Version 1.0

General Certificate of Education
June 2010

Physics A PHYA2

Mechanics, Materials and Waves

Unit 2

Final

Mark Scheme

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.

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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.

QWC	descriptor	mark range
Good - Excellent	*see specific mark scheme*	**5-6**
Modest - Adequate	*see specific mark scheme*	**3-4**
Poor - Limited	*see specific mark scheme*	**1-2**
The description and/or explanation expected in a good answer should include a coherent account of the following points: *see specific mark scheme*		

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.

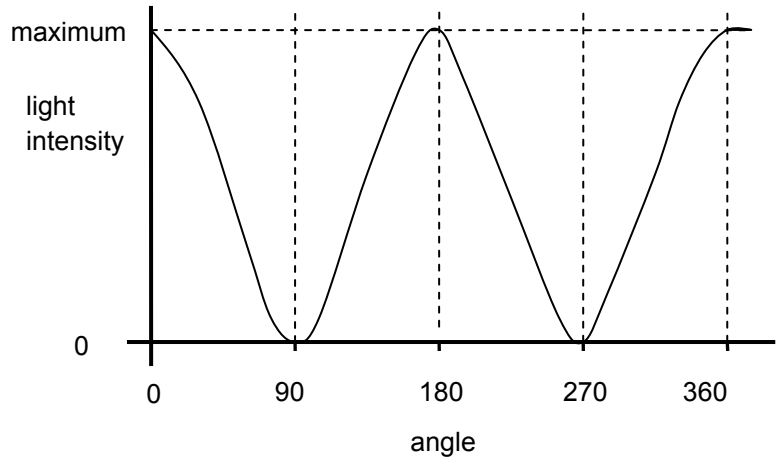
7 All other procedures including recording of marks and dealing with missing parts of answers will be clarified in the standardising procedures.

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

Question 1		
(a)	(sum of) clockwise moment**s** (about a point) =(sum of) anticlockwise moment**s** ✓ (for a system) in equilibrium ✓ accept *balanced* not *stationary*	**2**
(b)	(780 × 0.35 =) 270 (Nm) ✓ (273) **Nm** ✓ or newton metre(s) accept Newton metre(s) (not J, nm or nM, Nms, etc)	**2**
(c)	1 (b) + (1100 x 0.60) ✓ (=) F_A × 1.3 ✓ (F_A = 660 + 273/1.3 gets both marks) (= 933/1.3) = 720 (N) ✓ (717.7 or 715 for use of 930) ecf 1 (b) **2 sf only** ✓ independent mark	**4**
(d)	(780 +1100 – (1(c)) = 1200 ✓ (1162 N) ecf 1 (c)	**1**
(e)	$\left(F = \frac{P}{v}\right)$ = $\frac{7.5\,(\times 10^3)}{26}$ ✓ must be arranged in this form = 290 (N) ✓ (288.46)	**2**
	Total	**11**

Question 2		
(a)	any **two** from freefall is too quick (any indication of slower motion) ✓ (Galileo had) no (accurate) method to **time** freefall (or valid comment regarding timing of freefall or inclined plane) ✓ correct reference to **air** resistance or **drag** (not 'wind') ✓	**max 2**
(b) (i)	0.20 × 9.81 = 1.962 (N) ✓ (1.962 sin 1.8 =) 0.0616 or 0.062 seen ✓ (allow 0.061) (0.0628 for use of g = 10 gets 1 mark)	**2**
(b) (ii)	0.06(16)/0.20 **or** use of *a=F/m* with a clearly identified force but not the weight **or** g sin θ = g sin 1.8° ✓ 0.31 (ms^{-2}) ✓ (0.308) accept 0.3 or 0.30 correct answer only for second mark **or** ($a = 2s/t^2$) = 2 × 0.29/1.4^2 ✓ = 0.31 ✓ or use of other values from table	**2**
(c)	accelerating ✓ (accept increasing speed, etc but not increasing acceleration/quicker motion, etc) greater distance for each additional swing ('per unit time' must be implied) or gradient/ steepness/ slope increasing ✓ (accept curves upwards)	**2**

