YISHUN INNOVA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
Higher 2

CANDIDATE NAME	Suggested Solution & Marking Scheme		
CG		INDEX NO	

PHYSICS 9749/04

Paper 4 Practical

26 August 2024

2 hours 30 minutes

Candidates answer on the Question Paper.

Additional Materials: As listed in the apparatus list.

READ THESE INSTRUCTIONS FIRST

Write your name and class in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid/tape.

Answer **all** questions.

You will be allowed a maximum of one hour with the apparatus for Questions 1 and 2, and a maximum of one hour for Question 3. You are advised to spend approximately 30 minutes on Question 4.

Write your answers in the spaces provided on the question paper.
The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working, where appropriate, in the spaces provided.

Give details of the practical shift and laboratory, where appropriate, in the boxes provided.

At the end of the examination, fasten all your work securely together. The number of marks is given in brackets [ ] at the end of each question or part question.

Shift
Laboratory

For Examiner's Use	
1	**/11**
2	**/11**
3	**/22**
4	**/11**
Total	**/55**

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1 In this experiment, you will determine the resistivity of a metal.

(a) Set up the circuit as shown in Fig. 1.1.

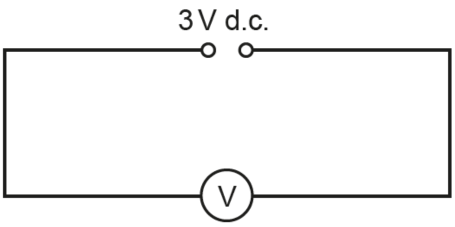


Fig. 1.1

Record the voltmeter reading E.

E = ...3.30 V...... V

Set up the circuit shown in Fig. 1. 2.

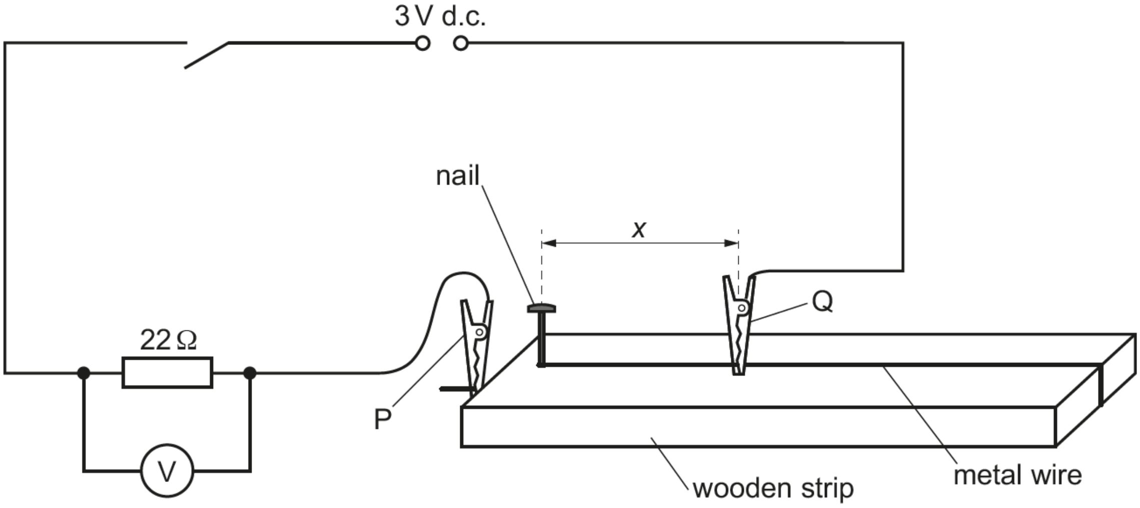


Fig. 1.2 (not to scale)

P and Q are crocodile clips.

The distance between the nail and Q is x, as shown in Fig. 1.2.

Adjust the position of Q until x is approximately 45 cm.

Close the switch.

The voltmeter reading is V.

Measure and record x and V.

- x is between 44.0 cm & 46.0 cm with precision 0.1 cm
- Range of V is 1.00 V to 2.00 V with precision 0.01 V

[1]

x = ...45.0 cm......

V = ...1.51 V......

[1]

Marker's comment:
Common mistake where students do not include the units. Some students made errors in the d.p. when recording in metre.

Open the switch.

(b) Vary x by adjusting the position of Q on the wire. For each value of x, measure V.

Record your results in a table.

x/cm	V / V	$\frac{1}{V}$ / V^{-1}
5.0	1.35	0.741
25.0	1.43	0.699
35.0	1.47	0.680
45.0	1.51	0.662
55.0	1.56	0.641
85.0	1.73	0.578

Presentation of Measured (M) Data
- At least 6 sets of x and V in the table.
- Range > 70.0 cm
- Precision of x is 0.1 cm
- Precision of V is 0.01 V
- (x = 45 cm point should be tabulated)

[1]

Table Headers (H)
- Column heading must contain a quantity and a unit (eg x/cm or x (cm).
- If no derived data, no mark

[1]

Calculated (C) Data
- Correction calculation for 1/V with appropriate s.f.
- If no derived, no mark

[1]

Marker's comment:
1. Common mistake in not including the units for 1/V.
2. The range is often incorrect – a range of 70 cm is expected.
3. Students should take care in rounding off the value for the calculated values.
4. Some students made errors in the d.p. when recording in metre.

(c) It is suggested that V and x are related by the expression:

$$\frac{1}{V} = Ax + B$$

where A and B are constants.

Plot a suitable graph to determine values of A and B.

- Gradient correctly calculated and in 2 or 3 s.f.
- y-intercept correctively derived from graph (within 1/2 small sq division) or correctly calculated. In 2sf/3sf

[1]

- Correct linearisation
- Equate gradient to A with correct units ($V^{-1}m^{-1}$ or $V^{-1}cm^{-1}$)
- Equate y-intercept to B with correct units (V^{-1})

[1]

