Ministry of Higher Education

The Higher Institute Of

Engineering & Technology

(Tanta)

Physics – Lab Experiments Maual

Physics (II) Lab Course

By

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Evaluation Sheet

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Contents

إرشادات الأمن والسلامة في معمل الفيزياء

التجارب العلمية مفهوم أساسي من مقومات دراسة الفيزياء، ولكن إذا لم يؤخذ الحذر عند إجراءها فإنها قد تكون مصدر خطر؛ ولهذا فإن الحرص على سلامتك وسلامة زملائك يقتضي منك التقيّد ببعض القواعد الضرورية لتجنب الخطر وهي:

1- مراعاة النظام والهدوء أثناء الدخول إلى المختبر وأثناء الخروج منه.

2- المختبر ليس مكاناً للعب واللهو، ولا مكاناً للتسلية وتبادل الحديث والسمر، بل هو مكان لتحصيل العلم وإتقان المهارة.

3- التزم بتعليمات المعيد ومسؤول المختبر وإرشاداتهما.

4- لا تستخدم اللمس والشم والتذوق للتعرف على المواد أو اختبارها، فقد يكون في ذلك ضرر كبير.

5- لا تعبث بالأجهزة الكهربائية، أو بالأدوات والآلات التي لا علاقة لها بالدرس.

6- تجنب الجلوس على الطاولات أو القواعد المخصصة للأجهزة، وليكن جلوسك في الأماكن المخصصة لك (المقاعد).

7- لا تعبث بمفاتيح الغاز أو المفاتيح الكهربائية، أو صنابير الماء، ولا تلمس مآخذ التيار الكهربائي ولا الأسلاك وبخاصة إذا كانت مكشوفة.

8- احذر لمس السوائل التي لا تعرف طبيعتها، أو التي قد تكون منسكبة على الطاولات.

9- نظّف الأدوات والأجهزة بعد الانتهاء من التجربة، وأعد كل شيء مكانه.

Experiment 1.

Measurement of Electrical Resistance and Ohm's Law

Ob iective

- To verify the relationship Ohm's Low and measure the unknown resistance.
- To investigate the equivalent resistance of series and parallel resistors.

Theory Overview

Georg Simon Ohm (1787–1854), a German physicist, is credited with finding the relationship between current and voltage for a resistor. This relationship is known as *Ohm's law*. Ohm's law states that

"For a fixed resistor, the current flowing through the resistor is directly proportional to the voltage across the resistor at constant temperature."

Mathematically:

$$I \propto V \qquad (2.1)$$

$$I = \frac{1}{R} \times V \qquad (2.2)$$

Ohm defined the constant of proportionality for a resistor to be the resistance *R*. (The resistance is a material property which can change if the internal or external conditions of the element are altered, e.g., if there are changes in the temperature.)

$$I = \frac{V}{R} \qquad (2.3)$$

$$V = IR \qquad (2.4)$$

Which is the mathematical form of Ohm's law. *R* in Eq. (2.4) is measured in the unit of ohms, designated **Ω**. Thus, the resistance R of an element denotes its ability to resist the flow of electric current; it is measured in ohms (**Ω**). That is, for a given current, an increase in resistance will result in a greater voltage. Alternately, for a given voltage, an increase in resistance will produce a decrease in current. As this is a first order linear equation, plotting current versus voltage for a fixed resistance will yield a straight line. The slope of this line is the conductance, and conductance is the reciprocal of resistance. Therefore, for a high resistance, the plot line will appear closer to the horizontal while a lower resistance will produce a more vertical plot line.

Equipment

(1) Adjustable DC power supply

(2) Ammeter

(3) Voltmeter

(4) Some Resistors

(5) Wires

(6) Rheostat

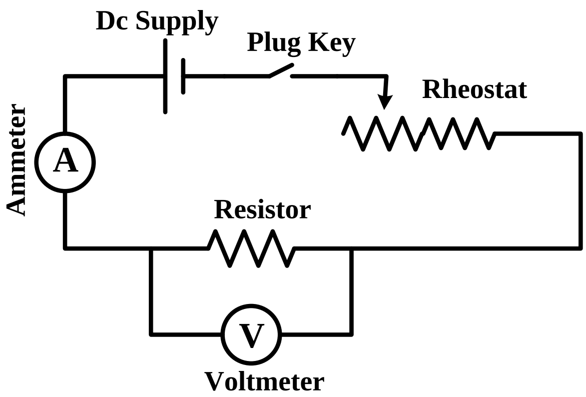

Fig.1.

