Name:		Centre/Index Number:		Class:	

DUNMAN HIGH SCHOOL
Preliminary Examination
Year 6

H2 PHYSICS

9749/04

Paper 4 Practical

27 August 2021

2 hours 30 minutes

Candidates answer on the Question Paper

READ THESE INSTRUCTIONS FIRST

Write your centre number, index number, name and class at the top of this page.
Give details of the practical shift and laboratory where appropriate, in the boxes provided.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Shift
Laboratory

Answer **all** questions 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 or if you do not use appropriate units.

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.

For Examiner's Use	
1	/ 14
2	/ 10
3	/ 19
4	/ 12
Total	/ 55

This document consists of **18** printed pages and **0** blank page.

For Examiner's Use

1 In this experiment, you will investigate the oscillations of a square shape.

(a) **(i)** Bend the wire to form a square shape so that the length L of each side is approximately 12 cm, as shown in Fig. 1.1.

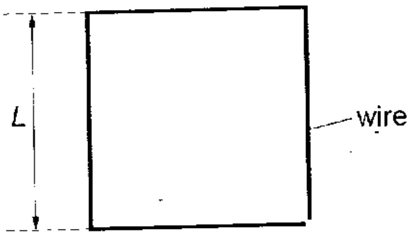

Fig. 1.1

Use the wire cutter to remove any excess wire.

Measure and record L.

L = ... [1]

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

percentage uncertainty = ... [1]

For Examiner's Use

(b) (i) Place the cork in the clamp and attach the clamp to the stand using the boss.

Hang the square wire from the pin as shown in Fig. 1.2.

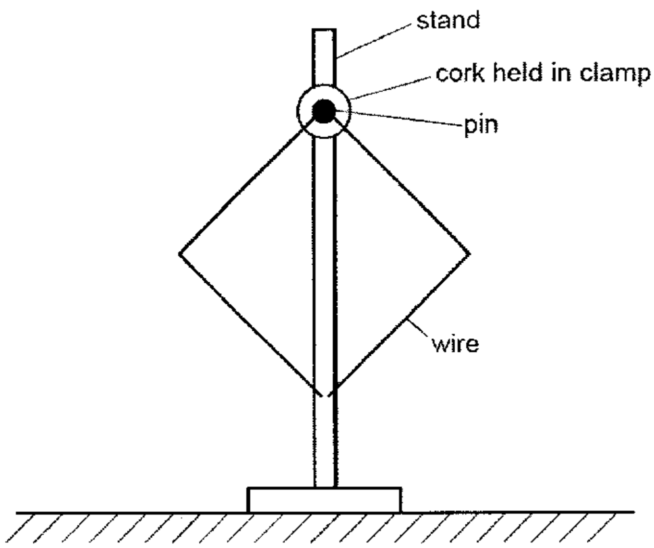

Fig. 1.2

Gently displace the square wire and release it so that it oscillates as shown in Fig. 1.3.

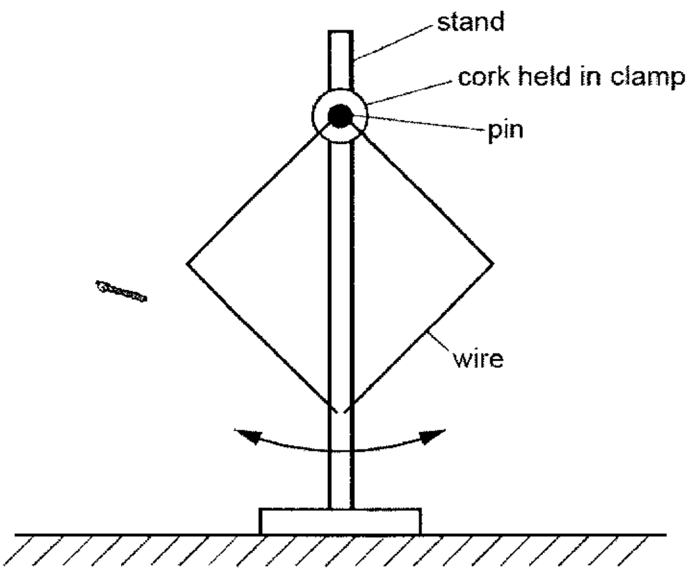

Fig. 1.3

For Examiner's Use

Determine the period T of the oscillations.