Gradient = $A = \frac{0.732-0.589}{0.10-0.80} = -0.204$

$A = -0.204\ V^{-1}\ m^{-1}$

To find B

Based on y = mx + c

0.732 = -0.204(0.10) + B

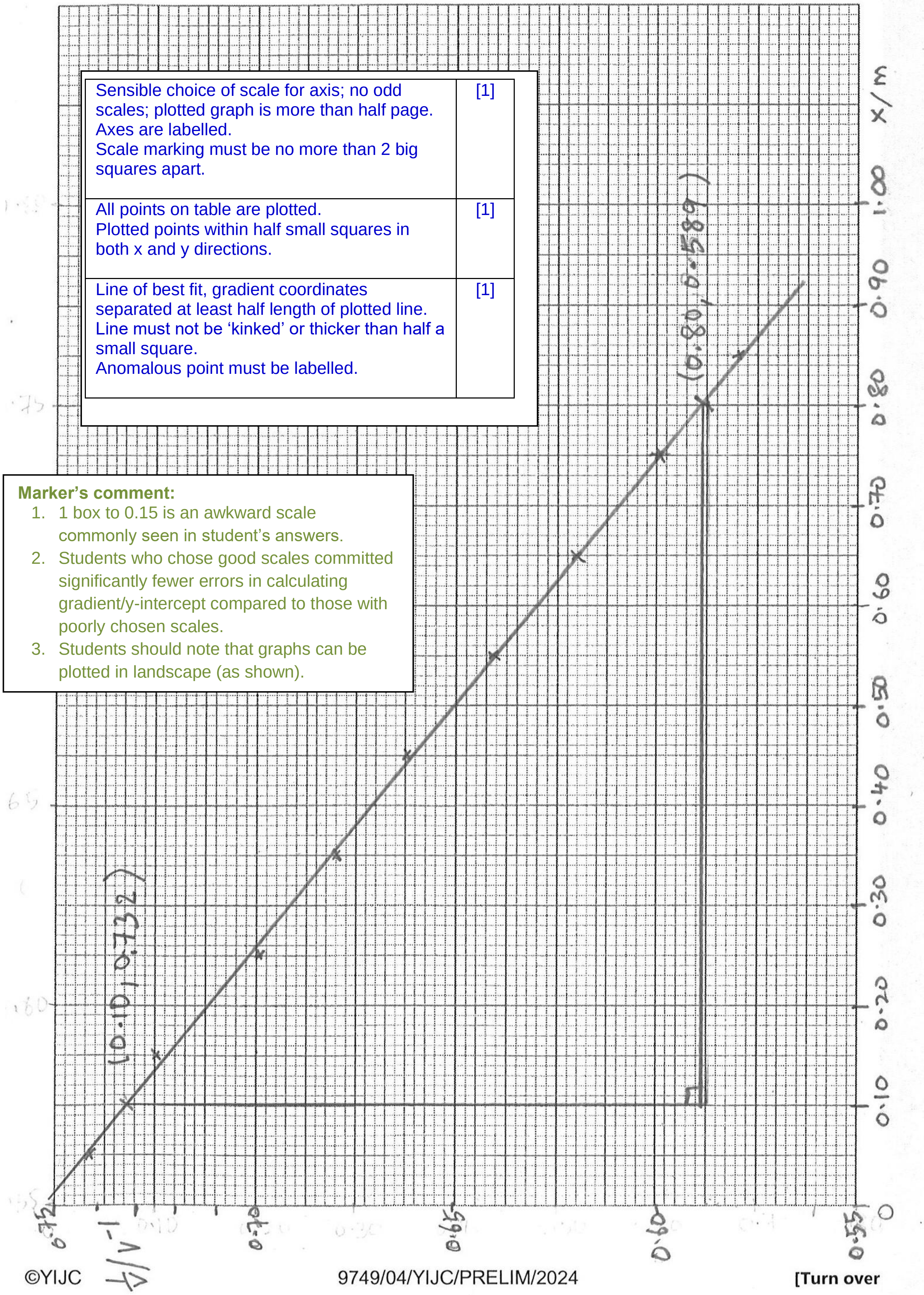
$B = 0.752\ V^{-1}$

A = ... $-0.204\ V^{-1}\ m^{-1}$ ....

B = ... $0.752\ V^{-1}$ ....

[5]

Marker's comment:
1. Many students were not careful with the units of A and B, either not stating any units, or stating the wrong units.
2. Some students still mistakenly read off the vertical intercept when the graph does not start from x = 0.
3. Some wrongly used data from the table to calculate B. Points must be read off from the graph drawn.



Sensible choice of scale for axis; no odd scales; plotted graph is more than half page. Axes are labelled. Scale marking must be no more than 2 big squares apart.	[1]
All points on table are plotted. Plotted points within half small squares in both x and y directions.	[1]
Line of best fit, gradient coordinates separated at least half length of plotted line. Line must not be ‘kinked’ or thicker than half a small square. Anomalous point must be labelled.	[1]

Marker’s comment:

1. 1 box to 0.15 is an awkward scale commonly seen in student’s answers.
2. Students who chose good scales committed significantly fewer errors in calculating gradient/y-intercept compared to those with poorly chosen scales.
3. Students should note that graphs can be plotted in landscape (as shown).

(d) Theory suggests that A is given by the equation

$$A = -\frac{4\rho}{\pi d^2 ER}$$

where d is the diameter of the wire, R is 22 Ω and ρ is the resistivity of the metal.

Determine a value for ρ.

Range of d is 0.25 – 0.35 mm
Repeated readings and finding average
[1]

Correct calculation of ρ. Allow for ECF.
s.f. consistent with raw data. 2/3 sf.
rho is between 10^{-7} to 10^{-5} ohm m
[1]

Average diameter
d_1 = 0.31 mm
d_2 = 0.31 mm
Average diameter d = 0.31 mm

$$(-0.2043) = -\frac{4\rho}{\pi\left(0.31\times10^{-3}\right)^2(3.30)(22)}$$

$\rho = 1.1 \times 10^{-6}$ Ωm

ρ = ... 1.1×10^{-6} ...... Ω m [2]

Marker's comment:
Many students had readings that did not make sense. Most likely some still do not know how to read the micrometre, and others did not realise that this part required measurement of the diameter after the 1h was up.

[Total: 11]

2 In this experiment, you will investigate the oscillations of a loaded wooden strip.

(a) You have been provided with a rectangular wooden strip with a hole in its centre.

Use some of the Blu-Tack to attach the two 100 g masses as near as possible to one end of the strip, as shown in Fig. 2.1 and Fig. 2.2.