<u>**Procedure:**</u>

Part A: Verifing the unknown resistance

1. The circuit is connected as per the circuit diagram fig.1.
2. The plug key is inserted and the rheostat is adjusted so that a definite amount of current (I) flows in the circuit. This value of current is

recorded.

3. As the current flows through the unknown resistance a potential difference is developed which is read from voltmeter (V).
4. The procedure is again adjusted to a different value of current (I) and the corresponding (V) values are noted down.
5. The procedure is repeated for at least 5-6 current readings and for voltage also, table 1.
6. A tabular column is drawn and the readings of I and V are tabulated.
7. Graph of V Vs I is down. A straight line is obtained.
8. The slope of the graph is found out. The slope gives the resistance (R) of the unknown resistance.

Table.1.

V(v)								
I(A)								

Part B: Verifing the equivalent resistance of series and parallel resistors.

1. Build a simple series circuit as fig.2.
2. Measure the voltage across the combination of resistors in series and measure the current.
3. Adjuste the rheostate to obtain a lot of values for voltage and current.
4. Record the values in [table.2 for series, table.3 for parallel]
5. Plote the graph of V vs I and then estimate the slope which equal the equivalent resistance of series
6. Repete steps (2-5) but with parallel circuit fig.3

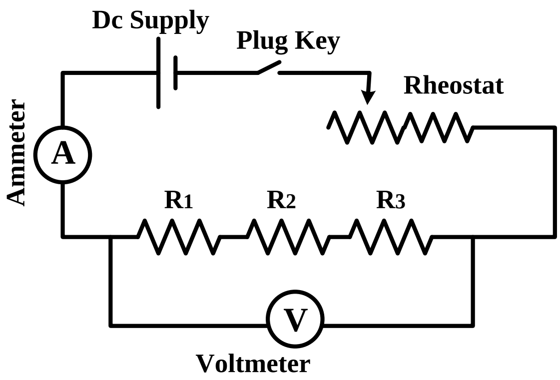

Fig.2. Combination of Resistors in series

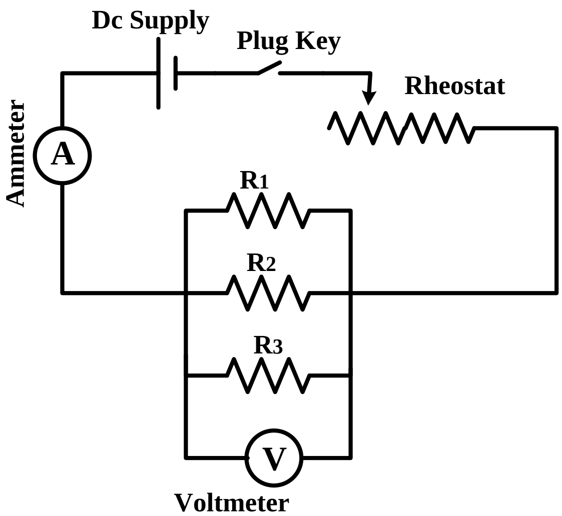

Fig.3. Combination of Resistors in parallel

Table.2. (Series)

V(v)								
I(A)								

Table.3. (Parallel)

V(v)								
I(A)								

Experiment 2.

Verifing Kirchhoff's Rules

Ob iective

1. To verify Kirchoff's Loop rule for voltages.
2. To verify Kirchoff's Junction rule for currents.

Introduction

Gustav Kirchoff was a prominent 19^{th} century Prussian physicist. He is still well known for his work in both circuit theory and spectroscopy. He won every prominent award for science in the middle part of the century, and is remembered along with his spectroscopist colleague Robert Bunsen1 by the Bunsen-Kirchoff Award for Spectroscopy. The study of electricity was still in its infancy in the early half of the century; you may recall that Georg Ohm only discovered the relationship between voltage, current, and resistance in 1827. Kirchoff was certainly familiar with this work, and he first discovered what are now called Kirchoff's Circuit Laws during his electrical studies while a student in the 1840s. This later formed the basis for his doctoral dissertation.

