Name: ______________________________________ CG: ___________ Date: _____________

Question 1 Suggested Mark Scheme

No	Marking Instructions	Mark	Score
(a)(i)	*d* recorded to nearest 0.1 mm with unit (2 dp in cm)	1	
(a)(ii)	*h* recorded to nearest 0.1 mm or 1 mm with unit (1dp or 2dp in cm) D recorded to nearest 0.1 mm with unit (2 dp in cm) with evidence of repeat measurement	1	
(b)(iii)	*x* calculated correctly to correct s.f. (with substitution)	1	
(b)(iv)	Correct justification of s.f. in *x* linked to s.f. in *D, d* and *h* (lowest s.f.)	1	
(c)(ii)	Value of *t* to correct d.p. with unit (5.0 s ≤ t ≤ 9.0 s) Evidence of repeat timing	1	
(c)(iii)	Correct calculation of % uncertainty (1 or 2 sf) using sensible value of Δt (0.2 s ≤ Δt ≤ 0.5 s).	1	
(d)	Second value of x calculated correctly Second value of average *t* with correct dp and unit	1 1	
(e)(i)	Correct calculations of the two *k* values with correct unit	1	
(e)(ii)	Draw conclusion based on stated criterion. (e.g. not obeyed because % difference of *k* values > 2 times % uncertainty of *t* in (c)(iii))	1	
(f)(i)	Sources of error might include: 1. Difficult to release small container from same position every time as placing fingers in water changes level of water surface making it difficult to maintain the same start point, affecting t 2. As the centre of gravity of the small container and marbles is located at one side of the container it does not always fall vertically and may hit the sides of the cylinder during descent, affecting t 3. Timing is too short making human reaction time a significant uncertainty in timing t 4. Difficult to identify end point as it is difficult to see the small container due to refraction/similar refractive indices of water, cylinder and container/glass curvature, affecting t 5. Bubble / air in container introduces extra buoyancy, affecting t	1	
(f)(ii)	One improvement each. Relevant points might include: 1. Better method to hold and release cylinder (e.g. use a pincer / make a mark for reference to ensure same water level for each release) 2. Method to attach string symmetrically / ensure symmetrical distribution of masses e.g. use glass beads/sand/modelling clay for even mass distributions 3. Use a longer tube / video the descent and view frame by frame 4. Method to identify end point (e.g. mark at bottom of cylinder/use colour container) 5. Puncture a small hole in the lid to release bubble / air	1	
	Total	12	

Question 2 Suggested Mark Scheme

No	Marking Instructions	Mark	Score
(a)(ii)	*x* recorded to nearest mm with unit (or 1 dp in cm, 3 dp in m)	1	
(b)(ii)	V_1 and V_2.recorded to correct d.p. with unit (3 d.p. in V) with $V_2 < V_1$	1	
(c)	Collected and tabulated 5 sets of data (for x till 90.0 cm) V_2/V_1 calculated correctly to correct s.f.	1 1	
(d)(i)	Linear graph with y-intercept. Appropriate scales – awkward scales (e.g. 3:10) are not allowed and scales must be chosen so that the plotted points occupy at least half the graph grid in both x and y directions. Correct labelling of axes with correct units. All observations plotted to an accuracy of half a small square and line of best fit drawn with a fair scatter of points on either side of the line	1 1	
(d)(ii)	Correct conclusion of the relationship based on student's result	1	
(d)(ii)	Line Z with steeper gradient and same y-intercept	1 1	
	Total	9	

Question 3 Suggested Mark Scheme

No	Marking Instructions	Mark	Score
(b)(i)	r recorded to nearest mm with unit with unit with evidence of repeat reading	1	
(b)(ii)	Measure diameter D of the masses in different orientations and calculate the average D. Record readings R_1 and R_2 of the outer edges of the masses. Then $r = ½ (R_2 – R_1 – D)$ <u>OR</u> Measure centre to centre (through the gap) of the 2 slotted masses Divide by 2	1 1	
(c)(ii)	2.6 s ≤ T ≤ 4.6 s Evidence of repeat timing	1	
(d)	Collected 6 or more sets of data (r, T). Award 1 mark if assistance was rendered, or collected only 5 sets of data	2	
	Each column heading contains an appropriate quantity and unit	1	
	Consistency in no. of d.p. for raw readings (r to nearest mm, T to 0.1 s)	1	
	Correct calculation of quantities (T^3, r^2)	1	
	All calculated values given to appropriate no. of s.f.	1	
(e)	Linearising equation and deriving gradient / y-intercept of graph	1	
	Appropriate scales – awkward scales (e.g. 3:10) are not allowed and scales must be chosen so that the plotted points occupy at least half the graph grid in both x and y directions. Correct labelling of axes with correct units	1	
	All observations plotted to an accuracy of half a small square	1	
	Line of best fit – with a fair scatter of points on either side of the line	1	
	Gradient – hypotenuse of the triangle is greater than half the length of the drawn line. Read-offs must be accurate to half a small square	1	
	Y intercept – read off directly from the graph to half a small square or determined from $y = mx + c$ using a point on the line	1	
	Value of a and b calculated correctly with correct units, if any	1	
(f)	Appropriate comment on any anomaly	1	
(g)	Diagram with workable arrangement: single spring (extension) with pivot at c.g. Do not accept spring compression methods. Appropriate method to measure and determine average extension x and period T Plot T^2 against x to show relationship where gradient gives c Correct explanation of difficulty in using spring constant with small k.	1 1 1 1	
	Total	22	