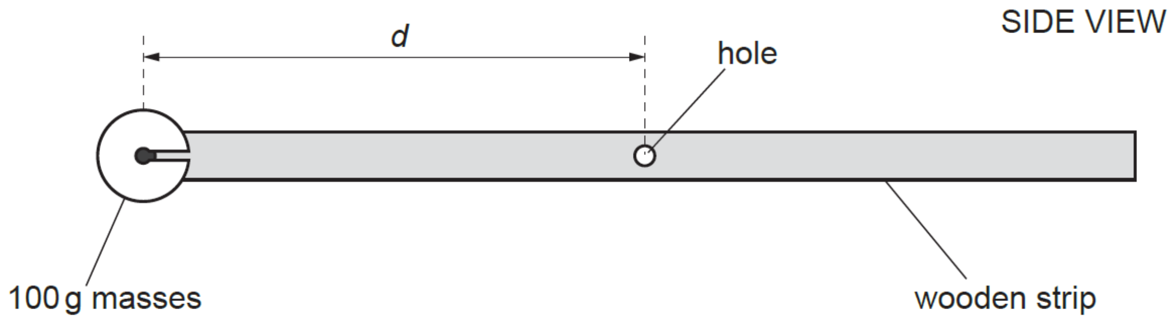


Fig. 2.1

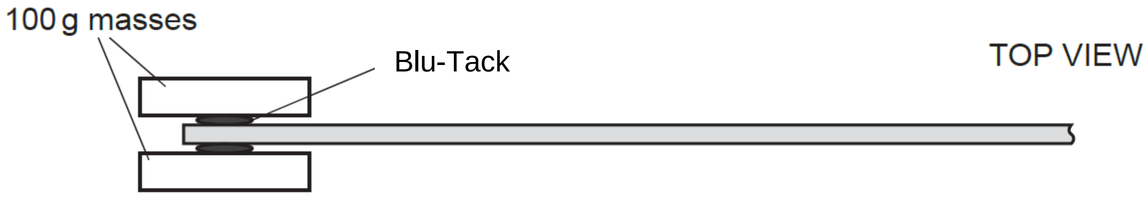


Fig. 2.2

The distance between the centre of the masses and the hole is *d*, as shown in Fig. 2.1.

Measure and record *d*.

Value for *d* with unit.
Range 23.0 cm to 25.0 cm
Precision is 0.1 cm
Repeated reading not required.
[1]

Marker's comment:
1. Some values are outside the acceptable range.

d = ... 24.0 cm [1]

(b) **(i)** Attach the two 20 g masses to the other end of the strip so that the distance between the centres of these masses and the hole is equal to *d*. Insert the nail into the hole in the centre of the wooden strip.

Set up the apparatus as shown in Fig. 2.3.

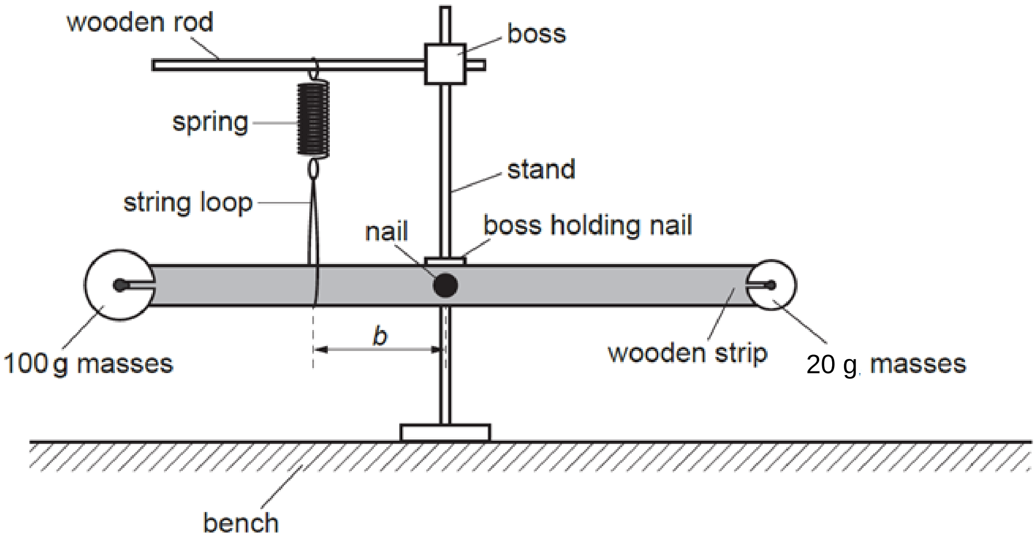


Fig. 2.3 (not to scale)

The distance between the string loop and the nail in the centre of the strip is *b*. Adjust the position of the string loop and spring until *b* is approximately 10 cm.

Adjust the heights of the bosses until the strip is horizontal and the spring and string loop are vertical.

Marker's comment:
1. Some values are outside the acceptable range. Students need to follow the instruction that *b* is approximately 10 cm.
2. A few students made the same mistakes in the precision for *b*.

Measure and record *b*.

Value for *b* with unit.
Range 9.0 cm to 11.0 cm
Precision is 0.1 cm
Repeated reading not required.
[1]

b = 10.0 cm [1]

(ii) Calculate α where

$$\alpha = \frac{b}{d}$$

Correct calculation for α.
s.f. based on s.f. of raw data (3.s.f.)
No units for alpha.
[1]

$$\alpha = \frac{10.0}{25.0} = 0.400$$

Marker's comment:
1. Common mistake in the significant figures.

α = 0.400 [1]

(iii) Estimate the percentage uncertainty in your value of α.

Marker's comment:
1. Some students worked out the absolute uncertainty instead of percentage uncertainty.
2. There were wrong estimates for the absolute uncertainty of *b* and *d*.

Percentage uncertainty based on absolute uncertainty 0.2 – 0.6 cm for *d* and *b*.
Correct method of calculation for percentage uncertainty. 2 s.f. [1]

$$\frac{\Delta\alpha}{\alpha}\% = \frac{\Delta b}{b}\% + \frac{\Delta d}{d}\% = \frac{0.2}{10.0}100 + \frac{0.2}{25.0}100 = 2.8\%$$

percentage uncertainty = ……………2.8 %……….. [1]

(c) Move the end of the strip with the two 100 g masses vertically down through a short distance. Release the end of the strip. The strip will oscillate up and down.

(i) Take measurements to determine the period *T* of these oscillations.

N = 20 oscillations
t_1 = 29.19 s
t_2 = 29.29 s
Period *T* = (29.19+29.29)/2(20)
= 1.462 s

Repeated measurement for time for N oscillations and more than 10.00 s. [1]
Final value of T with unit and range 1.200 – 1.800 s
Appropriate s.f. (based on s.f. of raw data) [1]

T = ..1.462 s…………..…. [2]

Marker's comment:
1. Readings of more than 10 s is required in oscillations that may experience resistive forces.
2. Students most likely had errors in their setup which reulsted in the period is falling outside the accepted range.
3. s.f. for the period is often indicated incorrectly.

(ii) Estimate the percentage uncertainty in your value of *T*.

Absolute uncertainty of T = abs uncertainty of total time for *N* oscillations / *N*
Absolute uncertainty of NT 0.2 s – 0.5 s.
Correct method of calculation for percentage uncertainty of *T*. 2 s.f.
[1]

$$\Delta T = \frac{\Delta t}{N} = \frac{0.3}{20} = 0.015s \quad \Rightarrow \quad \frac{\Delta T}{T}\% = \frac{0.015}{1.462}100 = 1.0\% \text{ or } \frac{\Delta t}{t}\% = \frac{0.3}{29.24}100 = 1.0\%$$

percentage uncertainty = …1.0 %……………………. [1]

Marker's comment:
1. Students need to show the determination of absolute uncertainty of the period clearly. This value cannot be estimated as it is a calculated data.
2. Students should record the percentage uncertainty to 2 s.f.

