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EXPERIMENT 1

RESISTANCE PER UNIT LENGTH

AIM: To determine the resistance per unit length of a given wire by plotting a graph of potential difference verses current.

APPARATUS: A wire of unknown resistance, battery, voltmeter, milli ammeter, rheostat, plug key and connecting wires.

PRINCIPLE: Current through the conductor (I) is directly proportional to the potential difference between its ends (V). (Temperature and other physical conditional must be constant)

Hence \( V \alpha I \) or \( V = IR \) Where \( R \) - Resistance of the conductor.

PROCEDURE: 1. Circuit connections are made as shown in the circuit diagram.

2. The key K is inserted and the rheostat contact is slid to one of its extreme end, so that current passing through the resistance wire is kept minimum.

3. The milliammeter and voltmeter readings are noted.

4. The rheostat contact is shifted slightly to increase the applied voltage. The milliammeter and voltmeter reading are noted.

5. The experiment is repeated for different settings of rheostat.

6. A graph of \( I \) vs \( V \) is drawn and slope (m) of straight line obtained is calculated.

7. The resistance \( R \) of the wire is calculated from the reciprocal of the slope.

8. Resistance per unit length is calculated using the given formula.
OBSERVATIONS:

Length of the given wire ................m

<table>
<thead>
<tr>
<th>Trail No</th>
<th>Potential difference V (V)</th>
<th>Current I (mA)</th>
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<tbody>
<tr>
<td>1</td>
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CALCULATIONS:

Resistance of the wire, \( R = \frac{1}{m} = \frac{\Delta V}{\Delta I} = \frac{BC \times X\text{-scale}}{AB \times Y\text{-scale}} = \)

\[ = \text{..................}\Omega \]

Result:

1. The potential difference across the given wire is found varying linearly with the current.

2. Resistance per unit length, \( \frac{R}{l} = \)

\[ = \text{...............}\Omega/m \]
Viva—Voce Questions with Answers

1. What is electrical resistance?
   Resistance is the opposition offered by the material to the flow of current. OR
   resistance is the ratio of potential difference across the conductor to the current
   through it.

2. What is the reciprocal of resistance? With what unit it is measured?
   Conductance. Unit is mho or siemen.

3. Why large amount of current is not preferred in this experiment?
   When large current passes, the conductor gets heated more and hence its resistance
   changes.

4. What is an ohmic conductor.
   Conductor which obeys Ohm's law is called an ohmic conductor.

5. Give an example for a conductor.
   Copper, (Aluminium, Iron)

6. In the above experiment two sets of readings were taken. The conductor is heated
   and two more voltage and current readings were taken. Will the four points form a
   straight line in the graph? Why?
   No. Because, the resistance changes with temperature. Hence two points
   corresponding to the readings taken after heating the conductor form a different
   straight line.

7. How do you conclude that the conductor used in the above experiment has obeyed
   Ohm's law?
   V-i graph obtained is a straight line. Hence Ohm's law is obeyed.

8. V-i graph for a material is a straight line. What is your conclusion?
   The conductor is an ohmic device which obeys Ohm's law. Hence potential difference
   across the conductor is directly proportional to the current through it.

9. On what factors does resistance of a conductor depend?
   Length of the conductor, Area of cross section, type of conductor and temperature.

10. Length of a material is halved. What happens to its resistance?
    Resistance will be halved.

11. Thick metal plates are used in a metre bridge for connections. Why?
    Thick metal plates have large area of cross section and hence less resistance. Hence
    parts of the instruments do not add to any resistance.
12. **What is current?**
   Rate of flow of charges is called current.

13. **Why can’t we use D.C. ammeters and voltmeters to measure A.C. current or voltages?**
   Because alternating current changes the direction every time and average value of current for full cycle will be zero.

14. **What is a rheostat?**
   It is a instrument used to vary current.

15. **What is the use of a rheostat?**
   Rheostat is used to vary current and as a potential divider.

16. **What is the principle of a galvanometer/ammeter/voltmeter?**
   Mechanical effect of electric current

17. **Give an example for variable resistor.**
   Rheostat, resistance box.

18. **What does the slope of I-V graph give?**
   Conductance

19. **What is the difference between a rheostat and a resistance box?**
   In resistance box, resistance varies in steps. In rheostat resistance can be varied continuously. Both are used to limit the current in a circuit.
EXPERIMENT 2

RESISTIVITY OF THE MATERIAL OF A WIRE

AIM: To determine the resistance of the given wire using metre bridge and hence to find the resistivity of the material.

