TEMASEK JUNIOR COLLEGE
2021 JC2 Preliminary Examination
Higher 2

NAME

CG

PHYSICS

Paper 4 Practical

9749/04

Candidates answer on the Question Paper.

30 August 2021

Additional Materials: As listed in the Confidential Instructions

2 hours 30 minutes

Shift
Laboratory

READ THESE INSTRUCTIONS FIRST

Write your name and C.G. in the spaces provided at the top of this page.
Write in dark blue or black pen on both sides of the papers.
You may use an HB pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

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 down 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 or if you do not use appropriate units.

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.
The number of marks is given in brackets [ ] at the end of each question or part question.

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

This booklet consists of **17** printed pages and 3 blank pages **[Turn over**

BLANK PAGE

1 In this experiment, you will investigate how the bending of a plastic ruler depends on load M.

(a) Set up the apparatus as shown in Fig. 1.1. Clamp the plastic ruler to the bench such that it bends from the 2 cm mark. Tie and secure the string near the end of the plastic ruler. Pass the string over the pulley and tie mass M at the other end of the string.

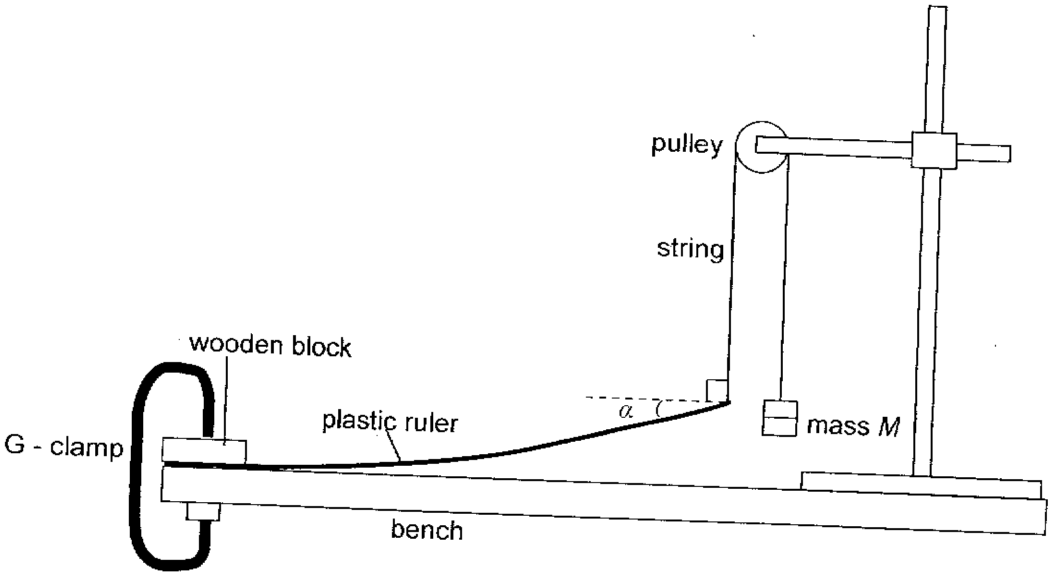


Fig 1.1

(i) With $M = 50\,\text{g}$, adjust the setup such that the string attached to the ruler is vertical.

(ii) Determine and record the angle α.

α = ... [2]

[Turn over

(b) Change the value of M and repeat steps **(a)(i)** and **(a)(ii)** to obtain further sets of readings for M and α in the range of $10\text{ g} \le M \le 60\text{ g}$. The string attached to the ruler is vertical in the setup.

[4]

(c) Theory suggests that M and α are related by the expression

$$\cos\alpha = \frac{M^{\frac{1}{2}}}{A} + B$$

where A and B are constants.

Plot a suitable graph to determine the values of A and B. Include units for A and B, if any.

A = ...

B = ... [7]

(d) The plastic ruler is re-positioned such that it is clamped at the 5 cm mark. Explain how this affects the measured angle α as mass M increases.

....

....

.... [2]

[Total: 15]

[Turn over

2 In this experiment, you will investigate how the motion of an oscillating system depends on the mass attached to the system.

(a) Set up the apparatus as shown in Fig. 2.1.