(d) Change the value of b to approximately 20 cm.

Adjust the heights of the bosses until the strip is horizontal and the spring and string loop are vertical.

Measure and record b.

b = 20.0 cm

Repeat **(b)(ii)** and **(c)(i)**.

$$\alpha = \frac{b}{d} = \frac{20.0}{25.0} = 0.800$$

Second value of α *is larger than first. Correct calculation* [1]

α = 0.800

Second value of b ≈ 20.0 cm ***[not marked for]***

N = 30 oscillations
t_1 = 23.81 s
t_2 = 23.79 s
Period T = (23.81+23.79)/2(30)
= 0.7930 s

Second value of T is smaller than first. Correct calculation [1]

T = 0.7930 s

[2]

Marker's comment:
1. Errors in d.p. and s.f. are not assessed here, but are often seen.
2. Some answers did not follow the expected trend, and therefore suggest errors in carrying out the experimental procedure.

(e) It is suggested that the relationship between T and α is

$$T = \frac{C}{\alpha}$$

where C is a constant.

(i) Using your data, calculate two values of C.

Two values of C calculated correctly with correct units (s) and to appropriate s.f. [1]

First C= $T\alpha$ = (1.462)(0.400) = 0.584 s

Second C = (0.7930)(0.800) = 0.634 s

first value of C = 0.584 s

second value of C = 0.634 s

[1]

Marker's comment:
1. Many students mistakenly assume that the constants have no units.

(ii) State whether your results support the suggested relationship in **(e)**. Justify your conclusion by referring to your values in **(b)(iii)** and **(c)(ii)**.

Percentage difference for the *C*'s = $\frac{0.634 - 0.585}{0.585} 100 = 8.4\%$

Combined percentage uncertainties from (b)(iii) and (c)(ii) = 2.8 + 1.0 = 3.8%

Since the percentage difference for *C* is greater than the sum of part (b) and (c), the result **does not** support the relationship.

Valid comment consistent with calculated values of *C* and testing against (b) and (c).
Accept percentage difference when divided by larger *C* (7.7%)
Accept percentage difference when divided by average *C* (8.0%)

[1]

[1]

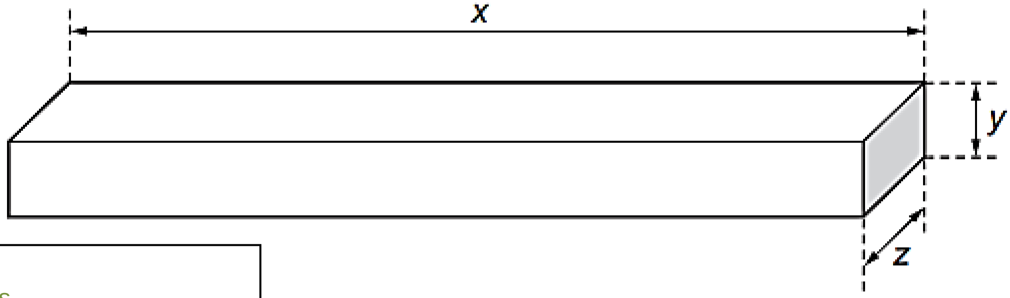
[Total: 11]

Marker's comment:

1. Significant number of students did not calculate out the resulting percentage uncertainty from (b)(iii) and (c)(ii).
2. Students are quite careless with the use of terms such as "error". It is important to use the correct jargon for clarity.

3 In this experiment, you will investigate a wooden strip resting at an angle.

(a) (i) You are provided with a wooden strip, as shown in Fig. 3.1



Marker's comment:
1. No repeated readings
2. Wrong precision
3. z was commonly misread as 12.0 cm instead of 2.0 cm

Fig. 3.1

The dimensions of the strip are x, y and z.

Measure and record x, y, and z.

x = (50.0 + 49.9)/2 = 50.0 cm
y = (1.0 + 1.0)/2 = 1.0 cm
z = (1.9 + 2.0)/2 = 2.0 cm

x = ... x = 50.0 cm ....
y = ... y = 1.0 cm ....
z = ... z = 2.0 cm ....

(ii) Use a weighing balance to determine the mass m of the wooden strip.

Repeat reading for x, y, and z. [1]

Precision of m = 0.1 g
Precision x,y,z to 0.1 cm [1]

m = ... 40.2 g .... [2]

(iii) The volume V of the strip is given by the equation:

$$V = xyz$$

Calculate V.

z = 1.8 – 2.2 cm
y = 0.8 – 1.2 cm
x = 49.8 – 50.2 cm
V = (0.018 x 0.008 x 0.498) to (0.022 x 0.012 x 0.502)
= 7.17 x 10^{-5} to 13.3 x 10^{-5} m^3

Correct values for x,y, and z. Correct calculation
Value of V is from (7 to 13) x 10^{-5} m^3
Value calculated to correct sf (2sf) based on correct measured values of x, y and z. [1]

V = (0.020 x 0.010 x 0.500)
= 1.0 x 10^{-4} m^3

V = ... 1.0 x 10^{-4} .... m^3 [1]

Marker's comment:
1. Many students had unit conversion and Power of Tens (P.O.T.) errors.
2. Some suggested a volume of 100 m^3, which is the roughly the size of a classroom.
3. Significant answers did not give the right no. of s.f. that are consistent with that of the raw data.

(b) Set up the apparatus as shown in Fig. 3.2.

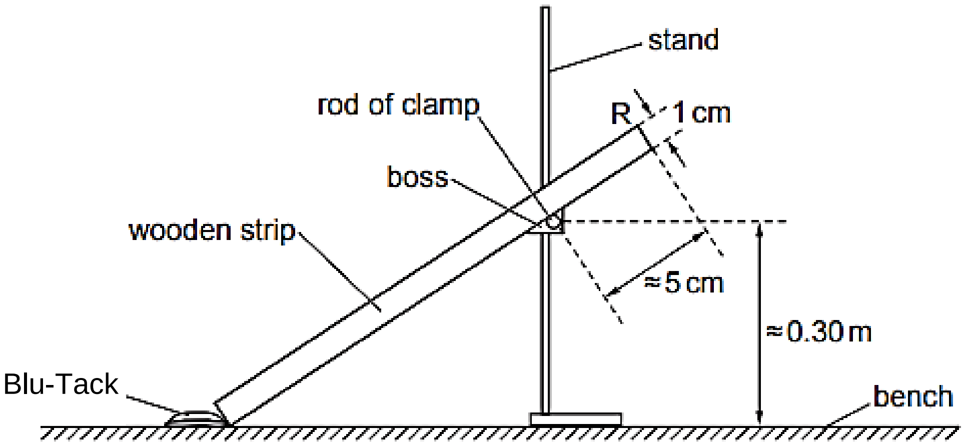


Fig. 3.2 (not to scale)

Adjust the position of the boss so that the rod of the clamp is approximately 0.30 m above the bench.