Theory

Kirchoff's Rules easy to state, but first we need to define a few terms. A loop in a circuit is any closed path that travels through one or more of the circuit elements and returns to its origin. A junction is any point where two or more components are connected by a conducting path. With these definitions, the Rules themselves are simple to state:

1. **Loop Rule**: The directed sum of the voltage drops around any loop in a circuit must be zero:

$$\Sigma V_i = 0$$

2. **Junction Rule:** The directed sum of all currents entering a junction in any circuit must be zero:

$$\Sigma I_i = 0$$

Procedures

Conduct the circuit as shown fig.1.

a. verify Kirchoff's Junction rule for currents:

1- from fig.1. at junction (B) the current into this junction is I_1, the currents out of the same junction are I_2 and I_3.

$\therefore\ I_1 - I_2 - I_3 = 0$

$\therefore\ I_1 = I_2 + I_3$

At junction (E):

$\therefore\ I_3 - I_4 - I_6 = 0$

b. Verify Kirchoff's Loop rule for Voltage:

1- Use digital multimeter to measure values of the resestors before connecting the voltage source.

2- Connect the switch (K) to the electric current pass.

3- Measure the potential difference of each resistance separately, and then calculate there current using ohmm's law: $I = \frac{V}{R}$

4- Record values in table.1.

Table.1.

R_1 =	V_1 =	I_1 =
R_2 =	V_2 =	I_2 =
R_3 =	V_3 =	I_3 =
R_4 =	V_4 =	I_4 =
R_5 =	V_5 =	I_5 =
R_6 =	V_6 =	I_6 =

5- Verify Kirchoff's Loop rule for voltages to three loops (I_a, I_b and I_c) as shown in fig.1.

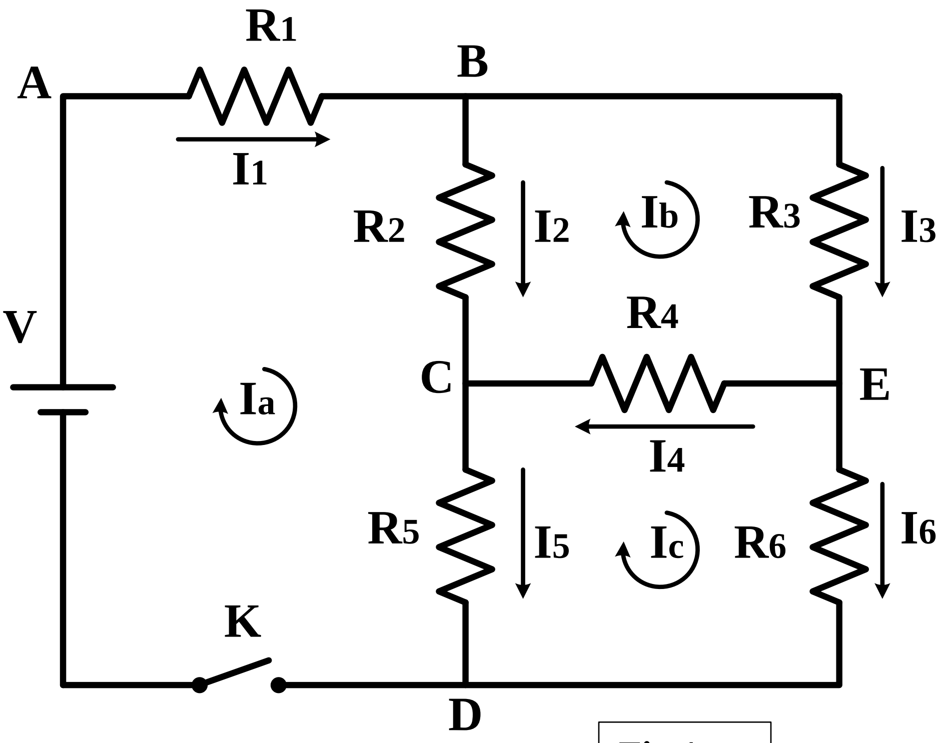

Fig.1.