APPARATUS: Metre Bridge, a wire about 1m long, a resistance box, a rheostat, galvanometer, jockey, key, a cell, connecting wires.

PRINCIPLE: This experiment is based on the principle of Wheatstone’s bridge. Wheatstone bridge is a circuit which is used to determine the value of unknown resistance.

When the condition \( \frac{R}{S} = \frac{l}{1-l} \) is satisfied, no current flows through the galvanometer.
Knowing the values of l and S, we can determine the value of R.

FORMULA: Resistance the wire \( R = \frac{SI}{1-l} \) (in \( \Omega \))

Where S- Standard resistance

\( l \) balancing length in metres

2. Resistivity \( \rho = \frac{\pi r^2 R}{L} \) in \( \Omega m \).

Where R- resistance of the wire

r- radius of the wire.

L- length of the experimental wire.

PROCEDURE:

1. The circuit is set up as shown in the circuit diagram.

2. Some resistance S is introduced in the circuit from the resistance box.

3. The jockey is brought in contact with terminal A first and then with terminal C. The direction of the deflection of the pointer of the galvanometer is noted in each case. Opposite deflections are obtained which confirmed that circuit is perfect. When one sided deflection is got, the circuit is reconstructed till opposite deflections are obtained when touched at the two ends of the wire.

4. The resistance S is introduced and the jockey is moved on the wire till the galvanometer showed zero deflection. The balancing length AD = l is measured.

5. Resistance of the wire is calculated using the formula \( R = \frac{SI}{1-l} \)

6. The experiment is repeated for different values of S and mean value of R is calculated.
7. Length ‘L’ and radius ‘r’ of the wire are noted and the resistivity of the wire is calculated using the formula 
\[ \rho = \frac{\pi r^2 R}{L} \]

1. Resistance of the wire, \( R = \ldots \ldots \ldots \Omega \)

2. Resistivity of the material of the wire, \( \rho = \ldots \ldots \ldots \Omega \text{m} \)

![Diagram](image)

**OBSERVATIONS:**

Radius of the experimental wire, \( r = \ldots \ldots \ldots \text{m} \)

Length of the experimental wire, \( L = \ldots \ldots \ldots \text{m} \)

<table>
<thead>
<tr>
<th>Trail No</th>
<th>Resistance S in Ω</th>
<th>Balancing length ( l ) in m</th>
<th>( R = \frac{SI}{1-l} ) in Ω</th>
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Mean value of \( R = \ldots \ldots \ldots \Omega \)

**CALCULATIONS:**

Resistance of the wire \( R = \frac{SI}{1-l} \)
Trail No 1:

Trail No 2:

Trail No 3:

Trail No 4:

Result:

1. Resistance of the wire, \( R = \ldots \ldots \).

2. Resistivity of the material of the wire  
\[
\rho = \frac{\pi r^2 R}{L} \\
= \ldots\ldots\ldots\ldots\ldots\Omega m.
\]

Viva-Voce Questions with Answers

1. Define resistivity (or specific resistance) of a material of a conductor. It is the resistance of a material having unit length and unit area of cross section.

2. On what factors does resistivity of a material depend? Resistivity depends on the material and temperature.

3. Does resistivity depend on length and area of cross section of the material? No.

4. Length of a conductor is doubled. What will be its new resistivity? Resistivity remains the same.

5. What is the principle of metre Bridge? Balanced Wheat stone’s network.

6. What is meant by balancing length in a metre bridge? Balancing length is the length of the metre bridge wire at which the galvanometer shows zero deflection.
7. What is null point?
Null point is the point on the meter bridge wire, at which a galvanometer connected through jockey shows zero deflection.

8. Why is metre Bridge preferred to measure the resistance?
It employs null method to measure resistance. Hence no error occurs in the measurement of resistance.

9. Balancing length as measured from left side in a metre bridge is more than 50cm. If F and S are resistances in left and right gaps respectively then which resistance is greater?
R > S

10. While performing the above experiment, after completing two trials, the galvanometer is changed and two more trials were performed. Is the unknown resistance values obtained in the last two trials different from the first two? Why?
No. Resistance will not change. Because, balancing condition is not decided by the resistance of the galvanometer.

11. The known resistance in the right gap of Metre Bridge is kept zero ohm. What will be the balancing length?
Ans: Galvanometer will not show zero deflection.