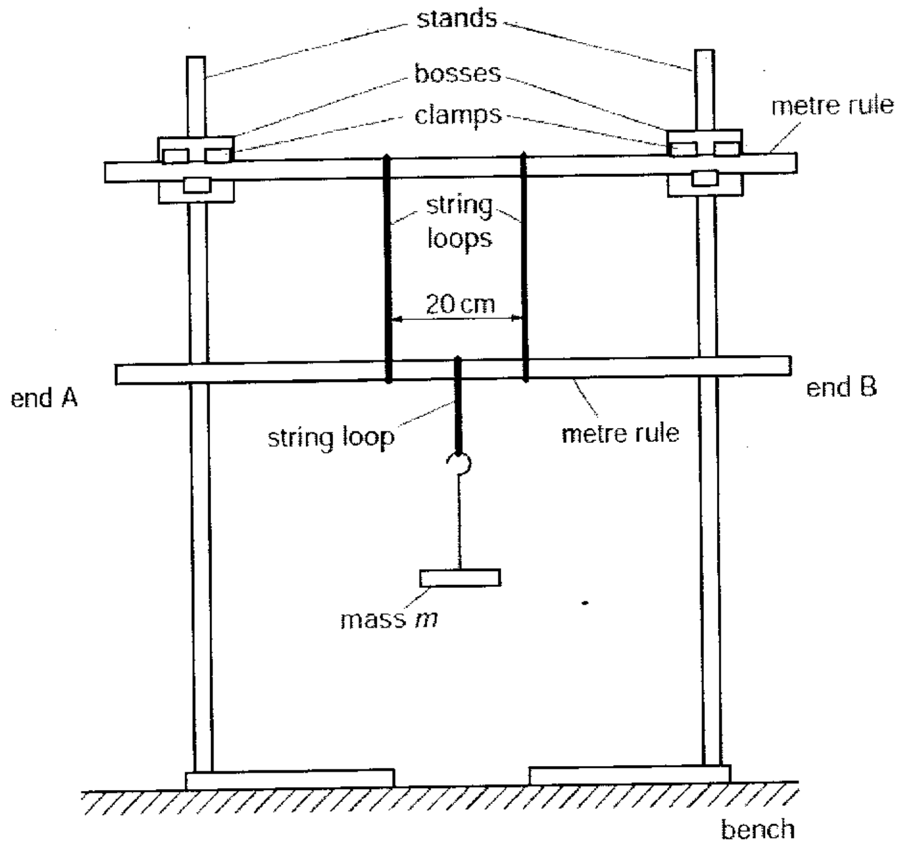


Fig. 2.1

Using the string provided, make two loops of string of approximately 40 cm in **circumference** each. Slide the two loops of string onto the rule on top and fix this rule in the clamps.

Adjust the clamps until the rule is parallel to the bench. Slide a second rule into the two loops. Both rules should have their markings facing you. The strings should be vertical, 20 cm apart and at equal distances from the centre of the second rule.

(i) Tie a string from the middle of the bottom rule to the mass hanger. Set the mass m at 200 g. The distance from the bottom of the rule to the top of mass hanger should be about 10 cm. Move the end A of the bottom rule towards you and the end B away from you. Release the rule and allow it to oscillate.

Determine the time taken for one oscillation T.

T = ... [1]

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

percentage uncertainty in T = ... [1]

(b) Increase m to 400 g and repeat **(a)(i)**.

T = ... [1]

(c) It is suggested that the quantities m and T are related by the equation

$$\frac{1}{T^2} = km \qquad \text{where } k \text{ is a constant.}$$

(i) Use your answers in **(a)** and **(b)** to determine two values of k.
Give your values of k to an appropriate number of significant figures, together with its unit.

First value of k = ...

Second value of k = ... [1]

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

....

....

....

.... [1]

[Turn over

(d) In an investigation with the mass m kept constant, it was found that *T* is inversely proportional to the distance between the string loops, D. Describe the graph you would plot to show that the relationship between T and D is true.

....

....

.... [2]

[Total: 7]

3 A light emitting diode (LED) as shown in Fig. 3.1, is a semiconductor light source that emits light of a specific wavelength when current flows through it. Early LEDs were often used as indicator lamps. Recent developments have produced white light LEDs suitable for room and outdoor area lighting.

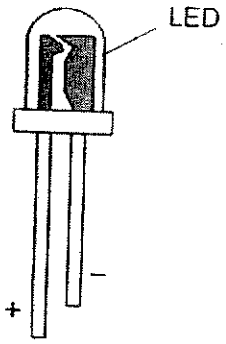
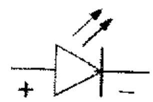


Fig. 3.1



circuit symbol

Fig. 3.2

The circuit symbol of the LED is shown in Fig. 3.2. It is very important that the LED is connected to a circuit in the right direction. The current can flow only from the positive (+) terminal to the negative (-) terminal. The **longer leg** in Fig. 3.1 is the **positive** pin and the **shorter leg** is the **negative** pin.

In this experiment, you will investigate the characteristics of LEDs, such as

- the minimum p.d. to turn on the LED,
- its behaviour when p.d. is applied in the forward and reverse direction,
- the variation of current with applied p.d. across the LED,
- the variation of the minimum p.d. with the wavelength of light emitted.

(a) **(i)** You are provided with a wire XY. Measure the diameter of the wire.

diameter = ... [1]

(ii) Given that the resistance per unit length of wire XY is 26.0 $\Omega\ m^{-1}$, calculate the resistivity of the wire.

resistivity = ... Ω m [1]

[Turn over

(b) Connect the circuit as shown in Fig. 3.3 with the LED connected in the forward direction.

