Version 1.0: 0905

ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Physics 6451
Specification A

PA10 Synoptic Unit

Mark Scheme

2005 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.

Instructions to Examiners

1 Give due credit to alternative treatments which are correct. Give marks for what is correct; 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 script to the Awards meeting if poor presentation forbids a proper assessment. In each paper candidates may be awarded up to two marks for the Quality of Written Communication in cases of required explanation or description. Use the following criteria to award marks:

2 marks: Candidates write legibly with accurate spelling, grammar and punctuation; the answer containing information that bears some relevance to the question and being organised clearly and coherently. The vocabulary should be appropriate to the topic being examined.

1 mark: Candidates write with reasonably accurate spelling, grammar and punctuation; the answer containing some information that bears some relevance to the question and being reasonably well organised. Some of the vocabulary should be appropriate to the topic being examined.

0 marks: Candidates who fail to reach the threshold for the award of one mark.

3 An arithmetical error in an answer should be marked AE thus causing the candidate to lose one mark. 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 (indicated by ticks). These subsequent ticks should be marked CE (consequential error).

4 With regard to incorrect use of significant figures, normally two, three or four significant figures will be acceptable. Exceptions to this rule occur if the data in the question is given to, for example, five significant figures as in values of wavelength or frequency in questions dealing with the Doppler effect, or in atomic data. In these cases up to two further significant figures will be acceptable. The maximum penalty for an error in significant figures is **one mark per paper**. When the penalty is imposed, indicate the error in the script by SF and, in addition, write SF opposite the mark for that question on the front cover of the paper to obviate imposing the penalty more than once per paper.

5 No penalties should be imposed for incorrect or omitted units at intermediate stages in a calculation or which are contained in brackets in the marking scheme. Penalties for unit errors (incorrect or omitted units) are imposed only at the stage when the final answer to a calculation is considered. The maximum penalty is **one mark per question**.

6 All other procedures, including the entering of marks, transferring marks to the front cover and referrals of scripts (other than those mentioned above) will be clarified at the standardising meeting of examiners.

PA10 Synoptic Unit

Question 1		
(a)	gain of E_p (= 160 × 9.81 × 5.0) = 7.85 × 10^3 (J) ✓ electrical energy supplied (= 14 × 230 × 22) = 70.8 × 10^3 (J) ✓ efficiency $\left(=\frac{7.85}{70.8}\right) = 0.11$ [11%] ✓ (10.9%) (allow C.E. for incorrect values in first two calculations) [or power delivered $\left(=\frac{mgh}{t}\right)$ = 357 (W) power supplied (= IV) = 3.2(2) × 10^3 (W) efficiency $\left(=\frac{357}{3220}\right)$ 0.11 [11%]]	**3**
(b) (i)	strain $\left(=\frac{\text{stress}}{E}\right) = \frac{F}{A}\times\frac{1}{E}$ ✓ $= \frac{160\times 9.81}{1.8\times 10^{-4}}\times\frac{1}{2.1\times 10^{11}}$ ✓ = 4.15 × 10^{-5} ✓ (4.1 or 4.2 × 10^{-5} accepted)	**5**
(ii)	extension (= strain × length) = 4.15 × 10^{-5} × 14 ✓ = 5.8 × 10^{-4} m ✓ (5.81 × 10^{-4} m) (allow C.E. for incorrect value of strain from (i))	

Question 2		
(a)	reasons: α particle has much more mass/momentum than β particle α particle has twice as much charge as a β particle α particle travels much slower than a β particle any **two** ✓✓	**2**
(b) (i)	energy absorbed per sec (= energy released per sec) = 3.2 × 10^9 × 5.2 × 10^6 ×1.6 ×10^{-19} ✓ = 2.7 ×10^{-3} (J) ✓ (2.66 ×10^{-3} (J))	**5**
(ii)	temperature rise in 1 minute $\left(=\frac{\text{energy absorbed in 1 minute}}{\text{mass}\times\text{specific heat capacity}}\right)$ $= \frac{2.7\times 10^{-3}\times 60}{0.20\times 10^{-3}\times 900}$ (for numerator) ✓ (for denominator) ✓ = 0.90 K (or °C) ✓ (allow C.E. for incorrect value in (i))	