Note:

a. If the direction of the path through the resistance is the same as the direction of the current assumed, the change in voltage becomes -IR and vice versa.

b. If the direction of the path through the source is from the positive terminal to the negative terminal, the change in voltage becomes -V and vice versa.

Loop ABCDA:

$-I_1R_1 - I_2R_2 - I_5R_5 + V =$

Or

$-V_1 - V_2 - V_5 + V =$

Loop BECB:

Loop CEDC:

Verify Kirchoff’s Junction rule for currents:

Verify Kirchoff’s Junction rule for current on nodes B, C, D, E.

Node B:

$I_1 - I_2 - I_3 =$

Node C:

Node D:

Node E:

Comparing theoretical and practical results:

In figure 1 assume three closed paths (I_a, I_b and I_c). The electric current through $R_2 = (I_a - I_b)$ and through $R_4 = (I_b - I_c)$. Record the results in table.2.

Table.2.

	R_1	R_2	R_3	R_4	R_5	R_6
Measured resistance						
Assumed current	I_a	$I_a - I_b$	I_b			

1. Use **Kirchoff's Loop rule for Voltage** to write three equations for unknown values of I_a, I_b and I_c using the results in table.1.
2. Solve the equations to calculate values of I_a, I_b and I_c and record there results in table.3.

   Forexample:

   Loop ABDA

   $V - I_aR_1 - (I_a - I_b) R_2 - (I_a - I_c) R_5 = 0$

   The final forms of the last equation and the equations of the loops (BECB & DCED) can write as:

   $\mathbf{c_{11}I_a - c_{12}I_b + c_{13}I_c = m_1}$

$$c_{21}I_a - c_{22}I_b + c_{23}I_c = m_2$$

$$c_{31}I_a - c_{32}I_b + c_{33}I_c = m_3$$

Table.3.

	Current (Experiment)	Current (Estimated)
R_1		
R_2		
R_3		
R_4		
R_5		
R_6		

Experiment 3.

Determination of the electrical dielectric constant

Ob iective

3. Determine the relationship between the capacitor capacitance and the distance between its plates.
4. Determine **the dielectric constant** of a material between the ends of the capacitor

Equipments:

1. AC. Power supply (0 : 500v)
2. Ruler
3. Two plates capacitor have the same dimensions
4. Plates of different insulation materials
5. Ammeter and Voltmeter
6. Wires

Procedures

1. **Connect the** circit as shown in fig.1.
2. Make the distance between the condenser plates equal 3cm.
3. Record the values of current (I) and voltage (v) in table.1
4. Plot the curve of voltage and the current and then calculate the slope:

$$Slope = X_C = \frac{1}{2\pi f C}$$

Where f is the frequency (50 Hz)

5. Repete the previous four steps at different values of distance between capacitor plates.
6. Plot the curve of capacitance and the distance between capacitor plates
7. Calculate the capacitance at the presence of different insulator between capacitor plates table.2.
8. Repete the steps from (1) to (5)
9. Determine **the dielectric constant** of a material between the ends of the capacitor from:

$$C = \frac{\varepsilon_o \varepsilon_r A}{d}$$

Where ***C*** is the capacitance, $\boldsymbol{\varepsilon_r}$ is the dielectric constant, $\boldsymbol{\varepsilon_o}$ is the permittivity of free space, ***A*** is the area of the plates, and ***d*** is the plate separation.

Results:

Table.1.

Without insulator							
d	V					slope	C
	I						
d	V						
	I						
d	V						
	I						
d	V						
	I						
d	V						
	I						

Table.2.

In presence of insulator							
d	**V**					**slope**	**C**
	I						
d	**V**						
	I						
d	**V**						
	I						
d	**V**						
	I						
d	**V**						
	I						

Experiment 4.

Measurment the specific heat solid meatal by method of mixture

Ob iective

To determine the specific heat of solid meatal by the method of heat transfer.

