

Marking Scheme

Physics (6091) Preliminary Examination 2026

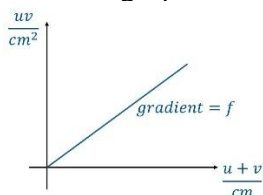
Mark scheme will use these abbreviations

/	alternatives
+	statements on both sides of the + are needed for that mark
R	reject
A	accept (for answers correctly cued by the question)
lg	ignore as irrelevant
ref	with reference to
ecf	error carried forward
AW	alternative wording (where responses vary more than usual)
AVP	alternative valid point
ORA	or reverse argument
OWTTE	or words to that effect
<u>underline</u>	actual word given must be used by candidate (grammatical variants excepted)
()	the word / phrase in brackets is not required but sets the context

Paper 3

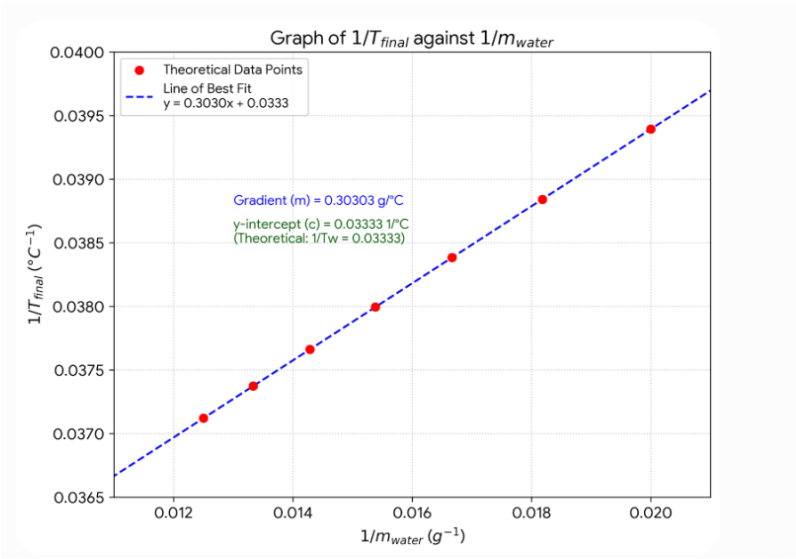
Qn	Marking Scheme	Remarks	Marker's Report
1ai	[1] l_1 = answer to 3 dp, in the range of (0.090 – 0.100) h_1 = answer to 3 dp, range of (0.027 – 0.033 m)	Stretched and 3 cm above $l_1 = 0.095 \text{ m } (\pm 10\%)$ $h_1 = 0.030 \text{ m}$	
1aii	[1] l_2 = answer to 3 dp in the range of (0.010 – 0.240) [1] h_2 = answer to 3 dp, $h_2 > h_1$		
1b	$k = 25 \text{ N/m}$ $W = 2.0 \text{ N}$		
1bi	$E_{ep} = 0.084 \text{ J (2 sf)}$ [1] Correct calculation [1] Correct sf with correct unit	Loss in elastic store $E_{ep} = 0.5 k (l_1 - l_2)^2$ $= 0.5(25)(0.095 - 0.013)^2$ $= 0.08405$	
1bii	$E_{gp} = 0.17 \text{ J (2 sf)}$ [1] Correct calculation with correct sf	Gain in gravitational store $E_{gp} = W (h_2 - h_1)$ $= 2.0 (0.113 - 0.030)$ $= 0.166$	
1c	$\frac{E_{ep}}{E_{gp}} = 0.51 \text{ (2 sf)}$ [1] Correct calculation with correct sf and no units	Ratio $\frac{E_{ep}}{E_{gp}}$ $= 0.08405 / 0.166 = 0.506 \text{ 325}$	