Question 3		
(i)	volume/sec (= $\pi r^2 L$) = $\pi \times 22^2 \times 15$ ✓ (= 2.3×10^4 m^3 s^{-1})	**Max 7**
(ii)	mass of air/(sec) (= vol/sec × density) = $2.3 \times 10^4 \times 1.2$ ✓ = 2.8×10^4 kg (s^{-1}) ✓ (2.76×10^4 kg (s^{-1})) (allow C.E. for incorrect value of vol/sec from (i))	
(iii)	E_k/(sec) (=½ × mass/sec × speed^2) = $0.5 \times 2.76 \times 10^4 \times 15^2$ ✓ = $3.1(1) \times 10^6$ J (s^{-1}) ✓ (use of 2.8×10^4 from (ii) gives $3.1(5) \times 10^6$ J (s^{-1})) (allow C.E. for value of mass/(sec) from (ii))	
(iv)	mass /sec is reduced to half ✓ E_k reduced to ($^1/_4$) or $\propto v^2$ (for a given mass/(sec)) ✓ (power $\propto E_k$) ∴ power reduced to ($^1/_8$)th ✓	

Question 4		
(a) (i)	magnetic field exerts a force on the wire when current passes through it ✓ current repeatedly reverses, so force repeatedly reverses ✓	**6**
(ii)	ac (or driving) frequency equals) the fundamental (or natural) frequency of vibration of the wire ✓ wire resonates ✓	
(iii)	λ (=2L) = 1.42 (m) ✓ c (= $f\lambda$) = 290 × 1.42 ✓ (= 410 m s^{-1})	
(b) (i)	$\mu\left(=\frac{T}{c^2}\right)=\frac{60}{410^2}$ ✓ = 3.6×10^{-4} kg m^{-1} ✓ ($3.57\ 10^{-4}$ kg m^{-1})	**5**
(ii)	mass of wire (= μL) = $3.57 \times 10^{-4} \times 0.71$ (= 2.53×10^{-4} (kg)) ✓ volume of wire (= $L \times \pi d^2/4$) = $0.71\times\frac{\pi}{4}\times(0.24\times10^{-3})^2$ (= $3.2(1) \times 10^{-8}$ (m^3)) ✓ density $\left(=\frac{\text{mass}}{\text{volume}}\right)=\frac{2.53\times10^{-4}}{3.21\times10^{-8}}$ = 7.9×10^3 kg m^{-3} ✓ (7.88×10^3 kg m^{-3}) (use of 2.5×10^{-4} and 3.2×10^{-8} gives $7.8(1) \times 10^3$ kg m^{-3}) (allow C.E. for incorrect values of mass and volume) [or area of c.s. (= $\pi d^2/4$) = $\pi(2.4 \times 10^{-4})^2/4$ (= 4.52×10^{-8} m^2) density $\left(=\frac{\text{mass per unit length}}{\text{area of c.s.}}\right)=\frac{3.57\times10^{-4}}{4.52\times10^{-8}}$ =7.9×10^3 kg m^{-3}]	

<table>
<tr><td>Question 5</td><td></td><td></td></tr>
<tr><td>(a)</td><td>

T/s	T^2/s^2	(l)
(0.25)	(0.063)	(316)
0.35	0.123	(333)
0.44	0.194	(349)
0.51	0.260	(364)
0.57	0.325	(381)
0.62	0.384	(397)

