20XC18 - APPLIED PHYSICS LAB

S. VARUN
D21PC35

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EXP 4 : THERMAL CONDUCTIVITY OF A CONDUCTOR

AIM :

To determine the thermal conductivity of a good conductor

APPARATUS :

Steam chamber, Long metal rod, thermometers, heater.

FORMULA :

Let B and C be reference points on the rod.

- Heat flowing per second across B = Heat lost per second from B to C.

- $KA\left(\frac{d\theta}{dx}\right)_B = \int_B^C A\,dx\,\rho\, s\left(\frac{d\theta}{dt}\right)$

$$K = \frac{\rho s \int_B^C \left(\frac{d\theta}{dt}\right) dx}{\left(\frac{d\theta}{dx}\right)} \quad Wm^{-1}K^{-1}$$

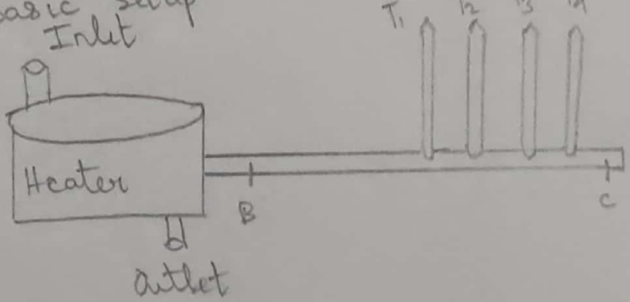
K → Thermal conductivity

ρ → Density

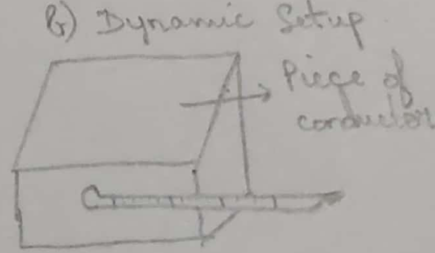
s → Specific Heat Capacity.

DIAGRAM :

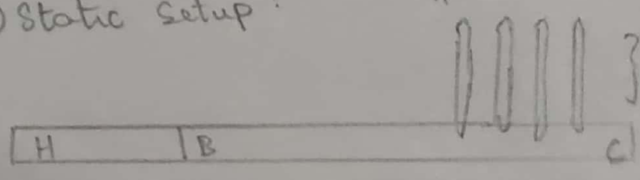
a) Basic setup



b) Dynamic Setup



c) Static setup :



PROCEDURE :

i) Firstly, start with the static experiment, to find $\left(\frac{d\theta}{dx}\right)_B$. Take 4 thermometers and place them aside. Now heat the given conductor to the required temperature.

- Place the thermometers side by side from the given reference points B to C.
- Now wait for half an hour till the steady state is reached.
- Record the temperature of the rod at different points b/w the points B & C.
- Mark temperature of first thermometer with the highest temperature which will be used as refrence in the second part of the experiment. (T_1).

ii) Dynamic experiment to find :- $\left(\frac{d\theta}{dt}\right) dx$.

- First take a small piece of the sample and heat it till it reaches $T_1 + 10^\circ C$ (T_1 – Reference temperature).
- Now wait till it reaches steady state.
- Now attach a thermometer to the small sample and let it cool down.
- While sample is cooling down note temp vs time for every 5 minutes.
- After noting down the values make a graph to find $\int_B^C \left(\frac{d\theta}{dt}\right) dx$ taking B as reference on graph.
- After finding all required information, substitute them in the formula for 'k'

TABULATION:

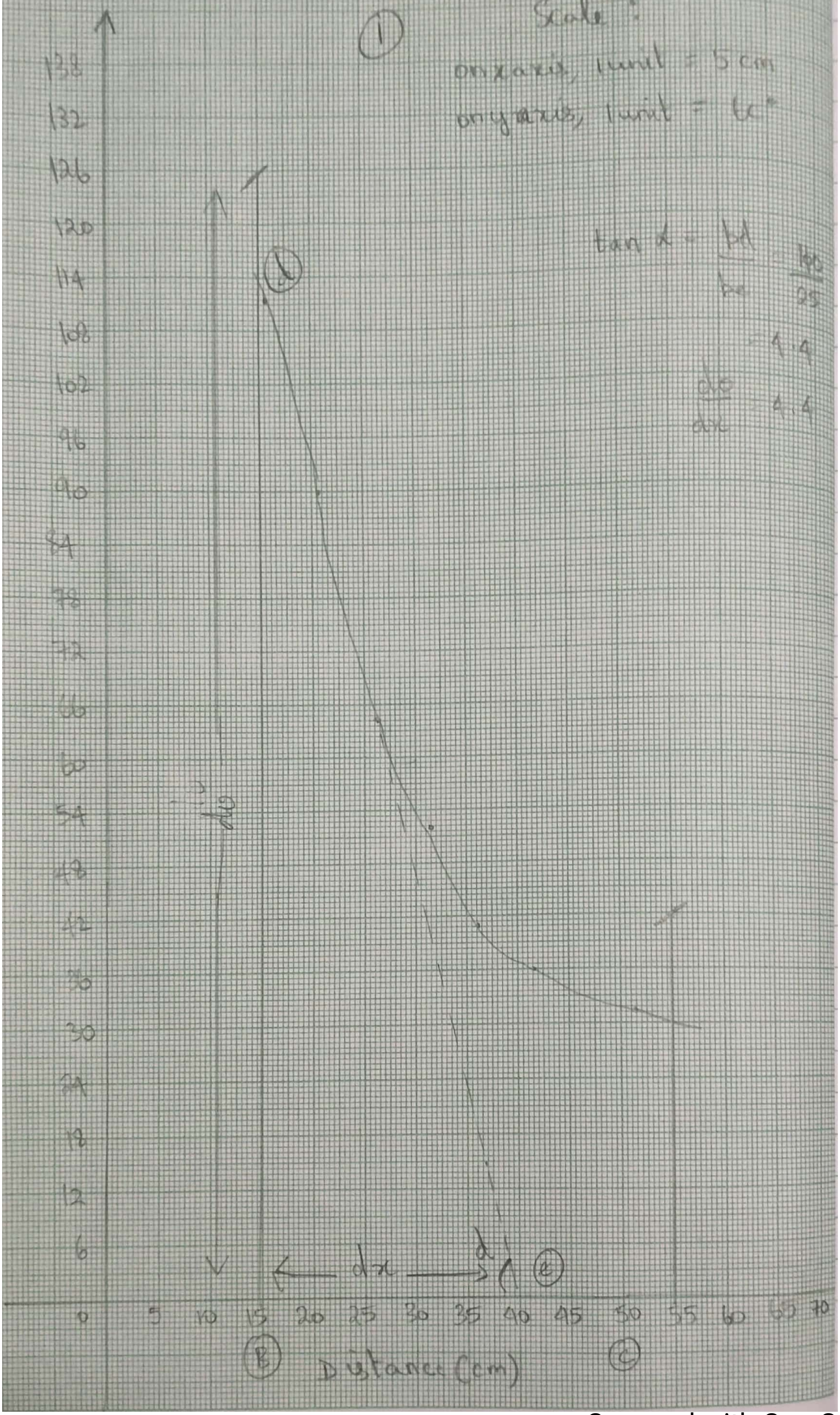
i) Static Experiment:

Reference points
B = 15cm
&
C = 55cm

Distance (cm)	Temperature (°c)
16.10	110
21.0	90
26.5	64
31.8	52
36.8	41
41.9	36
51.6	31

ii) Dynamic Experiment:

Time (min)	Temperature (°c)
0	120
5	113
10	89
15	78
20	70
25	62
30	57
35	51
40	47
45	44
50	41
55	39
60	37
65	36