Name of student:________________________________ CG:_____________

Q4 Planning Question Suggested Mark Scheme

Score	Marks	Marking Points
		Design (2 mark)
	A1	Labelled diagram showing method to produce air flow in line with turbine. Method of producing "wind" must be labelled. E.g. electric fan, hair dryer, leaf blower
	A2	Circuit connecting turbine to lamp with ammeter and voltmeter connected correctly. No additional power supplies in the lamp circuit.
		Procedure (5 marks)
	B1	Method to measure power $P = IV$. Use voltmeter to measure V and ammeter to measure I. Allow wattmeter or joule meter and stopwatch.
	B2	Method to determine angle θ. Measure angle with protractor or rule for measurements for trigonometry methods. Must be shown correctly on diagram or explained in text.
	B3	Method to measure wind speed v, e.g. wind speed meter/detector/sensor(with data logger, anemometer.
		Control of variables
	B4	<u>Expt A: Keep v constant, vary θ</u> Vary angle θ by tilting the plane of the wind turbine with respect to the horizontal/vertical.
	B5	<u>Expt B: Keep θ constant, vary v</u> Method to change wind speed v, e.g. change setting, variable power supply/ resistor/ change distance from fan.
		Safety and Analysis (2 marks)
	C1	Expt A: For constant I, $\lg P = m \lg \cos \theta + \lg (k v^n)$ Plot lg P vs lg $\cos\theta$. Gradient of the straight line is equal to m.
	C2	Expt B: For constant θ, $\lg P = n \lg v + \lg(k \cos\theta^m)$ Plot lg P vs lg v. Gradient of the straight line line is equal to n.
		Safety consideration (1 mark)
	C3	Wear goggles to avoid air flow entering eyes Avoid moving blades of fan using safety screen, switch off fan when changing experiment Wear gloves when handling hot lamp
		Details (Max 2 D marks)
	D1	Conduct pre-experiment to determine suitable range of θ and v to obtain measurable P.
	D2	Use of large wind speed to gain measurable readings.
	D3	Use of low resistance lamp or use turbine with low friction.
	D4	Additional detail on measuring θ *or* (cos) θ e.g. use a large protractor, projection method.
	D5	Measuring wind speed at fixed point from turbine.
	D6	Adjust height of fan so that air flow is horizontally aligned to the turbine.
	D7	Wait until airflow/turbine/meter readings constant before taking readings.
	D8	Keep windows shut/air conditioning switched off/use of wind tunnel to avoid draughts.
	D9	Any other good physics suggestion.
	12	

Question 1 Suggested solution:

(a)(i) d = ½ (1.62 + 1.62) = 1.62 cm

(a)(ii) h = ½ (3.60 + 3.60) = 3.60 cm (h can be measured using vernier caliper or 30 cm ruler, so h can be 2 or 1 dp)

D = ½ (2.42 + 2.42) = 2.42 cm

(b)(iii)

$$x = \frac{2nd^3}{3D^2h} = \frac{2(1)(1.62)^3}{3(2.42)^2(3.60)} = 0.134$$

(b)(iv) Since *x* is a product and quotient of D, d and h, *x* should follow the least significant figures of either D, d or h. Since the least significant figure is 3, *x* should be recorded to 3 significant figures.

