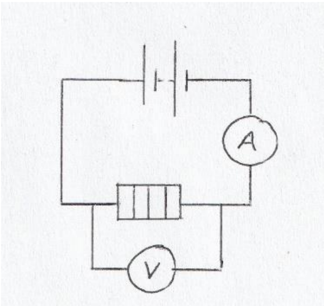
Mark Scheme (Results)

June 2021

Pearson Edexcel International Advanced Level
In Physics (WPH16)
Paper 1 Practical Skills in Physics II

Question number	Answer		Mark
1(a)	Measure (the number of divisions) between the same points on the pulses [Accept clearly labelled on diagram]	(1)	
	Multiply the number of divisions by the time per division.	(1)	
	Measure between the first and last pulse and divide by two **Or** Measure between successive pulses and determine a mean	(1)	**3**
	[Accept distance for number of divisions]		
1(b)	Use of $T = 2\pi / \omega$ **and** $v = \omega r$	(1)	
	T = 35.9 ms [Accept 36 ms]	(1)	
	Correct value of time per division calculated from time period and screen width **Or** Correct value of (maximum) time period on screen calculated using time scale and screen width	(1)	
	Valid time scale based on comparison of values	(1)	**4**
	[Accept calculation based on a screen width of between 5 and 10 divisions, or 2T]		
	<u>Example of calculation</u>		
	$\omega = v / r$ = 22.2 m s^{-1} / 0.127 m = 175 rad s^{-1}		
	$T = 2\pi / \omega = 2\pi$ / 175 rad s^{-1} = 35.9 × 10^{-3} s = 35.9 ms		
	The screen is 10 divisions wide, so each division would need to be at least 3.59 ms		
	Therefore use setting of 5 ms per division as 2 ms per division is too small		
			Total mark for Question 1 = 7

<table>
<tr><th>Question number</th><th>Answer</th><th></th><th>Mark</th></tr>
<tr><td>2(a)</td><td>Correct circuit diagram including a d.c. power supply, voltmeter and ammeter [Accept joulemeter or wattmeter in series for voltmeter and ammeter]

<u>Example of circuit diagram</u>


[Accept circuit drawn on diagram]

Wait until the water begins to boil
Record values of mass m
at times t with a stopwatch
Or
at energies E with a joulemeter

Plot appropriate graph for the measurements made
Correct gradient for the graph to obtain L
[Accept a labelled sketch graph]
<u>Examples of appropriate graphs</u>
<table>
<tr><th>y</th><th>x</th><th>gradient</th></tr>
<tr><td>m</td><td>t</td><td>VI/L or P/L</td></tr>
<tr><td>m</td><td>VIt or Pt or E</td><td>1/L</td></tr>
<tr><td>m</td><td>Vt</td><td>I/L</td></tr>
<tr><td>m</td><td>It</td><td>V/L</td></tr>
</table></td><td>(1)

(1)
(1)

(1)

(1)
(1)</td><td>6</td></tr>
<tr><td>2(b)</td><td>A significant source of error is energy transfer to the surroundings
Decreases the energy transferred to the water (per second)
Hence the value of L will be too large [dependent MP1 or MP2]
[Accept a reasonable source of error related to the experiment]</td><td>(1)

