Version 1.0



General Certificate of Education (A-level)
January 2012

Physics A PHYA2

(Specification 2450)

Unit 2: Mechanics, materials and waves

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 events which all examiners 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 examiner understands and applies it in the same correct way. As preparation for standardisation each examiner 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, examiners encounter unusual answers which have not been raised 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 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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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.

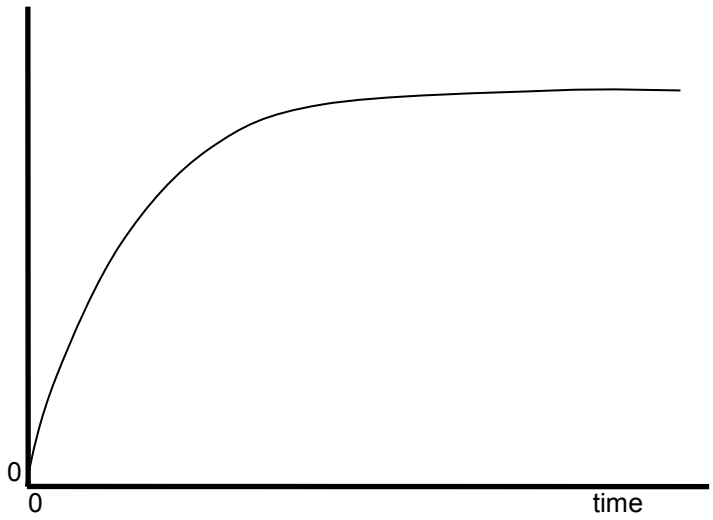
GCE Physics, Specification A, PHYA2, Mechanics, Materials and Waves

Question 1		
a	$170 \times 10^3 \times \cos 40$ (**or** 1.3×10^5) ✓ $\times 1000$ ✓ ($= 1.302 \times 10^8$ J)	**2**
b i	$(P = Fv) = 1.3 \times 10^5 \times 7.0$ ✓ $= 9.1 \times 10^5$ ✓ (911.6 kW) ecf wrong force from part a **or** correct alternative approach using $t=s/v$ and $P= E/t$	**2**
b ii	(total power =) 9.1 ($\times 10^5$) + 21 ($\times 10^5$) ✓ ecf from bi powers of 10 must be consistent for this mark (eg not 9.1 + 2.1) (percentage = (9.1/9.1 + 21) × 100) = 30 (%) ✓ ecf for power of 10 error in first mark ecf from bi, but must have attempted to calculate **total power** eg 9.1/21 gains zero	**2**
c	**any two from** (surface) **area** (of the sail) ✓ **wind** speed/strength/power/KE/force (not air resistance) ✓ acceleration or speed of the ship ✓	**max 2**
	Total	**8**

Question 2		
a i	($s = ½(u+v)\,t$) $t = 2s/v$ ✓ (correct rearrangement, either symbols or values) (= 100/6.7) = 15 ✓ (s) (14.925) or alternative correct approach	**2**
a ii	($KE = 1/2mv^2 = ½ \times 83 \times 6.7^2$) = 1900 ✓ (1862.9 J) **2 sf** ✓	**2**
a iii	GPE = 83 × 9.81 × 3.0 ✓ penalise use of 10, allow 9.8 = 2400 (2443 J) ✓ do not allow 2500 (2490) for use of g = 10	**2**
b i	5300 + 3700 (or 9000 seen) **or** – 2443 – 1863 (or (–) 4306 seen) ✓ = 4700 (J) ✓ (4694) ecf from parts aii & aiii	**2**

b	ii	mention of friction and appropriate location given ✓ mention of **air** resistance (or drag) ✓ do not allow energy losses or friction within the motor do not allow energy losses from the cyclist must give a **cause** not just eg 'heat loss in tyres'	**2**
		Total	**10**

Question 3			
a	i	180000 × 2.8 ✓ = 500000 ✓ (504000 Nm) ecf from first line for incorrect power of 10	**2**
a	ii	7.4 × lift fan thrust ✓ = 180000 × 2.8 (504000 Nm) ✓ ecf from part ai F = 68000 or 68 k (N) ✓ (68108 N) ecf	**3**
a	iii	180k – 68.1k = (111.9 =) 112 k (N) ✓ ecf from part aii **or** by taking moments	**1**
b	i	*(m = W/g)* = 180 000/9.81 ✓ (= 18349 kg) *a = F/m* = 155 000/18349 = 8.4 ✓ (8.4475 ms^{-2}) ecf for use of 180 in 1st mark use of weight rather than mass gets zero	**2**
b	ii	**cross-sectional or surface** area/shape/streamlining/aerodynamics/nature of surface/drag coefficient ✓ **correctly linked** to its effect on air resistance/drag ✓ **or maximum** thrust/force power of engine ✓ counterforce increases with speed **or** when drag equals thrust (forces are balanced) ✓	**2**

b ii	velocity  line starting at zero and **curving with decreasing gradient** ✓ reaching a constant velocity ✓	**2**
c	steepest/maximum gradient ✓	**1**
	Total	**13**