(c)(ii) <t> = ½ (7.5 + 6.5) = 7.0 s

(c)(iii)

$$\frac{\Delta t}{t} \times 100\% = \frac{0.5}{7.0} \times 100\% = 7.1\%$$

(d) x = 0.268

<t> = ½ (2.5 + 2.3) = 2.4 s

(e)(i) $k_1 = (7.0)^2\,(0.134) = 6.57\ s^2$

$k_2 = (2.4)^2\,(0.268) = 1.54\ s^2$

(e)(ii)

Percentage difference from smaller k value $= \frac{6.57 - 1.54}{1.54} \times 100\% = 300\%$, which is greater than 2 times the percentage uncertainty in t (= 14%). Hence, experiment does not support the suggested relationship.

(f)(i) Sources of error might include:

1. Difficult to release small container from same position every time as placing fingers in water changes level of water surface making it difficult to the same maintain the same start point, affecting t
2. As the centre of gravity of the small container and marbles is located at one side of the container it does not always fall vertically and may hit the sides of the cylinder during descent, affecting t
3. Timing is too short making human reaction time a significant uncertainty in timing t
4. Difficult to identify end point as it is difficult to see the small container due to refraction/similar refractive indices of water, cylinder and container/glass curvature, affecting t
5. Bubble / air in container introduces extra buoyancy, affecting t

f(ii) Improvement might include:

1. Better method to hold and release cylinder (e.g. use a pincer / make a mark for reference to ensure same water level for each release)
2. Method to attach string symmetrically / ensure symmetrical distribution of masses (e.g. use glass beads / sand / modelling clay for even mass distributions)
3. Use a longer tube / video the descent and view frame by frame
4. Method to identify end point (e.g. mark at bottom of cylinder/ use coloured container)
5. Puncture a small hole in the lid to release bubble / air

Question 2 Suggested solution:

(a)(i)	x = 20.0 cm	1
(b)(ii)	$V_1 = 0.870$ V	1
	$V_2 = 0.531$ V	
(c)	(table below)	2

x/ cm	V_1/V	V_2/V	V_2/V_1
20.0	0.870	0.531	0.610
35.0	0.842	0.573	0.681
50.0	0.800	0.602	0.752
65.0	0.779	0.643	0.825
80.0	0.763	0.673	0.882
90.0	0.735	0.686	0.934

(d)(i)	Graph of V_2/V_1 against x is a straight line	2
(d)(ii)	V_2/V_1 varies **linearly** with x with positive gradient	1
(d)(iii)	Steeper gradient with same intercept	2

Question 3 Suggested solution:

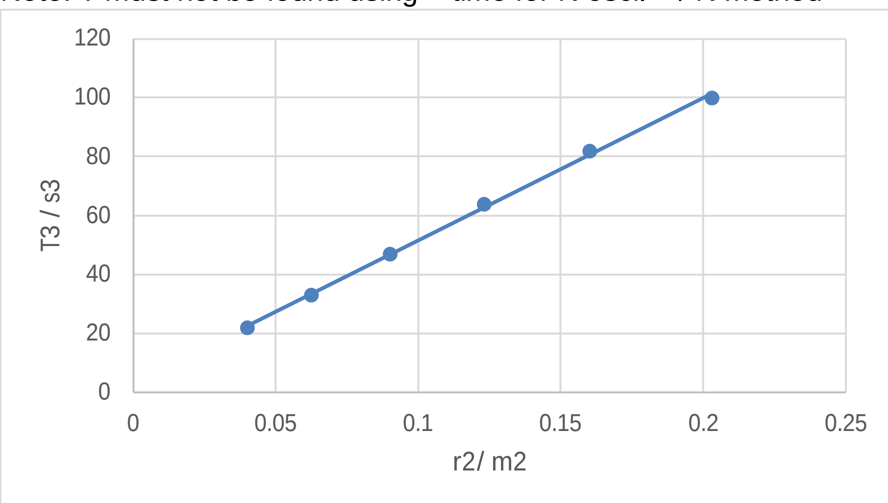
(b)(i) r = 0.5 [(80.0 – 20.0) + (80.0 – 20.0)] / 2 = 30.0 cm

(b)(ii) r is half the mean of the distance between inner edge of first mass and the outer edge of the second mass measured using metre rule, and the same measurement this time using the inner edge of second mass and the outer edge of the first mass.