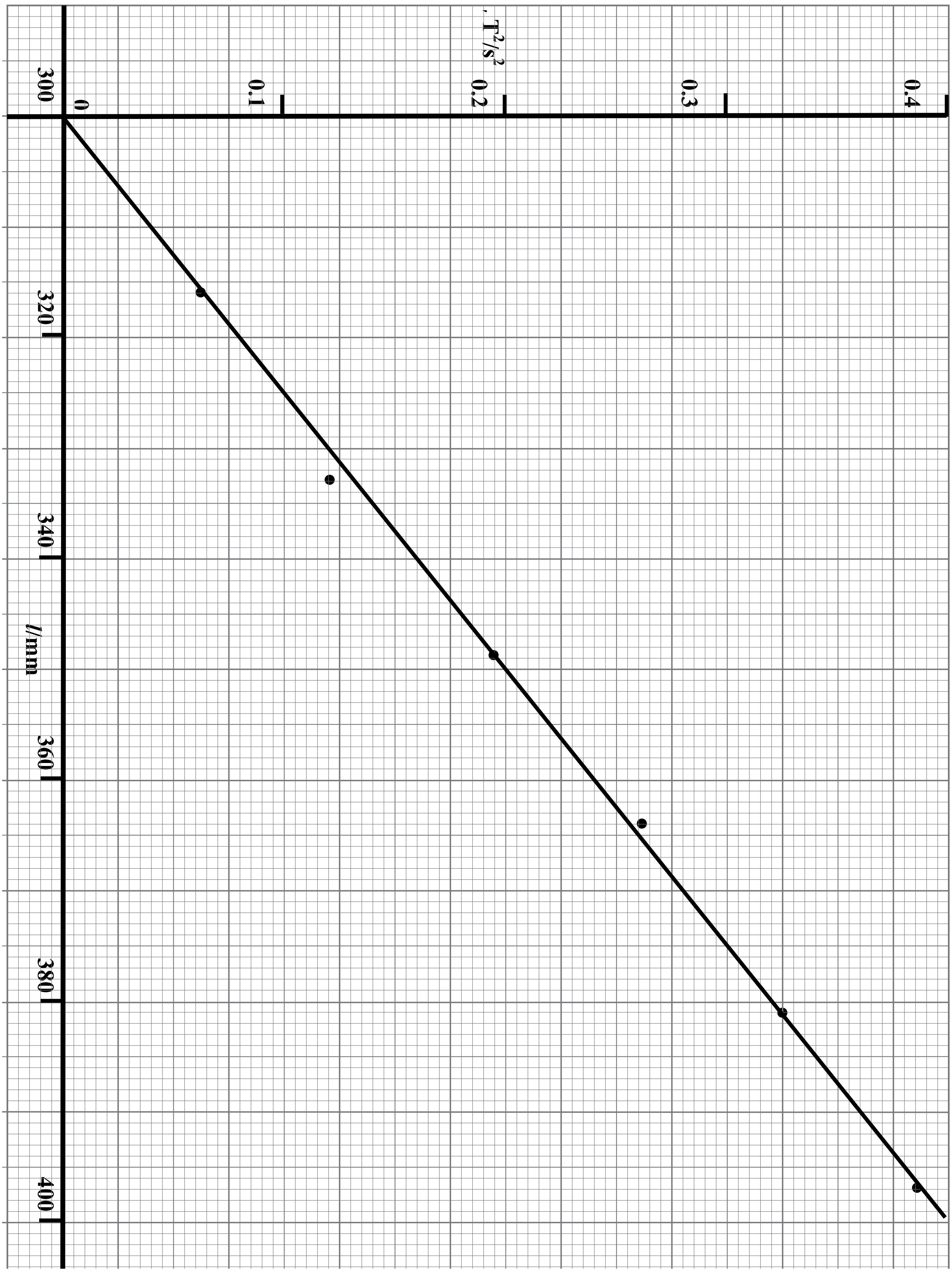
column T/s : 5 correct values to 2 d.p. ✓
column T^2/s^2; 5 correct values to 3 d.p. ✓</td><td>2</td></tr>
<tr><td>(b) (i)

(ii)

(iii)</td><td>$mg = k(l - l_0)$ ✓
(substituted into equation gives) $T = 2\pi\sqrt{\frac{(l-l_0)}{g}}$ and hence result ✓

suitable scales ✓
axes labelled, including units ✓
five points plotted correctly ✓
acceptable straight line ✓

gradient $\left(=\frac{4\pi^2}{g}\right) = \frac{0.400}{0.100} = 4.00\ (\pm 0.05)\ (\mathrm{s^2\ m^{-1}})$ ✓
$g = \frac{4\pi^2}{4.0} = 9.87\ (\pm 0.15)\ (\mathrm{m\ s^{-2}})$ ✓ (or 9.9 (± 0.2))
x-intercept = l_0 ✓
= 300 (± 5) mm ✓
[or use of given equation with suitable pair of coordinates from the graph to find y-intercept = $-4\pi^2 l_0/g$]</td><td>Max 9</td></tr>
<tr><td>(c)</td><td>for T = 1.00 s, $(l - l_0)\left(=\frac{T^2}{\text{gradient}}=\frac{1.00^2}{4.00}\right) = 0.250$ (m) ✓
(or similar calculation)
∴ l (=300 + 250) = 550 mm ✓
spring may not obey Hooke's law for large masses (or large extensions) ✓
beyond limit of proportionality/elastic limit, [or permanent extension or plastic deformation] ✓
[or spring might oscillate like a pendulum as pendulum time period is similar to spring time period (in each cycle of oscillations)]</td><td>4</td></tr>
</table>


