CHRISTIAN SOCIAL SERVICES COMMISSION (CSSC)

NORTHERN ZONE JOINT EXAMINATIONS SYNDICATE (NZ-JES)

FORM SIX PRE-NATIONAL EXAMINATIONS 2025

PHYSICS 3A

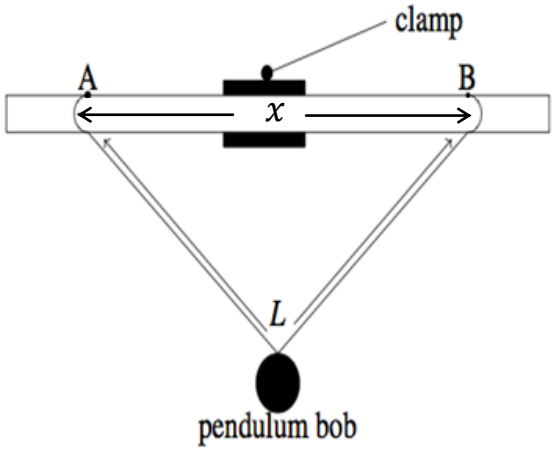
131/3A

Time: 3:20 Hours **Wednesday, 26th February 2025 a.m**

Instructions.

1. This paper consists of **three (3)** questions. Answer **all** questions.
2. Question 1 carries **20 marks** while the rest carries **15 marks** each.
3. Calculations should be clearly shown.
4. Mathematical tables and **non programmable** calculator may be used.
5. Cellular phones are **not allowed** in the examination room.
6. All answers must be written in the answer booklet(s) provided.
7. Write your **examination number** in every page of your answer booklet(s).
8. The following information may be useful:
   (a) Pie, $\pi = 3.14$
   (b) Specific heat capacity of copper $= 400$ Jkg^{-1}K^{-1}.
   (c) Specific heat capacity of liquid **W**$= 4{,}200$ Jkg^{-1}K^{-1}.

1. You provided with one-meter ruler, retort stand, bob, a string of 100cm and stopwatch. Arrange the apparatus as shown.



a) Tie a thread $L = 100cm$ as shown below in a way that $x = 80cm$.
b) Place a bob at midpoint and displace a bob through the small angle so as to oscillate vertically and record the time taken for 20 oscillations.
c) Without change the length of the thread proceed with procedure above for $x = 70cm, x = 60cm, x = 50cm$ and $x = 40cm$.
d) Tabulate your result including the columns of $t\ (s), T(\text{s}), T^4(sec^4)$ and $x^2(cm^2)$.
e) Plot the graph of $T^4(sec^4)$ against $x^2(cm^2)$.
f) Determine the slope of the graph.
g) Use the slope to determine the acceleration due to the gravity.
h) State any two source of error in this experiment.

2. In this experiment you are required to compare the rate of cooling for hot water in a small beaker when is inside and outside larger beaker. Proceed as follows.

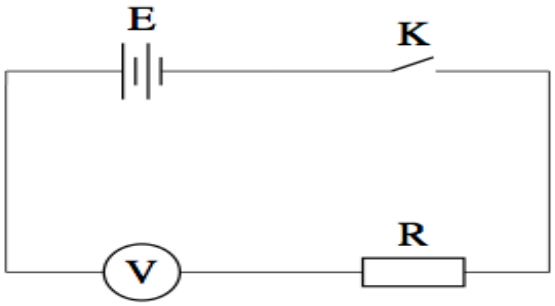
(a) Fill the beaker with heated water to the $50ml$ mark of the small beaker so that the thermometer read 85℃.

(b) Stir gently the hot water in the small beaker placed on a wooden base. Use the thermometer to stir gently while fanning constantly. Starts the stopwatch when it is exactly 80℃ and record time t_1 in minutes after every drop of 5℃ until it has fallen to 60℃.

(c) Repeat the procedure in (a) and (b) above with small beaker containing hot water, now inside a larger beaker. Record the time t_2 in minutes after every drop of 5℃ until it has fallen from 80℃ to 60℃.
(i) Tabulate your results.
(ii) Plot the graph of t_2 against t_1.
(iii) Determine the slope of the graph above.
(iv) Conclude on the rate of cooling between the two experiment using the value of the slope obtained in part (iii).
(v) State and explain any two (2) factors of which the rate of cooling depends.

