

1 Give due credit for alternative treatments which are correct. Give marks for what is correct in accordance with the mark scheme; do not deduct marks because the attempt falls short of some ideal answer. Where marks are to be deducted for particular errors, specific instructions are given in the marking scheme.

2 Do not deduct marks for poor written communication. Refer the scripts to the Awards meeting if poor presentation forbids a proper assessment. In each paper, candidates are assessed on their quality of written communication (QWC) in designated questions (or part-questions) that require explanations or descriptions. The criteria for the award of marks on each such question are set out in the mark scheme in three bands in the following format. The descriptor for each band sets out the expected level of the quality of written communication of physics for each band. Such quality covers the scope (e.g. relevance, correctness), sequence and presentation of the answer. Amplification of the level of physics expected in a good answer is set out in the last row of the table. To arrive at the mark for a candidate, their work should first be assessed holistically (i.e. in terms of scope, sequence and presentation) to determine which band is appropriate then in terms of the degree to which the candidate's work meets the expected level for the band.

<table>
<tr><th>QWC</th><th>descriptor</th><th>mark range</th></tr>
<tr><td>Good - Excellent</td><td>see specific mark scheme</td><td></td></tr>
<tr><td>Modest - Adequate</td><td>see specific mark scheme</td><td></td></tr>
<tr><td>Poor - Limited</td><td>see specific mark scheme</td><td></td></tr>
<tr><td colspan="3">The description and/or explanation expected in a good answer should include a coherent account of the following points:
see specific mark scheme</td></tr>
</table>

Answers given as bullet points should be considered in the above terms. Such answers without an 'overview' paragraph in the answer would be unlikely to score in the top band.

3 An arithmetical error in an answer will cause the candidate to lose one mark and should be annotated AE if possible. The candidate's incorrect value should be carried through all subsequent calculations for the question and, if there are no subsequent errors, the candidate can score all remaining marks.

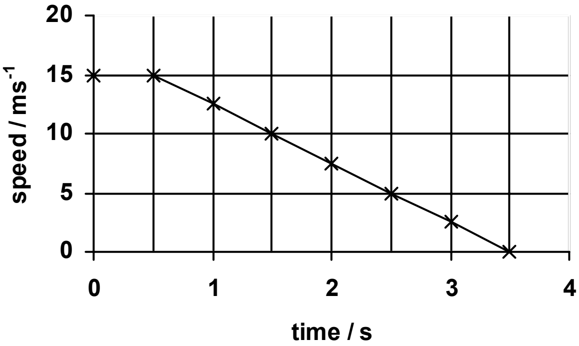
4 The use of significant figures is tested **once** on each paper in a designated question or part-question. The numerical answer on the designated question should be given to the same number of significant figures as there are in the data given in the question or to one more than this number. All other numerical answers should not be considered in terms of significant figures.

5 Numerical answers **presented** in non-standard form are undesirable but should not be penalised. Arithmetical errors by candidates resulting from use of non-standard form in a candidate's working should be penalised as in point 3 above. Incorrect numerical prefixes and the use of a given diameter in a geometrical formula as the radius should be treated as arithmetical errors.

6 Knowledge of units is tested on designated questions or parts of questions in each a paper. On each such question or part-question, unless otherwise stated in the mark scheme, the mark scheme will show a mark to be awarded for the numerical value of the answer and a further mark for the correct unit. No penalties are imposed for incorrect or omitted units at intermediate stages in a calculation or at the final stage of a non-designated 'unit' question.

7 All other procedures including recording of marks and dealing with missing parts of answers will be clarified in the standardising procedures.

