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General Certificate of Education

Physics 1451

Specification A

PHYA2 Mechanics, Materials and Waves

Mark Scheme

2009 examination - June 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 (eg 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 (ie 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)	(i)	($E_K = ½\, m v^2$ =) 0.5 × 68 × 16^2 ✓ = **8700** or 8704 (J) ✓	
	(ii)	($\Delta E_P = mg\Delta h$ =) 68 × 9.8(1) × 12 ✓ = **8000** or 8005 (J) ✓	
	(iii)	any **three** from gain of kinetic energy **>** loss of potential energy ✓ (because) cyclist does work ✓ energy is wasted (on the cyclist and cycle) due to air resistance or friction or transferred to thermal/heat ✓ KE = GPE + W – energy 'loss' ✓ (owtte) energy wasted (= 8000 + 2400 - 8700) = 1700 (J) ✓	**7**
(b)	(i)	(u = 16 m s^{-1}, s = 160 m, v = 0, rearranging $s = ½\,(u + v)\,t$ gives) 160 = ½ × 16 × t or $t = \frac{2s}{(u+v)}$ or correct alternative $\frac{2\times160}{16}$ (gets 2 marks) ✓ = 20 s ✓	
	(ii)	acceleration a = ($\frac{v-u}{t}$ =) $\frac{(0-16)}{20}$ ecf (b) (i) ✓ = (-) **0.80** (m s^{-2}) resultant force $F = ma$ = 68 × (-) 0.80 ✓ = (-) 54 (N) ✓ or 54.4 or (work done by horizontal force = loss of kinetic energy work done = force × distance gives) force = $\frac{\text{(loss of kinetic) energy}}{\text{distance}}$ ✓ = $\frac{8700\text{J}}{160\text{m}}$ ecf (a) (i) ✓ = 54 (N) ✓	**6**
		Total	**13**

Question 2			
(a)	(i)	weight of container (= mg = 22000 × 9.8(1)) = 2.16 × 10^5 (N) ✓ tension (= ¼ mg) = (5.39) 5.4 × 10^4 (N) or divide a weight by 4 ✓	
	(ii)	moment (= force × distance) = 22000 g × 32 ✓ ecf weight in (a) (i) = 6.9 or 7.0 × 10^6 ✓ **N m** or correct base units ✓ not J, nm, NM	
	(iii)	the counterweight ✓ provides a (sufficiently large) anticlockwise moment (about Q) or moment in opposite direction (to that of the container to prevent the crane toppling clockwise) ✓ **or** left hand pillar pulls (down) ✓ and provides anticlockwise moment **or** the centre of mass of the crane('s frame and the counterweight) is between the two pillars ✓ which prevents the crane toppling **clockwise**/to right ✓	**7**

(b)	(i)	(tensile) stress (= $\frac{\text{tension}}{\text{csa}}$) = $\frac{5.4\times10^{4}}{3.8\times10^{-4}}$ ecf (a)(i) ✓ = 1.4(2) × 10^8 ✓ **Pa** (or N m^{-2}) ✓	5
	(ii)	extension = $\frac{\text{length} \times \text{stress}}{E}$ or $\frac{FL}{EA}$ ✓ = $\frac{25\times1.4\times10^{8}}{2.1\times10^{11}}$ and (= 1.7 × 10^{-2} m) = 17 (mm) ✓	
		Total	**12**

Question 3			
(a)	(i)	(u = 0, s = 0.16 m, a = 9.8(1) m s^{-2}) (rearranging $s = ut + ½ at^2$ with u = 0 gives) $t^2 = \frac{2s}{a}$ or $v^2 = u^2 + 2gs$ or 0.16 = 1/2 × 9.81 t^2 or $t_o = \sqrt{\frac{(2\times0.16)}{9.8(1)}}$ ✓ = **0.1804 or 0.1806 or 0.181** etc ✓ (s) **2 sf only** ✓	5
	(ii)	($v_o = u + at_o$ =) 0 + 9.81 × 0.18 ecf 3(a)(i) or v^2= 2 × 9.81 × 0.16 ✓ = 1.8 or 1.77 (m s^{-1}) ✓	