T^2/s^2
0
0.1
0.2
0.3
0.4
l/mm
300
320
340
360
380
400

Question 6			
(a)	(i)	transit time of pulse = 6.0 (s) ✓ distance travelled by pulse (= speed × time = 1500 × 6.0) = 9000 (m) ✓ distance to submarine (= 9000/2) = 4500 m ✓	**Max 6**
	(ii)	pulse height greater ✓ as less attenuation (for shorter distance) ✓ transit time is less ✓ time/distance to pulse R across screen from transmitted pulse P halved ✓	
(b)	(i)	$\sin c = \frac{340}{1500}$ (× sin 90) (= 0.227) ✓ gives c = 13(.1)° ✓	**4**
	(ii)	beyond a certain distance, angle of incidence exceeds critical angle ✓ to give total reflection ✓	

Question 7			
(a)	(i)	at distance r from centre of planet of mass M, gravitational potential $V = -\frac{GM}{r}$, gravitational field strength $g = (-)\frac{GM}{r^2}$ ✓ (hence/show) $V = -gr$ ✓ (when $r = R$, $g = g_S$, to give required equation)	**5**
	(ii)	mass of oxygen molecule, $m = \frac{0.032\text{(kg)}}{6.02 \times 10^{23}} = 5.3(2) \times 10^{-26}$ (kg) ✓ E_P of molecule at surface = mV_S ✓ (or $-mg_SR$) $= -5.3 \times 10^{-26} \times 1.6 \times 1700 \times 10^3$ ✓ (= -1.4×10^{-19} J)	
(b)	(i)	E_k (= $^3/_2\,kT$) = $1.5 \times 1.38 \times 10^{-23} \times 400$ ✓ = 8.3×10^{-21} J ✓ ($8.2(8) \times 10^{-21}$ J)	**4**
	(ii)	to escape, **kinetic** energy of molecule must exceed 1.4×10^{-19} (J) ✓ $^3/_2\,kT$ is mean value, (or molecules have a range of speeds/kinetic energy) so some molecules will have sufficient energy/E_k/speed to escape ✓	

Question 8			
(a)	(i)	$F\left(=\dfrac{e^2}{4\pi\varepsilon_0 r^2}\right)=\dfrac{(1.6\times10^{-19})^2}{4\pi\times8.85\times10^{-12}\times(5.3\times10^{-11})^2}$ ✓ $= 8.2 \times 10^{-8}$ N ✓	6
	(ii)	(use of $F=\dfrac{mv^2}{r}$ gives) $v^2\left(=\dfrac{Fr}{m}\right)=\dfrac{8.2\times10^{-8}\times5.3\times10^{-11}}{9.1\times10^{-31}}$ ✓ $(= 4.8 \times 10^{12})$ $v = 2.1(8) \times 10^6$ m s^{-1} ✓ (allow C.E. for value of F from (i))	
	(iii)	ratio $\left(=\dfrac{h/mv}{2\pi r}\right)=\dfrac{6.6\times10^{-34}}{9.1\times10^{-31}\times2.2\times10^6\times2\pi\times5.3\times10^{-11}}$ ✓ = 1.0 ✓	
(b)	(i)	ΔE $(= 2.2 \times 10^{-18}\{1 - {}^1/_4\}) = 1.65 \times 10^{-18}$ (J) ✓ $\lambda\left(=\dfrac{c}{f}=\dfrac{hc}{\Delta E}\right)=\dfrac{6.6\times10^{-34}\times3.0\times10^8}{1.65\times10^{-18}}$ ✓ $= 1.2 \times 10^{-7}$ m ✓	5
	(ii)	wavelength is in ultraviolet ✓ all other transitions to ground state produce shorter wavelengths (i.e. uv) ✓	

Quality of Written Communication: Q2 (a) and/or Q4 (a) (i)	**2**