3. The aim of this experiment is to determine the resistance R_v of a voltmeter. Proceed as follows;

(a) Connect the circuit as shown below



(b) Set the value of R = 250Ω close the switch and quickly read and record the voltmeter reading, V. Always open the switch after readings.

(c) Repeat procedure (b) above for values of R = 500Ω, R = 750Ω, R = 1000Ω and R = 1250Ω.

(d) Record your results in a table showing the values R, V and $\frac{1}{V}$.

(e) Plot a graph of $\frac{1}{V}$ against R.

(f) From your graph, determine the values of,

(i) e.m.f of a battery

(ii) Internal resistance, R_v of the voltmeter. (Neglect the effect of internal resistance of the battery)

(g) Name two sources of errors that may interfere the values in (f) above.

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MARKING GUIDE:

of (d)

x (cm)	t (sec)	T (sec)	T^4 (sec^4)	x^2 (cm^2)
80	21.91	1.0955	1.44	6400
70	23.85	1.1925	2.02	4900
60	25.25	1.2625	2.54	3600
50	26.31	1.3155	2.99	2500
40	27.04	1.352	3.34	1600

of of of of Total 4 marks.

(e) from the graph.

Slope (G) = $\frac{\Delta T^4 (sec^4)}{\Delta x^2 (cm^2)}$ — of

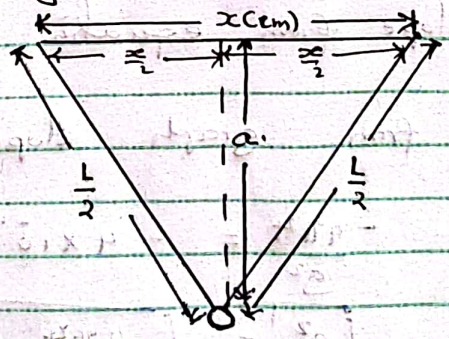
$G = \frac{(3.2 - 2.4)\ sec^4}{(2000 - 4000)\ cm^2}$ — of

$G = -4 \times 10^{-4}\ sec^4/cm^2$.

∴ the slope of the graph is $-4 \times 10^{-4}\ sec^4/cm^2$

(g) To determine the value of acceleration due to gravity first determine the relationship between $T^4 (sec^4)$ and $x^2 (cm^4)$ as follows.

from the diagram.



from the time period of simple pendulum.

$T = 2\pi \sqrt{\frac{a}{g}}$

but from pythagoras theorem

$(\frac{L}{2})^2 = a^2 + (\frac{x}{2})^2$ — of

$$a^2 = \left(\frac{L}{2}\right)^2 - \left(\frac{x}{2}\right)^2 \quad \text{(1)}$$

ie $$a = \sqrt{L^2/4 - x^2/4}$$

Then

$$T = 2\pi\sqrt{\frac{a}{g}}$$

$$T^2 = \frac{4\pi^2 a}{g}$$

$$T^2 = \frac{4\pi^2}{g}\sqrt{\left(\frac{L^2}{4} - \frac{x^2}{4}\right)} \quad \text{— of}$$

Then on Squaring both sides

$$T^4 = \frac{16\pi^4}{g^2}\left(\frac{L^2}{4} - \frac{x^2}{4}\right).$$

$$T^4 = \frac{4\pi^4 L^2}{g^2} - \frac{4\pi^4 x^2}{g^2} \quad \text{—}$$

$$T^4 = -\frac{4\pi^4 x^2}{g^2} + \frac{4\pi^4 L^2}{g^2}$$

then $$T^4 = \left(\frac{-4\pi^4}{g^2}\right)x^2 + \frac{4\pi^2 L^2}{g^2} \quad \text{— of}$$

$y = m x + C$

ie slope from equation $= -\frac{4\pi^4}{g}$.

and from graph slope $= -4\times10^{-4}\ \text{sec}^4/\text{cm}^2$.