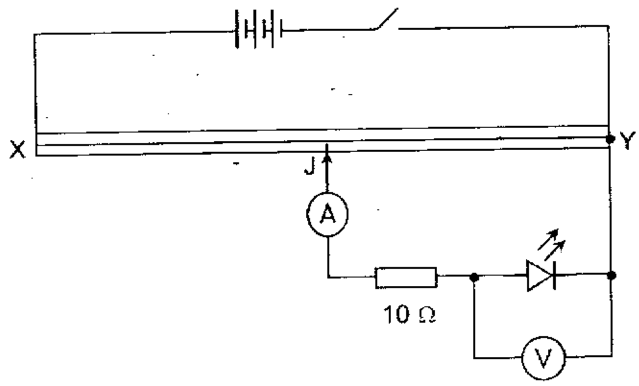


Fig. 3.3

(i) Close the switch.
Move the contact J from end Y gradually towards end X until the LED just turn on, i.e. it just emits a red light.

Record this voltmeter reading, V_{min}.

V_{min} = ... [2]

(ii) Suggest why the 10 Ω resistor was connected in series with the LED.

....

.... [1]

(iii) Move the contact J on the wire XY until the current is increased and the LED lights up.
Record the voltmeter reading V and the ammeter reading I.

V = ...

I = ... [2]

(iv) Calculate the resistance R of the LED when it is operated at this current.

R = ... [1]

(v) Adjust the contact J so that the ammeter reading is further increased. The LED should light up more brightly.

Record the voltmeter reading V and the ammeter reading I.
Calculate the resistance R of the LED.

$V =$ ....

$I =$ ....

$R =$ .... [1]

(vi) By comparing the values obtained in **(b)(iv)** and **(b)(v)**, describe how the resistance of the LED changes with the current, if any, in the forward direction.

....

....

.... [1]

(c) Reverse the polarity of the cells so that the p.d. across the LED is in the **reverse** direction.

(i) Adjust the contact J until it is at mid-point of wire XY.
Record the voltmeter reading V and ammeter reading I.

$V =$ ....

$I =$ .... [1]

(ii) State what your result in **(c)(i)** indicate about the resistance of the LED when the p.d. is applied in the reverse direction.

....

.... [1]

(d) In a similar experiment to the one you conducted in **(b)**, a set of LEDs emitting light of different colours was used. The minimum p.d. V_{min} to turn on the LED is measured for each LED and together with the wavelength λ and frequency f of light emitted, the results are recorded in Fig. 3.4.

colour	minimum p.d. V_{min} /V	wavelength λ/nm	frequency f /10^{14} Hz
red	1.54	665	4.51
orange	1.66	625	4.80
yellow	1.78	595	5.04
green	1.87	565	5.31
blue	2.37	470	6.38

Fig. 3.4

(i) Plot V_{min} against f on Fig. 3.5 and draw the line of best fit. [1]

