2022 Physics Prelim P3 – Mark Scheme

Deduct 1 m if wrong dp/sf (per section)

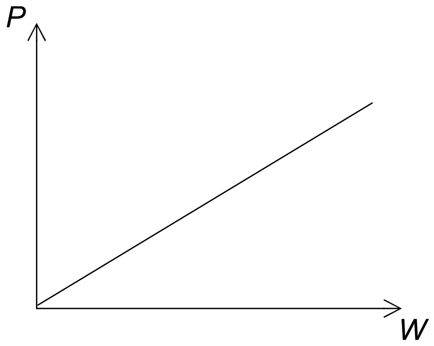
Deduct 1 m if wrong/no units (per section)

Separate scoring for tabulation (sf and units).

1ai	V_0 = 4.50 V	1	
	Following results for Q1 are based on old motor		
ii	V_1 = 2.50 V I_1 = 0.13 A	1 1	Old motors: 2.50 V – 2.70 V 0.12 A – 0.13 A (tested 5 pcs) New motors: 2.35 V – 2.50 V All 0.14 A (tested 6 pcs) (V_1 = 1.85 V – 2.90 V)
iii	$P_1 = V_1I_1$ = 2.50 x 0.13 = 0.33 W	1	
bi	V_2 = 0.25 V I_2 = 0.30 A	1	V_2 = 0.10 V – 0.50 V I_2 = 0.17 A accepted
ii	$R = \frac{0.25}{0.30}$ = 0.83 Ω	1	
c	$Q = \frac{0.13 \times 0.83}{2.50}$ = 0.043 J	1	
d	While the shaft is spinning, raise the height of the boss until the shaft just stops spinning. Measure the length of the spring and find its extension, e. Remove the wooden rod and motor. Hang a known weight from the spring and find the extension of the spring. Repeat for 5 further different values of extension and known weights. Plot a graph of the extension, e against the weight. From the graph, read the value of the force that corresponds to the extension e.	1 1	

	OR Find k by hanging the 5.0 N weight on the spring. Measure the extension e. Calculate k using k = $\frac{5.0}{e}$. Raise the boss till the motor just stops spinning. Measure the extension of the spring, e. Calculate with F = ke.	1 1	
e	Replace the spring with a spring balance.	1	

2a	h = 7.0 cm j = 32.2 cm k = 12.0 cm	1	h minimum 6.4 cm 8.5 cm NOK j = 26.8 cm NOK
b	t_1 = 5.87 s, t_2 = 5.99 s, t_3 = 5.99s <t> = $\frac{5.87+5.99+5.99}{3}$ = 5.95 s	1 1	Average of 2 timings OK
c	$P_1 = \frac{5 \times 0.010}{6.0}$ = 0.0083 W	1 1	
d	t_1 = 5.32 s, t_2 = 5.20 s, t_3 = 5.22s <t> = $\frac{5.32+5.20+5.22}{3}$ = 5.24 s $P_2 = \frac{2 \times 0.010}{5.24}$ = 0.00382 W	1	(after removing 3 weights, h = 3.7 cm) Working for <t> must be evident.

e	Constant variables: • mass-hangar and weights, • change of height Δh • length k • length j Independent variable: • weight W Dependent variable: • time taken to unwind fully, t	1	Type of weights and string used must be consistent. h, j and k must be constant as they affect the tension in the string. Dependent variable: OK if students write t and P.
	Set up the apparatus as shown in Fig. 2.1. Carry out steps (b) and (c) to obtain a set of values of W, t and P.	1	
	Repeat steps (b) and (c) to obtain 5 further sets of values of W, t and P by removing one weight from the mass-hangar for each set of reading. Tabulate the results of W, t and P.	1	
	The relationship between P and W can be found by plotting a graph of P against W: 	1	Graph with positive gradient (when W increases, P decreases). Accept curve graphs.