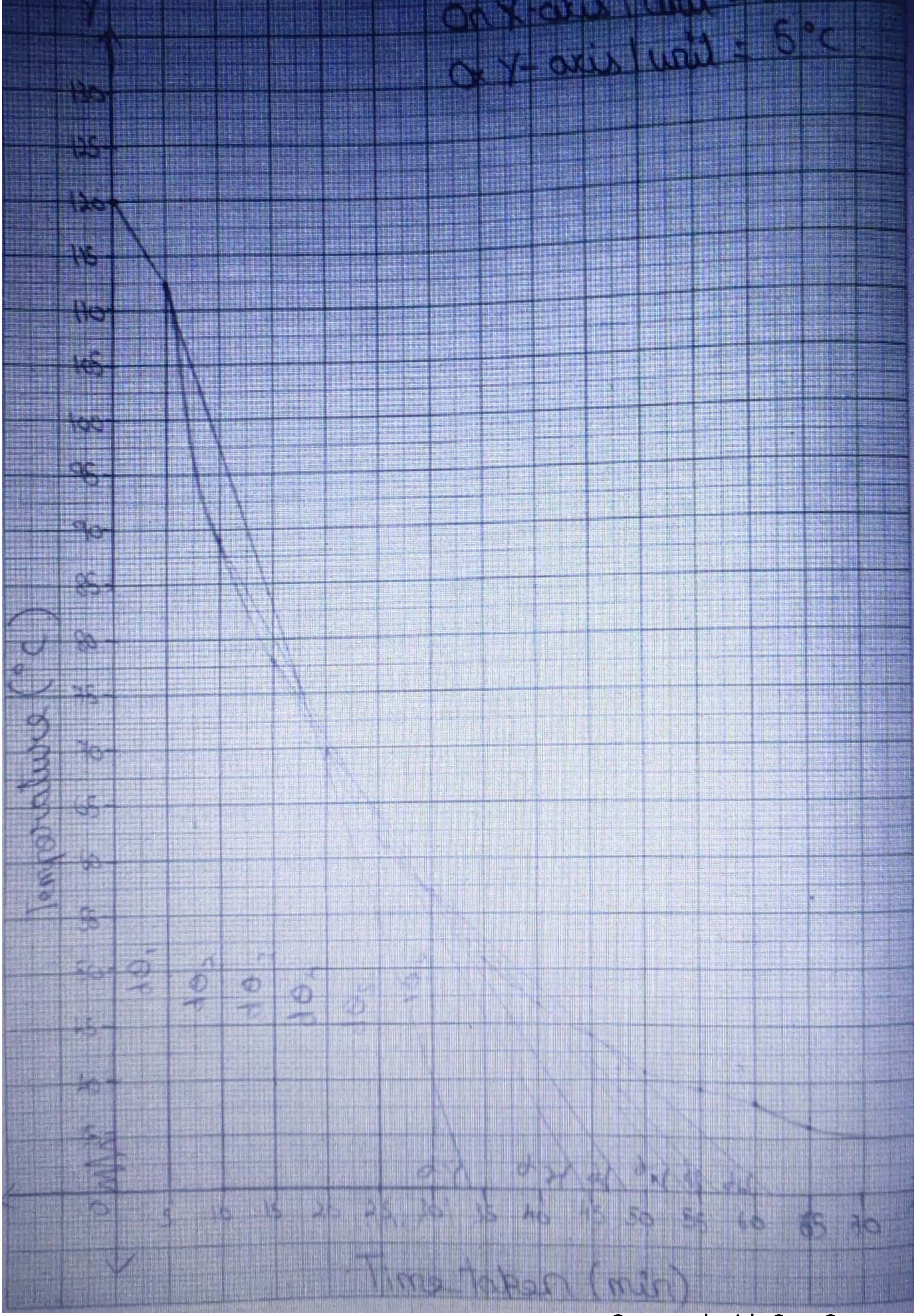

1
Scale :
on x axis, 1 unit = 5 cm
on y axis, 1 unit = 6°
tan α = bd / be = 110 / 25
= 4.4
dθ / dx = 4.4
138
132
126
120
114
108
102
96
90
84
78
72
66
60
54
48
42
36
30
24
18
12
6
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
dθ
dx
d
α
e
b
c
Distance (cm)