Theory Overview

Heat capacity of a body is the quantity of heat required to raise the temperature of the body by 1o C. The specific heat of a substance is the heat capacity per unit mass. Thus, heat capacity = mass x specific heat. The specific heat is essentially a measure of how thermally insensitive a substance is to the addition of energy. The water equivalent of a body is the mass of water, which would require the same amount of heat as the body in order to raise the temperature through one degree Celsius. The method of mixtures makes use of the principles that when two bodies at different temperatures exchange heat, the quantity of heat lost by the warmer body is equal to the heat gained by the cooler body, and some intermediate equilibrium temperature is finally reached. This is true provided no heat is lost or gained from/to the surroundings. The purpose of the calorimeter is to prevent heat lose to the surroundings. There are three methods of heat transfer: conduction, convection and radiation. In this experiment, a heated solid of known mass and temperature is dropped in the calorimeter containing known mass of cold water. The equilibrium temperature is then measured. The magnitude of the heat lost by the solid must be equal to the magnitude of the heat gained by the water, and calorimeter with stirrer.

Mass of the solid (metal) in kg = m

Specific heat of the metal = c

Initial temperature of (hot) solid = θ_1

Mass of calorimeter with stirrer = m_1

Mass of cold water = m_2

Initial temperature of cold water = θ_2

Final equilibrium temperature of mixture = θ_3

Specific heat of calorimeter = c_1

Specific heat of water = c_2 = 4186 J/kgC^o

Heat lost(Q^-) = -Heat gained (Q^+)

Heat lost by the solid **= [$m \times c \times(\theta_2 - \theta_1)$]**

Heat gained by water + (calorimeter & stirrer)

$$= [m_2 \times c_2 \times(\theta_3 - \theta_2)] + [m_1 \times c_1 \times(\theta_3 - \theta_2)]$$

Equating heat lost to heat gained:

$$-[m \times c \times (\theta_3 - \theta_1)] = [m_2 \times c_2 \times (\theta_3 - \theta_2)] + [m_1 \times c_1 \times (\theta_3 - \theta_2)] \qquad (2.1)$$

This equation is used to compute the unknown specific heat, c, of the metal.

Equipment

1. Calorimeter with stirrer
2. Weighing scale
3. Thermometer boiler (beaker and hotplate)
4. Small piece of metal solid
5. Paper towels
6. Sensitive balance
7. Heater

Procedure:

1. Fill the beaker about half way with water and start heating it.
2. Record the name of the metal being used in the data table.
3. Weigh the solid (m) metal, and then lower it into the beaker of hot water by means of a thread, to avoid burns.
4. While the solid is being heat go to step 5.
5. Weigh the inner chamber of calorimeter and the stirrer, together.
6. Fill the inner chamber of the calorimeter about half way with cool water and add one or two small pieces of crushed ice to the water.
7. Weigh the inner chamber of the calorimeter, stirrer and cold water ($m_1 + m_2$).
8. Place the inner chamber of the calorimeter into the outer calorimeter jacket and place the lid on, then record the temperature of the cold water (θ_2). Be sure to stir the water first.
9. Record the temperature of the hot solid when the temperature becomes steady (θ_1). This should occur after the water boils. Hint: The metal should be the same temperature as the hot water.
10. Now quickly transfer the solid from the hot water to the calorimeter without splashing any water. You must do this very quickly.
11. Place the lid onto the calorimeter and stir the water very gently and record the final equilibrium temperature (θ_3). Don't break the thermometer, while stirring.

Results:

Mass of calorimeter and stirrer (kg)	$m_1 =$
Mass of calorimeter, stirrer, and water (kg)	$m^{\backslash} =$
Mass of cold water	$m_2 = m^{\backslash} - m_1 =$
Mass of the solid metal (kg)	$m =$
Initial temperature of (hot) solid	$\theta_1 =$
Initial temperature of cold water	$\theta_2 =$
Final equilibrium temperature of mixture	$\theta_3 =$
Specific heat of calorimeter	$c_1 =$
Specific heat of water	$c_2 = 4186$ J/kgC^o
Heat lost by the solid	**$= [\, m \times c \times (\theta_2 - \theta_1)]$**
Heat gained by water + (calorimeter & stirrer)	$= [m_2 \times c_2 \times (\theta_3 - \theta_2)] + [m_1 \times c_1 \times (\theta_3 - \theta_2)]$ =
Spicific Heat of meatl:	**C=**

Experiment 5.