GCE Physics, Specification A, PHYA2, Mechanics, Materials and Waves

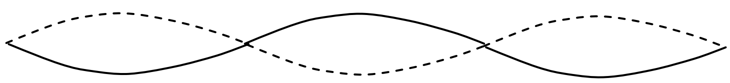
Question 1		
(a)	axes labelled correctly with correct units shown ✓ suitable scales ✓ 6 points plotted correctly ✓ all points plotted correctly ✓ both sections of line drawn correctly ✓  	**5**
(b) (i)	the gradient (of the slope section) represents the deceleration/ calculates $5\,\text{m}\,\text{s}^{-2}$ ✓ (deceleration is uniform because) the gradient is constant/line is straight ✓	**6**
(ii)	distance travelled = area under line (0 to 3.5 s or 0.5 to 3.5 s) ✓ (= 15.0 × 0.5) = 7.5 m in first 0.5 s ✓ (= 0.5 × 15.0 × 3.0) or $s = ½(u + v)t$, etc) = 22.5 m (from 0.5 s to 3.5 s) ✓ (= ½(0.5 + 3.5) × 15 gets all three method marks) (total distance travelled = 7.5 + 22.5) = 30 m ✓	
	Total	**11**

Question 2			
(a)	(i)	vector has direction **and** a scalar does not ✓	4
	(ii)	scalar examples; any two e.g. speed, mass, energy, time, power vector examples; any two e.g. displacement, velocity, acceleration, force or weight ✓✓✓ for 4 correct, ✓✓ for 3 correct, ✓ for 2 correct	
(b)	(i)	horizontal component (= 2.8 cos 35) = 2.3 (kN) (2293.6) ✓ vertical component (= 2.8 sin 35) = 1.6 (kN) (1606.0) ✓	5
	(ii)	power = force × velocity **or** 2.3 kN × 8.3 m s^{-1} ✓ (ecf from 2 (b) (i)) = 1.9×10^4 (19037 or 19100) ✓ ecf **W** (or J s^{-1}) ✓ (or 19 W (or kJ s^{-1}))	
(c)		(area of cross-section of cable =) $\pi \times (½\ 0.014)^2$ ✓ = $1.5(4) \times 10^{-4}$ (m^2) ✓ stress (= F/A) = $\frac{2800\,\text{N}}{1.54\times10^{-4}\,\text{m}^2}$ (allow ecf here if attempt to calculate area) ✓ = $1.8(2) \times 10^7$ ✓ ecf **Pa** (or N m^{-2}) ✓	5
		Total	**14**

Question 3		
(a)	the force (needed to stretch a spring is directly) is proportional to the extension (of the spring from its natural length) or equation with all terms defined ✓ up to the limit of proportionally ✓	**2**
(b) (i)		
QWC	**descriptor**	**mark range**
good - excellent	The candidate provides a comprehensive and coherent description which includes all the necessary measurements in a logical order. The description should show awareness of the need to use a range of standard masses. In addition, the use of the measurements is explained clearly, including an outline of a graphical method to find the mass of the rock sample, or calculation using two or more standard masses and averaging. For 6 marks there must be a description of how to make accurate measurements.	**5 - 6**
modest - adequate	The candidate's description includes the necessary measurements using one standard mass as well as the rock sample. The description may not be presented in a logical order and they show little consideration in relation to making the measurements accurately. A clear explanation is provided of how to find the mass of the rock sample from their measurements, including correct use of Hooke's law through calculations or inadequate graphical method.	**3 - 4**
poor - limited	The candidate knows the necessary measurements to be made using a standard mass and the rock sample. The explanation of how to find the mass of the rock sample may be sketchy.	**1 – 2**
	The explanations expected in a competent answer should include a coherent account of the following measurements and their use **measurements** (use a metre rule to) measure the length of the spring ✓ when it supports a standard mass (or known) mass (m) and when it supports the rock sample repeat for different (standard) masses accuracy – use a set square or other suitable method to measure the position of the lower end of the spring against the (vertical) mm rule or method to reduce parallax **use of measurements** *either* plot graph of mass against length (or extension) ✓ read off mass corresponding to length (or extension) due to the sample ✓ *or* the extension of the spring = length – unstretched length ✓ mass of rock sample = $\frac{\text{extension of spring supporting rock sample}}{\text{extension of spring supporting known mass}} \times M$ ✓	