T = ... [3]

(ii) Calculate T^2.

T^2 = ... [1]

(iii) Justify the number of significant figures you have given for your value of T^2.

....

....

.... [1]

(c) (i) Remove the square wire from the pin.

Form a new square shape from the wire so that L is approximately 6 cm.

Use the wire cutter to remove any excess wire.

Measure and record L.

L = ... [1]

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

T = ...

T^2 = ... [1]

For Examiner's Use

(d) It is suggested that the relationship between T and L is

$$T^2 = \frac{L}{k^2}$$

where k is a constant.

(i) Use your values from **(a)(i)**, **(b)(ii)**, **(c)(i)** and **(c)(ii)** to determine two values of k.

Give your values of k to an appropriate number of significant figures.

first value of k = ...

second value of k = ... [2]

(ii) State and explain whether the results of your experiment support the suggested relationship in **(d)**.

Justify your conclusion by referring to your values in **(a)(ii)**.

....

....

.... [2]

(e) A value for the acceleration of free fall g near the surface of the Earth is given by

$$g = \frac{20\pi^2}{3\sqrt{2}}k^2$$

Use your second value of k to calculate a value for g.

g = ... m s^{-2} [1]

[Total: 14 marks]

For Examiner's Use

2 In this experiment, you will investigate combinations of resistors in an electrical circuit.

(a) You have been provided with three identical resistors A, B and C.

Take measurements to determine the resistance of each resistor.

The resistance of resistor A is R_A.
The resistance of resistor B is R_B.
The resistance of resistor C is R_C.

R_A = ...

R_B = ...

R_C = ... [2]

(b) Set up the circuit as shown in Fig. 2.1 with resistor A between F and G.

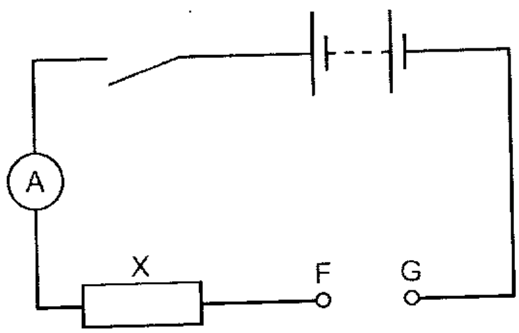

Fig. 2.1

Record the total resistance R between F and G.

R = ...

Close the switch.

Record the ammeter reading I.

I = ... [1]

Open the switch.

For Examiner's Use

(c) Use various arrangements of the three resistors A, B and C to provide six other different total resistances between F and G.

For each arrangement, record R and I in a table.

Include values of **(b)** and $\frac{1}{I}$ in your table.

[5]

(d) It is suggested that the quantities I and R are related by the equation

$$E = I\,(R + X)$$

where E is the electromotive force (e.m.f.) of the power supply and X is the resistance of resistor X.

Suggest how you would use the data collected in **(c)** to determine the value of X.

....

....

....

.... [2]

[Total: 10 marks]

For Examiner's Use

3 In this experiment, you will determine the force constant of a spring.

(a) You have been provided with three identical springs, attached to a ring.

The length of an unstretched spring is *S*, as shown in Fig. 3.1.

Measure and record *S* for **one** of the springs using a vernier calliper.

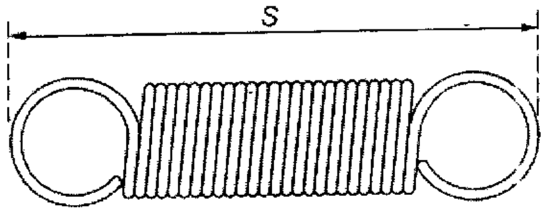

Fig. 3.1

S = ... [1]