12. Resistance in the right gap of a metre bridge is increased. What happens to the balancing length?
Balancing length decreases.

13. In a metre bridge circuit, galvanometer is showing deflection in one side only. What may be wrong in the circuit?
(i) Resistance in the right gap may not unplugged (zero ohms)
(ii) left gap (where unknown resistance is connected) may be short.
EXPERIMENT NO: 3

COMBINATION OF RESISTANCES IN SERIES

AIM: To verify the law of combination of resistances in series.

APPARATUS: jockey, key, a cell and connecting wires.

PRINCIPLE: This experiment is based on the principle of balanced Wheatstone's bridge. Wheatstone bridge is a circuit which is used to determine the value of unknown resistance. When the bridge is balanced no current flows through the galvanometer. The balance condition is

\[ \frac{R_s}{S} = \frac{l}{1-l} \]

Knowing the values of \( l \) and \( S \), \( R_s \) can be determined.

FORMULA: Resistance in the left gap of metre bridge \( R_s = \frac{sl}{1-l} \) (in \( \Omega \))

Where \( S \) is the Standard resistance, \( l \) is the balancing length in metre.

If \( R_1 \) and \( R_2 \) are two resistors in series then their equivalent resistance \( R_e = R_1 + R_2 \)

PROCEDURE:

1. The circuit is set up as shown in the circuit diagram.
2. Some resistance \( S \) is introduced from resistance box.
3. The circuit is checked for opposite deflections by placing the jockey at the two ends of the metre bridge wire \( AB \). When one sided deflection is got, the circuit is reconstructed till opposite deflections are obtained when touched at the two ends of the wire.
4. The resistance \( S \) is introduced and the jockey is moved on the wire till the galvanometer showed zero deflection. The balancing length \( AD = l \) is measured.
5. Series resistance \( R_S \) is calculated using the formula \( R_s = \frac{sl}{1-l} \)
6. The experiment is repeated for different values of \( S \) and mean value of \( R_S \) is calculated.
7. Experimental value of \( R_S \) and the theoretical value of \( R_S = R_1 + R_2 \) are compared.
**OBSERVATIONS:**

Resistance $R_1 = \ldots \ldots \ldots \Omega$

Resistance $R_2 = \ldots \ldots \ldots \Omega$

<table>
<thead>
<tr>
<th>Trail No</th>
<th>Resistance S in $\Omega$</th>
<th>Balancing length $l$ in m</th>
<th>$R = \frac{SI}{1-l}$ in $\Omega$</th>
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Mean value of $R_0 = \ldots \ldots \ldots \ldots \ldots \Omega$

**CALCULATIONS:**

Theoretical value of resistance $R_0 = R_1 + R_2 = \ldots \ldots \ldots \ldots \ldots \Omega$

Trail No 1:

Trail No 2:

Trail No 3:

Trail No 4:
Inference:

Experimental value of series combination of resistances agreed with the theoretical value. Hence law of combination of resistances in series is verified.

Viva—Voce Questions with Answers

1. What is metre bridge? Why is it used?
   Metre bridge is a device used to measure unknown resistance working on the principle of balanced Wheatstone's bridge.

2. Which combination of resistors gives maximum value of resistance?
   Series combination.

3. Which combination of resistors gives minimum value of resistance?
   Parallel combination.

4. When do you say that two resistances are in series?
   When current through them is same.

5. When do you say that two resistors are in parallel?
   When potential difference across them is same.

6. Two resistors are in series. What is common in them? Current or voltage?
   Current

7. Two resistors are in parallel. What is common in them? Current or voltage?
   Voltage

8. Balancing point is at the midpoint of metre bridge wire. What does it imply?
   Resistance values at both the gaps of metre bridge are same.

9. What happens to the balancing length if the positive and negative terminal connections of the battery connected to metre bridge are interchanged?
   Balancing length remains the same.
EXPERIMENT NO: 4

COMBINATION OF RESISTANCES IN PARALLEL

AIM: To verify the law of combination of resistances in parallel.

APPARATUS: Metre Bridge, two resistors of different values, resistance box, a rheostat, galvanometer, jockey, key, a cell, connecting wires.

PRINCIPLE: This experiment is based on the principle of balanced Wheatstone’s bridge. Wheatstone bridge is a circuit which is used to determine the value of unknown resistance. When the bridge is balanced no current flows through the galvanometer. The balance condition is

\[
\frac{R_p}{l} = \frac{1}{1-l} .
\]

Knowing the values of \( l \) and \( S \), \( R_p \) can be determined.