Adjust the wooden strip so that the distance between the rod and the raised end R of the wooden strip is approximately 5 cm. Use some of the Blu-Tack to prevent the wooden strip from slipping.

(i) Use Blu-Tack to attach the 50 g mass holder to the wooden strip. Adjust the distance *d* between the lower end of the wooden strip and the centre of the mass holder so that it is approximately 0.15 m, as shown in Fig. 3.3.

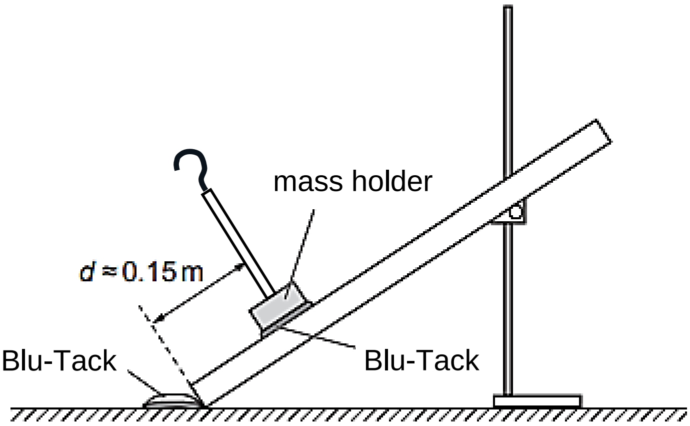


Fig. 3.3

Measure and record *d*.

Value of *d* = 0.14 – 0.16 m Precision of *d* is 0.1 cm [1]

15.0 cm

d = ……………………… [1]

(ii) Use Blu-Tack to attach the loop of string at the raised end of the wooden strip, as shown in Fig. 3.4.

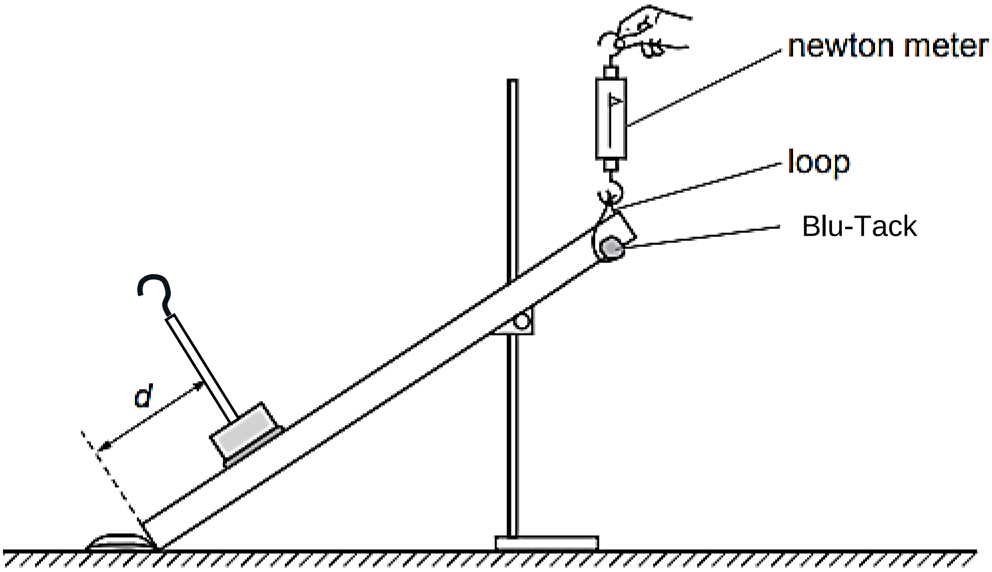


Fig. 3.4

Use the newton-meter to determine the vertical force F needed to just lift the wooden strip from the rod.

F measured to nearest 0.01 N.
F in the range 0.30 – 0.40 N [1]

F_{ave} = (0.34 + 0.33)/2
= 0.34 N

F = ... 0.34 .... N [1]

(iii) The combined mass of the mass holder and the slotted masses is M. Vary M by adding more 50 g slotted mass onto the mass holder and repeat **(a)(ii)**.

Present your results clearly.

	1st trial	*2nd trial*	*Average*
M / g	F / N	F / N	F / N
50	0.34	0.33	0.34
100	0.47	0.49	0.48
150	0.60	0.59	0.60
200	0.71	0.70	0.71

Correct column header with correct units [1]
F measured to nearest 0.01N. Average F given to 0.01 N [1]
Repeated reading of F. 4 sets of readings including **(ii)**. [1]

[3]

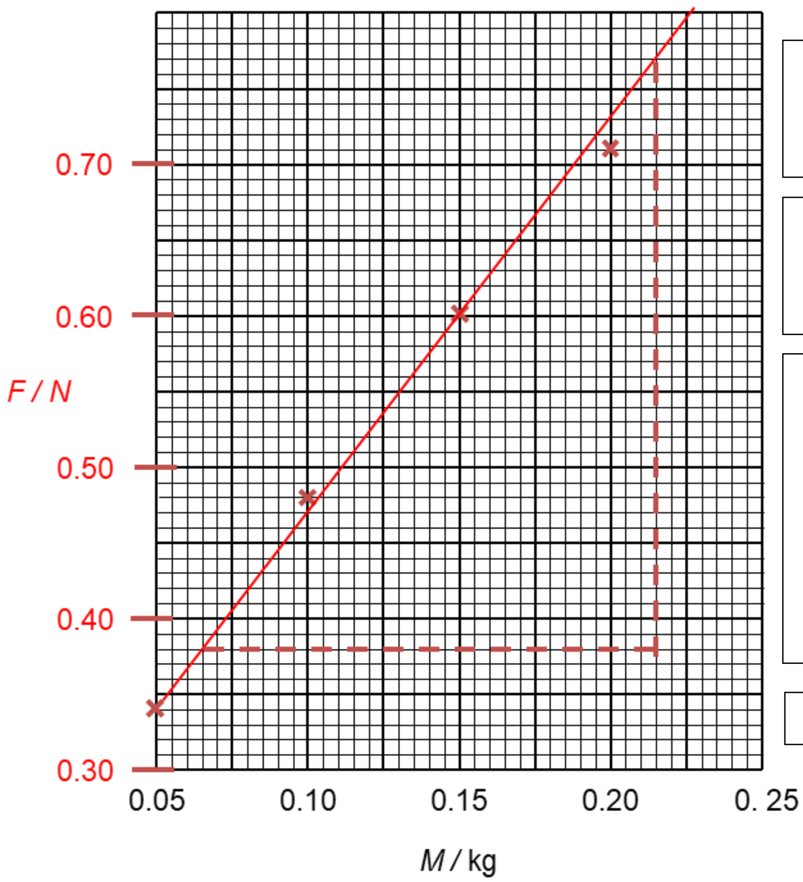
Marker's comment:
1. Some students did not include the mass of the holder (50 g) and only presented 3 data points only.
2. Some measured the 'force' on the newtonmeter for the slotted mass only.
3. Many answers did not show repeated readings for F.