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

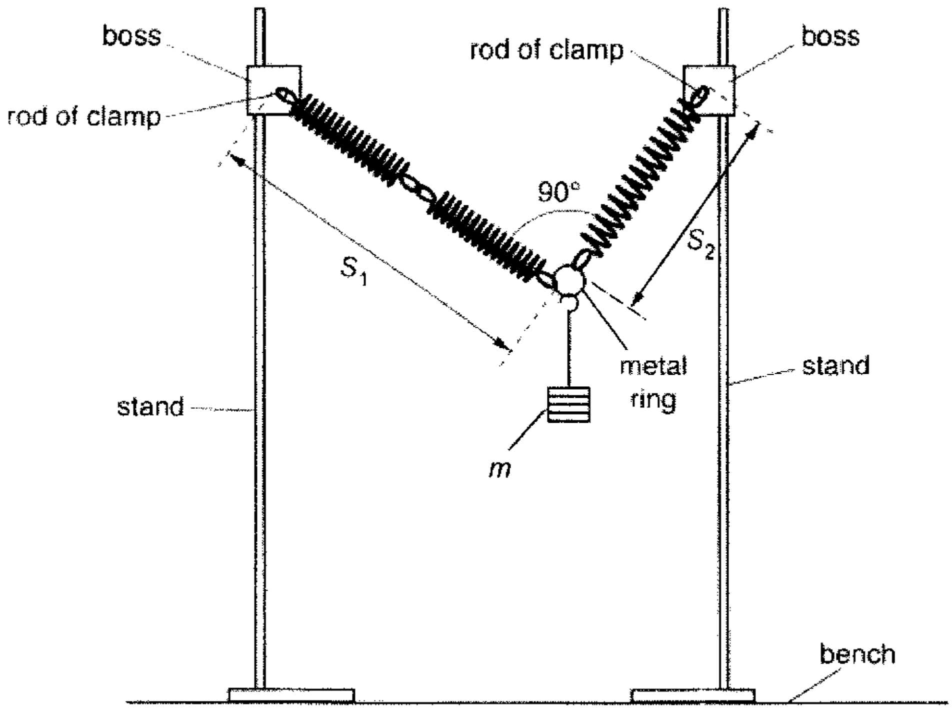

Fig. 3.2

The extended length of the double spring is S_1 and the extended length of the single spring is S_2.

The extensions are p and q where

$$p = S_1 - 2S \text{ and } q = S_2 - S.$$

(ii) Hang appropriate masses on the mass hanger so that m is 400 g.

(iii) Adjust the apparatus so that the angle between the springs is 90°.

Measure and record S_1 and S_2 using a metre ruler.

S_1 = ...

S_2 = ...

[1]

(iv) Calculate p and q.

p = ...

q = ...

[1]

[Turn over

For Examiner's Use

(c) Vary m, obtaining a suitable range of values between 100 g and 400 g inclusive, and repeat **(b)(iii)** and **(b)(iv)**, keeping the angle between the springs 90° throughout.

[4]

(d) Theory suggests that

$$m^2g^2 = \frac{k^2p^2}{4} + k^2q^2$$

where k is the spring constant of one of the springs and g = 9.81 m s^{-2}.

Plot a suitable graph to determine k.

k = ... [3]

For Examiner's Use

[3]

For Examiner's Use

(e) Comment on any anomalous data or results that you may have obtained. Explain your answer.

....

....

....

.... [1]

(f) (i) Suggest one significant source of uncertainty in this experiment.

....

....

....

.... [1]

(ii) Suggest an improvement that could be made to the experiment to reduce the uncertainty identified in **(f)(i)**.

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

....

....

....

.... [1]

For Examiner's Use

(g) The force constant *k* of a spring can be found by another method.

Plan an investigation to find *k* for a fixed length of a spring in tension.

You would be provided with several masses.

You may suggest the use of any additional apparatus commonly found in a school physics laboratory.

Your account should include:

- a diagram
- your experimental procedure
- control of variables

....

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....

....

....

....

....

....

....

....

.... [3]

[Total: 19 marks]

For Examiner's Use

4 As incident light passes through a glass block, the intensity decreases. This is known as light attenuation.

A student suggests that the ratio $\dfrac{\text{amplitude of light transmitted through glass, } A}{\text{initial amplitude of light, } A_0}$ is related to the thickness t of glass and the frequency f of light.