1d	[1] SOE 1 (about spring): - As the spring stretches, it is not possible to find the same reference points to measure length of the spring, hence there will be inaccuracies in the readings of l_1 and l_2. - As the spring unstretches, it may not return to its original unstretched length, hence there will be inaccuracy in the readings of l_2. - The spring may not be exactly vertical, hence there will be inaccuracies in the readings of l_1 and l_2. [1] SOE 2 (about ruler): - The half metre ruler cannot be held steadily by hand close to the spring and the load, hence there will be inaccuracies in the readings of l_1, l_2, h_1 and h_2. - The half metre rule is not held exactly vertical, hence there will be inaccuracies in the readings of l_1, l_2, h_1 and h_2. [1] Improvement: - Use a spring with a reference wire/pin on both ends. Clamp a metre rule vertically close to the spring. - Use a set square against the base of the retort stand and the spring/rule to ensure that spring/rule is exactly vertical.	Accept: Uncertainty as to where e is zero. Affecting l_2 or h_2. Uncertainty in reading l_2 or h_2 when the mass is held by hand as it may unconsciously be moved.
[Total: 10]		
2a	[1] Alignment for z-axis: Align the retort stand, block with lenses and screen along the side of the metre rule and ensure that they are perpendicular to the rule. [1] Ensuring for correct position of screen: Place the screen at the 50.0 cm mark of the rule and move it slowly towards the lenses. Move the screen a little bit away and towards the lenses to ensure correct position of the screen. [1] Ensuring for focused image: Stop when you see that the image of the triangle has sharp corners.	
2b	[1] v = answer to 1 dp with units in the range of (0.133 – 0.147) [1] Averaging 2-3 values to increase accuracy.	$v = (13.9 + 14.1) / 2$ $= 14.0 \text{ cm } (\pm 5\%)$
2ci	$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ $\frac{1}{f} = \frac{v}{uv} + \frac{u}{uv}$ $\frac{1}{f} = \frac{v+u}{uv} \text{ [1]}$ $uv = f(u + v) \text{ (PROVEN)}$	

