THE UNITED REPUBLIC OF TANZANIA
NATIONAL EXAMINATIONS COUNCIL OF TANZANIA
DIPLOMA IN SECONDARY EDUCATTION EXAMINATION

731/2A **PHYSICS 2**

(ACTUAL PRACTICALS 2A)

Time: 3 Hours **Year: 2024**

Instructions.

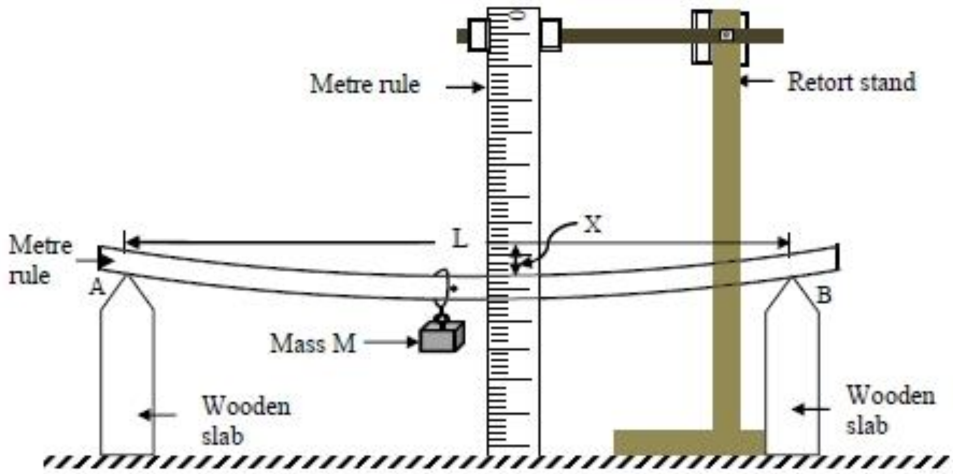
1. This paper consists of **three (3)** questions
2. Answer **all** questions
3. Cellular phones are **note** allowed in the examination room.
4. Write your **examination Number** on every page of your answer booklet(s).

SECTION A (40 Marks)

1. Timbers used in bridge construction are chosen and arranged depending on the maximum load they are supposed to carry. An engineer wants to construct a bridge in one of the highways using timbers which are the same as those used in making common metre rule. Since metre rules are available in your Laboratory, conduct an experiment through the given procedures to ascertain whether such timber will meet the requirement.

Procdures:

(a) Arrange the apparatus as illustrated in Figure 1.



(b) Using sellotape, fix a pin at the middle of the horizontal metre rule so that it serves as a pointer. Make sure the vertical metre rule is in the line with the centre of the horizontal metre rule.

(c) Measure l = 90 cm as the distance AB. Record the pointer reading Xo on the vertical rule when there is no any mass on the horizontal metre rule.

(d) Load the horizontal metre rule by suspending a mass M = 500 g at the centre using a piece of thread, then record the pointer reading X on the vertical rule. Determine the depression $d = (x - x_o)$ cm.

(e) Without changing the position of 500 g mass, repeat the procedure in (c) by changing distance between the wooden slabs to 80 cm, 70 cm, 60 cm and 50 cm.

(f) Using a vernier caliper, measure the breadth and thickness t of the metre rule.