Then

$$\frac{-4\pi^4}{g^2} = -4\times10^{-4}\ \text{sec}^4/\text{cm}^2. \quad \text{— of}$$

$$\sqrt{g^2} = \sqrt{\frac{4\pi^4}{4\times10^{-4}}\ \text{cm}^2/\text{sec}^4}$$

$$g = \sqrt{\frac{4\pi^4}{4\times10^{-4}}\ \text{cm}^2/\text{sec}^4}$$

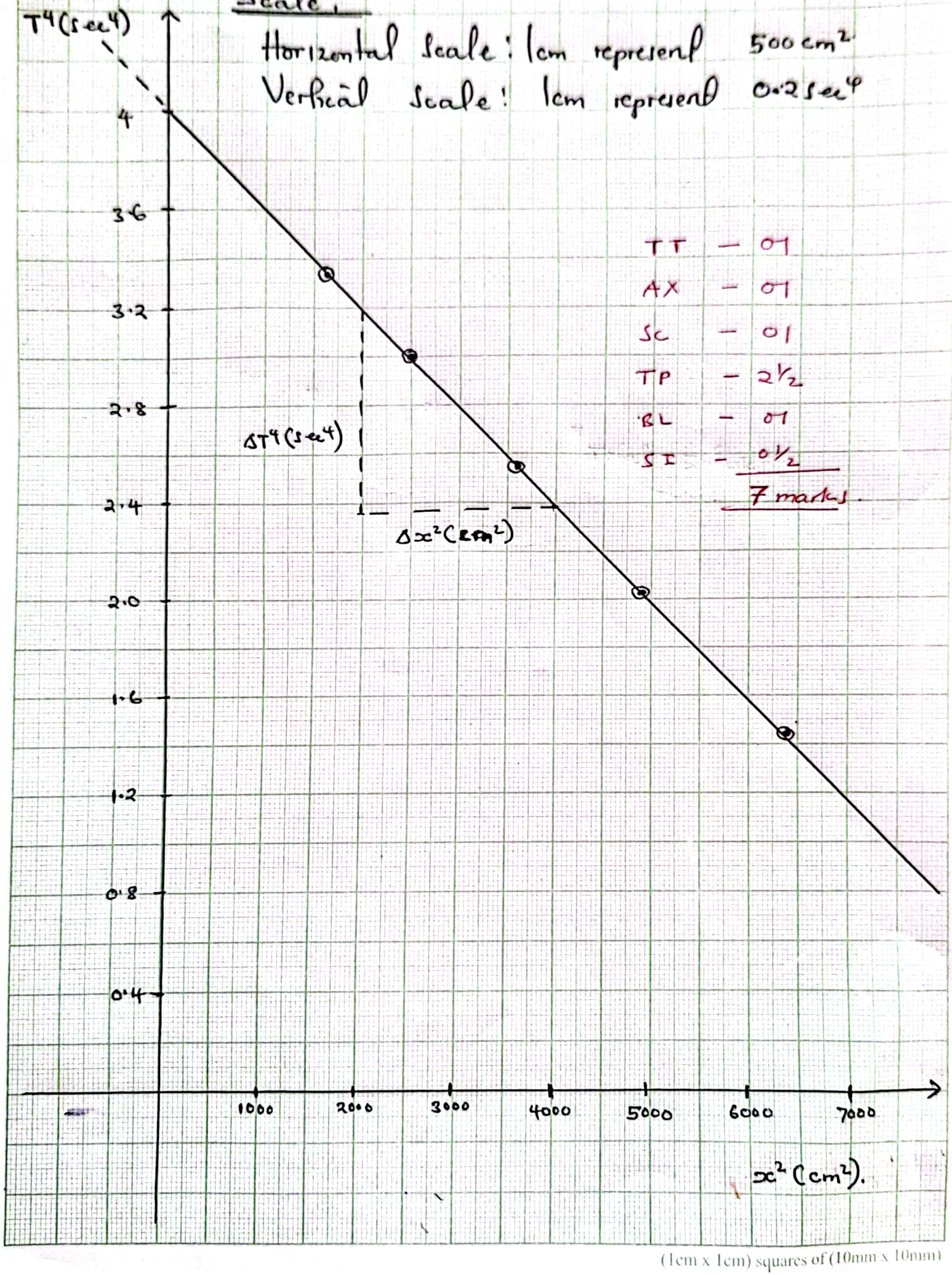
$$g = 986.96\ \text{cm/sec}^2. \quad \text{— of}$$

A GRAPH OF $T^4(sec^4)$ AGAINST $x^2(cm^2)$

Scale:

Horizontal scale: 1cm represent $500\ cm^2$

Vertical scale: 1cm represent $0.2\ sec^4$



TT – 01
AX – 01
Sc – 01
TP – 2½
BL – 01
SI – 0½
7 marks.

(1cm x 1cm) squares of (10mm x 10mm)

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∴ The value of acceleration due to gravity.
is 986.96 cm/sec².

