Anglican High School
Secondary Four
Preliminary Examination 2023

S4

CANDIDATE NAME

CLASS 4

CLASS INDEX

PHYSICS

6091/03

Paper 3 Practical Test

14 August 2023

1 hour 50 minutes

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, index number and name on all the work you hand in.
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.

Answer **all** questions.
All of your answers should be written in this Question Paper: scrap paper must **not** be used.
Graph paper is provided in this Question Paper. Additional sheets of graph paper should be used only if it is necessary to do so.

You will be allowed to work with the apparatus for a maximum of 55 minutes for each section.
You are expected to record all your observations as soon as they are made.
An account of the method of carrying out the experiments is **not** required.

The use of an approved scientific calculator is expected, where appropriate.

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	
2	
3	
Total	

This document consists of **12** printed pages.

Section A

1 *In this experiment, you will investigate the mass and volume of a brass mass.*

You are provided with:

- a brass mass **Note: Deduct max 1m for precision error(s) and max 1m for unit error (s)**
- a ruler
- two set squares
- an electronic balance

(a) **(i)** Describe one precaution you must take before measuring the mass of the brass mass using an electronic balance.

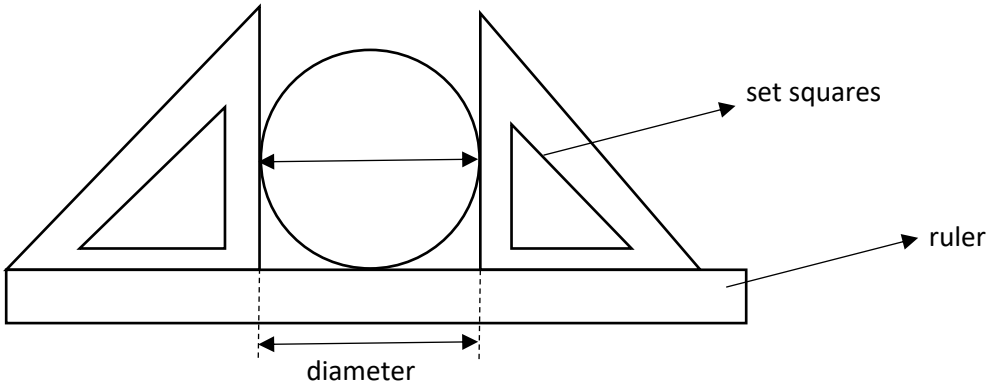
…Press the '0' or tare button to ensure that the initial reading is 0.00 g. ……. [1]

(ii) Measure and record the mass of the brass mass.

Between 99.00 g to 101.00 g (to 2 d.p.)

mass = …….. [1]

(b) **(i)** Draw a labelled diagram to show how to use the ruler and the set squares to measure the diameter of the brass mass.



correct use of set squares (to determine the boundary of the diameter)

and use of rule to measure the diameter [1]

(Note: The 30-cm ruler's zero mark is not at the edge. Not all set squares have the zero mark at the edge)

correct labelling of mass, set squares and ruler [1] (provided the set-up is correct)

(ii) Measure and record the diameter *d* of the brass mass.

d = 2.5 cm to 2.7 cm to 1 d.p.[1] *d* = …… [1]

(c) **(i)** Measure and record the total length *l* of the brass mass, as shown in Fig. 1.1.

2.8 cm – 3.4 cm [1] in 1 d.p

Fig. 1.1 (not to scale)

l = ... [1]

(ii) Estimate the volume *V* of the brass mass using the equation

$$V = \frac{\pi}{4} ld^2$$

Correct calculations with correct units (cm^3) [1]

(14 to 19 cm^3)

V = ... [1]

(iii) The volume calculated in **(c)(ii)** is an estimate of the volume of the brass mass.

Explain why it is only an estimate and whether it is a good or poor estimate of the actual volume of the brass mass.

Why it is an estimate: length included spaces occupied by air / uneven diameter throughout the length [1]

Why it is a poor estimate: Poor estimate of actual volume of brass mass as the volume of air is of a significant percentage of volume calculated in c(ii) / the difference was very large compared to the total volume [1]

(iv) Describe how the method for determining the volume of the brass mass may be improved.