Questions

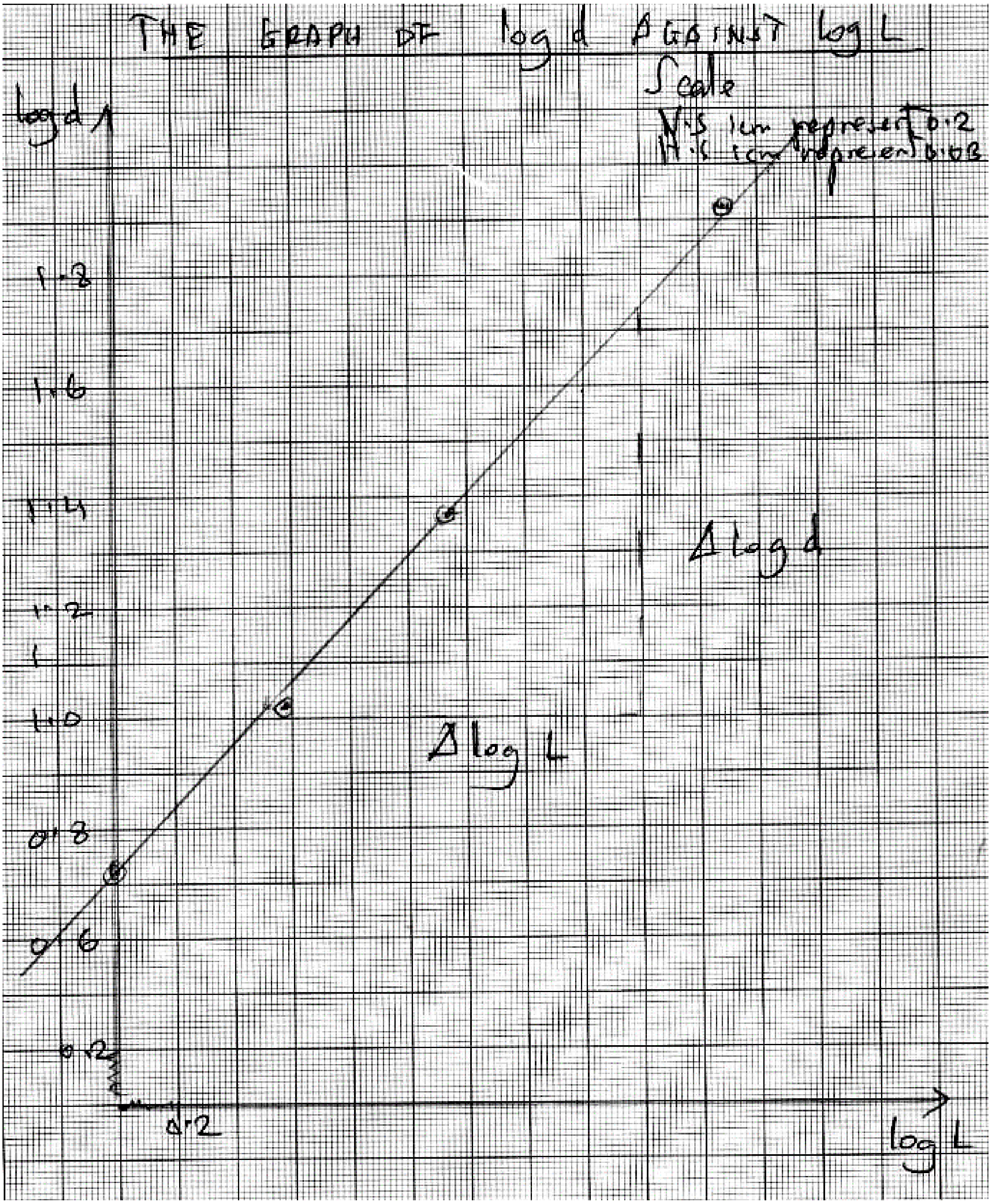
(i) Tabulate your results including the values for log d and log l.

Let's fill in the table carefully using the given data:

l (cm)	**x_0 (cm)**	**x (cm)**	**d (cm) $= x - x_0$**	**log l**	**log d**
90	48	52.0	4.0	1.9542	0.6021
80	48	51.0	3.0	1.9031	0.4771
70	48	50.05	2.05	1.8451	0.3118
60	48	50.0	2.0	1.7782	0.3010
50	48	49.0	1.0	1.6989	0.0000

(ii) Plot a graph of log d against log l.

The graph is a straight line with log d on the y-axis and log l on the x-axis.



(iii) Determine the Young's Modulus of the metre rule given that log d = 3 log l + log k
From the graph:

- Gradient (slope) = 3

Using the relation:
log d = 3 log l + log k
The intercept is log k.