(c) Theory suggests that

$$F = \frac{Mgd}{x} + S$$

where g is 9.8 N kg^{-1}.

Plot a suitable graph to determine the value of S.



Correct Linearisation (plot F, F/g, etc)
Plotted points cover more than half the graph grid (ecf correctly plotted points)
Correct axis labels [1]

Correct plots (points pltted to within half of the small squares in both x and y directions
Best fit line drawn correctly [1]

Correct read off for two points.
Read off accurate to half the smallest division in both x and y directions.
The two points farther than half the drawn line apart.
calculation of grad/y-intercept
OR
Correct read off for one point.
Correct substitution for g, d and x.
[1]

Correct calculation of S. [1]

$$F = \frac{Mdg}{x} + S$$

$$gradient = \frac{0.77 - 0.38}{0.215 - 0.065} = 2.6 \text{ N kg}^{-1}$$

$$0.77 = 2.6(0.215) + S$$

$$S = 0.211\text{N} \ (3\text{sf})$$

Marker's comment:

4. Students need to ensure that data points are spread out.
5. BFL cannot be credited if only 2 points are considered.
6. Many students carelessly assumed that the y-intercept is on the plotted graph.
7. Students should pick easy-to-read points when calculating the gradient.

S = ... 0.211 N ....

[4]

(d) S is related to the density ρ of the wooden strip by the equation

$$S = \frac{1}{2}\rho V g$$

Calculate ρ.

$$\rho = \frac{2(S)}{Vg} = \frac{2(0.209)}{(1.0\times10^{-4})(9.8)}$$

$$= 427 \text{ kg m}^{-3} \ (3\text{sf})$$

ρ correctly calculated.
ρ given to correct sf based on values of V and S. (1sf or 2sf) [1]

Correct units for ρ. [1]

Marker's comment:
- Students did not realise that 9.8 is used here (not 9.81)

ρ = ... 427 kg m^{-3} [2]

(e) **(i)** Suggest **one** significant sources of uncertainties in this experiment.

Marker's comment:
Many students addressed the issue of fluctuating reading by stating that they should connecting newton meter to another clamp and slowly lifting it. This is not viable as it is difficult to make fine adjustments to the clamp height without causing it to shake.
Accepted solutions include using a pulley system and lifting the newton meter by pulling the string.

.... [1]

(ii) Suggest **one** improvement that can be made to this experiment to reduce the uncertainty identified in **(e)(i)**.

You may suggest the use of other apparatus or a different procedure.

Source of uncertainty – any 1 [1]
- *Difficult to measure d because the centre of mass is difficult to locate*
- *Difficult to get a value of F as the reading oscillates once the strip leaves the rod.*
- *Difficult to ensure the newton meter is vertical.*
- *Difficult to determine the exact point when the wooden strip lifts off the rod.*

Improvement – any 1 [1]
- *Measure the slotted mass' diameter and the distance from to the edge of the slotted mass. d is ½ diameter + distance to the edge.*
- *Record the lifting of the strip off the rod with a video recorder. Determine the frame when the strip just lifts off. Read off the value of F in that frame.*
- *Use another retort stand to clamp a straight edge/ruler next to the set up and align the newton meter to the straight edge/ruler as you lift it.*
- *Use a plumb line / use a clamped ruler that is aligned vertical using a set square/protractor as a reference to ensure the newton meter is vertical.*

.... [1]

(f) A ladder leaning on a wall experiences frictional forces to keep it from slipping. A person stands on the ladder a distance *d* along the ladder from the ground.

It is suggested that the expression of the **minimum** angle *θ* that the ladder makes with the ground before the ladder slips is

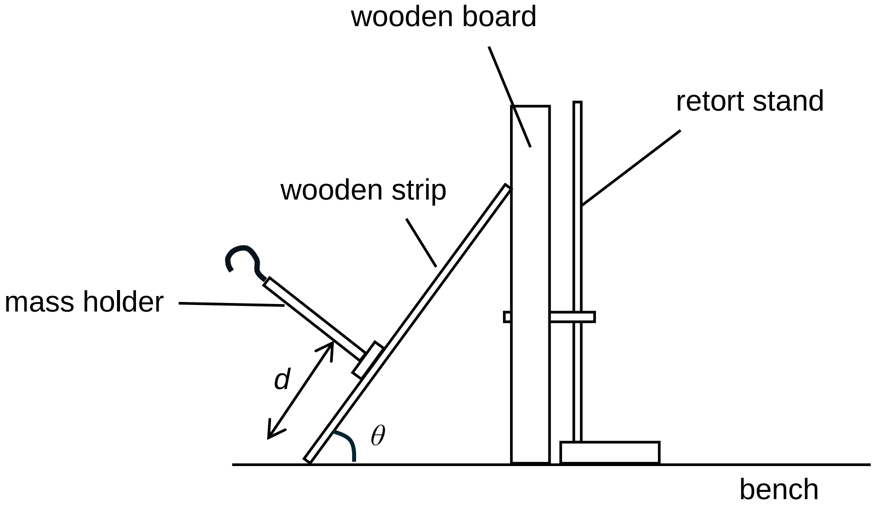
$$\tan\theta = Pd + Q$$

where *P* and *Q* are constants.

Plan an investigation to find *P* and *Q*, using the mass holder as a model of a person, and the wooden strip as a model of the ladder by leaning it against a vertical wooden board.

Your answer should include a diagram and your experimental procedure.

Use your apparatus to determine *P* and *Q* by obtaining **two** sets of values of *θ* and *d*.