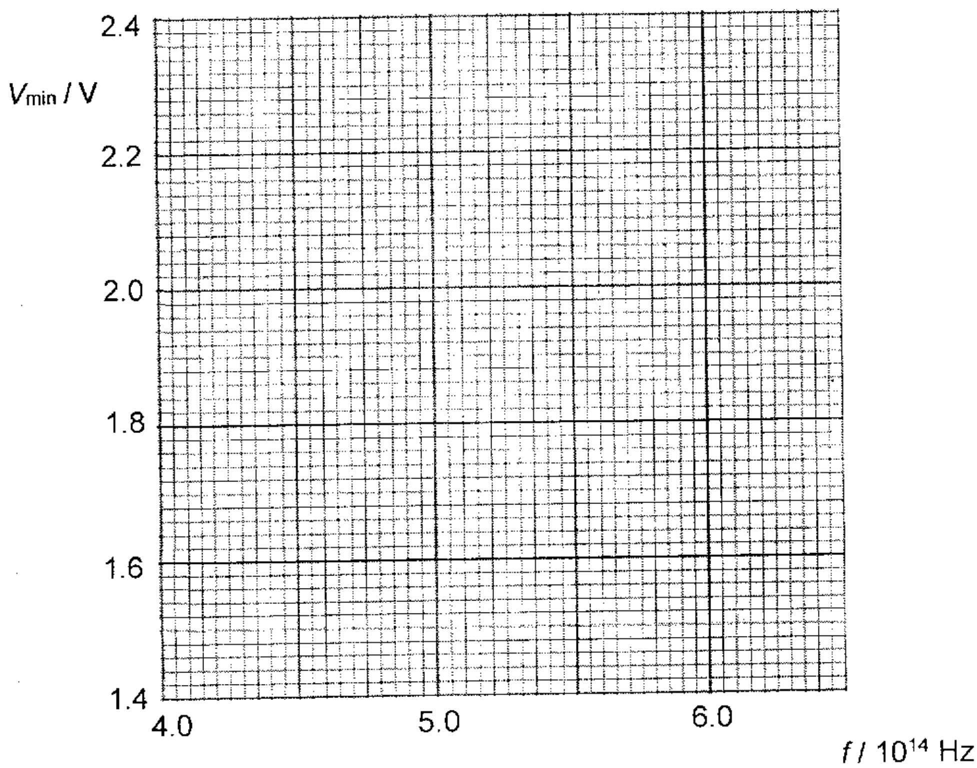


Fig. 3.5

(ii) Theory predicts that the energy lost by the electron in passing through the LED is the energy of the emitted photon. Hence

$$eV_{min} = hf$$

where h is the Planck constant and $e = 1.60 \times 10^{-19}$ C.

Use your graph to determine the value for h.

h = ... J s [2]

(iii) The accepted value for h is 6.63×10^{-34} J s.
Calculate the percentage difference between the value calculated in **(d)(ii)** and the accepted value.

percentage difference = ... [1]

(iv) Suggest one significant source of error which could have contributed to the percentage difference calculated in **(d)(iii)**.

....

....

.... [1]

(v) Suggest an improvement that could be made to reduce the error identified in **(d)(iv)**.

....

....

.... [1]

[Turn over

(e) Red, green, and blue are the primary colours of light. They can be combined in different proportions to make all other colours. When red, green and blue light of the same intensity are combined together, white light is observed.

You are provided a set of one red, one green and one blue LED, each of which have different minimum turn-on voltages.

Describe, using a suitable diagram, how you would ensure that the intensity of the light emitted from each coloured LED is the same so that white light is observed when the three LEDs are switched on.

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

-- [3]

[Total: 21]

4 A spark plug is a device for delivering electric current from an ignition system to the combustion chamber of a spark-ignition engine to ignite the compressed air-fuel mixture by an electric current.

Air gap separation between two electrodes of the spark plug is one of the crucial factors in proper engine operation. A narrow gap might prevent a spark from developing fully to ignite the air-fuel mixture, while a wide gap might prevent a spark from firing at all.

A student wishes to investigate how the production of a spark is affected by various factors.

Fig. 4.1 shows a typical spark plug.

Fig. 4.1

It is suggested that the minimum voltage V required to generate a spark across an air gap between two electrodes varies with d, the separation between the electrodes, as well as p, the pressure of the air, by the relationship

$$V = k\,d^n\,p^m$$

where k, n and m are constants.

Design an experiment to determine the values of n and m.

The following equipment is available: a pressure chamber, a pressure gauge, an air pump, a variable high DC voltage supply and two electrodes. You may use any other equipment usually found in a physics laboratory.

Draw a labelled 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 you would measure the minimum voltage V

(d) the control of variables

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

[Turn over

Diagram

[Turn over

[Total: 12]

BLANK PAGE

BLANK PAGE

2021 TJC Prelim Paper 4 solution

Suggested Solution for Question 1:

(a) $M = 0.050$ kg

(ii) $\alpha_1 = 56°$

$\alpha_2 = 56°$

$\alpha = \frac{56+56}{2} = 56°$

(b)

M/kg	α_1/°	α_2/°	cos (α/°)	$M^{\frac{1}{2}}$/kg$^{\frac{1}{2}}$
0.010	13	13	0.98	0.10
0.020	28	28	0.88	0.14
0.030	40	40	0.77	0.17
0.040	50	50	0.64	0.20
0.050	56	56	0.56	0.22
0.060	62	62	0.48	0.24

(c) $\cos\alpha = \frac{M^{\frac{1}{2}}}{A} + B$

Plot a graph of cos α against $M^{\frac{1}{2}}$ where $\frac{1}{A}$ is the gradient and B is the y-intercept.