From the plotted points, estimate log k using any of the points. Let's use (log l = 1.8451, log d = 0.3118):
Substituting into the equation:
0.3118 = 3 × 1.8451 + log k
0.3118 = 5.5353 + log k
log k = 0.3118 – 5.5353
log k = –5.2235

Now, k = antilog (–5.2235)
$k \approx 5.98 \times 10^{-6}$
Then, using the formula:
Young's modulus,
$E = (M g l^3) / (4 k b d^3)$
Given:
M = 0.5 kg
$g = 9.81\ m/s^2$
b = breadth of metre rule (use standard 0.025 m if not measured)
d = thickness (use standard 0.005 m if not measured)
Substituting:
$E = (0.5 \times 9.81 \times (0.70)^3) / (4 \times 5.98 \times 10^{-6} \times 0.025 \times (0.005)^3)$
$E = (0.5 \times 9.81 \times 0.343) / (4 \times 5.98 \times 10^{-6} \times 0.025 \times 1.25 \times 10^{-7})$
$E \approx (1.683) / (7.4725 \times 10^{-14})$
$E \approx 2.252 \times 10^{13}\ N/m^2$

(iv) Justify whether the material represented by a metre rule meets the requirements
The calculated Young's modulus value is several orders of magnitude higher than that of typical construction timber, which ranges between 0.5×10^9 and $2 \times 10^9\ N/m^2$.
Therefore, the metre rule timber would not meet the structural requirements for a bridge, since a material with excessively high or low modulus either fails to withstand load effectively or lacks necessary flexibility for structural safety.

It suggests either the timber used in the metre rule is not designed for structural applications, or the experiment conditions (approximated breadth and thickness) need careful adjustment. A proper decision would require precise measurement of dimensions and comparison with standard allowable stress for bridge timbers.

2. You are assigned a task to investigate the relationship through experiment between the loss of heat from a copper calorimeter and the excess temperature over the surroundings under the conditions of forced convection. Given the following apparatus and materials; copper calorimeter with lid, thermometer, hot water and cardboard, perform the experiment through the given procedures and answer the questions that follow.

Procedures:
(a) Record the room temperature as θo.
(b) Fill about three quarter of the calorimeter with hot water heated to about 85 °C or more.
(c) Place the copper calorimeter on a wooden base and cover it with lid. When the temperature of water reaches 80 °C start a stopwatch and gently stir the hot water while recording the temperature for every 1 minute. Take your readings for 14 minutes.

Questions
(i) Tabulate your results as shown in the following table:

Time t (sec)	temperature θ^o	$(\theta - \theta_o)$ °C	$\log(\theta - \theta_o)$

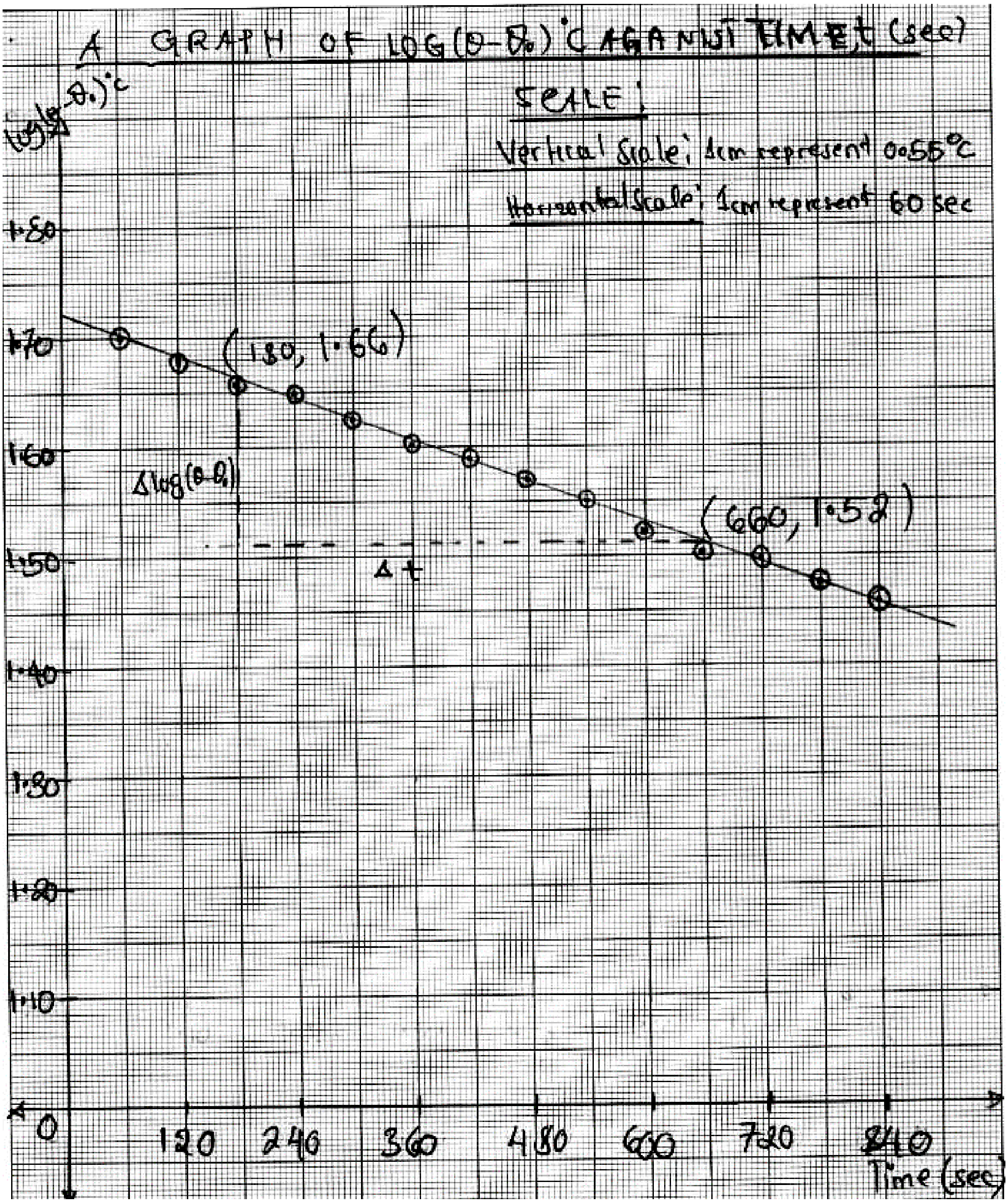
(ii) Plot a graph of $\log(\theta - \theta_o)$ against time, (t).

Room temperature θ_o = 24°C .

Time t (sec)	Temperature θ°C	$(\theta - \theta_o)$°C	$\log(\theta - \theta_o)$
60	77	53	1.724
120	75	51	1.708
180	73	49	1.690
240	71	47	1.672
300	69	45	1.653
360	67	43	1.633
420	65	41	1.613
480	63	39	1.591
540	62	38	1.580
600	60	36	1.556
660	59	35	1.544