He suggests the following relationship $A/A_0 = k\,t^p f^q$

where k, p and q are constants.

Design a laboratory experiment to investigate the relationship between A/A_0, t and f.

You are provided with several identical glass blocks. You are also provided with several lasers of unknown frequencies and other equipment usually found in a Physics laboratory.

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) how the ratio A/A_0 is measured

(d) the control of variables

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

Diagram

For Examiner's Use

For Examiner's Use

For Examiner's Use

For Examiner's Use

....

....[12]

Materials and apparatus for Question 1 (per set of apparatus unless otherwise specified)

1. Stand of height at least 60 cm.
2. Clamp.
3. Boss.
4. Piece of 16 SWG copper wire of approximate diameter 1.68 mm and approximate length 50 cm.
5. Cork, e.g., from a bottle. See Note 1.
6. Pin of approximate length 3 cm. See Note 1.
7. Stop-watch reading to the nearest 0.1 s or better.
8. 30 cm ruler with a millimetre scale.
9. Wire cutter

Notes

1. The pin should be inserted into the cork along its axis with approximately 1 cm protruding as shown in Fig. 1.1.

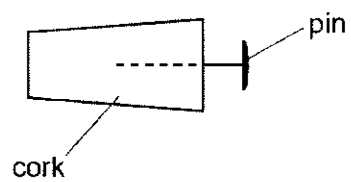

Fig. 1.1

2. The apparatus should be laid out on the bench. If the apparatus is to be used by another candidate, then it should be restored to its original state. A new piece of 16 SWG copper wire must be provided.

Materials and apparatus for Question 2 (per set of apparatus unless otherwise specified)

1. 2 x 2.0 V d.c. power supply.
2. 2 x digital multi-meters
3. 1 x 33 Ω resistor.
    a. The markings and resistance value of the resistor should be covered.
    b. The resistor should be labelled X.
    c. See Note 1.
4. 3 x 68 Ω resistors.
    a. The markings and resistance value of the resistor should be covered.
    b. One resistor must be labelled R_A.
    c. Another resistor must be labelled R_B.
    d. The third resistor must be labelled R_C.
    e. See Note 1.
5. 1 x set of connecting wires (12 wires)
    a. 8 x both ends with crocodile clips
    b. 4 x one end with crocodile clip and other end with jack connector
6. Switch.

Notes

1. All resistors should have a minimum power rating of 0.25 W and a tolerance of 5% (e.g. RS Components stock number 806-6499 for the 33 Ω resistor).

2. The apparatus should be laid out on the bench. If the apparatus is to be used by another candidate, then it should be dismantled and restored to its original state.

Materials and apparatus for Question 3 (per set of apparatus unless otherwise specified)

1. 2 x retort stand (with boss and clamp)
2. 1 x metre rule
3. 1 x vernier calliper
4. 3 x 100 g slotted masses
5. 1 x 50 g slotted mass
6. 1 x 100 g mass hanger
7. 3 x identical springs
8. 1 x set-square
9. 1 x metal ring

Notes

1. The apparatus should be laid out on the bench. If the apparatus is to be used by another candidate, then it should be restored to its original state.