FORMULA: Resistance in the left gap of metre bridge \( R_p = \frac{Sl}{1-l} \) (in \( \Omega \))

Where \( S \) is the standard resistance, \( l \) is the balancing length in metre.

If \( R_1 \) and \( R_2 \) are two resistors in parallel then their equivalent resistance \( R_p \)

\[
= \frac{R_1 \times R_2}{R_1 + R_2}
\]

PROCEDURE:

1. The circuit is set up as shown in the circuit diagram.
2. Some resistance \( S \) is introduced from resistance box.
3. The Circuit is checked for opposite deflections by placing the jockey at the two ends of the metre bridge wire AB. When one sided deflection is got, the circuit is reconstructed till opposite deflections are obtained when touched at the two ends of the wire.
4. The resistance \( S \) is introduced and the jockey is moved on the wire till the galvanometer showed zero deflection. The balancing length \( AD = l \) is measured.
5. Parallel resistance \( R_p \) is calculated using the formula \( R_p = \frac{Sl}{1-l} \).
6. The experiment is repeated for different values of \( S \) and mean value of \( R_p \) is calculated.
7. Experimental value of \( R_p \) and the theoretical value of \( R_p = \frac{R_1 \times R_2}{R_1 + R_2} \) are compared.
OBSERVATIONS:

Resistance $R_1 = \ldots \ldots \ldots \Omega$

Resistance $R_2 = \ldots \ldots \ldots \Omega$

<table>
<thead>
<tr>
<th>Trail No</th>
<th>Resistance $S$ in $\Omega$</th>
<th>Balancing length $l$ in m</th>
<th>$R = \frac{sl}{1-l}$ in $\Omega$</th>
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Mean value of $R_\phi = \ldots \ldots \ldots \Omega$

CALCULATIONS:

Theoretical value of resistance $R_\phi = \frac{R_1 R_2}{R_1 + R_2} = \ldots \ldots \ldots \ldots \Omega$

Trail No 1:

Trail No 2:

Trail No 3:

Trail No 4:
RESULT: Experimental value of parallel combination of resistances agreed with the theoretical value. Hence law of combination of resistances in parallel is verified.

Viva—Voce Questions with Answers

10. What is a metre bridge? Why is it used? Metre bridge is device used to measure unknown resistance working on the principle of balanced Wheatstone's bridge.


12. Which combination of resistors gives minimum value of resistance? Parallel

13. When do you say that two resistances are in series? When current through them is same.

14. When do you say that two resistors are in parallel? When potential difference across them is same.

15. Two resistors are in series. What is common in them? Current or voltage? Current

16. Two resistors are in parallel. What is common in them? Current or voltage? Voltage

17. Balancing point is at the midpoint of metre bridge wire. What does it imply? Resistance values at both the gaps of metre bridge are same.

18. What happens to the balancing length if the positive and negative terminal connections of the battery connected to metre bridge are interchanged? Balancing length remains the same.
EXPERIMENT NO: 5

COMPARISION OF EMFs OF TWO CELLS

AIM: To compare the emfs of given two cells using a potentiometer.

APPARATUS: Potentiometer, two cells, a rheostat, galvanometer, jockey, Two- way key, plug key, a battery, connecting wires.

PRINCIPLE: Potentiometer is based on the principle that balancing length is proportional to the EMF of a cell in the secondary circuit.

\[ E \propto l \quad \text{or} \quad \frac{E_1}{E_2} = \frac{l_1}{l_2} \]

FORMULA: \[ \frac{E_1}{E_2} = \frac{l_1}{l_2} \]

Where \( E_1 \) is the emf of first cell

\( E_2 \) is the emf of the second cell.

\( l_1 \) is the balancing length for first cell and

\( l_2 \) is the balancing length of second cell

PROCEDURE:

1. The circuit is set up as shown in the circuit diagram.
2. The key K is closed. Then the two way key is closed so that current flows through battery \( E_1 \).
3. Circuit is checked for opposite deflections by placing the jockey at the two ends of the potentiometer wire AB
4. The jockey is moved on the potentiometer wire till the galvanometer showed zero deflection.
5. Balancing length \( l_1 = AC \) is measured.
6. Then the two way key is closed so that current flows through battery \( E_2 \).
7. Steps 3 and 4 are repeated and balancing length \( l_2 \) is noted.
8. The ratio \( \frac{E_1}{E_2} \) is calculated using the formula, \[ \frac{E_1}{E_2} = \frac{l_1}{l_2} \]
9. Experiment is repeated by changing the current in the primary circuit using a rheostat and the mean value of \( \frac{E_1}{E_2} \) is calculated.
OBSERVATIONS:

<table>
<thead>
<tr>
<th>Trail No</th>
<th>Balancing length, ( l_1 ) (m)</th>
<th>Balancing length, ( l_2 ) (m)</th>
<th>( \frac{E_1}{E_2} = \frac{l_1}{l_2} )</th>
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CALCULATIONS:

Ratio of two cells \( \frac{E_1}{E_2} = \frac{l_1}{l_2} \)

Trail No 1:

Trail No 2:

Trail No 3:

Trail No 4:
RESULT: Ratio of emfs of two cells, $\frac{E_1}{E_2} = \text{.............}$

Viva-Voce Questions with Answers

1. What do you mean by emf of a cell?
   EMF is the potential difference between the positive and negative terminals of the cell when it is in open circuit.

2. Why is potentiometer preferred to measure or compare emfs of cells instead of using a voltmeter?
   Potentiometer has two advantages: (i) It draws no current from the voltage source being measured. (ii) emf measured by potentiometer is unaffected by the internal resistance of the source.

3. What is the difference in using a potentiometer having a wire of length 1m and another having a wire of length 100m or 10m?
   Accuracy in balancing length readings will be more if we use longer wires (say 100m length).

4. Why can't you measure the emf of a cell just by using a voltmeter?
   Potentiometer has two advantages: (1) It draws no current from the voltage source being measured. (ii) emf measured by potentiometer is unaffected by the internal resistance of the source.

5. What is potential gradient?
   Potential drop per unit length of the wire is called potential gradient.

6. Is it necessary that the area of cross section of wire be uniform?
   Yes. If area of cross section is uniform, then the resistance per unit length of the wire is also uniform and hence potential gradient is uniform.
EXPERIMENT NO: 6

INTERNAL RESISTANCE OF A CELL

AIM: To determine the internal resistance of a given cell using a potentiometer.

APPARATUS: Potentiometer, two keys, a rheostat, galvanometer, jockey, resistance box, plug key, a battery, connecting wires.

PRINCIPLE: Potentiometer is based on the principle that terminal potential difference across the cell in the secondary circuit is directly proportional to balancing length.

FORMULA: Internal resistance \( r = \frac{R(I_1 - I_2)}{I_2} \)

Where \( R \) - resistance unplugged in the resistance box

\( I_1 \) is the balancing length for experimental cell with infinite resistance across it

\( I_2 \) is the balancing length for the experimental cell with resistance \( R \) across it.

PROCEDURE:

1. The circuit is set up as shown in the circuit diagram.
2. The key \( K_1 \) is closed and \( K_2 \) is opened (so that resistance across the battery is infinity)
3. Circuit is checked for opposite deflections by placing the jockey at the two ends of the potentiometer wire AB
4. The jockey is moved on the potentiometer wire till the galvanometer showed zero deflection.
5. Balancing length \( I_1 = AC \) is measured.
6. A suitable resistance \( R \) is unplugged in the resistance box and key \( K_2 \) is closed.
7. Above steps 4 & 5 are repeated and the balancing length \( I_2 \) is measured.
8. Internal resistance is calculated using the formula \( r = \frac{R(I_1 - I_2)}{I_2} \)
9. Experiment is repeated for different values of \( R \) and the mean value of internal resistance ‘\( r \)’ is calculated.
OBSERVATIONS:

When R is infinity, balancing length, \( l_1 = \ldots \ldots \ldots \) m

<table>
<thead>
<tr>
<th>Trail No</th>
<th>Resistance R in ( \Omega )</th>
<th>Balancing length, ( l_2(\text{m}) )</th>
<th>( r = \frac{R(l_1-l_2)}{l_2} ) in ( \Omega )</th>
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CALCULATIONS:

Internal resistance \( r = \frac{R(l_1-l_2)}{l_2} \)

Trail No 1:

Trail No 2:

Trail No 3:

Trail No 4:
RESULT: The internal resistance of the given cell varied between ...........Ω and...............Ω.

Viva-Voce Questions with Answers

1. What do you mean by internal resistance of a cell?
   Resistance offered by the cell to the flow of current through itself.