(c)(ii) T = 0.5 (3.6 + 3.6) = 3.6 s

r/ cm	T_1 / s	T_2 / s	T^3 / s^3	r^2/ m^2
45.0	4.8	4.6	100	0.203
40.0	4.4	4.3	82	0.160
35.0	4.0	4.0	64	0.123
30.0	3.6	3.6	47	0.0900
25.0	3.2	3.2	33	0.0625
20.0	2.8	2.8	22	0.0400

Note: T must not be found using < time for N oscil > / N method



(e) Plot T^3 / s^3 vs r^2/ m^2

a = gradient = $\frac{93.0-20.0}{0.200-0.036}$ = 445 $s^3 m^{-2}$

Substitute (0.200, 93.0) into eqn,

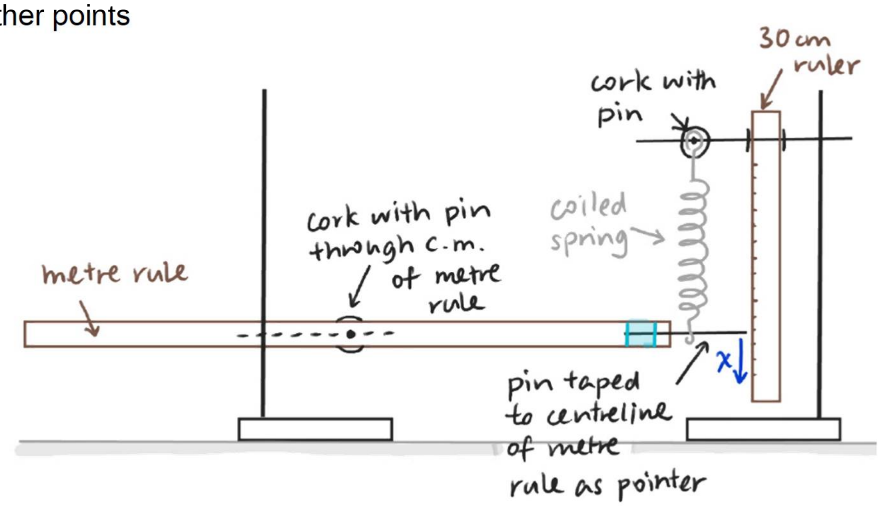
… b = 2.0 s^3

(f) There is no anomalous data as all the points are similarly close to the best fit line relative to one another.

OR

There is one anomalous point at (,   ) which is significantly further from the best fit line relative to all other points

(g)



1. Set up apparatus as shown.
2. Record equilibrium position reading on 30cm rule R_0. Tilt metre rule by displacing right end of rule by extension $x = |R_1 – R_0|$, where R_1 is the reading at the extended position.
3. Using stopwatch, measure and record the time T for it to move up and then down again to its lowest position. Repeat for average period <T>.

Consideration for marker: Depending on spring used, several oscillations to find t and then T is acceptable but not the usual 20 oscillations to stay true to the original objective of expt.

4. Repeat for at least 6 sets of *x* and <*T*> and plot T^2 against *x.* If a best fit straight line trend can be obtained, the equation is probably valid (based on expt data).

Do not accept lack of validity conclusion by just stating the usual gradient and vertical-intercepts.

Question 4 Suggested solution

Diagram (2 marks)