2. The springs and ring need to be connected together.

Mark Scheme for Practical

Qn	Marking Point	Marks
1(a)(i)	Raw L to the nearest 0.1 cm **and** final value in the range 11.5–12.5 cm.	1
1(a)(ii)	Percentage uncertainty based on an absolute uncertainty ΔL in the range 2–5 mm. If repeat readings have been taken, then the absolute uncertainty can be half the range (but not zero) if the working is clearly shown. Correct method of calculation to obtain percentage uncertainty.	1
1(b)(i)	All **raw times** measured either to the nearest 0.1 s or all to the nearest 0.01 s. Evidence of measurement of nT repeated where $nT \geqslant 10.0$ s. Value of T in the range $0.5 \text{ s} \leqslant T \leqslant 1.0$ s.	1 1 1
1(b)(ii)	Calculation of T^2 correct.	1
1(b)(iii)	Justification of the number of significant figures in terms of the number of s.f. in **(raw) time** only.	1
1(c)(i)	Raw L to the nearest 0.1 cm **and** final value in the range 5.5–6.5 cm.	1
1(c)(ii)	Second value of T < first value of T.	1
1(d)(i)	Calculated correctly two values of k with unit and recorded to the least no. of sf among T and L. The final k values must not be fractions. Unit: $cm^{0.5} s^{-1}$ or equivalent	1 1
1(d)(ii)	Justification of Relationship **Note: The given relation is valid for a compound pendulum.** □ Calculated correctly $\%k_{uncertainty} = \frac{\Delta k}{k_{ave}} \times 100\%$ **OR** $\%k_{uncertainty} = \frac{\Delta k}{k_{smaller}} \times 100\%$ □ $\Delta k = \lvert k_1 - k_2 \rvert$ **OR** $\Delta k = \lvert k_1 - k_2 \rvert / 2$ □ Chose a criterion from the value in **(a)(ii)**. □ Concluded that **results do not support the suggestion** if $\%k_{uncertainty}$ > the criterion chosen. OR Concluded **results support the suggestion** if $\%k_{uncertainty} \leq$ the criterion chosen. **(Expected)**	1 1
1(e)	Correct calculation of g using candidate's second k **and** in range $9.0 \text{ m s}^{-2} \leqslant g \leqslant 11.0 \text{ m s}^{-2}$.	1

	number of oscns, n	time for n oscn, $t1$ / s	time for n oscn, $t2$ / s	T / s	L / m	k / m s^-1	g / m s^-2	%L/L	Comment
(b)(ii)/ (b)(iii)	14	10.6	10.5	0.754	0.120	0.459	9.81	1.7	this should be the more appropriate 2nd value of k used to find g due to smaller % error
(c)(ii)	40	21.8	21.6	0.542	0.060	0.45	9.5	3.3	

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Fig. 1 Excel-Generated Theoretical Table for Q1			
		Total	14

Qn	Marking Point	Marks
2(a)	R measured while resistor is in operation i.e., $R = \frac{V}{I}$	1
	Value of R_A, R_B and R_C with unit in the range 64 - 72 Ω.	1

	V / V	I / mA	R / ohm	Nominal / ohm	Multimeter / ohm
R_A	2.03	29.9	67.9		68.2
R_B	2.02	30.1	67.1		67.8
R_C	2.02	30.2	66.9		67.5
			67.3	68.0	**67.8**

Fig. 2a Excel-Generated Theoretical Table for Q2a

Qn	Marking Point	Marks
2(b)(i)	Value of I with unit in the range 30.0–50.0 mA.	1
2(c)	Seven sets of readings of R: 22.7 Ω, 34.0 Ω, 45.3 Ω, **68.0 Ω**, 102 Ω, 136 Ω & 204 Ω Six sets of readings of R	**2 or 1**
	Column headings: Each column heading must contain a quantity, a unit, and a separating mark where appropriate. The presentation of quantity and unit must conform to accepted scientific convention, e.g. R / Ω, I / mA and $\frac{1}{I}$ / mA^{-1}.	1
	Consistency of presentation: All raw values of I must be given to 0.1 mA or all to 0.01 mA.	1
	Significant figures: All values of $\frac{1}{I}$ must be given to the same number of s.f. as the number of s.f. in raw I. Calculation: Values of $\frac{1}{I}$ are correct.	1

	V / V	I / mA	R / ohm	1/I / mA^-1
R _A only	2.76	40.9	67.5	0.0244
R _A and R _B in parallel	2.07	61.3	33.8	0.0163
R _A, R _B and R _C in parallel	1.65	73.6	22.4	0.0136
R _A and R _B in series	3.32	24.5	135.5	0.0408
R _A. R _B and R _C in series	3.56	17.5	203.4	0.0571
R _A and R _B in series w R _C in parallel	2.36	52.7	44.8	0.0190
R _A and R _B in parallel w R _C in series	3.11	30.7	101.3	0.0326

(b)

Fig. 2b Excel-Generated Theoretical Table for Q2c

2(d)	Stated appropriate graph $\left(\frac{1}{I} \text{ against } R\right)$ to be plotted.	1
	E is determined by the inverse of the gradient. X is determined by product of y-intercept and E.	1
	Total	**10**