2. What is the internal resistance of an ideal cell?
   Zero

3. Does the internal resistance depend on the current drawn from the cell? (Or external resistance R?)
   Yes.

4. On what factors does the internal resistance of a cell depend?
   Separation between the electrodes, Area of electrodes, Conductivity of electrolyte.

5. What happens to internal resistance of the experimental cell as the resistance connected across it increases?
   Internal resistance varies with external resistance. (Questions from previous experiment may be added)
Experiment-7

CONVERSION OF GALVANOMETER INTO VOLTMETER

Aim:
To convert the given galvanometer (of known resistance and figure of merit) into a voltmeter of desired range.

Apparatus and material required: A galvanometer of known resistance and figure of merit, Resistance box, battery, key, rheostat and voltmeter.

Principle: A galvanometer can't be used directly as a voltmeter because its resistance is not very high. A voltmeter must have very high resistance. A galvanometer can be converted into voltmeter by connecting a very high resistance in series with it.

Formula:
1. Current required for full scale deflection in galvanometer, \( I_g = NK \)
   where \( N \) is the number of divisions in galvanometer, \( K \) is the figure of merit of galvanometer

2. Theoretical value of high resistance to be connected in series \( R = \frac{V}{I_g} - R_g \) where \( R_g \) is the resistance of the galvanometer. \( V \) is the range of the voltmeter to be constructed.

Circuit diagram:

- \( Ba \) - Battery
- \( G \) - Galvanometer
- \( K \) - Key
- \( Rh \) - Rheostat
- \( V \) - Voltmeter
- \( R \) - Resistance Box.
**Procedure:**

1. Galvanometer resistance \( R_g \), figure of merit \( K \), number of divisions \( N \) and the range of voltmeter (V) are noted.
2. Current required for full scale deflection in galvanometer is calculated using the formula, \( I_g = NK \)
3. The value of series resistance to be connected in series with the galvanometer is calculated using the formula \( R = \frac{V}{I_g} - R_g \)
4. A suitable high resistance is unplugged in the resistance box (to safeguard galvanometer).
5. Rheostat is adjusted such that the voltmeter shows voltage V (range)
6. Resistance in the resistance box is adjusted till the galvanometer shows full scale deflection.
7. Resistance in the resistance box is noted as \( R^l \).
8. \( R \) and \( R^l \) are compared.

**Observations:**

1. Galvanometer resistance, \( R_g = \Omega \)
2. Figure of merit of the galvanometer, \( K = A \ \text{div}^l \)
3. Number of divisions on either side of zero of galvanometer scale, \( N = \)
4. Range of the voltmeter to be constructed, \( V = \text{volts} \)
5. Experimentally observed value of series resistance, \( R^l = \)

**Calculations:**

1. Current required for full scale deflection in the galvanometer,
   \( I_g = NK = A \)
2. Series resistance required, \( R = \frac{V}{I_g} - R_g = \)
   \( = \Omega \ f \)

**Result:** 1. Theoretically calculated value of series resistance, \( R = \Omega \)
2. Practically observed value of series resistance, \( R^l = \Omega \)
**Inference:** The theoretical and experimental values of series resistances are found to agree with each other within the limits of experimental errors.

**Viva-Voce Questions with Answers**

1. What is an ammeter?  
   Instrument used to measure current

2. What is a voltmeter?  
   Instrument used to measure potential difference.

3. How do you connect an ammeter in a circuit?  
   In series.

4. How do you connect a voltmeter in a circuit?  
   In parallel.

5. How do you convert a galvanometer into an ammeter?  
   By connecting a very low resistance in parallel with the galvanometer.

6. How do you convert a galvanometer into a voltmeter?  
   By connecting a very high resistance in series with the galvanometer.

7. Why can't we use a galvanometer directly as an ammeter or voltmeter?  
   An ammeter should have very low resistance and a voltmeter should have very high resistance. But the resistance of a galvanometer is neither very high nor very low.

8. What is the resistance of an ideal ammeter?  
   Zero

9. What is the resistance of an ideal voltmeter?  
   Infinity

10. Can you convert a voltmeter into an ammeter and vice versa? How?  
    Yes. To convert a voltmeter into an ammeter connect a very low resistance in parallel with the voltmeter. To convert an ammeter into a voltmeter connect a very high resistance in series with ammeter.

11. A galvanometer is converted into a voltmeter of range 'V' volts. If the range has to be increased how should the series resistance be varied?  