$$\text{gradient} = \frac{0.955 - 0.495}{0.124 - 0.236} = -4.11$$

$$\frac{1}{A} = \frac{0.460}{-0.112}$$

$$A = -0.243\,\text{kg}^{\frac{1}{2}}$$

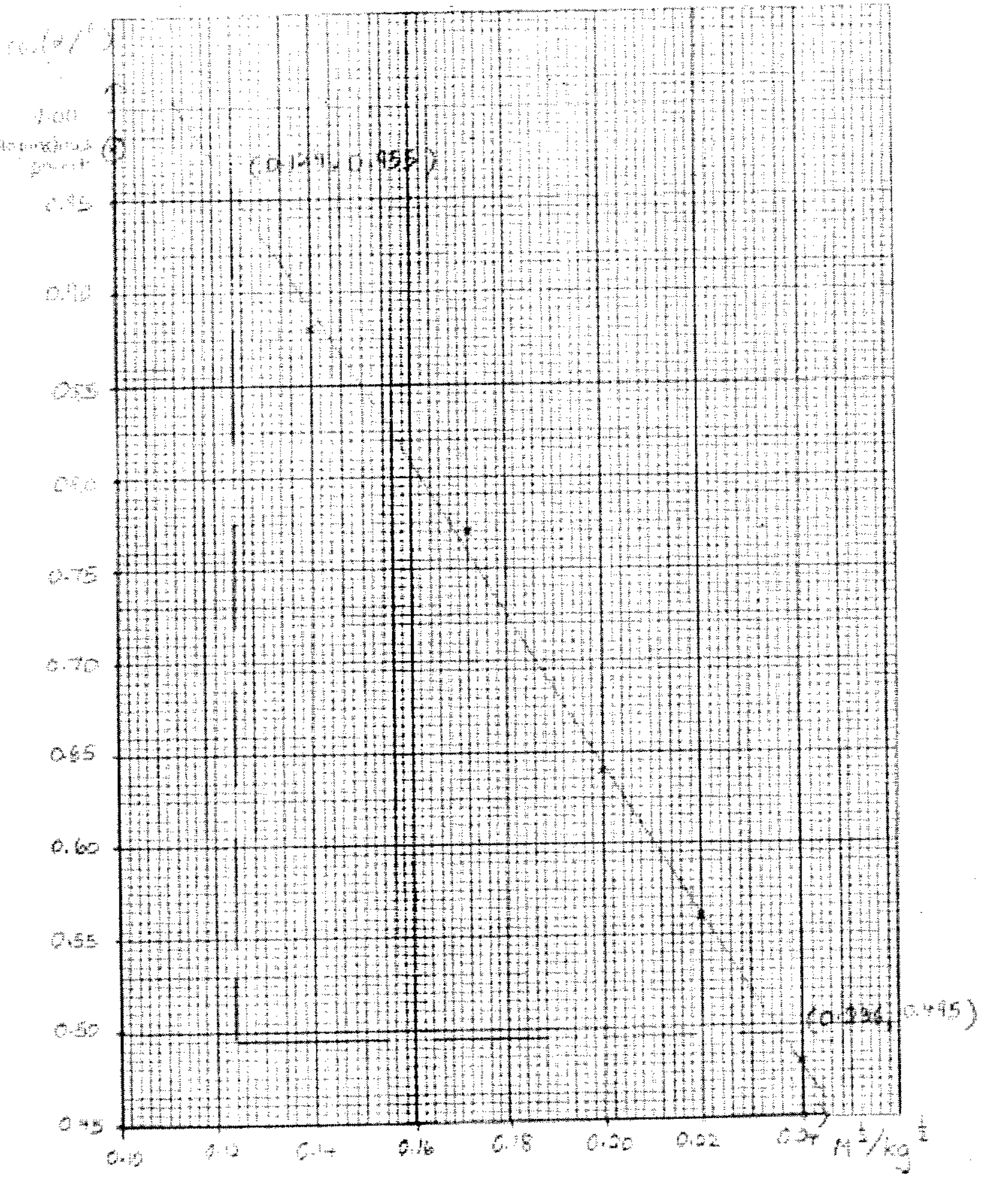
Substitute (0.124, 0.955) into the equation,

$$(0.955) = \left(\frac{0.460}{-0.112}\right)(0.124) + B$$

B =1.46

(d) The measured angle α is smaller.

The perpendicular distance from the line of action of the string tension to the pivot is shorter. Hence a smaller anti-clockwise moment and the ruler bend a smaller angle.


(0.1394, 0.955)
(0.236, 0.495)
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.10
0.12
0.14
0.16
0.18
0.20
0.22
0.24

Suggested Mark Scheme for Question 1:

No	Mark Scheme	Mark	Score
1(b)	α measured to nearest degree, and is between 40 to 70° Evidence of repeated measurement	1 1	
1(c)	Tabulate at least 6 sets of readings Award 0 marks if ≤ 5 readings are taken. Award 0 marks if assistance is provided in setup. Correct column headings with units Consistent d.p for α (consistent nearest degree throughout the column) Correct s.f. *for cos* α and $M^{1/2}$ **(Evidence of repeated α was accounted in 1(b)) – 1 mark in 1(b)**	1 1 1 1	
(d)	Linearising equation and deriving gradient/y-intercept of graph Correct labelling of axes and graph should occupy at least half of graph paper. Awkward scales (e.g. 3:10) are not allowed All observations plotted to an accuracy of half a small square Line of best fit – with a fair scatter of points on either side of the line 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 y-Intercept - read off to the nearest half small square or determined from $y = mx + c$ using a point on the line. Value of B calculated correctly, from y-intercept Value of *A* calculated correctly, with units from gradient	1 1 1 1 1 1 1	
(d)	Correct explanation Correct conclusion	1 1	
	Total	15	

Suggested solution for Question 2:

(a)(i) N = 10 oscillations

t_1 = 14.6 s, t_2 = 15.1 s

Average t = (14.6+15.1) /2 = 14.9 s. Period = 14.9/10 = 1.49 s.