1. *Set up the apparatus as shown.*
2. *The independent variable is the length x and the dependent variable is the angle θ.*
3. *Measure d using a 30 cm ruler.*
4. *Lean the wooden strip against the vertical wooden board so that it remains stationary. Decrease the angle θ until the wooden strip starts to slip.*
5. *Measure θ using a protractor just before the wooden strip starts to slip.*
6. *Repeat step 3-5, with a larger value of d.*

d / cm	*θ* / °
15.0	47
30.0	57

$\tan(47°) = P(0.15) + Q$..................(1)

$\tan(57°) = P(0.30) + Q$...................(2)

solving sumultaneuously,

$P = 3.12\ \text{m}^{-1}$

$Q = 0.605$

[6]

[Total: 22]

Q3(f): Leaning Ladder.

Suggested Marking Scheme

Symbol		Marks
D	Defining the problem	1
M	Procedure / Methods of data collection	3
A	Method of analysis	2
	Total	6

Marking Scheme

	Defining the Problem: Control Variable (1 mark)	
D1	Identify 1 control variable: • Mass of the mass holder that is placed on the wooden strip. • Surface of the wooden board used should be the same. • Surface of the base should be the same.	[1]
	Procedure / Methods of data collection (5 marks)	
M1	Labelled diagram of workable arrangement including *d* correctly labelled. θ correctly labelled. Bench, retort stand, wooden board, wooden strip and mass holder labelled.	[1]
M2	Description of how to obtain θ. e.g., decrease the angle until the wooden strip just slips.	[1]
M3	Measure θ with a protractor Measure *d* with a ruler. OR 2 values of θ and *d* measured and recorded to correct precision.	[1]
	Analysis	
A1	Correct method to calculate P and Q using simultaneous equation. Linearisation method not accepted as we need to take multiple data to plot graph.	[1]
A2	Correct calculation for value of P and Q. Correct units for P and Q.	[1]

Common mistakes:

- Some literately stated using a leaning ladder and a man standing on it. The question stated clearly to use the apparatus to model after this scenario.
- The diagram of the setup was incomplete as *d* and θ were not indicated.
- The use of measuring devices (eg metre rule, protractor) were not explicit.
- The control variable (e.g., type of surface, length of rod, mass of the holder) were not stated.
- Some treated this mini planning like the typical Q4 type planning question in that they stated safety precautions and reliability which do not give any extra points.
- Some did not proceed to find two sets of data to find P and Q. Here plotting of a graph is not required and so stating the graph to plot and stating the gradient is P and the y-intercept is Q will not satisfy the requirement to find the values of P and Q. The units for P were not included.

4 When a light plastic ball is placed in a vertical column of moving air, the ball becomes stationary at a height h, as shown in Fig. 4.1.

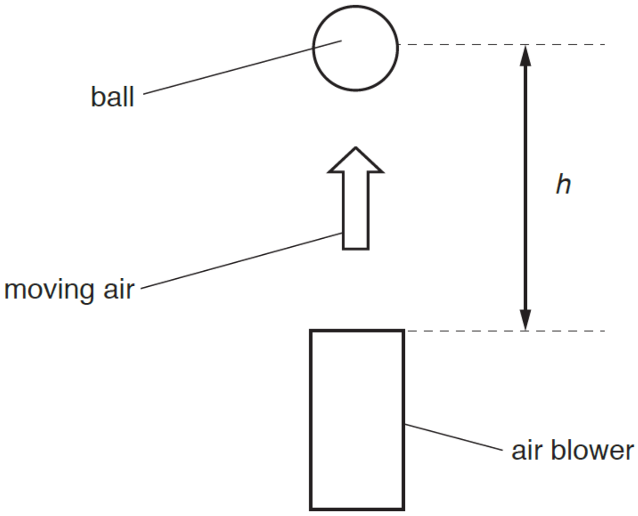


Fig. 4.1

A student is using an air blower to create a vertical column of moving air. The student connects the motor of the air blower to a d.c. power supply.

It is suggested that h is related to the diameter d of the ball and the power p of the motor by the relationship

$$h = C\, d^a\, p^b$$

where C is a constant.

Design a laboratory experiment to determine the values of a and b.

Draw a diagram to show the arrangement of your apparatus. You should pay particular attention to:

(a) the equipment you would use

(b) the procedure to be followed

(c) the control of variables

(d) any precautions that should be taken to improve the accuracy and safety of the experiment.

Diagram

Q4 : Ball suspended by air blower

Suggested Marking Scheme

Symbol		Marks
D	Defining the problem	2
M	Procedure / Methods of data collection	5
R	Reliability and accuracy	1
A	Method of analysis	2
S	Safety concerns	1
	Total	11

Marking Scheme

	Defining the problems (2marks)		
D1	The height *h* is the dependent variable. *The diameter d and the power p of the air blower* are the independent variables. Both must be stated	[1]	
D2	<u>At least one controlled variable</u> - Use balls of various diameters but keep the mass the same. - Ensuring that the air is always blowing vertically upwards so that the ball is vertically suspended from the blower.	[1]	
	Procedure / Methods of data collection (5 marks)		
M1	Labelled diagram of workable arrangement including Labelled air blower Labelled ball vertically above the blower. Vertical rule from the top of the blower to ball to measure *h*. Reject setup which has no label and which lack essential parts **AND** Circuit diagram to determine *P* eg voltmeter and ammeter connected to the motor and power supply. *P = VI. Vary the power P by changing V.* Use of vernier calipers or rule with set squares to measure the diameter *d* of the ball.	[1]	
M2	Use a pair of vernier calipers to measure *d*. OR other feasible method to measure *d*. **AND** Use metre rule to measure *h*. Ensure ball is stationary before measuring *h*. OR other feasible method to measure *h*.	[1]	
M3	Measure current and potential difference of the motor using an ammeter and voltmeter respectively. The power of the motor is potential difference × current. OR other feasible method to measure *p.*	[1]	
M4	Evidence of experiment carried out with a method to vary *d* and obtain *h*, to find *a.* Fix power *p* with appropriate method	[1]	
M5	Evidence of experiment carried out with a method to vary *p* and obtain *h*, to find *b.* Fix diameter *d* with appropriate method	[1]	
	Reliability and accuracy (1 mark)		
R1	<u>Any of below</u> • Use a retort stand on the bench with clamped rule (or with plumbline) to measure the vertical height *h* more accurately. • Finding *h eg reading of bottom of ball - top of blower* .+ *(diameter/2)* • Repeated diameter *d* measurement in different directions and find average. • Shielding the setup from draughts eg switch off the fan, close the window. • Video the ball and playback in slow motion to get more precise value for *h*.	[1]	