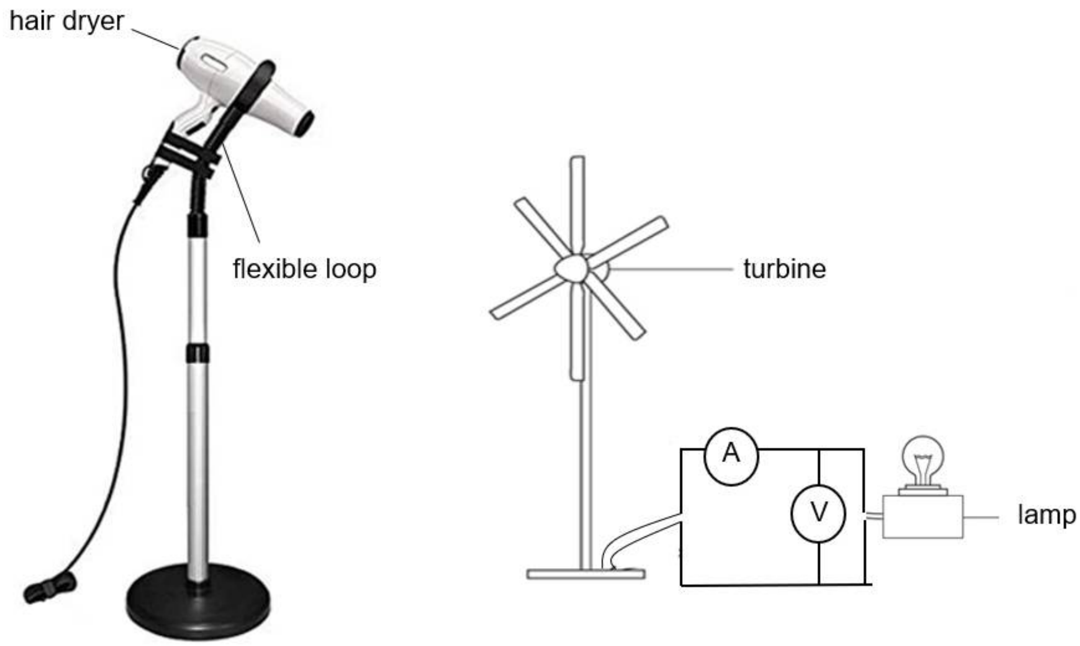


Fig. 1 set-up of experiment

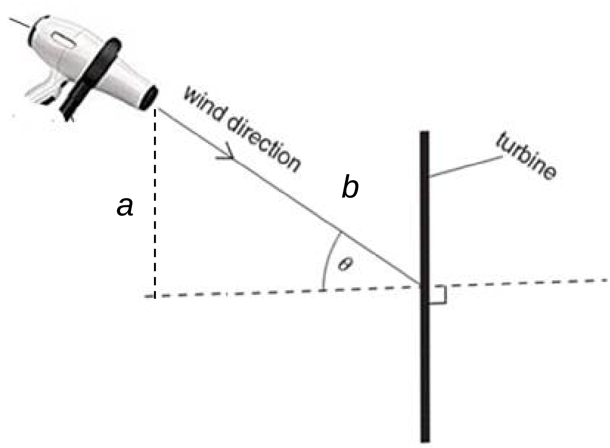


Fig. 2 how angle is measured

Defining the problem
(cos) θ is the independent variable, or vary (cos) θ.
P is the dependent variable, or measure P.

Control of variables:
Ensure surrounding temperature is constant and no draughts in the room, by conducting the experiment in a temperature-controlled enclosed room.

Method of data collection (5 marks)

Expt A: Keep v constant, vary θ

5. Set up the apparatus as shown in Fig. 1.
6. The hairdryer is mounted on a stand that has a flexible loop which can be tilted/rotated to change the angle at which the hairdryer makes with the horizontal, see Fig. 1.
7. The speed of wind v emerging from hairdryer is measured by using a wind speed indicator. Keep the speed v constant by using the same power setting of hairdryer.
8. The angle θ at which the wind strikes the blade is determined by equation $\theta = \tan^{-1}$ a/b where a and b are distances as shown in Fig. 2, Measure distance a and b using a metre rule.
9. As the blades of wind turbine rotates, it powers the lamp which will lit up. The power P delivered to the lamp is determined using $P = VI$ where V is voltmeter reading and I is the ammeter reading.
10. To vary θ, tilt the flexible loop and measure a and b to obtain different values of θ.
11. Repeat steps 3-5 for at least 6 sets of P and θ..

Expt B: Keep θ constant, vary v.

1 The hairdryer chosen should have 6 varying power setting which enable different speeds of wind v emerging from it.
2 Fix the angle θ, for example let $\theta = 0$ so that the wind strikes the blades of turbine perpendicularly.
3 Measure the speed v of wind using a wind speed indicator
4 The power P delivered to the lamp is determined using $P = VI$ where V is voltmeter reading and I is the ammeter reading.
5 Change the power setting of the hairdryer to vary v
6 Repeat steps 1-5 for at least 6 sets of P and v.

Method of analysis (2 marks)

Expt A: For constant l, $\lg P = m \lg \cos \theta + \lg (k\, v^n)$

Plot $\lg P$ vs $\lg \cos\theta$. Gradient of the straight line is equal to m.

Expt B: For constant θ, $\lg P = n \lg v + \lg(k \cos\theta^m)$

Plot $\lg P$ vs $\lg v$. Gradient of the straight line line is equal to n.

Safety consideration (1 mark)

Wear goggles to avoid air flow entering eyes

Avoid the moving blades of the fan using safety screen / switch off fan when changing experiment)

Wear gloves when handling hot lamp

Additional details (2 marks)

1. Conduct pre-experiment to determine suitable range of values of θ and v to obtain measurable P.
2. Use of large wind speed to gain measurable readings.
3. Use of low resistance lamp or use turbine with low friction.
4. Additional detail on measuring θ or (cos) θ – e.g. use a large protractor, projection method.
5. Measuring wind speed at fixed point from turbine.
6. Adjust height of fan so that air flow is horizontally aligned to the turbine.
7. Wait until airflow/turbine/meter readings constant before taking readings.
8. Keep windows shut/air conditioning switched off/use of wind tunnel to avoid draughts.
9. Any other good suggestion.