Use displacement method to find volume of brass mass from the change in volume of water in measuring cylinder [1]

Or Measure volume of water displaced from a Eureka can when mass is placed inside [1]

Or Using formula, density = mass / volume, determine volume with density of brass and mass known. [1]

Or Measuring the dimensions of the main body and the protrusion separately, then calculate the individual volumes before adding them together

2 *In this experiment, you will investigate the deviation of a ray of light passing through a glass block.*

You are provided with **Note: Deduct max 1m for precision error(s) and max 1m for unit error (s)**

(a) Fig. 2.2 is on page 5 of your question paper. **On Fig. 2.2**,

(i) draw a normal to the line XY at point M, above and below the line XY,

(ii) draw a line from M at an angle of 60° to the normal towards the top left edge of the page. Label this line L.

(iii) Extend this line from M to the bottom right edge of the page. Label this line K.

Met all requirements (i) – (iii), lines L and K need not reach the edges of page [1]

(b) Place the block on Fig. 2.2, with one of its long sides on the line XY. The top left-hand corner of the block should be at X, as shown in Fig. 2.1.

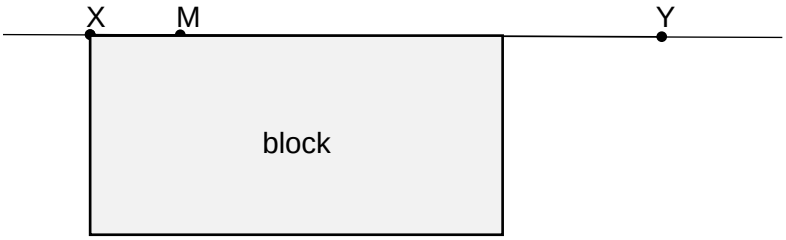


Fig. 2.1

(c) **(i)** On Fig. 2.2, draw the outline of the block.

(ii) Position the illuminated slit so that a ray of light passes along line L from the top left edge of the page towards M.

(iii) On Fig. 2.2, mark and label two points P_1 and P_2 on the ray that leaves the block. You should choose the position of these two points so that the position of the ray can be accurately drawn.

Show refraction on lower surface of glass block in the correct direction & points P_1 and P_2 should be at least 5.0 cm apart. [1]

(d) **(i)** Remove the block. Draw a line through P_1 and P_2 to touch the outline of the block at a point. Label this point N.

(ii) Draw a straight line from M to N and measure the length *l* of the line MN.

. correctly determined from the drawing and answer to 1 d. p. (allow for ecf)

l = e.g. 7.6 cm….. [1]

(iii) Measure the perpendicular distance *d* between the line K and the line through P_1 and P_2.

correctly determined from the drawing and answer to 1 d. p. *d* = e.g. 3.5 cm [1]

(iv) Calculate $\frac{d}{l}$. correct calculation with no units [1] $\frac{d}{l}$ = …… [1]

Fig. 2.2

(e) A student claims that the value of $\frac{d}{l}$ is linearly related to θ, the angle the ray of light from the illuminated slit makes to the normal.

Using the same apparatus, plan an experiment to find out if the student's claim is correct.

Your plan should include

- a list of quantities that you should keep constant,
- a detailed description of how you will perform the experiment,
- a statement of the graph that you would plot to test the relationship,
- a sketch of the graph that you would obtain if the suggested relationship is correct.

Variables mentioned anywhere in the answer:

Constant variables (at least 2) [1]

- point at which the light ray is incident on the glass block / light ray must pass through M

- orientation of glass block (largest face down) / always place glass block on outline drawn)

Independent variable – angle of incidence at M, θ

Dependent variable – value or ratio of $\frac{d}{l}$

Steps:

1. Set up the apparatus as shown in Fig. 2.1 with angle θ at 60 ^{o} (any logical starting angle) at point M.

2. Determine the values of d, l and $\frac{d}{l}$ as described in steps 2(b) to 2(d) on page 4 of the question paper. [Steps 1 & 2 [1]]

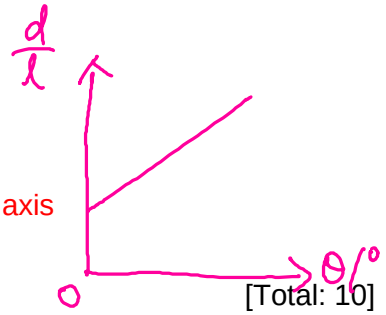
3. Repeat steps 1 – 2 for 5 more sets of readings by varying angle θ. [1]

   Make sure that the light ray pass through M and that the glass block is placed on the outline with the largest face down. (This sentence emphasizes the variables to be kept constant).