(4). (i) Time reaction error in starting and stopping stopwatch.
(ii) Parallax error in reading length of string from meter ruler.
(iii) Variation of angle of displacement for different length of pendulum.
(iv) Error due to environment like wind etc.
~~Any two.~~
2 marks @ 1 marks

02. c. (i)

θ (°c)	t_1 (min)	t_2 (min)
80	0.00	0.00
75	0.79	1.02
70	1.39	2.22
65	2.55	4.13
60	4.26	6.26.

01 01
Total 2 marks

(iii) The slope of the graph (G)

$$G = \frac{\Delta t_2 (min)}{\Delta t_1 (min)}$$ — 01

$$G = \frac{(6.96 - 2.70)\ min}{(2.70 - 2.13)\ min}$$

$$G = \frac{1.26}{0.57}$$ — 01

$$G = 2.21 \quad (\text{range } 1.5 - 2.5)$$

∴ The slope of the graph is 2.21

(iv) From the slope of the graph.

slope = 2.21.

ie $\frac{\Delta t_2}{\Delta t_1} = 2.21$

ie $\Delta t_2 = 2.21\ \Delta t_1$. ——— 01

ie Because the time taken for water in a small beaker which is placed inside larger beaker, is 2.21 times the time taken for water to cool in a small beaker which is outside then. ——— 01

the rate of cooling of water in small beaker placed just outside is greater (or cool faster) than water in small beaker placed inside the larger beaker.

ie $\left(\frac{dQ}{dt_2}\right) > \left(\frac{dQ}{dt_1}\right)$ ——— 01

(v)

(i) Excess of temprature of the body above that surrounding.

(ii) Nature of surface of the body or surface area of the body.

(iii) type of insulating materal and air circulation.

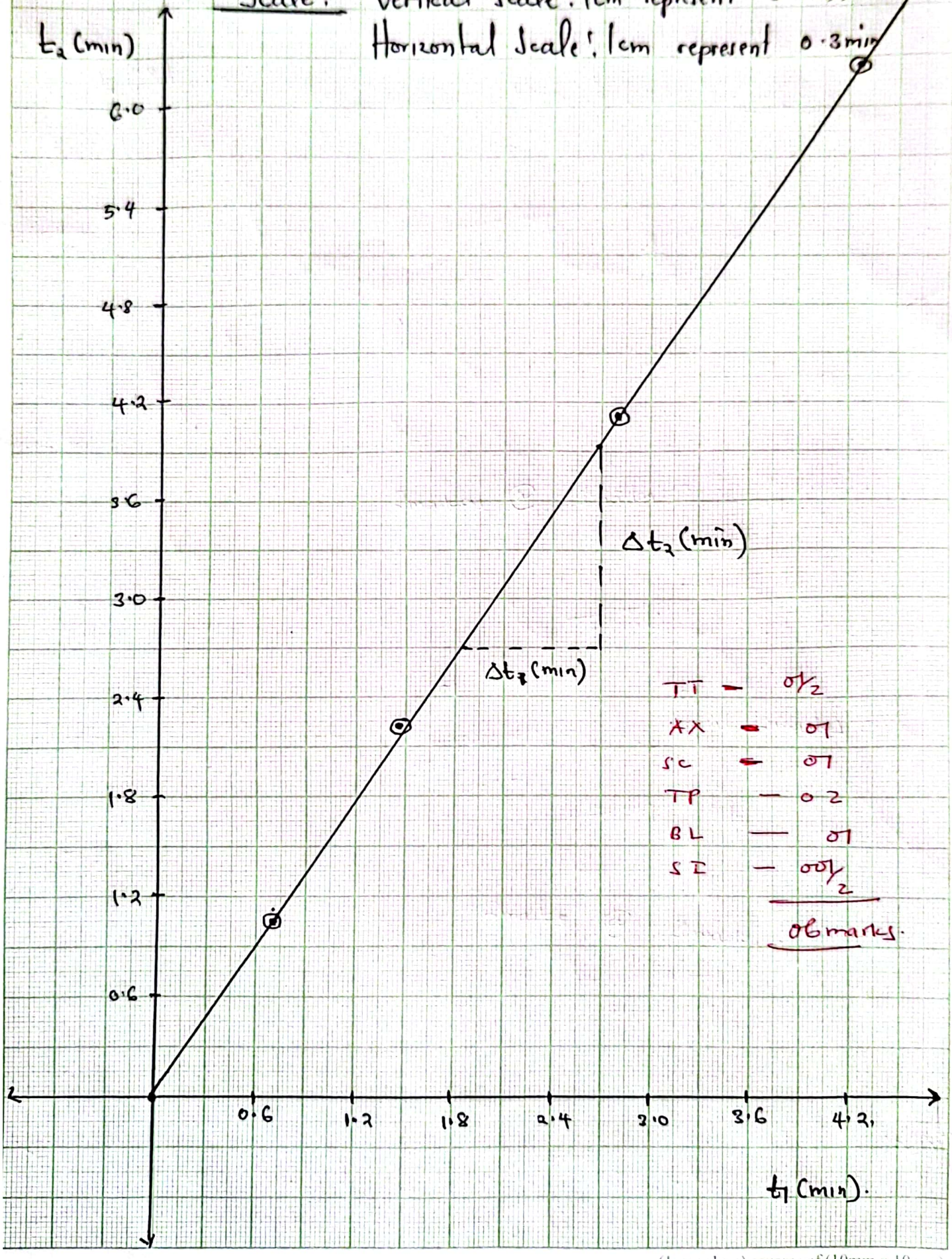
(iv) Specific heat capacity.