<table>
<tr><td>3a</td><td>L_0 = 0.022 m</td><td>1</td><td></td></tr>
<tr><td>bi</td><td>L = 0.147 m

x = 0.147-0.022 = 0.125 m

x = 0.125 m</td><td>1

1</td><td>

Need to show working for x.</td></tr>
<tr><td>ii</td><td>1. Avoid parallax error by reading the mark on the scale of the half-metre rule at eye level when taking measurements.

2. Ensure the metre rule was vertical by aligning it to a vertical feature (eg. door frame) or the use of set square placed between the bench and the metre rule.

3. The readings of x was taken</td><td>1

1</td><td>“accuracy of x” refers to taking the readings of x, not the experimental set up.</td></tr>
<tr><td>iii</td><td>k = $\frac{0.300\,kg \times 10\,N/kg}{0.125\,m}$
= 24 N/m</td><td>1
1</td><td></td></tr>
<tr><td>iv</td><td>E = $\frac{0.300\,kg \times 10\frac{N}{kg} \times 0.125\,m}{2}$
= 0.19 J</td><td>1</td><td></td></tr>
<tr><td>c</td><td><table>
<tr><td>m / kg</td><td>L / m</td><td>x / m</td><td>x^2 / m^2</td><td>E / J</td></tr>
<tr><td>0.050</td><td>0.035</td><td>0.013</td><td>0.00017</td><td>0.0033</td></tr>
<tr><td>0.100</td><td>0.058</td><td>0.036</td><td>0.0013</td><td>0.018</td></tr>
<tr><td>0.150</td><td>0.079</td><td>0.057</td><td>0.0032</td><td>0.043</td></tr>
<tr><td>0.200</td><td>0.100</td><td>0.078</td><td>0.0061</td><td>0.078</td></tr>
<tr><td>0.250</td><td>0.123</td><td>0.101</td><td>0.010</td><td>0.13</td></tr>
<tr><td>0.300</td><td>0.147</td><td>0.125</td><td>0.016</td><td>0.19</td></tr>
</table>
(accept 2dp for m/kg, need to be consistent)</td><td>1 – headings

1 – 6 sets of readings

1 – correct dp for m, L, and x. Correct sf for x^2 and E

1 – correct calculations of x^2 and E</td><td>Mass m can be recorded in ascending or descending order.

E and x^2 can be 2 sf or 3sf, but must be consistent in the column.

Allow 1 mistake for calculations.</td></tr>
<tr><td>d</td><td>See attached</td><td>1 – Axis
1 – Scale
1 – Plotting
1 – Best fit</td><td></td></tr>
<tr><td>ei</td><td>Gradient
= $\frac{0.180-0.052}{0.0148-0.0040}$
= 12 (2 sf) or 11.9 (3 sf)</td><td>1
1</td><td>Gradient triangle in graph must be shown as part of working</td></tr>
</table>

			If no x and y labels in gradient triangle, OK.
ii	G = 12 and 0.5k = 0.5 x 24 = 12 N/m, which is within the limits of experimental error. Therefore G = 0.5k is supported.	1	
f	**Method 1: Equation of line** Equation of line is: $E = 13x^2 + 0.001$ (y-intercept is 0.001) When m = 0.600 kg, the extension will be 0.125 x 2 = 0.250 m. Therefore, the energy stored will be: $E = 13\,(0.250)^2 + 0.001$ $= 0.81$ J	1	NO marks if students state their answer without working or reasoning. Students need to show line equation and working.
	Method 2: Trend From data, when the mass m is doubled, the value of E will be on average 4.9 times larger. Therefore, the predicted energy stored will be 4.9 x 0.19 = 0.93 J.	1	
	Method 3: Calculation based on k Taking k from student's results, and sub m = 0.600 kg, $k = \frac{mg}{x}$, so $x = \frac{mg}{k}$ = …………m $E = \frac{mgx}{2}$ = …………J	1	
	Method 4: Calculation based on x When m = 600 g, x will be twice for m = 300g. So x = ……….. $E = \frac{mgx}{2}$ = …………J	1	