Verifing Newton's law of cooling

Ob iective

To study the relationship between the temperature of a hot body and time by plotting a cooling curve. (Verifing Newton's law of cooling)

Theory Overview

The rate at which a hot body loses heat is directly proportional to the difference between the temperature of the hot body and that of its surroundings and depends on the nature of material and the surface area of the body. This is Newton's law of cooling. For a body of mass ***m*** and specific heat ***s***, at its initial temperature θ higher than its surrounding's temperature θ_o, the rate of loss of heat is: $\frac{dQ}{dt}$, where dQ is the amount of heat lost by the hot body to its surroundings in a small interval of time.

Following Newton's law of cooling we have

Rate of loss of heat,

$$\frac{dQ}{dt} = -k(\theta - \theta_o) \qquad (3.1)$$

Also

$$\frac{dQ}{dt} = ms\frac{d\theta}{dt} \qquad (3.2)$$

Using Eqs. (3.1) and (3.2), the rate of fall of temperature is given by

$$\frac{d\theta}{dt} = -\frac{k}{ms}\frac{dQ}{dt} \qquad (3.3)$$

where *k* is the constant of proportionality and *k'*= *k/ms* is another constant (The term *ms* also includes the water equivalent of the calorimeter with which the experiment is performed). Negative sign appears in Eqs. (3.2) and (3.3) because loss of heat implies temperature decrease. Eq. (3.3) may be re written as

$$\frac{d\theta}{dt} = -k'(\theta - \theta_o) \qquad (3.4)$$

Apparatuse

Newton's law of cooling apparatus that includes a copper calorimeter with a wooden lid having two holes for inserting a thermometer and a stirrer and an open double – walled vessel, two celsius thermometers (each with least count 0.5 oC or 0.1 oC), a stop clock/watch, a heater/ burner, liquid (water), a clamp stand, two rubber stoppers with holes, strong cotton thread and a beaker.

Descripsion of apparatus

As shown in Fig.1, the law of cooling apparatus has a double walled container, which can be closed by an insulating lid. Water filled between double walls ensures that the temperature of the environment surrounding the calorimeter remains constant. Temperature of the liquid and the calorimeter also remains constant for a fairly long period of time so that temperature measurement is feasible. Temperature of water in calorimeter and that of water between double wal

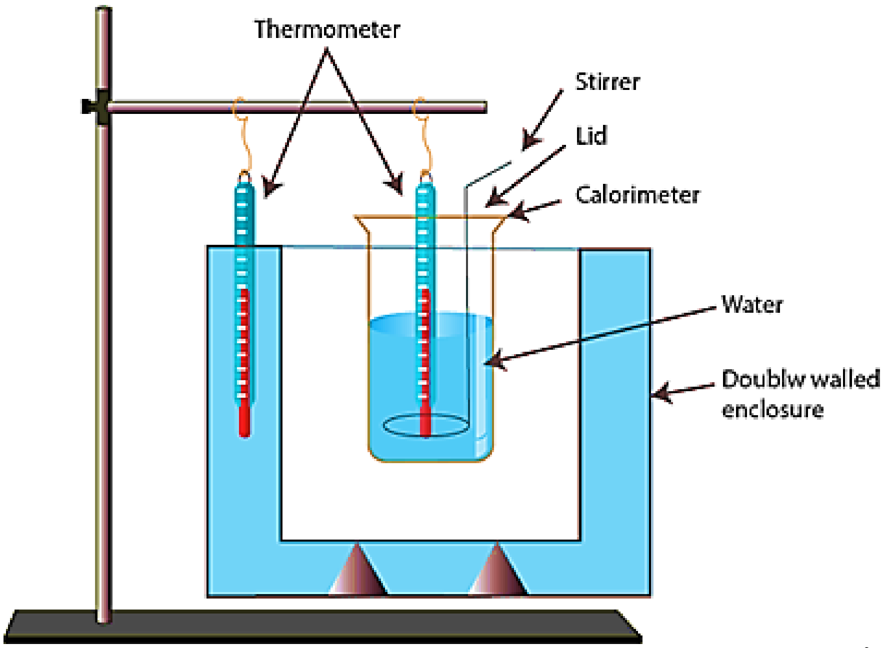

Fig.1.