2cii	1. Assemble the apparatus as shown in Fig. 2.1. Follow the steps before (a) and in 2(a). 2. Determine an accurate value for the distance v by averaging two values [1] (or more) of v. 3. Record your values of u and v in a table. Include columns for uv and $(u + v)$. For six values of u from 15.0 cm to 25.0 cm, determine corresponding values of v, uv and $(u + v)$. [1] Record all of your measurements and calculations in your table. <table><tr><th>$\frac{u}{\text{cm}}$</th><th>$\frac{v}{\text{cm}}$</th><th>$\frac{uv}{\text{cm}^2}$</th><th>$\frac{u + v}{\text{cm}}$</th></tr><tr><td>15.0</td><td></td><td></td><td></td></tr><tr><td>17.0</td><td></td><td></td><td></td></tr><tr><td>19.0</td><td></td><td></td><td></td></tr><tr><td>21.0</td><td></td><td></td><td></td></tr><tr><td>23.0</td><td></td><td></td><td></td></tr><tr><td>25.0</td><td></td><td></td><td></td></tr></table> 4. Plot a graph of uv against $(u + v)$. [1]  5. The gradient [1] of your line of best fit is numerically equal to the focal length f of the combination of lenses. Determine f.			$\frac{u}{\text{cm}}$	$\frac{v}{\text{cm}}$	$\frac{uv}{\text{cm}^2}$	$\frac{u + v}{\text{cm}}$	15.0				17.0				19.0				21.0				23.0				25.0				Aim: To determine the focal length of the combination of lenses IV: object distance u DV: image distance v CV: - (frequency of) light from torch - temperature/humidity of air - material (refractive index) of lenses - shape of lenses	
$\frac{u}{\text{cm}}$	$\frac{v}{\text{cm}}$	$\frac{uv}{\text{cm}^2}$	$\frac{u + v}{\text{cm}}$																														
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[Total: 10]																																	
3ai	[1] V = answer to 0.5 ml, with unit, in the range of (59.0 – 61.0)	Read to half of the smallest division of the measuring cylinder. $V = 60.0 \text{ ml}$ ($\pm 1.5\%$) $T_{\text{warm}} = 30.0^\circ\text{C}$																															
3aii	[1] Correct calculation of m_w with unit and correct s.f	$m_w = 1.0 \times 60.0$ (2sf x 3sf) $= 60 \text{ g}$ (2sf)																															
3b	[1] T_{final} = answer to 0.5°C, with unit	Read to the half of the smallest division of the thermometer.																															
3c	[1] Correct headings with quantities and units (as shown below) [1] Range of volumes evenly distributed (60, 70, 80, 90, 100, 110) [1] Correct trend (as V increases, T_{final} increases) [1] Correct dp for measurements and correct sf for calculations [1] Correct calculations and rounding <table><tr><th>$\frac{V}{\text{cm}^3}$</th><th>$\frac{m_w}{\text{g}}$</th><th>$\frac{1}{\frac{m_w}{\text{g}^{-1}}}$</th><th>$\frac{T_{\text{final}}}{^\circ\text{C}}$</th><th>$\frac{1}{\frac{T_{\text{final}}}{^\circ\text{C}^{-1}}}$</th></tr><tr><td>to 1 dp</td><td>to 2 sf</td><td>to 2 sf</td><td>to 1 dp</td><td>to 3 sf</td></tr><tr><td></td><td></td><td></td><td></td><td></td></tr></table>			$\frac{V}{\text{cm}^3}$	$\frac{m_w}{\text{g}}$	$\frac{1}{\frac{m_w}{\text{g}^{-1}}}$	$\frac{T_{\text{final}}}{^\circ\text{C}}$	$\frac{1}{\frac{T_{\text{final}}}{^\circ\text{C}^{-1}}}$	to 1 dp	to 2 sf	to 2 sf	to 1 dp	to 3 sf																				
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3di	[1] axes labelled with quantities and units [1] good scale (not odd, points span > 50% of graph paper) [1] points correctly plotted [1] best fit line drawn	
3dii	Correct G calculated from the student's graph. [1] Correct working (gradient triangle and 2 pairs of coordinates) [1] Correct answer, correct unit and correct sf (according to student's graph)	
3diii	Correct c_b calculated from the student's G. [1] Correct working [1] Correct answer, correct unit and correct sf $G = \frac{c_b \times m_b}{c_w \times T_{warm}}$ $c_b = \frac{G \times c_w \times T_{warm}}{m_b} = \frac{0.303 \times 4.2 \times 30.0}{100} = 0.38178 \approx 0.38 \text{ J (g } ^\circ\text{C)}^{-1}$	
3div	[1] Correct Y obtained/calculated from the student's graph. (Correct working) Correct answer, correct unit and correct sf $Y = 0.033 \text{ } ^\circ\text{C}^{-1}$ $\frac{1}{Y} = 30 \text{ } ^\circ\text{C}$ [1] Compares values of $\frac{1}{Y}$ from (div) and T_{warm} in (a), and explains that the (percentage) difference is insignificant/significant. Yes, agree with suggestion since value of T_{warm} from (a) is 30.0°C and there is no difference between $\frac{1}{Y}$ in (div) and T_{warm} in (a).	
3e	[1] SOE and [1] Improvement: There is energy transferred from the surroundings to the styrofoam cup and its contents, hence affecting the accuracies of T_{final}. Use a lid to reduce the energy transfer. The temperature of the tap water may not stay constant, hence affecting the accuracies of T_{warm} and T_{final}. Measure the temperature of the tap water using data loggers. The starting temperatures of the styrofoam cup may not have enough time to reset in between readings, hence affecting the accuracies of T_{warm}, and hence T_{final}. Use more sets of cups, so as to allow time for reset.	Accept: Heat is gained during transfer between the ice bath and the Styrofoam cup. Reduce the temperature of the room using air conditioning/temperature controlled enclosure.
[Total: 10]		

$\frac{V}{\text{cm}^3}$	$\frac{m_w}{\text{g}}$	$\frac{1}{\frac{m_w}{\text{g}^{-1}}}$	$\frac{T_{\text{final}}}{^\circ\text{C}}$	$\frac{1}{\frac{T_{\text{final}}}{^\circ\text{C}^{-1}}}$
to 1 dp	to 2 sf	to 2 sf	to 1 dp	to 3 sf
50.0	50	0.020	25.4 = 25.0	0.0394
55.0	55	0.018	25.7 = 26.0	0.0389
60.0	60	0.017	26.0	0.0385
65.0	65	0.015	26.2 = 26.0	0.0381
70.0	70	0.014	26.5 = 27.0	0.0378
75.0	75	0.013	26.7 = 27.0	0.0375
80.0	80	0.013	26.8 = 27.0	0.0373



There is energy transferred from the surroundings to the brass, hence affecting the accuracies of T_{cold} and T_{final} .

Use a larger mass of brass to reduce the rise in temperature of the brass when it is moved from the water bath to the styrofoam cup.