Question 4		
a	extension divided by its **original** length ✓ do not allow symbols unless defined ✓	**1**
b	1.9×10^8 (Pa) ✓	**1**
c	point on line **marked 'A'** between a strain of 1.0×10^{-3} and 3.5×10^{-3} ✓	**1**
d	clear evidence of gradient calculation for **straight section** eg 1.18 (1.2) $\times 10^8 / 1.0 \times 10^{-3}$ ✓ = 120 GPa **and stress used ≥ 0.6×10^8 Pa** ✓ allow range 116 – 120 GPa **Pa or Nm^{-2} or N/m^2** ✓	**3**
e i	clear attempt to calculate correct area (evidence on graph is sufficient) ✓ (32 whole squares + 12 part/2 = 38 squares) (38 × 10000 =) 380000 ($J\,m^{-3}$) ✓ allow range 375000 to 400000	**2**
e ii	$V = m/\rho$ **or** 0.015/8960 **or** 1.674×10^{-6} (m^3) ✓ $380\,000 \times 1.674 \times 10^{-6} = 0.64$ (0.6362 J) ✓ ecf from ei	**2**
f	straight line passing through origin (small curvature to the right only above 160 MPa is acceptable) end at 176 MPa ✓ (allow 174 to 178) straight section to the left of the line for copper (steeper gradient) ✓	**2**
	Total	**12**

Question 5		
a	**max three from** central maximum shown ✓ two equally spaced first order maxima ✓ central and one first order labelled correctly ✓ central white maximum ✓ indication of spectra/colours in at least one first order beam ✓ at least one first order beam labelled with violet (indigo or blue) closest to the centre **or** red furthest ✓	**max 3**
b	**dark/black** lines **or** absorption spectrum **or** Fraunhofer lines ✓ (reveal the) composition (of the star's atmosphere) ✓ accept dark 'bands' accept atoms or elements in the star **or** the peak of intensity ✓ (is related to) the temperature ✓ **or** Doppler (blue or red) shift ✓ (speed of) rotation **or** speed of star (relative to Earth) ✓	**2**
c i	grating and screen shown with both labelled ✓ laser or laser beam labelled ✓	**2**
c ii	**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. • correct use of $(n)\lambda = d \sin\theta$ • **and** measure appropriate angle (eg 'to first order beam' is the minimum required) • **and** method to measure angle (eg $\tan\theta = x/D$, spectrometer, accept protractor) • **and** at least **one** way of improving accuracy/reliability • for **full** marks: also explain how d is calculated, eg d = 1/ lines per mm ($\times 10^3$)	**max 6**

	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. • use of $(n)\lambda = d \sin\theta$ • **and** measure appropriate angle (eg 'to first order beam' is the minimum required) • **and** method of measurement of θ (eg $\tan\theta = x/D$, spectrometer, accept protractor) **or** at least **one** way of improving accuracy/reliability **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. • use of $(n)\lambda = d \sin\theta$ • **or** measure appropriate angle (eg 'to first order beam' is the minimum required) • **or** at least **one** way of improving accuracy/reliability **Incorrect, inappropriate of no response: 0 marks** No answer or answer refers to unrelated, incorrect or inappropriate physics. **The explanation expected in a competent answer should include** **Accuracy/reliability points** • measure between more than one order (eg 2 θ) • measure θ for different orders (for average λ **not average angle**) • check or repeat/repeat for different distances (D) • use of spectrometer • use large distance to screen (D) • protractor with 0.5 degree (or less) intervals • graphical method: **plot sin θ against n** (gradient = λ/d)	
	Total	**13**

Question 6		
a i	sin 56 = n_{glass} sin 30 ✓ (n_{glass} = sin56/sin30) (= 1.658) = 1.7 ✓	**2**
a ii	sin θ_c = 1/1.658 ✓ ecf from ai θ_c = (37.09 or 37.04) = 37 (degrees) ✓ accept 36 (36.03 degrees) for use of 1.7	**2**
b	TIR from the upper side of the prism ecf from part aii **and** correct angle ✓ refraction out of the long edge of the prism away from the normal ✓	**2**
	Total	**6**

Question 7		
a	the **maximum displacement** (of the wave or medium) ✓ from the equilibrium position ✓ accept 'rest position', 'undisturbed position', 'mean position'	**2**
b	(vertically) **down**wards (¼ cycle to maximum negative displacement) ✓ then **upwards** (¼ cycle to equilibrium position and ¼ cycle to maximum positive displacement) ✓ **down** (¼ cycle) to **equilibrium position**/**zero** displacement **and** correct reference to either **maximum** positive or negative displacement **or** correct reference to fractions of the cycle ✓ candidate who correctly describes the motion of a knot 180 degrees out of phase with the one shown can gain maximum two marks (ie knot initially moving upwards)	**3**
c	**max 3 from** **stationary wave** formed ✓ by **superposition or interference** (of two progressive waves) ✓ knot is at a **node** ✓ waves (always) cancel **where the knot is** ✓ allow 'standing wave'	**max 3**
	Total	**8**

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