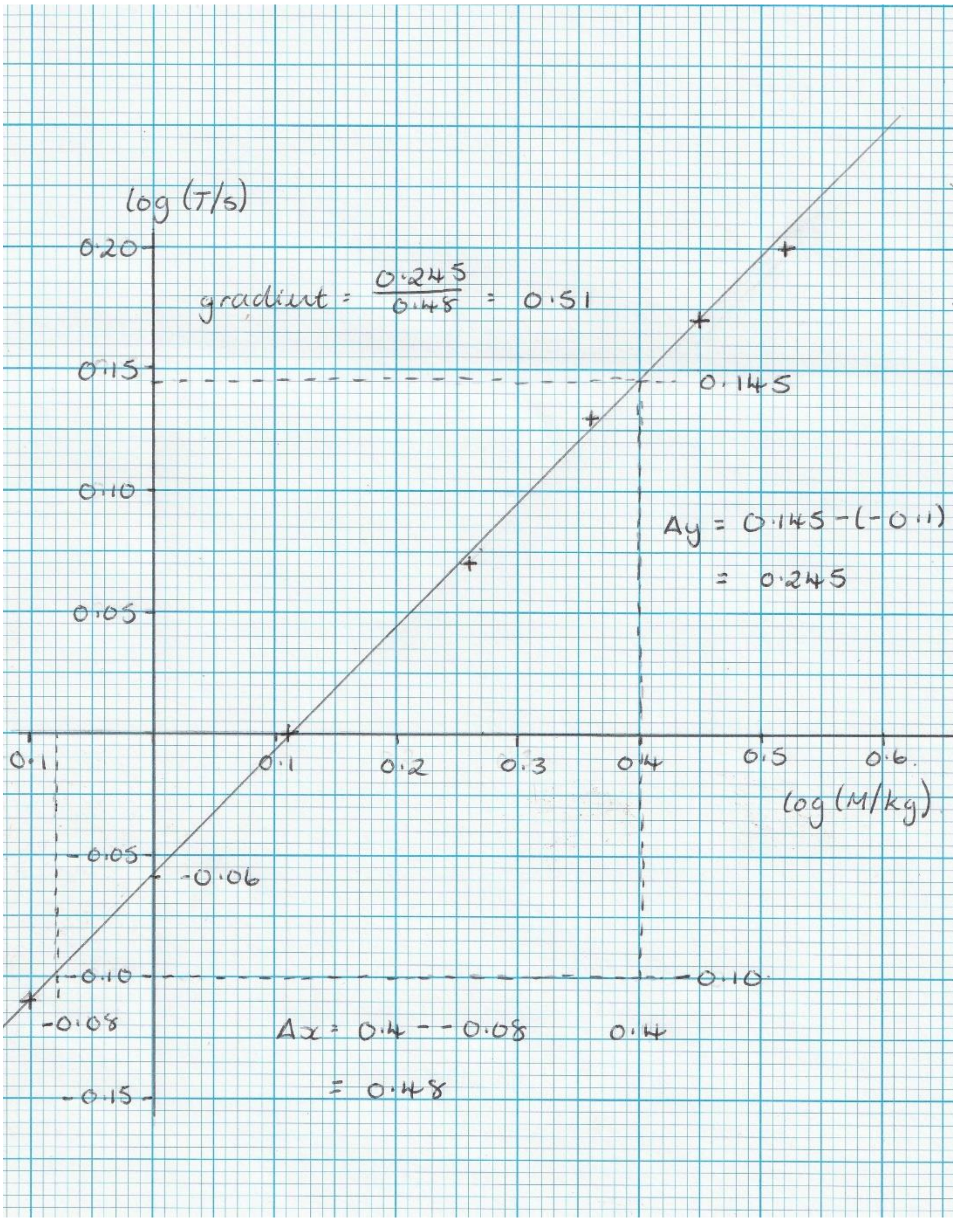
(1)
(1)</td><td>3</td></tr>
<tr><td colspan="4">Total mark for Question 2 = 9</td></tr>
</table>

Question number	Answer		Mark
3(a)(i)	Place a (timing) marker on the bench [Accept labelled diagram] (Marker) directly below a specific point on the trolley when (undisplaced from) the equilibrium	(1) (1)	2
3(a)(ii)	Max **TWO** from Time multiple oscillations **and** divide by the number of oscillations Repeat **and** calculate a mean Start timing after several oscillations have completed [Credit reference to a stationary timing marker in (a)(i)]	(1) (1) (1)	2
3(b)(i)	log T values correct and consistent to 2 d.p. [Accept 3 d.p] log M values correct and consistent to 2 d.p. [Accept 3 d.p] Axes labelled: y as log(T / s) and x as log(M / kg) Most appropriate scales for both axes Plots accurate to ± 1mm Best fit line with even spread of plots	(1) (1) (1) (1) (1) (1)	6
3 (b)(ii)	$\log T = \log (2\pi/\sqrt{k}) + ½\log M$ is in the form $y = c + mx$ with a gradient of 0.5 [dependent MP1] Correct calculation of gradient using large triangle shown Value of gradient in range 0.47 to 0.54, to 2 or 3 s.f., no unit Valid conclusion based on gradient value <u>Example of calculation</u> *gradient* = (0.145 – –0.10)/ (0.4 – –0.08) = 0.245 / 0.48 = 0.51 As the gradient is approximately 0.5 the prediction is valid [Credit gradient calculation given in (b)(iii) or on graph]	(1) (1) (1) (1) (1)	5

