GARVIT SHAH
F-24

EXPERIMENT : No. 6

- **Aim:** To verify Newton's Law of Cooling of different materials & different liquids & draw the cooling curve

- **Theory:**
Temperature difference in any situation results from energy flow into a system or energy flow from a system to surroundings. The former leads to heating, whereas ~~#~~ latter leads to cooling of an object.

It states that the rate of temp. of the body is proportional to the difference between the temp. of the body & that of surroundings medium. This statements leads to the classic eq^n of exponential decline over time which can be applied (Newton's law of cooling) to many phenomena in science & engineering including the discharge of a capacitor and the decay in radioactivity

Newton's Law of cooling is useful for studying water heating because it can tell us how fast the hot water in pipes cools off. A practical application is that it can tell us how fast a water heater cools down if you turn off the ~~b~~ ~~heater~~ breaker when you go on vacation.
Suppose that a body with initial temp. T°C is allowed to ~~cool~~ cool in air which is maintained

at a constant temp. T_2°C.
Let the temp. of the body be T°C at time t, then by Newton's Law of ~~vaity~~ cooling -

$$\frac{dT}{dt} = -k(T-T_2) \quad - \quad (1)$$

here $T - T_2 > 0$

$\therefore \frac{dT}{dt} < 0$

k - depends on surface properties of material being cooled.

Initial condition is given by $T = T_1$ & $t = 0$

$$\therefore \quad -kt = \log(T_1 - T_2) + \log c$$

$$\Rightarrow \quad \boxed{T_1 - T_2 = ce^{-kt}} \quad - \quad (2)$$

Applying initial conditions, $c = T_1 - T_2$
Substituting the value of c in (2) gives -

$$\boxed{T = T_2 + (T_1 - T_2)e^{-kt}}$$

NEWTON'S LAW OF COOLING

If $k < 0$, $\lim t \to \infty$, $e^{-kt} = 0$ & $T = T_2$

Cooling curve : The graph drawn between the temp. of the body & time.
Slope of this curve at any any pt. gives the rate of fall of temp.
Generally,

$$T(t) = T_A + (T_H - T_A)e^{-kt}$$

$T(t)$ - temp. at time t
T_A - ambient temp.
T_H - Initial temp.
k - +ve constant
t - time

- **Procedure -**

1. The calorie meter is filled $2/3^{rd}$ with the given liquid & is heated to a temp. of 80°C. This liquid will act as a hot body which is subjected to cooling.
2. The thermometer is inserted in to the calorimeter.
3. When the temperature reading is 70°c the stopwatch is started. The time readings are noted for every 5° fall of temp. up to the room temp.
4. The readings are ~~drawn~~ tabulated
5. A graph is drawn with temp. θ along Y axis & time (t) along X-axis, $d\theta/dt$ is found by taking slopes to tangents drawn at various temp. on the cooling curve. Hence Newton's Law of cooling is verified.

- **Result :**

Newton's Law of cooling is verified.

Observation Table –

Material : Brass
Liquid : Water

Time (s)	Temp (°c)
0	100
4.16	90
8.9	80
14.9	70
22.1	60
32.1	50
47.1	40
79.2	30
150	25

Material : Brass
Liquid : Milk

Time	Temp
0	100
3.9	90
8.5	80
10	70
21	60
30.3	50
44.4	40
74.4	30
150	25

Material : Brass
Liquid : Veg. Oil

Time	Temp.
0	100
1.8	90
4.0	80
6.53	70
9.8	60
14.1	50
20.6	40
34.9	30
120	25

Material : Copper
Liquid : Water

Time (s)	Temp (°C)
0	100
1.15	90
2.4	80
4.0	70
6.0	60
8.8	50
12.5	40
21.6	30
70	25