(d)	**tangent used**: tangent drawn at 3.0m ± 0.3 on graph ✓ their time from graph × 1.4 ✓ = 1.28 to 1.44 ($m\,s^{-1}$) ✓ **or suvat used**: use of $v = \frac{2s}{t}$ or $v = (u) + at$ with a from 2 (b) (ii) ✓ (t =) 4.4 to 4.5 (s) ✓ (speed =) 1.3 to 1.4 (ms^{-1}) ✓	**3**
	Total	**11**

Question 3			
(a)		**maximum displacement** from equilibrium/mean position/mid-point/etc ✓	**1**
(b)	(i)	any **one** from: surface of water/water waves/in ripple tank ✓ rope ✓ slinky clearly qualified as transverse ✓ secondary ('s') waves ✓	**max 1**
(b)	(ii)	transverse wave: oscillation (of medium) is perpendicular to wave travel or transverse can be polarised or **all** longitudinal require a medium ✓	**1**
(c)	(i)	vertical line on B ± 5° ✓	**1**
(c)	(ii)	 max 0, 180, 360 + min 90, 270 ✓ **and** line reaches same minimum and maximum every time and reasonable shape ✓	**2**

(d)	appropriate use ✓ reason for Polaroid filter being used ✓ **eg** **Polaroid** glasses/**sun**glasses/ windscreens — to reduce glare camera — reduce glare/enhance image (in a) microscope — to identify minerals/rocks polarimeter — to analyse chemicals/concentration or type of sugar stress analysis — reveals areas of high/low stress/ other relevant detail LCD displays — very low power/other relevant detail 3D glasses — enhance viewing experience, etc	**2**
	Total	**8**

Question 4		
(a)	(ΔEp= $mg\Delta h$) = **55** × 9.8(1) × 4.2 ✓ = 2300 (J) ✓ (2266.1)	**2**
(b) (i)	(E_k = 3.2/4.2 x 2264 or uses suitable kinematics equation) = 1700(J) ✓ (= 1724.8 = 1720) ecf 4 (a)	**1**
(b) (ii)	($E_k = \frac{1}{2}mv^2$ = 1724.8) $v = \sqrt{\frac{2 \times 1724.8}{55}} = \sqrt{62.72}$ ecf (b) (i) or use of $v^2 = 2as$ ✓ = 7.9 m s^{-1} ✓ (= 7.9196)	**2**
(c)	one arrow, vertical, upward pointing, starts on soles of feet ✓	**1**
(d)	(use of $\alpha = \frac{\Delta v}{\Delta t}$ gives) = $\frac{7.920}{0.26}$ ✓ or ecf 4 (b) (ii)/0.26 = 30 ($m s^{-2}$) ✓ (30.46) **or use** $\alpha = \frac{2s}{t^2}$ of or $\alpha = \frac{v^2}{2s}$ ✓ allow incorrect values of *s* here = 29.6 or 31.4 respectively ✓	**2**

(e)	**The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.** The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria. **High Level (Good to excellent): 5 or 6 marks** The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. Candidate must state that: • (elastic potential) energy is transformed to **kinetic or** trampoline does work (on gymnast) • (KE) is transformed into (gravitational) **potential** energy • (the gymnast) must 'jump'/bend knees/do work/'use' chemical energy/supply energy (to increase height) For 6 marks, must also state that (the gymnast) must overcome resistive forces (drag/heat loss/reference to energy 'lost' in trampoline, etc) **Intermediate Level (Modest to adequate): 3 or 4 marks** The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. Candidate must state **one** from: • chemical energy (transferred) to elastic, kinetic or gravitational energy • PE (from trampoline) to KE (of gymnast) • KE (gymnast) to (G)PE (gymnast) **and one** of the following: • work is done by the trampoline (on the gymnast) • that work is done on the trampoline (by the gymnast) • work done against resistive forces • (additional) energy input required (to achieve additional height) **Low Level (Poor to limited): 1 or 2 marks** The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate. Candidate must • give **one** relevant energy gain or loss in the system **or** state that energy is input to reach greater height For two marks, a relevant energy transformation must be given **or** one further marking point from next page	**max 6**