Qn	Marking Point	Marks
3(a)	Value of S with unit in the range 4.50 – 5.50 cm.	1
3(b)(iii)	<u>Measurement and Observation</u> Recorded **two values** of S_1 and **two values** of S_2, and their **averages** to **nearest 0.001 m (i.e., 0.1 cm).**	1
3(b)(iv)	p and q calculated correctly, and recorded to **nearest 0.001 m (i.e. 0.1 cm).**	1
3(c)	Six (or more) sets of readings of m, including m = 100 g and m = 400 g	1
	Column headings: Each column heading must contain a quantity, a unit, and a separating mark where appropriate. The presentation of quantity and unit must conform to accepted scientific convention, e.g. m / g, S_1 / cm, S_2 / cm, p / cm, q / cm, mg / N and $\sqrt{\frac{p^2}{4}+q^2}$ / cm.	1
	Consistency of presentation: All raw values of S_1 and S_2 must be given to 0.1 cm. All raw values of m must have no d.p. in g.	1
	Decimal places: All values of p and q must be given to the same number of d.p. as the number of d.p. in raw S_1 and S_2 respectively. Significant figures: All values of mg must be given to the same number of s.f. as the number of s.f. in raw m. All values of $\sqrt{\frac{p^2}{4}+q^2}$ must be given to the **least no. of s.f. among p and q** Calculation: Values of mg and $\sqrt{\frac{p^2}{4}+q^2}$ are correct.	1

m / g	S1,1 / cm	S2,1 / cm	S1,2 / cm	S2,2 / cm	p_ave / cm	q_ave / cm	mg / N	((p^2)/4+q^2)^0.5 / cm
400	27.8	18.0	27.8	18.0	17.8	13.0	3.9	15.8
350	24.8	16.5	24.8	16.5	14.8	11.5	3.4	13.7
300	22.5	15.0	22.5	15.0	12.5	10.0	2.9	11.8
250	19.8	13.2	19.8	13.2	9.8	8.2	2.5	9.6
200	17.1	11.5	17.1	11.5	7.1	6.5	2.0	7.4
100	13.2	8.4	13.2	8.4	3.2	3.4	1.0	3.8

Fig. 3 Excel-Generated Theoretical Table for Q3c

3(d) **(GRAPH)**	• Sensible scales must be used. Awkward scales (e.g., 3:10) are not allowed. Scales must be chosen so that plotted points occupy at least half the graph grids in both x and y directions. • Axes must be labelled with the quantity which is being plotted.	1
	• Straight line of best fit- judge by scatter of points about the candidate's line. No curved lines allowed. • There must be an even distribution of points on either side of the line along the full length. • Allow maximum (correctly identified) one anomalous point if clearly indicated on graph i.e., circled or labelled. There must be at least five points left after the anomalous point is disregarded. • Lines must not be kinked or thick. No hairy lines. (No curved lines allowed).	1
	All observations in table must be plotted. Work to an accuracy of plot ≤ 0.5 small square.	1
3(d) **(CALN)**	• Equation linearised correctly. • Plot a <u>sensible graph</u> that allows for straight line to be drawn and k to be determined from the gradient. e.g. mg / N vs $\sqrt{\frac{p^2}{4}+q^2}$ / cm.	1
	• Gradient calculated correctly with clear working. • The hypotenuse of the gradient triangle must be greater than half the length of the drawn line. • Read-offs must be accurate to half a small square.	1
	• k determined correctly from gradient with unit.	1
3(e)	Comments on whether there are any anomalous data - with the anomalous data clearly identified e.g., *"There are no anomalous points as all plotted points are evenly distributed on both sides of the best fit line and no point is <u>significantly further</u> from the best fit line <u>compared to other points.</u>"* Justifies whether there is any anomalous data based on deviation of the points from the linear trend e.g., "*Point* (4.300, 7.00) *is an anomalous point because point (4.300, 7.00) is <u>significantly further</u> from the best fit line as compared to other points.*"	1
3(f)(i)	Difficult to measure angle with reason e.g., hand shakes / curve at bottom / position of zero uncertain / parallax / holding set square without a stand	1
3(f)(ii)	Trace on a card / use graph paper / project onto screen and measure angle / use trigonometry / take photo and measure angle / clamp set square	1