Material : Copper
Liquid : Milk

Time (s)	Temp.
0	100
1	90
2.2	80
3.7	70
5.6	60
8.2	50
12	40
20.1	30
60	25

Material : Copper
Liquid : Veg Oil

Time	temp.
0	100
0.5	90
1.05	80
1.8	70
2.6	60
3.83	50
5.6	40
9.42	30
35	25

Material : Al
Liquid : Water

Time	Temp
0	100
2	90
4.31	80
7.15	70
10.6	60
15.32	50
22.5	40
37.7	30
100	25

Material : Al
Liquid : Milk

Time	Temp.
0	100
1.9	90
4	80
6.76	70
10	60
14.55	50
21.2	40
33.6	30
100	25

Material : Al
Liquid : Veg. Oil

Time	Temp.
0	100
0.95	90
2.1	80
3.5	70
5.2	60
7.6	50
11	40
18.5	30
50	25

Material : Silver
Liquid : Water

Time	Temp.
0	100
1	90
2.22	80
3.65	70
5.45	60
7.98	50
11.55	40
19.6	30
60	25

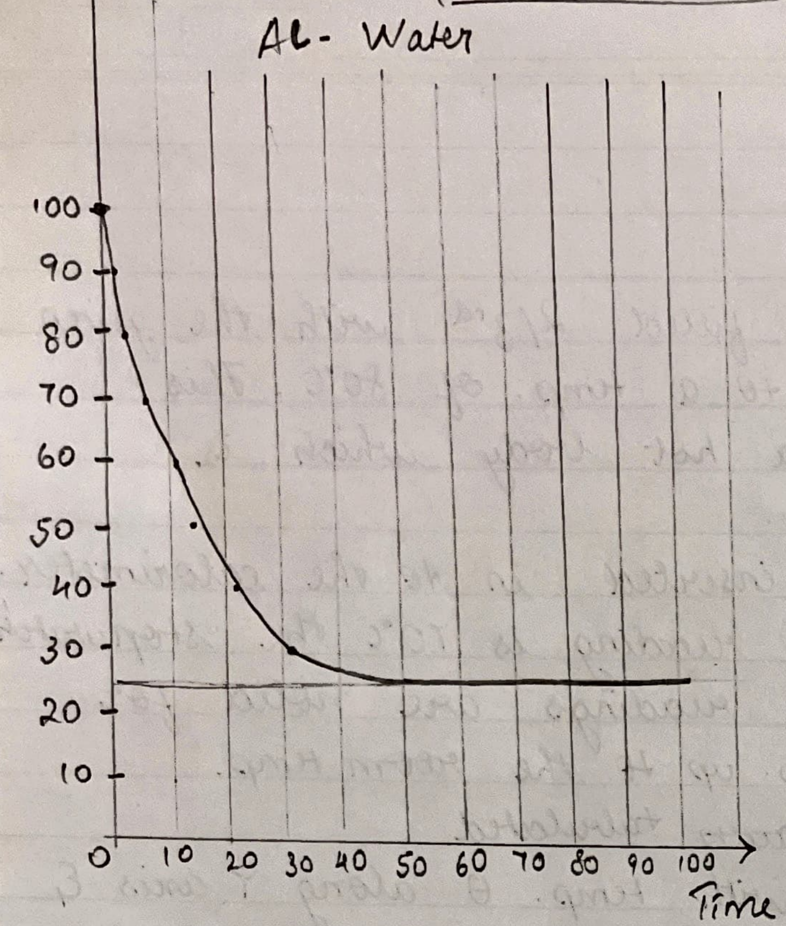
Material : Silver
Liquid : Milk

Time	Temp.
0	100
0.96	90
2.11	80
3.95	70
5.17	60
7.45	50
10.9	40
18.2	30
70	25

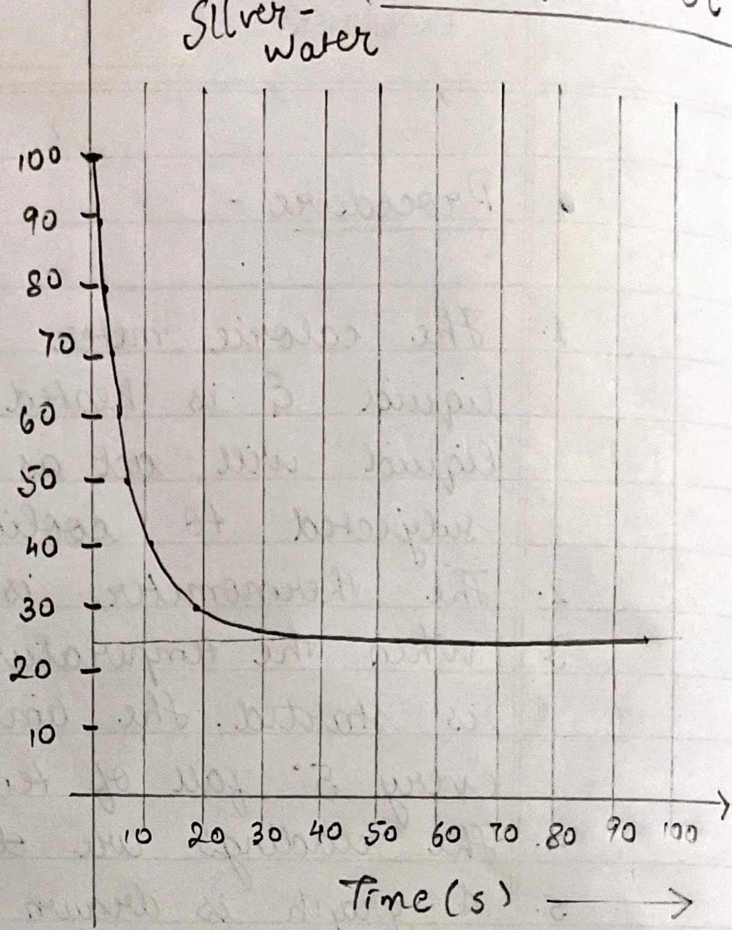
Material : Silver
Liquid : Veg. Oil

Time	Temp.
0	100
0.49	90
0.95	80
1.56	70
2.3	60
3.35	50
4.9	40
8.22	30
40	25

SCALE
X axis 1 unit = 10 s
Y axis 1 unit = 10°C



SCALE
X axis 1 unit = 10 s
Y axis 1 unit = 10°C



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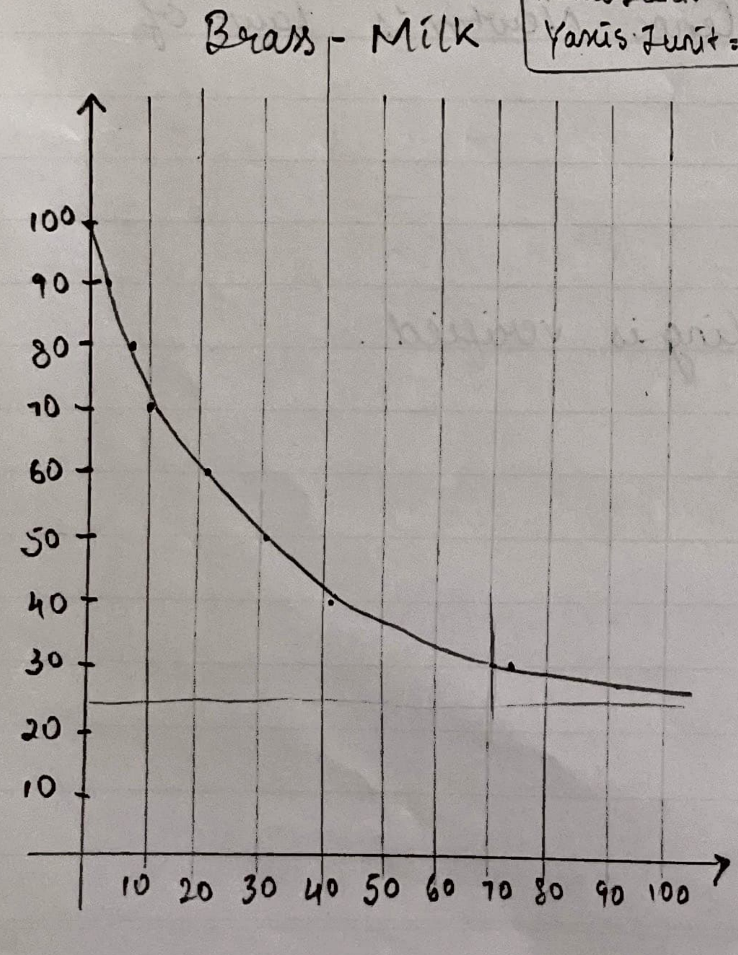

SCALE
X axis 1 unit = 10 s
Y axis 1 unit = 10°C