	Further marking points: • (to reach the same height) the gymnast must do work in order to replace the energy wasted as the springs and the trampoline (rubber) unload (contract) • to reach a greater height, the gymnast must do additional work by (bending and) extending her legs (jumping) as the trampoline moves upwards • the additional downward force keeps the trampoline extended for longer, thus increasing the impulse • correct reference to law of energy conservation	
	Total	**14**

Question 5		
(a)	returns to original length/shape/position/state/zero extension/no **permanent** extension ✓	**1**
(b)	(12 to 14 big squares/318 small squares ± 8 area of 1 big square = 10N × 0.05m = 0.50/small = 2 × 0.01 = 0.02) statement of method that refers to **area** ✓ accept triangle if **area** is mentioned 5.0 to 8.0 (J) or clear attempt to calculate correct area ✓ triangle OK here 5.1 (J) for single triangle is max 2 6.0 to 7.0 (J) ✓	**4**
(c)	(*E* =) $\frac{FL}{A\Delta L}$ ✓ (=) $\frac{10 \times 0.50}{5.0 \times 10^{-6} \times 0.04}$ ✓ also gets first mark incorrect values of *F* and *ΔL* get first mark only 2.5×10^{7} (Pa) ✓ **or** (stress = *F/A* =) $10/5 \times 10^{-6}$ (= 2.0×10^{6} Pa) ✓ (strain = *ΔL/L* =) 0.04/0.5 (= 0.08) ✓ $2 \times 10^{6}/0.08$ gets both marks *E* correctly evaluated from incorrect value of stress and incorrect value of strain gets 1 mark only use of 50 (N) and 0.04 (m) giving 1.25×10^{8} (Pa) gains 2 marks use of 5(N) and 0.4 (m) is max 2 2.5×10^{7} (Pa) ✓	**3**
(d) (i)	straight line through origin finishing at the same point as the rubber ± 1 small division ✓	**1**
(d) (ii)	**point beyond which** graph is no longer linear **or** force no longer proportional to extension **or** Hooke's law limit ✓	**1**
	Total	**10**

Question 6		
(a)	λ correct ✓ d correct ✓ arrow or line needed, both ends extending beyond central black line	**2**
(b)	angle θ gets smaller ✓ because path difference gets smaller/***d* constant**, (λ smaller) so sin θ smaller ✓ max 1 for correct explanation for λ increasing	**3**
(c)	boxes 1,5,6 ✓✓ two correct 1 mark 4 ticks max 1 5 or 6 ticks gets 0	**2**
(d) (i)	3.3×10^{-6} m ✓ (1/300 = 3.33×10^{-3} **mm**, 3300 **nm**) DNA 1 sf here DNA 1/300 000 as answer accept 3 1/3 x 10^{-6}, 3.33 x 10^{-6} recurring, etc	**1**
(d) (ii)	(sin θ =) $\frac{540 \text{ to } 560 \times (10^{-9})}{((d)(i))}$ ✓ correct wavelength used and seen (**545 to 548 x 10^{-9}**) **and** 9.4 to 9.6 (°) ✓ ecf (d) (i), for correct wavelength only (545 to 548 × 10^{-9})	**2**
	Total	**10**

Question 7		
(a)	reflects at correct angle by eye (use top of '27' and bottom of '42' as a guide) **or 27**° or **63**° correctly marked ✓ refracts away from normal at glass/air ✓ symmetrical by eye or refracted angle (42°) correctly marked and at least one normal line added ✓	**3**
(b)	(n_g) = $\frac{\sin 42}{\sin 27}$ ✓ DNA 42/27 = 1.56 = 1.47 (1.474) 3 sf shown ✓	**2**
(c)	63 (°) ✓ allow 62 to 62.99 **with** reasoning, allow 'slightly less than 63' without reason given	**1**
(d)	$\left(\frac{n_l}{n_g} = \frac{\sin 63}{\sin 90}\right) n_l$ = 1.474 sin (7 (c)) ✓ or use of n = 1.5 = 1.3(1) or 1.34 if n = 1.5 used ✓	**2**
	Total	**8**