720	58	34	1.531
780	56	32	1.505
840	55	31	1.491

$\theta_o = \theta° + \theta t = 24° + 27°$ $\theta = 26°C$.

ii) To plot a graph of log (θ - θ₀) against t.



From the graph,

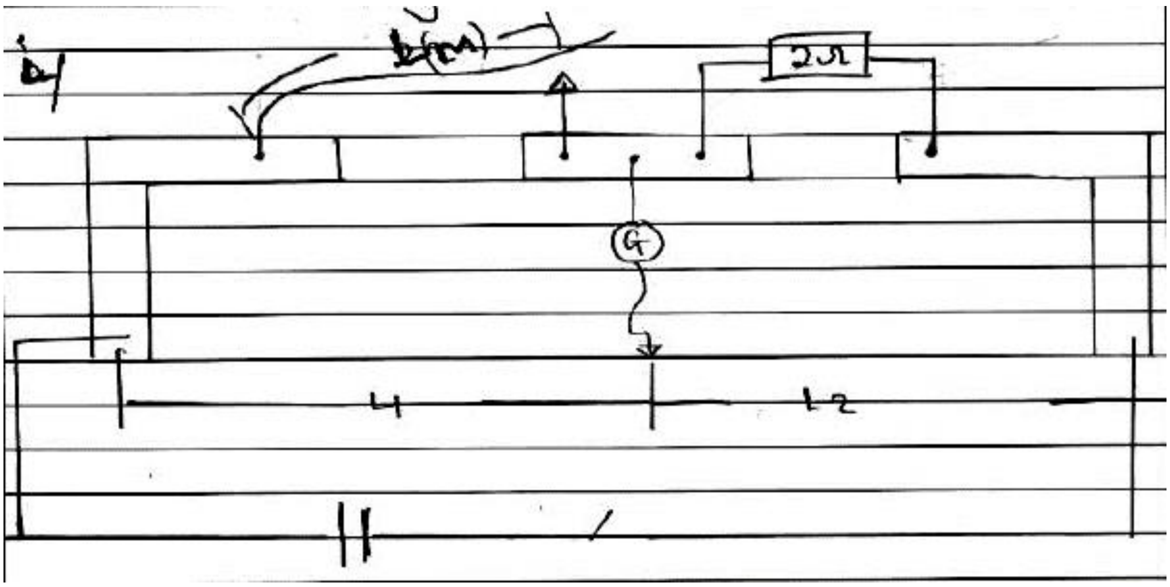
slope = (Δ log ($\theta - \theta_0$)) / Δt
= (1.52 - 1.66) / (660 - 180)
slope = -0.000292 °C/sec
log ($\theta - \theta_0$) = -Kt + c
y = mx + c
Slope = -K
-K = -2.92×10^{-4} °C/sec
K = 2.92×10^{-4} °C/sec
The physical meaning of K is constant temperature.