Procedure:

1. Fill the space between the double walls of the enclosure with water and keep it on top of a table.
2. Fill two-thirds of the calorimeter with water heated to about 90 °C.
3. Suspend the calorimeter inside the enclosure with a thermometer in it. Cover it with a wooden lid with a hole in the middle.
4. Suspend a thermometer from the clamp and stand into the enclosure water and the other thermometer in calorimeter water.
5. Note the least count of thermometers.
6. Set the stop clock to zero and note down its least count.
7. Note the temperature θ_0 of water in the enclosure.
8. Start stirring the water in calorimeter so that it cools uniformly.

9. When the calorimeter has convenient temperature reading, note it down and start and stop the clock watch
10. Continue stirring and note the temperature after every few minutes. The temperature falls quickly in the first few minutes
11. Note down the enclosure water temperature every five minutes.
12. When the temperature fall becomes slow, note down the temperature at an interval of two minutes for ten minutes and then an interval of 5 minutes.
13. Stop when the fall of temperature becomes very slow.
14. Record your observation as given in the table below
15. Plot a graph between (θ – θo) and *t* as shown in Fig. 2 taking *t* along x-axis and (θ – θo) along y-axis. This is called cooling curve

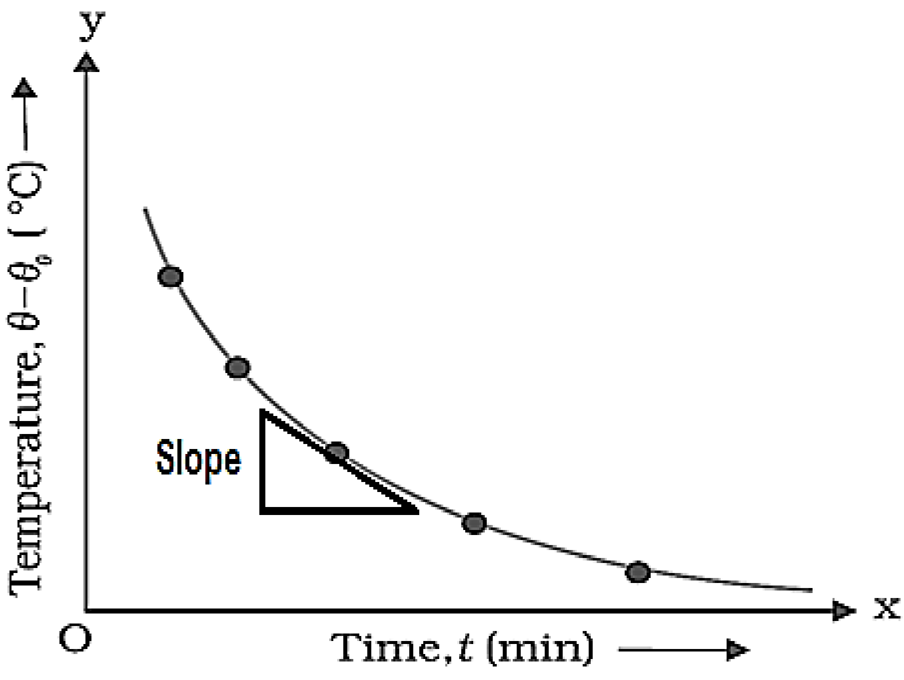

Fig.2.

Observation

Least count of both the identical thermometers = ... °C

Least count of stop-watch/clock = ... s

Initial temperature of water in the enclosure θ1 = ... °C

Final temperature of water in the enclosureθ2 = ... ^{o}C

Mean temperature of the water in the enclosure

$$\theta_o = (\theta 1 + \theta 2)/2 = ...\ ^{o}C$$

Table.1.

	Time (*t*) (*s*)	**Temperature of hot water θ °C**	**Excess Temperature of hot water (θ – θ0) °C**	**Slope = $\frac{d\theta}{dt}$**
1				
2				
3				
4				
5				
6				
7				
8				

16.Plot a graph between (θ – θo) along x-axis and $\frac{d\theta}{dt}$along y-axis to virify Newton’s law of cooling.