(b)	the mark scheme for this part of the question includes an overall assessment for the Quality of Written Communication	
QWC	**descriptor**	**mark range**
good - excellent	The candidate provides a correct description of the motion of the ball including its **deceleration in the fluid decreasing** and **becoming zero** (or attaining constant velocity). They should give a comprehensive and coherent explanation which includes nearly all the necessary principles in a logical order. In their explanation, the candidate should refer to the forces including their **directions** acting on the ball, why the **resistive force decreases** and why the acceleration becomes zero.	**5 - 6**
modest - adequate	The description should refer to the ball decelerating in the fluid until it becomes zero or attains **constant velocity**. Their explanation should be fairly coherent although it may not be comprehensive and may focus only on the forces acting when the ball attains constant velocity – **balanced forces** - or on the reason for the initial deceleration.	**3 - 4**
poor - limited	The candidate knows that the ball **decelerates** (acceleration with direction) or is acted on by an **upward** force (as well as the force of gravity). Their explanation of why the ball attains constant velocity may be absent. May be sketchy and lacks key considerations. They may not appreciate that the two forces are equal and opposite when the ball is moving at constant velocity.	**1 – 2**
incorrect, inappropriate or no response	No answer at all or answer refers to unrelated, incorrect or inappropriate physics.	**0**
	The explanation expected in a competent answer should include a coherent selection of the following physics ideas. The ball decelerates/slows down in the fluid ✓ if acceleration is used the direction must be specified • because a force due to fluid friction/resistance/viscosity acts (upwards) on the ball ✓ • (and) the force due to the fluid is greater than the weight of the ball ✓ • resistive force is upwards ✓ • resistive force decreases ✓ The deceleration decreases (to zero) ✓ • because the force due to fluid friction/resistance/viscosity decreases as the ball's speed decreases ✓ • until it is equal (and opposite) to the weight of the ball ✓ (or the resultant force is zero) • gradient of graph gives the acceleration and the ball moves at constant/terminal velocity/a=0 ✓	
	Total	**11**

Question 4		
(a) (i)	the lines are not straight (owtte) ✓	3
(ii)	there is no permanent extension ✓ (or the overall/final extension is zero or the unloading curve returns to zero extension)	
(iii)	(area represents) **work done** (on or energy transfer to the rubber cord) or **energy** (stored) ✓ not heat/thermal energy	
(b)	the mark scheme for this part of the question includes an overall assessment for the Quality of Written Communication	
QWC	**descriptor**	**mark range**
good - excellent	The candidate provides a comprehensive and coherent description which includes nearly all the necessary procedures and measurements in a logical order. The descriptions should show awareness of how to apply a variable force. They should know that measurements are to be made as the force is increased then **as it is decreased**. In addition, they should know how to calculate/measure the extension of the cord. **At least five different masses/'large number' of masses are used. Minimum 7 masses to reach 6 marks**. The diagram should be detailed.	**5 - 6**
modest - adequate	The description should include most of the necessary procedures including **how to apply a variable force** and should include the necessary measurements. They may not have described the procedures in a logical order. They may not appreciate that measurements are also to be made as the cord is unloaded. They should know **that the extension** of the cord must be found and name a **suitable measuring instrument (or seen in diagram – label need not be seen)/how to calculate**. The diagram may lack some detail.	**3 - 4**
poor - limited	The candidate knows that the **extension or cord length** is to be measured for **different forces** – may be apparent from the diagram. They may not appreciate that measurements are also to be made as the cord is unloaded. They may not state how to calculate the extension of the cord. The diagram may not have been drawn.	**1 – 2**
incorrect, inappropriate or no response	No answer at all or answer refers to unrelated, incorrect or inappropriate physics.	**0**
	The explanation expected in a competent answer should include a coherent selection of the following physics ideas. diagram showing rubber cord fixed at one end supporting a weight at the other end or pulled by a force ✓ means of applying variable force drawn or described (eg use of standard masses or a newtonmeter) ✓ means of measuring cord drawn or described ✓ *procedure* measured force applied (or known weights used) ✓ cord extension measured or calculated ✓ repeat for increasing then decreasing length (or force/weight) ✓ extension calculated from cord length – initial length ✓	
	Total	**9**