(a)(ii) Percentage uncertainty to 2sf.

Uncertainty = $\frac{\Delta T}{T} \times 100\%$

$$\frac{\Delta T}{T} \times 100\% = \frac{0.3}{14.9} \times 100\% = 2.0\%$$

(b) Allow ecf for repeat timing.

N = 10 oscillations

t_1 = 11.6 s, t_2 = 11.4 s

Average t = (11.6+11.4)/2 = 11.5 s. Period = 11.5/10 = 1.15 s.

(c)(i) $k_1 = 1/(0.200 \times 1.49^2) = 2.25\ kg^{-1}\ s^{-2}$

$k_2 = 1/(0.400 \times 1.15^2) = 1.89\ kg^{-1}\ s^{-2}$

(c)(ii) Percentage difference of k = $(k_1 - k_2)/k_2 \times 100\%$

= [(2.25-1.89)/1.89] x100% = 19%

Percentage difference of k value is greater than the percentage uncertainty of T. Hence, experiment does not support the suggested relationship.

(d) Vary D and measure the period T
Plot the graph of T vs 1/D
The graph should be a straight line passing through the origin.

Suggested Marking Scheme for Question 2:

No	Marking Instructions	Mark	Score
(a)(i)	N oscillations chosen such that total time t > 10s Value of t to correct d.p. with unit Evidence of repeat timing Value of T to correct s.f. with unit	1	
(a)(ii)	Correct calculation of % uncertainty using sensible value of Δt (0.2 s ≤ Δt ≤ 0.5 s). (May vary based on students' repeat values) Percentage uncertainty expressed to 1 or 2 s.f.	1	
(b)	Value of t to correct d.p. with unit Evidence of repeat timing [Allow ecf] Value of T to correct s.f. with unit	1	
(c)(i)	Correct calculations of the two k values Expressed to correct sf with units	1	
(c)(ii)	Draw conclusion based on stated criterion. (e.g. not obeyed because % difference of k values > % uncertainty of T in (c)(iii))	1	
(d)	Vary D and measure the period T Plot the graph of T vs 1/D The graph should be a straight line passing through the origin.	1 1	
	Total	7	

Suggested Solution for Question 3:

3 **(a)** **(i)** Zero reading = 0.000 mm
Diameter = ½ (0.18 + 0.18) = 0.18 mm
(ii) Resistivity $\rho = RA/l = 26.0 \times \pi (0.09 \times 10^{-3})^2 = 6.6 \times 10^{-7}\ \Omega m$
(b) **(i)** V_{min} = ½ (1.59+1.61) = 1.60 V
(ii) acts as protective resistor to prevent large current to LED
(iii) V = 1.94 V
I = 8.5 mA
(iv) R = 1.94/8.5m = 230 Ω
(v) V = 2.18 V
I = 63.0 mA
R = 34.6 Ω
(vi) Resistance of LED decreases as current increases.
(c) **(i)** V = 1.71 V
I = 0.0 mA
(ii) Resistance of LED is infinite/infinity.
(Do not accept: resistance of LED is very high)
(d) **(i)** Accurate plot of points
Best fit line drawn
(ii) $$\text{Gradient} = \frac{2.16-1.40}{(6.0-4.2)\times 10^{14}} = 4.22 \times 10^{-14}$$

Gradient = h/e = 4.22×10^{-14}
$h = 4.22 \times 10^{-14} \times 1.60 \times 10^{-19} = 6.76 \times 10^{-34}$ Js

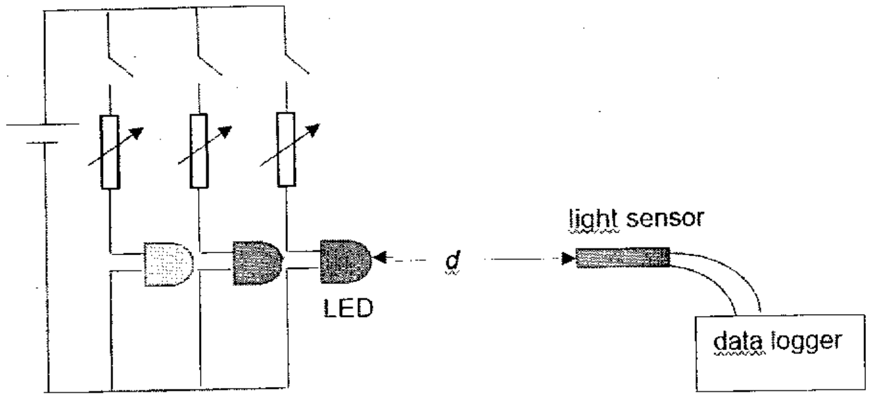
(iii) $$\text{Percentage difference} = \frac{(6.76-6.63)x10^{-34}}{6.63\ x10^{-34}} \times 100\% = 1.5\ \%$$