(i) Parallax error due to the reading of thermometer
(ii) Error due to the start and stopping of stopwatch

3. To avoid faulty of electrical appliances, wire cables are specified basing on the resistivity of materials making up the wire. You are provided with the following materials; a wire of length 1 m, a metre bridge, galvanometer, jockey, a switch, a standard resistor of 2 Ω, two dry cells connected in series and micrometre screw gauge. Carry out an experiment to determine the resistivity and corresponding resistance of a 1m wire whose labels have been removed.

Procedures:
(a) Connect the circuit by fixing a wire of length, x = 0.1 m on the left gap of a metre bridge and standard resistor of 2 Ω on the right gap.
(b) Close the switch and move the sliding contact along the bridge wire to the balancing point. Measure and record the lengths l_1 on the left and l_2 on the right of the balancing point.
(c) Repeat the procedures in 3 (a) to (b) for the values of x = 0.2 m, 0.3 m, 0.4 m, 0.5 m, 0.6 m, 0.7 m and 0.8 m.
(d) Measure and record the diameter of the wire.

Questions
(i) Draw the circuit diagram showing your experimental set up.

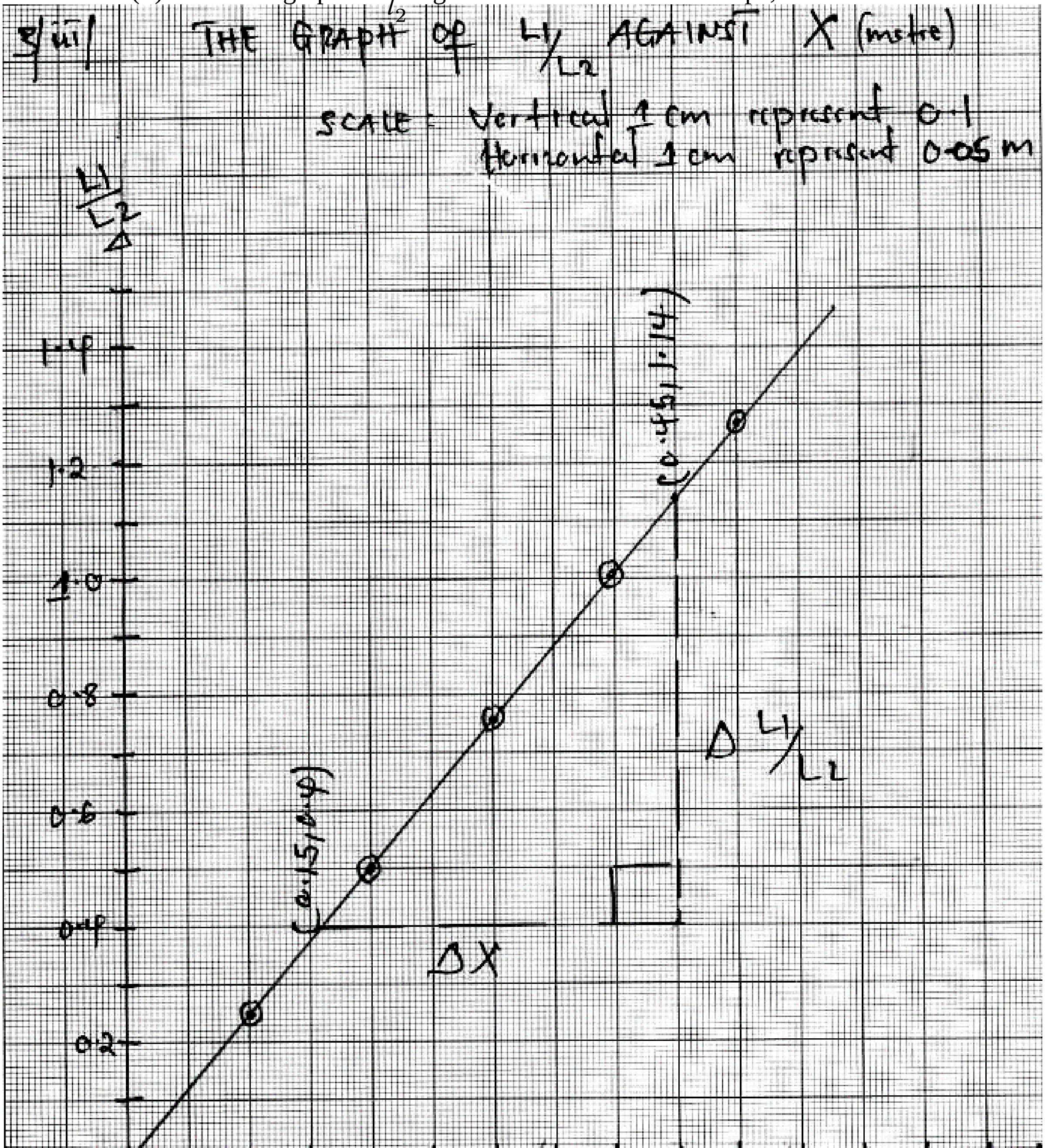


(ii) Tabulate your results including the values of $\frac{l_1}{l_2}$.

table of result

length (X) metre	**L_1 (cm)**	**L_2 (cm)**	**L_1/L_2**
0.1	20.30	79.70	0.25
0.2	33.80	66.20	0.51
0.3	43.30	56.70	0.76
0.4	50.50	49.50	1.02
0.5	56.00	44.00	1.27

(ii) Plot a graph of $\frac{l_1}{l_2}$ against x and determine its slope, S.



(iv) Compute the resistivity of the wire.

Slope = $\dfrac{\frac{\Delta L_1}{L_2}}{\Delta x}$

Slope = $\dfrac{1.14-0.4}{0.45-0.15}=2.46667$

Slope = 2.47 m^{-1}

Then,

$$\frac{l_1}{l_2}=\left(\frac{\rho}{2A}\right)x\ +\ C$$

Y = mx + C

$$m\ =\ slope\ =\ \frac{\rho}{2A}$$

ρ ≈ 4.76 × 10^{-7} Ω·m

(v) Determine the resistance of the whole wire.
Using the relation:
R = ρ × (L / A)
Substituting the earlier found values:
R = (4.76 × 10^{-7} Ω·m) × (1 / 1.9635 × 10^{-7})
R =5 Ω

(vi) What precautions would you take to minimize sources of errors?

First, I would ensure that all connections in the circuit are clean, firm and tight. Loose or corroded connections would increase resistance and affect accuracy.

Second, I would use a micrometer screw gauge in several positions along the wire to accurately measure its diameter and calculate an average to account for irregularities in thickness.

Third, I would avoid touching the wire with bare fingers during measurements, since body heat can change resistance by heating the wire.

Fourth, I would ensure that the jockey makes firm but light contact with the wire to avoid damaging it or altering its resistance at the point of contact.

Fifth, I would confirm that the wire is straight, smooth and free from kinks or irregularities, which can affect resistance distribution along its length.