3(g)

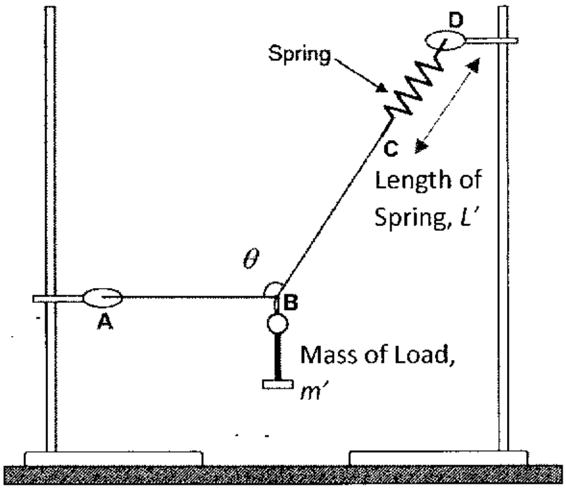

Fig. I

[1] for diagram

(a) Measure the provided masses, m' **using an electronic balance** and labelled them.
(b) Measure the natural length of spring CD, L'_0 using **a metre ruler**.
(c) Set up the apparatus as shown in Fig. I.
(d) Record the known mass m'.
(e) Record the angle θ **using a protractor** while **keeping AB horizontal**.
(f) Record the length L' using **a metre ruler**. Ensure it is **constant**.
(g) Repeat steps (d), (e) and (f) while varying the mass of the load m' to obtain 5 additional sets of readings.

[1] control of variables

(h) Resolving forces vertically,

$m'g = T_{CD}\sin(180^{\circ} - \theta) = k(L' - L'_0)\sin\theta$

where T_{CD} is the tension in spring CD and
g is the acceleration of freefall.

Plot a graph of $\sin\theta$ **against** $m'g$,

which is a straight-line graph through the origin with gradient

$\frac{1}{k(L' - L'_0)}$ is the gradient.

(i) $k = \frac{1}{\text{gradient}(L' - L'_0)}$

[1] for process and how to determine k

Total 19

Qn	Marking Point	Marks
4	**Mark Scheme**	
	Defining the problem A1: identify independent (frequency f of light, thickness of glass t) and dependent (ratio A/A_0) variables A2: identify control variable (e.g. keep distance between light source and sensor constant)	1 1
	Method of data collection B1: labelled diagram showing a setup of laser, glass block(s) and light sensor in a line B2: method to determine the different frequencies of laser (e.g. using diffraction grating and $n\lambda = d \sin \theta$ B3: method to determine thickness of glass t, using vernier calipers or metre rule B4: method to measure intensity of light e.g. use light sensor / light intensity meter connected to datalogger and taking initial reading of I_0) B5: determination of A / A_0 from the formula $I \propto A^2$ B6: identifying 2 runs required (run 1: vary thickness, keep frequency constant) (run 2: vary frequency, keep thickness constant)	1 1 1 1 1 1
	Method of Analysis C1: linearization of relationship $\ln(A / A_0) = \ln(k) + p\ln(t) + q\ln(f)$ C2: Run 1: plot $\ln(A / A_0)$ against $\ln(t)$, straight line with gradient p, y-intercept $\ln(k) + q\ln(f)$ Run 2: plot $\ln(A / A_0)$ against $\ln(f)$, straight line with gradient q, y-intercept $\ln(k) + p\ln(t)$	1 1
	Safety D1: do not look directly into the light source.	1
	Additional details: (max 3) E1: perform experiment in dark room to reduce noise in the form of ambient light E2: detailed description to determine the angle of diffraction through the grating, by measuring distances and using trigonometry relations E3: measure thickness of the glass blocks at different positions and average t. E4: take preliminary measurements of the intensity with the largest thickness before the start of the experiment. If the intensity is too low, reduce the maximum thickness of glass block. E5: ensure light reaches the light meter perpendicularly.	1 1 1 1 1
	MAX	**12**