4. Tabulate all readings.

5. Plot a graph of $\frac{d}{l}$ against θ. [1]

Correct sketch of graph with $\frac{d}{l}$ as vertical axis and θ as horizontal axis with c ≠ 0 (non-zero y-intercept) [1]



[Total: 10]

OR:

1. Set up the apparatus as shown in Fig. 2.1 with angle θ at 60 ^{o} (any logical starting angle) at point M. Draw line L along this angle to the top left edge of page. Extend this line to the bottom right edge of the page and label it K.
2. Position the illuminated slit so that a ray of light passes through the glass block at 60 ^{o} along line L.
3. Mark and label two points on the ray that leaves the block. Draw a line through the two points until it touches the outline of the glass block at point N.
4. Join points M and N, and measure the length of line MN, l.
5. Measure the perpendicular distance d, between the line passing through the two points and line K.
6. Calculate and record $\frac{d}{l}$. [Underlined parts of steps 1, 4, 5, 6 [1]]
7. Repeat steps 1 – 6 for 5 more sets of readings by varying angle θ. [1]
8. Tabulate all readings.
9. Plot a graph of $\frac{d}{l}$ against θ. [1]

Correct sketch of graph with $\frac{d}{l}$ as vertical axis and θ as horizontal axis with c ≠ 0. [1]

Section B

Note: Deduct max 1m for precision error(s) and max 1m for unit error (s)

3 *In this experiment, you will determine the specific heat capacity of cooking oil.*

You are provided with:

- an arrangement of resistors to act as a heater
- an ammeter
- a voltmeter
- a power supply
- a switch
- leads and crocodile clips.

The heater is made from five resistors connected in parallel. Do **not** separate the resistors.

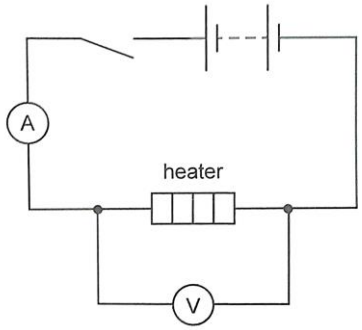


Fig. 3.1

Assemble the apparatus shown in Fig. 3.1. Close the switch. Take the readings in **(a)** and then immediately open the switch.

(a) Record the current I.

answer to 2 d.p in amperes (precision of 0.01A) with unit

I = 0.70 A ……..….

Record the potential difference V across the heater.

answer to 2 d.p. in volts (precision of 0.05 V) with unit V = 3.05 V……..…

All correct [1]

Disconnect the voltmeter from the circuit.

(b) You are also provided with:

- a beaker containing cooking oil held in a clamp, boss and stand
- a second boss and clamp
- a thermometer
- a stopwatch

Arrange the apparatus shown in Fig. 3.2 with the heater placed in the cooking oil. The thermometer should be placed close to, but not in contact with the heater.

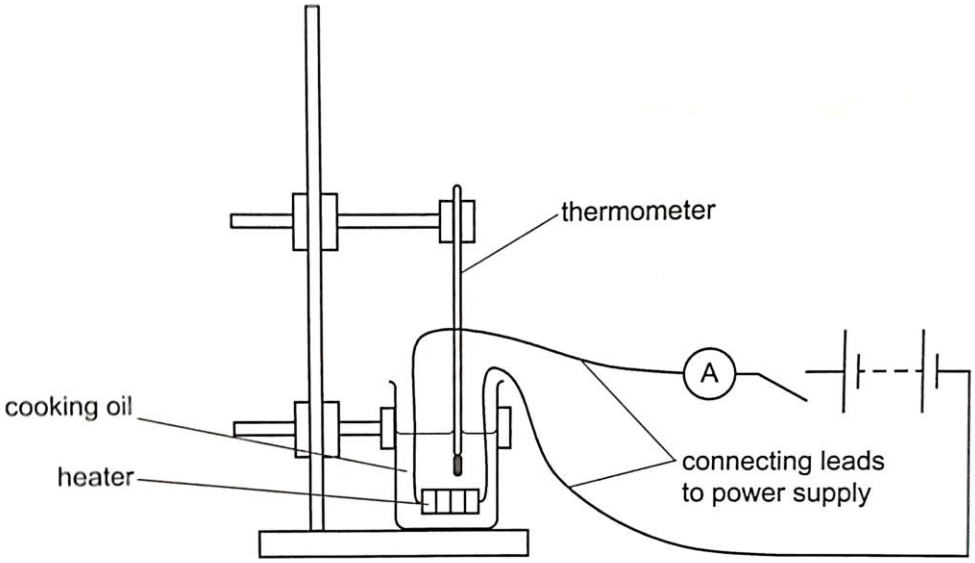


Fig. 3.2

(i) Suggest **one** way in which you assembled the apparatus to make the temperature readings accurate.