Any two

2marks @ 1marks.

THE GRAPH OF t_2(min) AGAINST t_1(min)

Scale: Vertical scale: 1cm represent 0.3 min
Horizontal Scale: 1cm represent 0.3min



TT — 01/2
AX — 01
SC — 01
TP — 02
BL — 01
SI — 00 1/2

06 marks.

(1cm x 1cm) squares of (10mm x 10mm)

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03. (d)

R (Ω)	V (volt)	1/V (V⁻¹)
250	2.8	0.36
500	2.6	0.38
750	2.4	0.42
1000	2.2	0.45
1250	2.0	0.50

½ ½ Total 2 marks

(i) from the graph:

slope (G) = $\frac{\Delta \frac{1}{V}(V^{-1})}{\Delta R(\Omega)}$ —— ½ mark

$G = \frac{0.46 - 0.37\ (V^{-1})}{(1062.5 - 375)\ \Omega}$

$G \simeq 1.3 \times 10^{-4}\ \Omega^{-1} V^{-1}$ —— ½ mark

Range from $1.0 \times 10^{-4}\ \Omega^{-1} V^{-1}$ to $1.5 \times 10^{-4}\ \Omega^{-1} V^{-1}$

and $\frac{1}{V}$-intercept $\simeq 0.325\ V^{-1}$. —— ½ mark

Then (i) from Krichhoff's voltage Law

$E = IR + IR_V + Ir$

$E = I(R + R_V + r)$ —— ½ mark

$I = \frac{E}{R + R_V + r}$

but $V = IR_V$

$V = \frac{ER_V}{R + R_V + r}$ —— ½ mark

$\frac{1}{V} = \frac{R + R_V + r}{ER_V}$

$\frac{1}{V} = \left(\frac{1}{ER_V}\right) R + \frac{R_V + r}{ER_V}$

but $r = 0$ (negligible).

ie $\frac{1}{V} = \left(\frac{1}{ER_V}\right) R + \frac{1}{E}$ —— ½ mark

$y = m \quad x \quad + \quad c$

From equation $\frac{1}{V}$-intercept $= \frac{1}{E}$ (1)

i.e. $0.325\ V^{-1} = \frac{1}{E}$ —— 01/2 marks.

Then $E = 3.076\ V \simeq 3\ V$

Again

Slope of the graph $= 1.3 \times 10^{-4}/\Omega V$

but $\frac{1}{E R_V}$

then $\frac{1}{E R_V} = 1.3 \times 10^{-4}/\Omega V$ —— 01/2 marks.

$R_V = \frac{1}{E(1.3 \times 10^{-4})}\ \Omega$

$R_V = \frac{1}{(3)(1.3 \times 10^{-4})}\ \Omega$ —— 01/2 marks.

$R_V = 2564\Omega \simeq 3000\Omega$

Range from 2500Ω to 3000Ω.