Question 5		
(a) (i)	0.4(0) m ✓	5
(ii)	speed (= frequency × wavelength) = 22 × 0.4(0) ecf ✓ = 8.8 ($m\,s^{-1}$) ✓	
(iii)	90 or 450 ✓ ° **or degrees** ✓ or 0.5π or 2.5π or 5π/2 ✓ **rad**(ians) or **r** or ^{r} ✓ no R, Rad, etc	
(b)	displacement of Y will be a **positive (or 'up') maximum** at ¼ of a period (or cycle) (0.0114 s) ✓ returns to original position (at 0.5 of a period or cycle) (owtte) ✓	2
	Total	**7**

Question 6		
(a) (i)	(using $n_1 \sin\theta_1 = n_2 \sin\theta_2$ or $\sin\theta_c = n_2/n_1$ gives) correct substitution in either equation (eg 1.55 sin *c* = 1.45 (sin 90) or sin *c* = 1.45/1.55) ✓ = 0.9355 (accept less sf) ✓ *c* = 69.3(°) ✓ (accept 69.4°, 69° **or** 70°)	7
(ii)	the angle (of incidence) is less than the **critical angle** or values quoted ✓	
(iii)	(using $n_1 \sin\theta_1 = n_2 \sin\theta_2$ gives) 1.55 sin 60 = 1.45 sin θ ✓ (sin θ = 1.55 sin 60/1.45 =) 0.9258 or 0.926 or 0.93 ✓ θ = 67.8° ✓ (accept 68° **or** 68.4)	
(b)	any **two** from: keeps signals secure ✓ maintains quality/reduces pulse broadening/smearing (owtte) ✓ it keeps (most) light rays in (the core due to total internal reflection at the cladding-core boundary) ✓ it prevents scratching **of the core** ✓ (keeps core away from adjacent fibre cores) so helps to prevent crossover of **information/signal/data** to **other** fibres ✓ cladding provides (tensile) strength for fibre/prevents breakage ✓ given that the core needs to be very thin ✓	max 2
	Total	**9**

Question 7		
(a) (i)	$= 590 \times 10^{-9}$ m ✓ (using $d \sin\theta = n\lambda$ gives) $\sin\theta = \frac{n\lambda}{d}$ or $= \frac{2\times590\times(10^{-9})}{1.67\times10^{-6}}$ ✓ = **0.707** or 7.07×10^{8} if nm used ✓ $\theta = 45.0°$ ✓ (accept 45°)	
(ii)	($\sin\theta \le 1$) gives $\frac{n\lambda}{d} \le 1$ or $n \le \frac{d}{\lambda}$ or $= \frac{1.67\times10^{-6}}{590\times10^{-9}}$ ✓ = 2.83 ✓ so 3rd order or higher order is not possible ✓ alternative solution: (substituting) ***n* = 3** (into $d \sin\theta = n\lambda$ gives) ✓ $\sin\theta$ (= $\frac{n\lambda}{d}$ = $\frac{3\times590\times10^{-9}}{1.67\times10^{-6}}$) = 1.06 ✓ gives 'error'/which is not possible ✓	**7**
(b)	(using $d \sin\theta = n\lambda$ gives) $2\lambda = 1.67 \times 10^{-6} \times \sin 42.1$ ✓ λ (= $0.5 \times 1.67 \times 10^{-6} \times \sin 42.1$) = $5.6(0) \times 10^{-7}$ m (or 560 nm) ✓	**2**
	Total	**9**