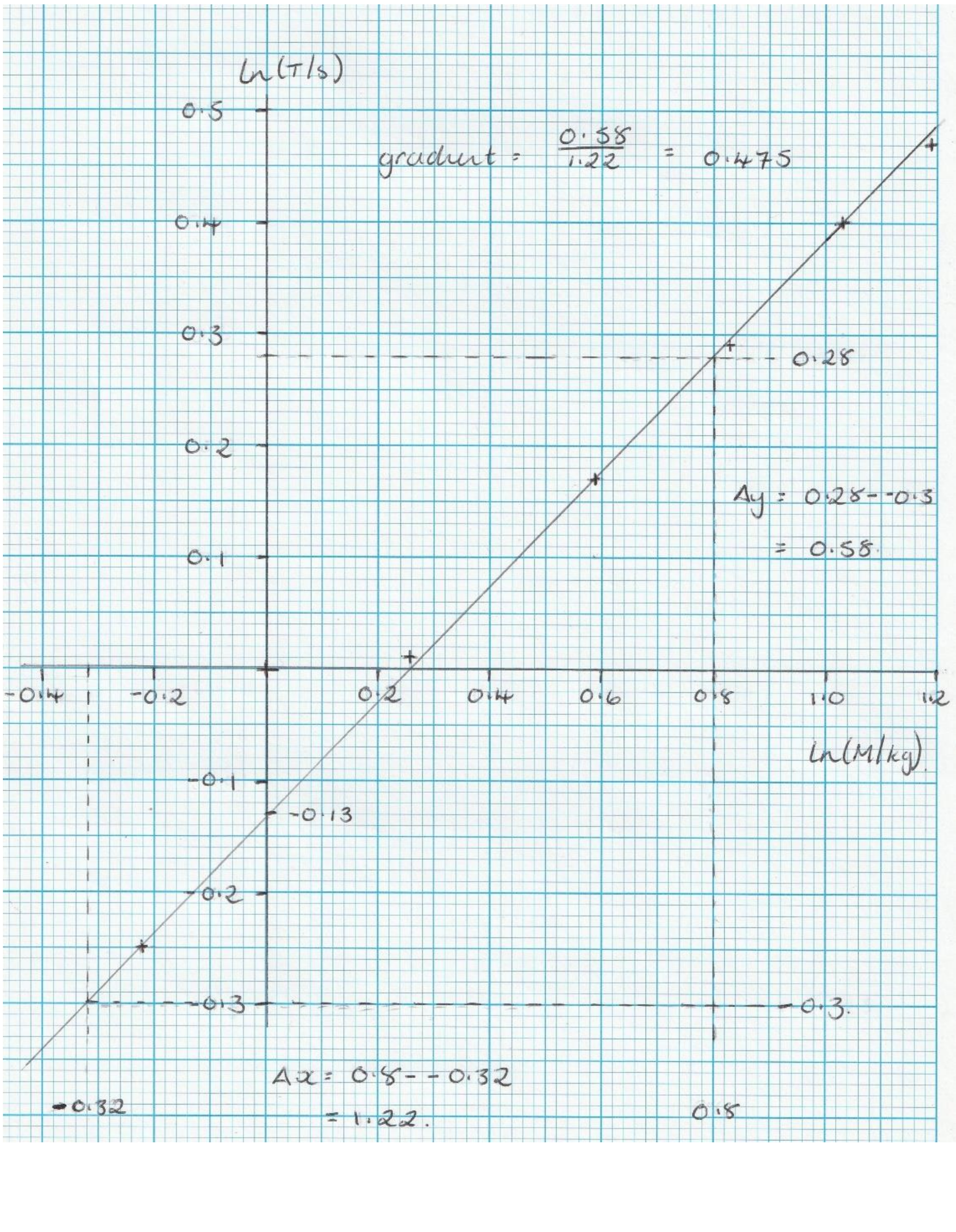
3 (b)(iii)	Correct value of y-intercept read from graph shown Calculation using antilog to determine $2\pi/\sqrt{k}$ shown Value of k in range 50 to 54 to 2 or 3 s.f. with unit of kg s^{-2} [Accept N m^{-1}] <u>Example of calculation</u> $c = -0.06 = \log(2\pi/\sqrt{k})$ $(2\pi/\sqrt{k}) = 10^{-0.06} = 0.87$ $k = (2\pi/0.87)^2 = 52$ kg s^{-2} **Or** Correct value of y-intercept using coordinates from point on best fit line with gradient shown [e.c.f. (b)(ii)] Calculation using antilog to determine $2\pi\sqrt{k}$ shown Value of k in range 50 to 54 to 2 or 3 s.f. with unit of kg s^{-2} [Accept N m^{-1}] <u>Example of calculation</u> From best fit line, $y = 0.095$, $x = 0.3$ $c = y - mx = 0.095 - (0.51$ ´ $0.3) = 0.095 - 0.153 = -0.058$ $(2\pi/\sqrt{k}) = 10^{-0.058} = 0.875$ $k = (2\pi/0.875)^2 = 52$ kg s^{-2} **Or** Correct antilog of coordinates from point on best fit line shown Use of $T = 2\pi\sqrt{(M/k)}$ shown Value of k in range 50 to 54 to 2 or 3 s.f. with unit of kg s^{-2} [Accept N m^{-1}] <u>Example of calculation</u> From best fit line, $y = 0.095$, $x = 0.3$ $T = 10^{0.095} = 1.24$, $M = 10^{0.3} = 2.00$ $k = 4\pi^2 M / T^2 = 4\pi^2$ ´ $2 / 1.24^2 = 79 / 1.54 = 51$ kg s^{-2}	(1) (1) (1) (1) (1) (1) (1) (1) (1)	 3
Total mark for Question 3 = 18			