(8) (i) the e.m.f of battery = 3V
(ii) the internal resistance of voltmeter $R_V \simeq 3{,}000\Omega$

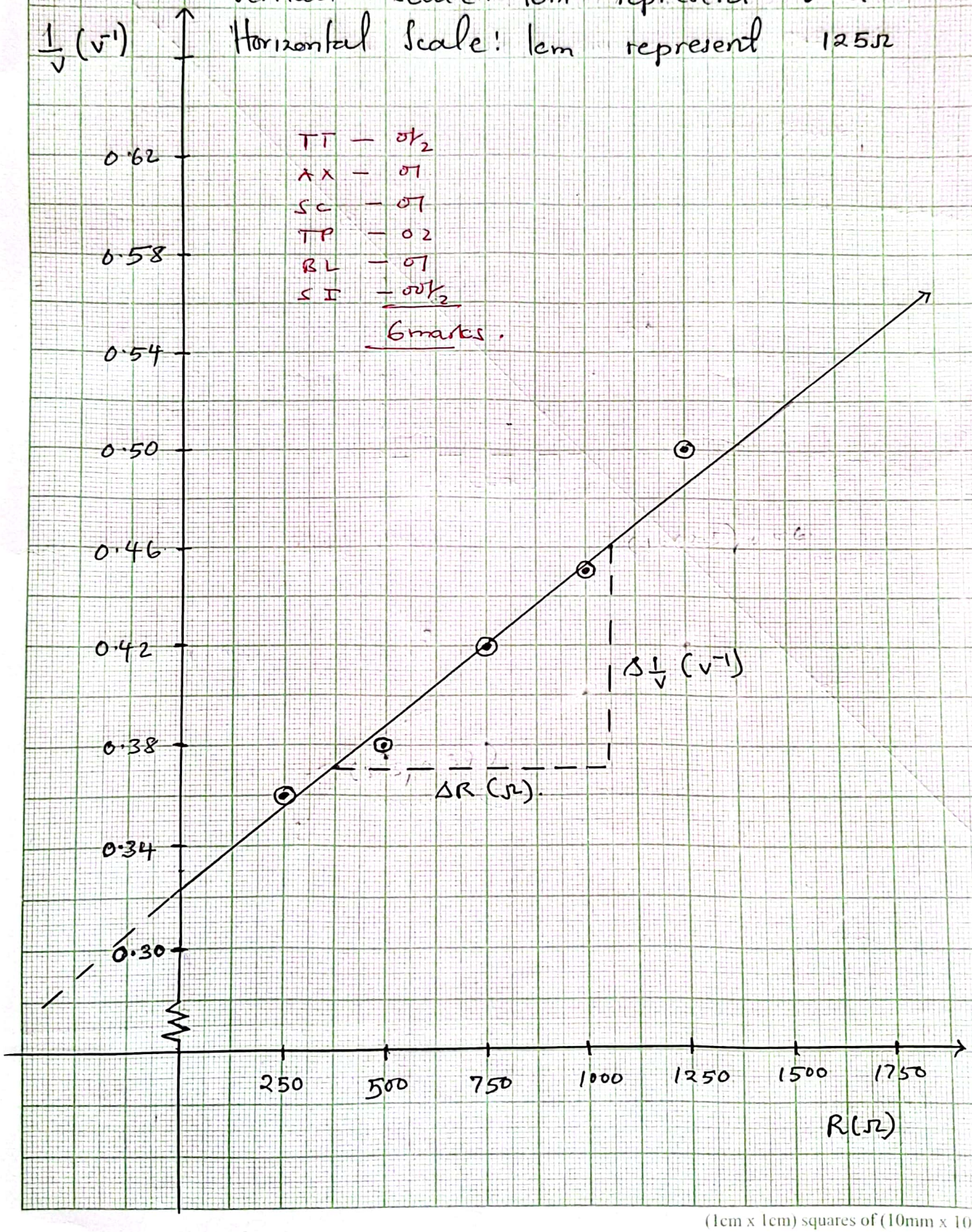
(9) (i) Parallax error in reading the voltmeter
(i) Loose connection of wire
(ii) polarization of battery etc
Any two
2marks @ 1 marks.

GRAPH OF $\frac{1}{V}(V^{-1})$ AGAINST $R(\Omega)$.

Scale:

Vertical Scale: 1cm represent $0.02\ V^{-1}$

Horizontal Scale: 1cm represent 125Ω



TT – 01/2
AX – 01
SC – 01
TP – 02
RL – 01
SI – 01/2

6marks.

(1cm x 1cm) squares of (10mm x 10mm