(ii)	use a (G) clamp (or suitable heavy weight) to fix/clamp the base of the stand to the table ✓ clamp (or weight) provides an anticlockwise moment (about the edge of the stand greater than the moment of the object on the spring)/ counterbalances (the load) ✓ **or** adjust the stand so the spring is nearer to it ✓ so the moment of the load is reduced (and is less likely to overcome the anticlockwise moment of the base of the stand about the edge of the stand) ✓ **or** turn the base of the stand/rotate the boss by 180° ✓ so the weight of the load acts through the base ✓	
	Total	**10**

Question 4		
(a)	velocity vector tangential to path and drawn from the ball, arrow in correct direction ✓ acceleration vector vertically downwards, arrow drawn and in line with ball ✓	**2**
(b) (i) (ii)	$s = ½ gt^2$ gives $t = \sqrt{\frac{2y}{g}} = \sqrt{\frac{2\times24}{9.8(1)}}$ ✓ = 2.2(1) s ✓ v (= s/t) = 27/2.2(1) ✓ = 12(.2 m s^{-1}) or 12(.3) ✓ (ecf from (b)(i)) (answer only gets both marks)	**4**
	Total	**6**

Question 5		
(a)	(progressive waves travel from centre) to ends and reflect ✓ two (progressive) waves travel in opposite directions along the string ✓ waves have the same frequency (or wavelength) ✓ waves have the same (or similar) **amplitude** ✓ superposition (accept ‘interference’) ✓	**max 3**
(b) (i) (ii)	wavelength (= 2 × PQ = 2 × 1.20 m) = 2.4 m ✓ speed (= wavelength × frequency = 2.4 × 150) = 360 m s^{-1} ✓ (answer only gets both marks) diagram to show three ‘loops’ ✓ **and** of equal length and good shape ✓ (or loop of one third length ✓) 	**4**
	Total	**7**

Question 6			
(a)	(i)	(refractive index of water = 1/sin 49.0) = **1.33** (not 1.3 or 1.325) ✓	**4**
	(ii)	ray P shown in the air to right of vertical ✓ refracted away from the normal in the correct direction ✓ correct partial reflection shown ✓	
(b)	(i)	**critical angle** for water-air boundary = 49.0° or angle of (incidence of) Q is θ_c ✓ the angle of incidence (of R) exceeds the critical angle ✓	**6**
	(ii)	figure 6 shows that R undergoes TIR at water surface and strikes the glass side ✓ angle of incidence at glass side = 30° ✓ R enters the glass and refracts towards the normal ✓ because $n_g > n_w$ ✓ (or water is optically less dense than glass) (calculates angle = 26.2° gets last two marks)	
		Total	**10**

<table>
<tr><th>Question 7</th><th></th><th></th></tr>
<tr><td>(a) (i)

(ii)

(iii)</td><td>diffraction ✓

any 4 points from

interference (fringes formed) ✓

where light from the two slits overlaps (or superposes) ✓

bright (or red) fringes are formed where light (from the two slits) reinforces (or interfere constructively/crest meets crest) ✓

dark fringes are formed where light (from the two slits) cancels (or interferes destructively/trough meets crest) ✓

the light (from the two slits) is coherent ✓

either
reinforcement occurs where light waves are in phase (or path difference = whole number of wavelengths) ✓

or
cancellation occurs where light waves are out of phase of 180° (in anti-phase) (or path difference = whole number + 0.5 wavelengths) ✓ (not ‘out of phase’)

($w = \frac{\lambda D}{s}$) gives $\lambda = \frac{ws}{D}$ ✓

w (= 3.6/4) = 0.9(0) mm ✓ (failure to /4 is max 2)

λ (= $\frac{ws}{D}$) = $\frac{0.90\times(10^{-3})\times0.56\times(10^{-3})}{0.80}$ ✓ = 6.3×10^{-7} m ✓</td><td>9</td></tr>
<tr><td>(b)</td><td>central (bright) fringe would be white ✓

side fringes are (continuous) spectra ✓

(dark) fringes would be closer together (because λ_{red} > average λ_{white}) ✓

the bright fringes would be blue on the side nearest the centre (or red on the side away from the centre) ✓

bright fringes merge away from centre ✓

bright fringes wider (or dark fringes narrower) ✓</td><td>max 3</td></tr>
<tr><td></td><td align="right">Total</td><td>12</td></tr>
</table>