(iv) Possible error
- difficulty in judging when LED "just turn on" based on visual inspection thereby affecting measurement/accuracy of V_{min}

Do not accept:
-Joule heating of LED causing resistance to change (LED just lights up so the p.d. is low so insignificant joule heating)
-Crocodile clip has a wide surface area (experiment does not require measurement of length of potentiometer wire so replacing by jockey does not improve the error)

(v) Improvements
- conduct experiment in a dark room and use light sensor connected to data logger/light meter to measure intensity of light when LED just lights up
- repeat measurement of V_{min} to find average

(e) Set up a circuit with a d.c. power supply to the 3 coloured LEDs in **parallel**. Each LED branch has a switch and a series variable resistor as shown.



Place a light sensor with data logger at a **fixed distance** from each LED.

Close the switch for the Red LED. Adjust the variable resistor to give a suitable current to light it up. Record the reading of the light sensor.

Repeat with the Green and Blue LED in turn, adjusting the series variable resistance to ensure the **same light sensor reading**

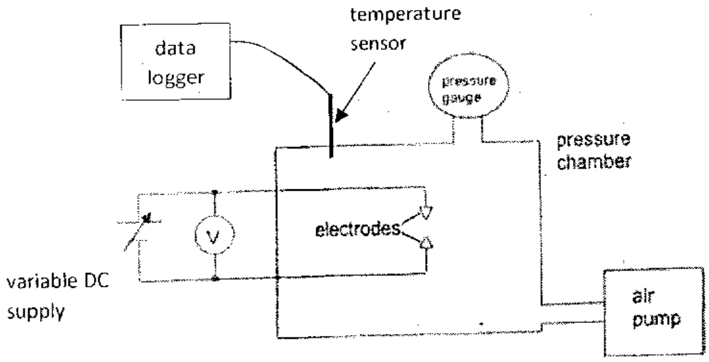
Turn on all LEDs at once and observe the white light produced

Note:
Same power does not mean same intensity emitted.

Suggested Mark Scheme for Question 3:

		Marking Instructions	Mark	Score
3	**(a) (i)**	Repeat measurement of diameter recorded <u>with unit</u> and <u>correct d.p</u>	1	
	(a) (i)	Correct calculation of resistivity and expressed to appropriate s.f. Range of resistivity: (5.9 - 7.4) x 10^{-7} Ωm	1	
	(b) (i)	Repeat measurement of V_{min} Voltage V_{min} in the range 1.55 to 1.65 volts (inclusive) recorded <u>with unit</u> and <u>correct d.p</u>	1 1	
	(b) (ii)	Correct explanation of use of series resistor	1	
	(b) (iii)	V recorded to correct d.p and unit I recorded to correct d.p and unit	1 1	
	(b) (iv)	Value of resistance calculated correctly and expressed in appropriate s.f. and units	1	
	(b) (v)	Value of new resistance calculated correctly and expressed in appropriate s.f. and units	1	
	(b) (vi)	Correct explanation of variation of resistance – as current increases, resistance decreases	1	
	(c) (i)	Current = 0.0 mA in the reverse direction (1 dp with unit) <u>Ig</u>nore V.	1	
	(c) (ii)	Correct statement that diode has <u>infinite</u> resistance in the reverse direction	1	
	(d) (i)	All observations plotted to ½ small square Line of best fit is drawn, with fair scatter of points on either side	1	
	(d) (ii)	Recognition that gradient = *h*/e 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 Value of *h* calculated correctly, expressed to appropriate s.f (minus 1 mark if h is found by substitution)	1 1	
	(d) (iii)	Percentage difference calculated correctly and expressed in 2 or 3 s.f.	1	
	(d) (iv)	Possible errors • difficulty in judging when LED "just turn on" based on visual inspection thereby affecting measurement/accuracy of V_{min}	1	
	(d) (v)	Improvements • conduct experiment in a dark room and use light sensor connected to data logger/light meter to measure intensity of light when LED just lights up • repeat measurement of V_{min} to find average	1	
	(e)	Circuit diagram showing d.c. supply, variable resistor in series with each LED. The 3 coloured LEDs are connected in parallel. Use of <u>light sensor/meter to measure intensity</u>, placed <u>at fixed distance</u> in front of LED. Adjust variable resistance so that the light sensor/meter reading is the <u>same</u> for each LED at the fixed distance	1 1 1	
			21	

Suggested solution for Question 4:	
4	**Diagram**



Defining the problem

Dependent variable is minimum voltage V

Independent variable is pressure of the air-fuel mixture p and air gap separation d

Variables to keep constant:

1. Temperature of the air-fuel mixture is kept constant by conducting the experiment in a temperature controlled pressure chamber and monitored regularly using the temperature sensor connected to a data logger.
2. The same type of gas is used.
3. The material and shape of the electrodes are kept constant by using the same type of electrodes throughout the experiments.