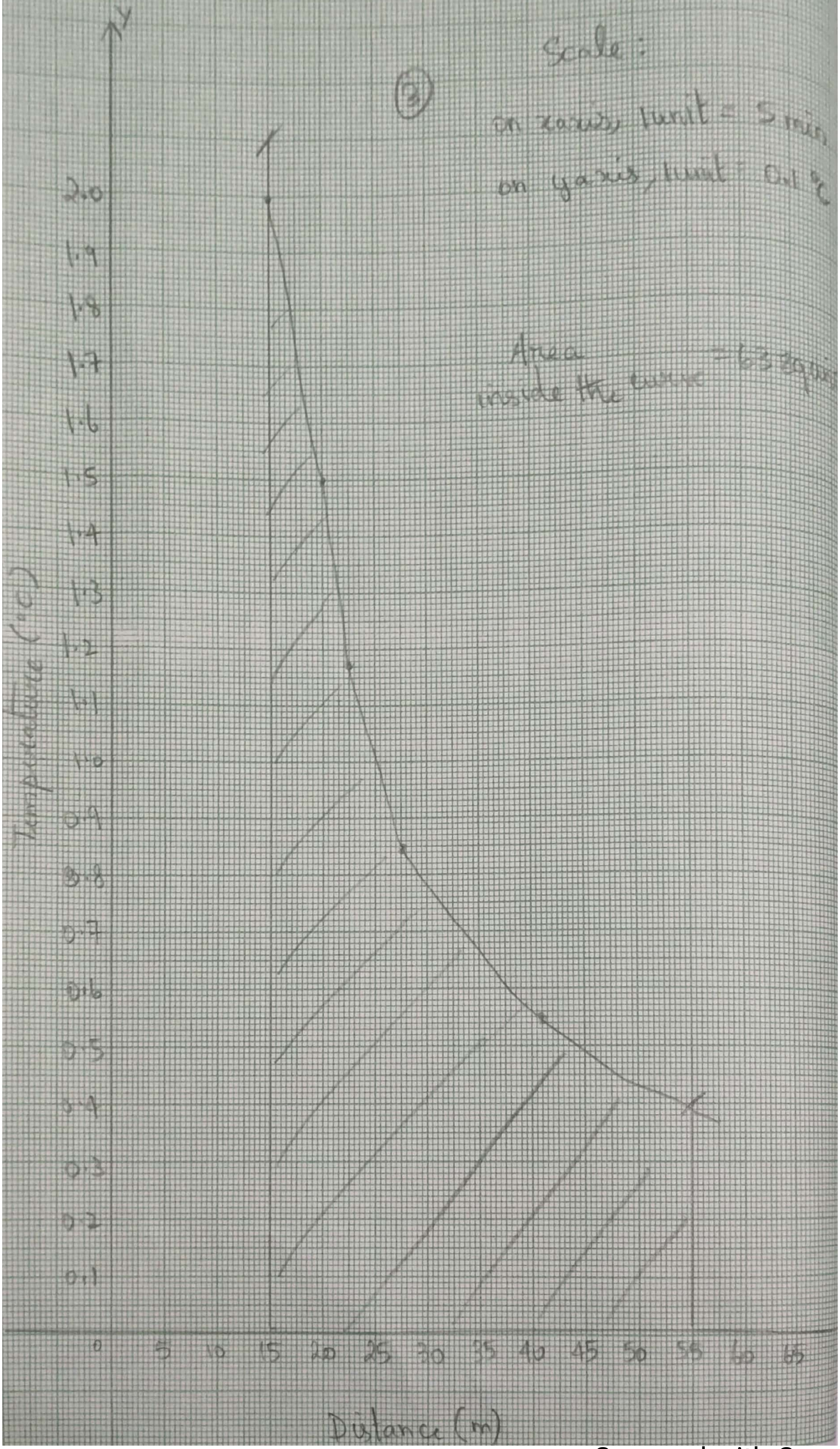
2

Scale -

On X-axis 1 unit = 5 min

& Y-axis 1 unit = 6°C





3
Scale:
on x axis, 1 unit = 5 min
on y axis, 1 unit = 0.1 °C
Area inside the curve = 63 squares
Y
Temperature (°C)
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
5
10
15
20
25
30
35
40
45
50
55
60
65
Distance (m)

CALCULATIONS:

i) From static experiment & graph 1:

$$\left(\frac{d\theta}{dx}\right)_B = \tan\alpha = \frac{DB}{DE} = \frac{110^\circ C}{2.5}$$

$$\Rightarrow \frac{383.15}{0.25} = 1532.6$$

ii) From dynamic experiment of graph 2 and 3.

$$\text{Area under graph } 3 = \int_B^C \left(\frac{d\theta}{dt}\right) dx$$

$$\Rightarrow \int_B^C \left(\frac{d\theta}{dt}\right) dx = 65 \text{ sq. units (approx)}$$

$$\therefore K = \frac{es \int_B^C \left(\frac{d\theta}{dt}\right) dx}{\left(\frac{d\theta}{dx}\right)_B} = \frac{es \times \text{Area shaded}}{DB / BE} \; Wm^{-1}K^{-1}$$

$$K = \frac{6900 \times 460 \times 65}{1532.6} = 134614.3807 \; Wm^{-1}K^{-1}$$

RESULT:

Thermal conductivity of conductor is 134614.38 $Wm^{-1}K^{-1}$