Bulb is fully immersed in oil.

OR: Bulb is placed directly above the heater without touching.

OR: Heater not touching the beaker

[1]

(ii) Measure and record the starting temperature θ_0 of the cooking oil.

Reading to 1 d. p. (precision of 0.5 °C) [1] θ_0 = ... [1]

(iii) Calculate the mass m of the cooking oil using the equation

$$m = \rho v$$

where the density of the oil ρ is 0.90 g / cm^3 and the volume of oil v is 40 cm^3.

m = density x volume = 0.90 x 40 = 36 g (correct calculation with units) [1]

m = ... [1]

(c) Close the switch and start the stopwatch.
Stop the stopwatch when the temperature of the oil has increased by $\Delta\theta$ = 2.0 °C.

Open the switch.

Convert the reading on the stopwatch into seconds.
Record the reading *t* in seconds.

Range of time – more than 100 s [1]

t = ……123 s……..……

(accept 0 dp – 2 dp)

Use the values of *V* and *I* recorded in **(a),** and the equation $E = V I t$, to calculate the energy *E* supplied to the oil.

3sf 3sf

Correct substitution of values of V, I and t

E = 3.05 (0.70) (123) = 263 J

Correct calculation with units [1]

2sf

E = ……...

Calculate the specific heat capacity c_1 of the oil using the equation

$$c_1 = \frac{E}{m\Delta\theta}$$

Correct substitution of values of E, m, temp rise

Correct calculation with units [1]

c = 263 / (36 x 2.0) = 3.7 J / (g °C)

$Jg^{-1}°C^{-1}$ or $J/(g°C)$

c_1 = …… [3]

(d) Reset the stopwatch.

Measure and record the temperature θ of the oil at time t = 0 seconds.

θ = ...

Close the switch and start the stopwatch.

In a suitable table, record the reading on the stopwatch, t in seconds, each time the temperature θ of the oil increases by 1.0 °C. Include the temperature θ of the oil at time t = 0 s in the table.

Continue the experiment until the temperature θ of the oil has increased by 6.0 °C.

Open the switch and stop the stopwatch.

Temp θ / °C	t / s	E / J
33.5	0	0
34.5	103	220
35.5	157	340
36.5	213	450
37.5	277	590
38.5	367	780
39.5	466	990

- 7 sets of readings (must include data at t = 0)
- Table with all required columns (temp & t) of readings with correct headings & units (minus 1 m for missing or wrong units even if already done so in the previous parts)
- Precision of temp and time (do not double penalise precision error for temp precision of time can be 0 dp to 2 dp, but must be consistent in column) [3]

(e) **(i)** Calculate E, the total energy supplied for each value of t.

Record your values in a separate column of the table. [1]

Correctly calculated using $E = VIt$ to 2 s.f. in joules [1] (because current is in 2 s.f.)

(ii) Using the grid provided, plot a graph of E against θ.

Draw the line of best fit. [4]

- Correct axis labels
- Suitable scale
- Correctly plotted points
- Best fit line