12. Increase the series resistance.

13. A galvanometer is converted into an ammeter of range 'I' amperes. If the range has to be increased how should the shunt resistance be varied?  
    Decrease the shunt resistance.
Experiment-8

FIGURE OF MERIT OF A GALVANOMETER

**Aim:**
To determine the resistance of a galvanometer by half deflection method and to find its figure of merit.

**Apparatus and material required:** Pointer galvanometer, Keys, resistance boxes and variable battery.

**Principle:** Deflection in the galvanometer is directly proportional to the current through it.

\[ I = K \theta \]

K is called figure of merit of the galvanometer.

**Formula:**

Figure of merit of the galvanometer (in A div⁻¹)

\[ K = \frac{E}{(R+R_g)\theta} \]

**Procedure:**

1. The connections are made as shown in the circuit diagram.
2. Emf of the battery is adjusted to a suitable value E.
3. The key K₁ is closed and K₂ is opened.
4. A suitable resistance R is unplugged to get an even deflection \( \theta \) in the galvanometer.
5. Now K₂ is closed and S is adjusted so that deflection in the galvanometer reduces to \( \theta / 2 \).
6. Value of S is noted in the column as \( R_g \).
7. The experiment is repeated for different values of \( \theta \) and average value of \( R_g \) is found out.
8. For each trial, figure of merit of the galvanometer is calculated using the above formula
9. Mean value of K is calculated.
Observation:

Emf of the battery, \( E = \ \text{V} \)

<table>
<thead>
<tr>
<th>Trial number</th>
<th>Resistance (( \Omega ))</th>
<th>Deflection ( \theta ) in div</th>
<th>( S=R_0 \体制 (\theta/2) ) ( \Omega )</th>
<th>( K = \frac{E}{(R+R_0)\theta} ) (A/div)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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</tbody>
</table>

Average value of \( R_0 = \ \text{\( \Omega \)} \)

Average value of \( K = \ \text{A/div} \)

Calculations:

\[
K = \frac{E}{(R+R_0)\theta}
\]
Result: 1. Resistance of the given galvanometer, G = Ω

2. Figure of merit of the pointer galvanometer, k = A/div

Viva-Voce Questions with Answers

1. What is a galvanometer?
   Galvanometer is an instrument used to detect the presence of current.

2. What do you mean by figure of merit of a galvanometer?
   Current required for unit deflection is called figure of merit or sensitiveness.

3. On what factors does the figure of merit of a galvanometer depend?
   Number of turns in the galvanometer coil, area of coil, strength of magnetic field.

4. How does the galvanometer resistance ‘G’ vary as the current through the galvanometer increases?
   G does not vary with current.

5. Is the galvanometer resistance constant?
   Yes

6. What happens if the experiment is performed without high resistance R?
   High current will pass through the galvanometer and damage it.

8. Resistance S required to produce half deflection is taken as galvanometer resistance G. Why?
   Let S be open. Now current passes only through G and produces a deflection. When we unplug S such that current flowing through galvanometer earlier, now reduces to half and remaining half flows through S. Deflection in G reduces to 0/2. 24
Experiment-9

FREQUENCY OF A.C. USING SONOMETER

**Aim**: To determine the frequency of alternating current using a sonometer and an electromagnet.

**Apparatus and material required**: A sonometer, an electromagnet, and slotted weights with hanger.

**Principle**: At resonance, frequency of vibration of sonometer wire is

(i) directly proportional to the square root of tension (T)
(ii) inversely proportional to resonating length (l) and
(iii) inversely proportional to mass per unit length of the wire (m)

**Formula**:

Frequency of alternating current (in Hz) \( f = \frac{1}{\sqrt{4lm \times \text{slope}}} \)

Slope is of \( T \) versus \( l^2 \) graph and \( m \) is mass per unit length.

**Procedure**:

1. A suitable mass \( M \) is attached to the hanger. The tension applied to the string is calculated using the formula \( T = Mg \).
2. The Position of electromagnet is adjusted such that its one pole lies close to the middle of the sonometer wire.