	Method of analysis (2 marks)		
A1	Two graphs are plotted. Expt 1 (fixed *p*) lg *h* vs lg *d* where the gradient of line of best fit= *a*	[1]	
A2	Expt 2 (fixed *d*) lg *h* vs lg *p* where the gradient of line of best fit = *b*	[1]	
	Safety concerns (1 mark)		
S1	Use a large tray to collect the ball to prevent ball bouncing and rolling on floor. Ear plugs if noise from motor is too loud. Wear goggles in case ball shoots up too fast resulting in eye injury.	[1]	
	Total	[11]	

Common mistakes:

Defining problem:

- Not stating the right controlled variable

Procedure:

- Students do not have a circuit diagram. Some students connect their voltmeter and ammeter wrongly.
- Not indicating the apparatus used for measurement
- Incorrect method of determining the power
- Not stating how to vary power (diameter) while keeping diameter(power) fixed

Reliability and accuracy:

- Not stating how to increase the accuracy. For eg, some students merely state “ensure that there is little wind” without stating to do the experiment in enclosed area or switching off the fan

Analysis:

- Most students can linearise the equation and state the right axis to plot

Safety:

- Some students mentioned to ensure that hand is dry while using motor, however, there is no use of water in the experiment

Ball suspended by air blower (Suggested Answer)

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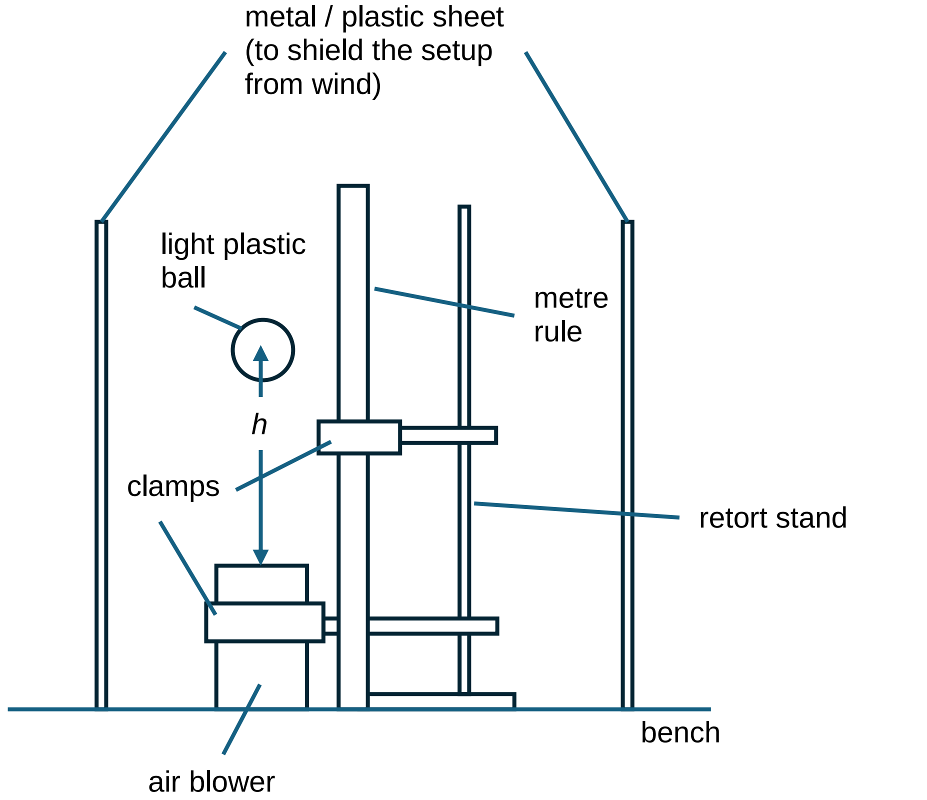
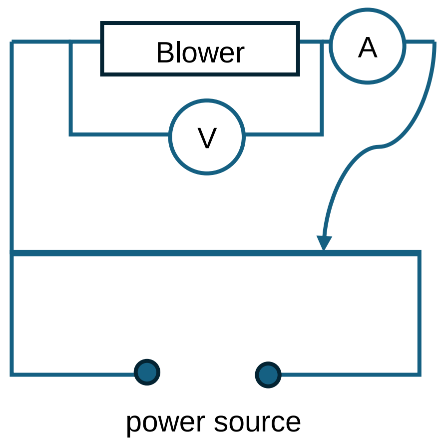
Diagram





You do not need to write a list of all the required apparatus. It is sufficient to have a clearly labelled schematic diagram of your experimental setup. Students are advised to draw separate physical setup and circuit diagrams.

</td>
<td>M1</td>
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</table>

Defining the problem The aim of the experiment is to find the unknowns a and b in the relationship $h = C\, d^a\, p^b$ The dependent variable is the height h of the suspended ball in the air column. There are two independent variables – diameter of the ball d and the power p of the air blower. The other factors to be fixed (controlled) are (state at least 1 controlled variable) • the mass of the ball is constant despite its dimension. • The air column is vertical (using a spirit level or plumbline)	 D1 D2
Procedure / Methods of data collection / Reliability and accuracy 1. Measure the diameter d of one light plastic ball using a vernier calliper. Repeat the measurement of d in different orientations and find the average value. 2. Set up the apparatus as shown in the diagram. 3. Determine the power p of the air blower from the equation $p = IV$ where V is the potential difference across the blower and I is the current flowing through the blower. V is measured using the voltmeter and I is measured using the ammeter. 4. Use metal sheets to shield the set up from draughts. Switch off the fans as well. 5. Adjust the air blower until the ball stays stationary. 6. Determine the height of the levitated ball from the equation $h = ½\, d + h'$, where h' is the distance from the top of the blower to the bottom of the ball. Use a retort stand to clamp a ruler. Use a set square to ensure the ruler is vertical. Use a metre rule to measure h'. Experiment 1 (fixed power p) 7. Use 5 other balls of different diameters and repeat steps 1-6. Ensure the mass of the balls are kept constant by measuring the mass with a top-pan balance. Experiment 2 (fixed diameter d) 8. Vary the power of the blower by adjusting the potentiometer to vary the potential difference across the blower and repeat steps 4-6 for 5 more readings of h. Use the same ball for all readings to keep the diameter d constant.	 M2-i R1 M3 (R1) (R1) (R1) M2-ii M4 M5
Method of analysis $\lg h = \lg C + a \lg d + b \lg p$ Experiment 1 (fixed power p) Plot a graph of lg h against lg d. The gradient of the line of best fit = a. Experiment 2 (fixed diameter d) Plot a graph of lg h against lg p. The gradient of the line of best fit = b.	 A1 A2
Safety concerns (State at least 1) • Use a large tray to collect the ball to prevent ball bouncing and rolling on floor. • Ear plugs if noise from motor is too loud. • Wear goggles in case ball shoots up too fast resulting in eye injury.	 S1 (S1) (S1)
Total	11