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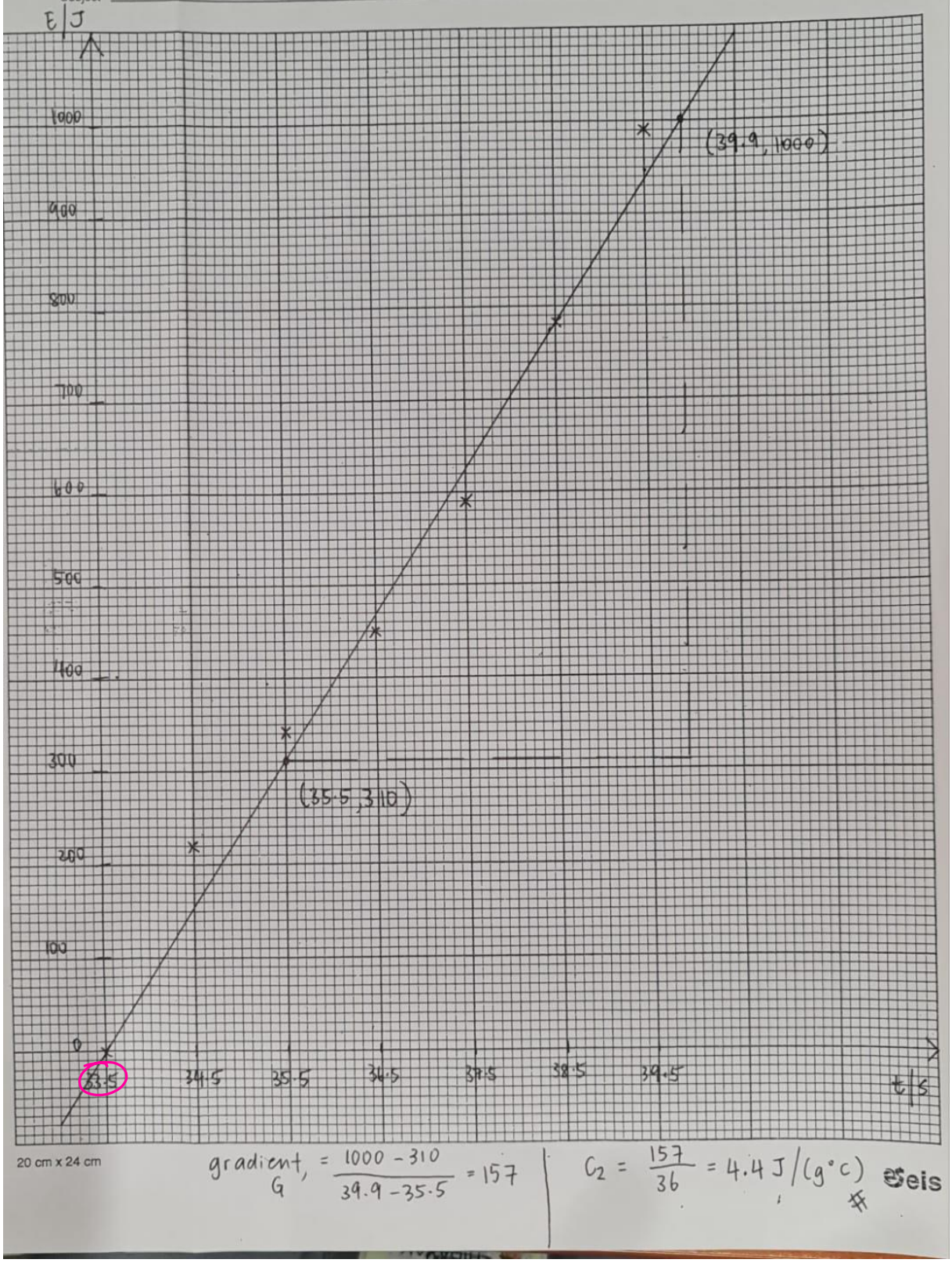
Name _____ Index No. _____

Subject _____ Class _____ Date _____



20 cm x 24 cm

gradient, G = $\frac{1000 - 310}{39.9 - 35.5} = 157$

$C_2 = \frac{157}{36} = 4.4\ J/(g°C)$

eis

Determine the gradient *G* of the line of best fit.

- Dotted triangle (longer than ½ the length of best fit line)
- Correctly calculated gradient to 2 or 3 sf (no need unit)

G = ... [2]

Calculate a second value of c_2, the specific heat capacity of the oil, using the equation

$$c_2 = \frac{G}{m}$$

where *m* is the mass of oil calculated in **(b)(iii)**.

Correctly calculated based on (f) to ~~2 or 3 sf~~ in J / (g ^{o}C)

(do not double penalise if error was made in (c)) [1]

c_2 = ... [1]

(f) Explain **two** sources of error in the experimental procedure that cause the value of c_1 to be different from the value of c_2.

State a source of error with correct explanation [1] each;
State two sources of error correctly but without explanations [1]; Otherwise [0].

- Since the beaker is not lagged / insulated / not covered, some heat is lost / dissipated / transferred to the surrounding air. Hence the time taken for heater to raise the temperature of oil is greater or more energy E is supplied to raise the temperature of oil.
- Since there is no stirring of the oil, the temperature recorded may not be accurate as the temperature in the oil may not be uniform throughout.
- The beaker was not covered and some oil may have evaporated during heating, hence the mass of oil will be lesser than calculated initially.
- As the switch is kept closed for a long time, the power / voltage / current supplied by the source decreases over time (due to usage and increase of resistance of wires caused by heating). Hence the calculated values of E will be inaccurate / Hence a longer time is required to raise the temperature of oil.
- It is difficult to look at both the stopwatch and thermometer at the same time, hence the temperature / time recorded may not be taken exactly at the planned time.

*Note: Human reaction time is not accepted as a suitable source of error in this context because the time frame of the experiment is long (more than 400 s) and the human reaction time is around 0.3 s, which will not affect the results significantly (0.3 / 400 = 0.075%).