Procedure

Expt 1: Keep d constant, Independent variable is p , dependent variable is V

1. Set up apparatus as shown in diagram.
2. Air gap separation is kept constant by clamping the 2 electrodes at a fixed distance and measured using a Vernier calliper/travelling microscope.
3. Adjust the air pressure p of the chamber to a suitable pressure using the air pump/vacuum pump.
4. Measure and record p using the pressure gauge/pressure senor connected to data logger.
5. Switch on the variable DC supply.
6. While keeping p constant, **slowly** increase the variable DC supply until a spark is observed.
7. Measure and record the minimum voltage V, by reading off the voltmeter.
8. Find the measurement of V and find average V.
9. Repeat steps 3 to 8 for different pressures by pumping/removing air from the chamber with the use of air pump/vacuum pump for 5 further sets of data.

Expt 2: Keep p constant, Independent variable is d, dependent variable is V

1. Set up apparatus as shown in diagram.
2. Adjust the air pressure of the chamber to a suitable pressure using the air pump/vacuum pump.
3. The pressure of air is kept constant by keeping the mass of air constant and monitored using the pressure gauge/pressure sensor connected to data logger.
4. Adjust the air gap between the 2 electrodes to a suitable separation using the clamps.
5. Measure and record d using the Vernier Calliper/travelling microscope.
6. Switch on the variable DC supply.
7. **Slowly** increase the variable DC supply until a spark is observed.
8. Measure and record the minimum voltage V, by reading off the voltmeter.
9. Find the measurement of V and find average V.
10. Repeat steps 4 to 9 for different air gap separation by adjusting the distance between the electrodes for 5 further sets of data.

	Analysis: Experiment 1 $V = kd^n p^m$ $\lg V = m \lg p + \lg(kd^n)$ Plot a graph of lg$V$ against lg$p$, gradient = m Experiment 2 $V = kd^n p^m$ $\lg V = n \lg d + \lg(kp^m)$ Plot a graph of lg$V$ against lg$d$, gradient = n
	Other reliability measures/Additional details 1. Do a pre-experiment to find a suitable range of d and p to ensure sparks are produced. **OR** Do a pre-experiment to find a suitable range of d and p to have measureable V. 2. Perform experiment in the dark so the sparks can be seen clearly. 3. Use of a microammeter/current sensor connected to a data logger to detect a surge in current due to sparking across the electrodes. 4. Repeat measurement of V and find average. 5. Align the 2 electrodes so that the pointed ends are facing each other vertically/horizontally.
	Safety precaution 1. Wear goggles to protect the eyes from high intensity sparks/uv radiation from sparks. 2. Wear insulated gloves to prevent electric shocks from static charges accumulated. 3. Handle high voltage variable DC supply with care. 4. Construct a safety screen around the pressure chamber to protect from explosion/implosion.

Suggested Marking Scheme for Question 4:

	A1	**Design [1 mark]** Clearly labelled diagram: 2 electrodes connected to variable d.c supply and voltmeter across electrodes Circuit must be drawn outside the pressure chamber Pressure chamber, air pump and pressure gauge
		Procedure [5 marks]
	B1	Method of measuring p using pressure gauge
	B2	Method to vary p using of air pump or vacuum pump for 6 sets of data
	B3	Method to vary d and measure d using vernier Calliper/travelling microscope for 6 sets of data
	B4	Method to keep control variable constant, i.e. temperature/type of gas/type of electrode constant
	B5	Method to measure V using voltmeter and to vary p.d across electrodes until sparks across gap
		Safety and analysis [3marks]
	C1	$\lg V = m \lg p + \lg(kd^n)$, Plot a graph of lg$V$ against lg$p$, gradient = m
	C2	$\lg V = n \lg d + \lg(kp^m)$, Plot a graph of lg$V$ against lg$d$, gradient = n
	C3	Either one: -Wear goggles to protect the eyes from high intensity sparks/uv radiation from sparks. -Handle high voltage variable d.c supply with care. -Construct a safety screen around the pressure chamber to protect from explosion/implosion.
		Detail [Maximum 3 marks]
	D1	Do a pre-experiment to find a suitable range of d and p to ensure sparks are produced. OR Do a pre-experiment to find a suitable range of d and p to have measureable V.
	D2	Perform experiment in the dark so the sparks can be seen clearly.
	D3	Use of a microammeter/current sensor connected to a data logger to detect a surge in current due to sparking across the electrodes.
	D4	Repeat measurement of V, d and p and find average.
	D5	Align the 2 electrodes so that the pointed ends are facing each other vertically/horizontally.
	D5	Other possible good physics suggestions
	12	