Examples of completed tables and graphs

***M* / kg**	***T* / s**	**log (*M*/kg)**	**log (*T*/s)**
0.800	0.78	–0.10	–0.11
1.300	1.01	0.11	0.00
1.800	1.18	0.26	0.07
2.300	1.34	0.36	0.13
2.800	1.49	0.45	0.17
3.300	1.60	0.52	0.20



M / kg	*T* / s	ln (*M*/kg)	ln (*T*/s)
0.800	0.78	–0.22	–0.25
1.300	1.01	0.26	0.01
1.800	1.18	0.59	0.17
2.300	1.34	0.83	0.29
2.800	1.49	1.03	0.40
3.300	1.60	1.19	0.47



Question number	Answer		Mark
4(a)(i)	Vernier calipers as the range of the micrometer is too small [Accept clear reference to range of micrometer as 25 mm]	(1)	**1**
4(a)(ii)	There may be a <u>systematic error</u> **Or** there may be zero error (on the Vernier calipers) (Therefore) the values may not be close to the true value **Or** (therefore) there may be a constant value added to the measurements	(1) (1)	 **2**
4(b)	Mean x = <u>2.12</u> (mm) Uncertainty of <u>0.02</u> (mm) from calculation of half range [Accept furthest from the mean] <u>Example of calculation</u> mean x = (2.11+2.10+2.13+2.14+2.11) mm/5 = 2.118 = 2.12 mm Uncertainty = (2.14–2.10) mm/2 = 0.02 mm	(1) (1)	 **2**
4(c)(i)	Use of $n = 1 + \frac{d^2+(t-x)^2}{8f(t-x)}$ Correct value of n to 2 or 3 s.f. [e.c.f (b)] <u>Example of calculation</u> $n = 1 + \frac{d^2+(t-x)^2}{8f(t-x)} = 1 + \frac{5.10^2+(0.830-0.212)^2}{8\times9.8\times(0.830-0.212)} = 1 + \frac{26.01+0.618^2}{48.45}$ $= 1.54$	(1) (1)	 **2**
4(c)(ii)	Addition of U in t and U in x shown Conversion to %U to minimum 2 s.f. [e.c.f (b)] <u>Example of calculation</u> U = 0.01 + 0.02 = 0.03 %U = 0.03 / (8.30 – 2.12) × 100% = 0.49 %	(1) (1)	 **2**

4(c)(iii)	Use of 2× %U in d **or** 2× %U (t–x) shown [e.c.f (b)] Calculation of U in d^2 **or** U in $(t–x)^2$ shown Addition of U in d^2 and U in $(t–x)^2$ shown Correct value of U to minimum 3 s.f. [do not penalise if square root of final value is taken] <u>Example of calculation</u> %U in $d^2 = 2 \times (0.01/5.1 \times 100) = 0.392\%$ U in $d^2 = 5.1^2 \times 0.392/100 = 0.102$ %U in $(t - x)^2 = 2 \times 0.49 = 0.98\%$ U in $(t - x)^2 = 0.618^2 \times 0.98/100 = 0.004$ U = 0.102 + 0.004 = 0.106	(1) (1) (1) (1)	**4**
4(c)(iv)	Correct calculation of %U in n shown [e.c.f. (c)(ii) and (iii)] Calculation of relevant limit shown [e.c.f (c)(i)] Valid conclusion based on comparison of calculated values [MP3 dependent on MP2] <u>Example of calculation</u> %U = (0.106/26.4 × 100) + 0.485 + (0.3/9.8 × 100) = 0.402 + 0.485 + 3.06 = 3.95% Upper limit = 1.54 × 1.04 = 1.60 Lower limit = 1.54 × 0.96 = 1.48 The lens is most likely to be made of crown glass as it is the only value to fall within the range **Or** Correct calculation of %U in n shown [e.c.f. (c)(ii) and (iii)] Correct calculation of relevant %D shown [e.c.f (c)(i)] Valid conclusion based on comparison of calculated values [MP3 dependent on MP2]	(1) (1) (1) (1) (1) (1)	**3**

	<u>Example of calculation</u> %U = (0.106/26.4 × 100) + 0.485 + (0.3/9.8 × 100) = 0.402 + 0.485 + 3.06 = 3.95% Crown glass %D = (1.54–1.52)/1.52 × 100 = 1.32 % Flint glass %D = (1.66–1.54)/1.66 × 100 = 7.23 % The lens is most likely to be made of crown glass as the %D is less than the %U whereas %D is larger than %U for flint glass.		
	Total mark for Question 4 = 16		