3. AC is switched on and the sonometer wire is made to vibrate.

4. Distance (AB) between the wedges is adjusted till the string vibrated with maximum amplitude.

5. Resonating length = AB is measured.

6. The experiment is repeated for different values of T and the corresponding values of l are tabulated.

7. A graph of T vs l is plotted. Slope of the straight line graph is found.

8. Frequency of alternating current is calculated using the above formula.

**Observations:**

1. Mass per unit length of the wire, m = \( \text{kg m}^{-1} \).

2. Acceleration due to gravity, g = 9.8 \( \text{ms}^{-2} \).

<table>
<thead>
<tr>
<th>Trial number</th>
<th>Load M (kg)</th>
<th>Tension T = Mg (N)</th>
<th>Resonating length l (m)</th>
<th>( l^2 ) (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td></td>
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<tr>
<td>3</td>
<td>1.5</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>4</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>5</td>
<td>2.5</td>
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</tr>
</tbody>
</table>

**Calculations:**

Slope = \( \frac{AB \times Y \text{scale}}{BC \times X \text{scale}} \)

Frequency of ac,

\( f = \frac{1}{\sqrt{4 \text{ m slope}}} = \text{Hz} \)
Result:

1. T vs $I^2$ - graph is a straight line

2. Frequency of alternating current, $f = \ldots$ Hz

Viva—Voce Questions with Answers

1. Define frequency of A.C.?
   Number of ac cycles repeated in one second.

2. What do you mean by A.C.?
   Current which varies sinusoidally with time.

3. Which type of current is supplied by KPTCL for our domestic use?
   Alternating Current.

4. Which type of current is supplied by a dry cell available in shops?
   Direct Current.

5. What is the frequency of ac supplied by KPTCL?
   50Hz

6. What is resonance?
   When the frequency of applied force and natural frequency of a system are same, the condition is called resonance.
   OR When the natural frequency of the resonating wire is equal to frequency of applied force, wire vibrates with maximum amplitude. Now the condition is called resonance.

7. What is electrical resonating length?
   The length of the sonometer wire (or between the wedges) at which resonance occurs is called resonating length.

8. What is an electromagnet?
   When a wire is wound on a ferromagnetic material and current is passed through it, the material turns into a magnet. The magnet is called electromagnet.

9. Using this experiment can you measure the frequency of D.C.?
   If yes, how? If no Why?
   No. Frequency of dc is zero. Hence the sonometer wire does not vibrate.

10. What is a sonometer?
    It is an instrument to determine the frequency of vibration of a string.

11. How does resonating length vary with tension, T?
    Resonating length is directly proportional to tension.

12. Frequency of ac is 50Hz. What is the frequency of vibration of sonometer wire?
    Why?
    For every cycle of ac, electromagnet gets magnetized and demagnetized twice. Hence the sonometer wire vibrates twice for a cycle of ac. Its frequency of vibration is 100Hz.
Experiment-10

FOCAL LENGTH OF A CONCAVE MIRROR

Aim:
To determine the focal length of a concave mirror by finding image distance for different object distances.

Apparatus and material required: Optic bench, two pins, concave mirror, metre scale.

Principle: When parallel rays are incident on a concave mirror, after reflection, they meet at a point. The point is called focus. Distance between the pole and the principal focus of concave mirror is called focal length. Knowing object distance and image distance, focal length can be calculated.

Formula:
Focal length of concave mirror (in m), \( f = \frac{uv}{u+v} \)

where \( u \) is object distance and \( v \) is image distance.

Procedure:

1. Light from distant object (like a tree) is incident on concave mirror. The distance between screen and mirror is adjusted to get a clear image on screen. The distance between mirror and screen is approximate focal length of mirror.

2. The object pin \( P_1 \) is fixed at a suitable distance from the mirror. It is adjusted such that \( 2f > u > f \).

3. An inverted image of object pin is observed, by suitable adjustment of distance between mirror and screen.

4. The distance between screen \( P_2 \) and mirror is measured as image distance \( v' \).

5. Focal length of the mirror is calculated using the above formula.

6. Experiment is repeated for different values of \( u' \) and average value of focal length \( f' \) is calculated.
Observations:

<table>
<thead>
<tr>
<th>Trial number</th>
<th>Object distance, ( u ) (m)</th>
<th>Image distance, ( V ) (m)</th>
<th>Focal length ( f = \frac{uv}{u+v} ) (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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</table>

Mean value of Focal length = \( \text{m} \)

Calculations:

Focal length \( f = \frac{uv}{u+v} = \text{(m)} \)

(show the substitution for each trail)

Result:

Focal length of the concave mirror = \( \text{m} \)
Viva-Voce Questions with Answers

1. What is focal length of a mirror?
   Paraxial rays incident on a mirror, after reflection meet at point. Distance from this point to
   the pole of the mirror is called focal length

2. What difference will you find in the virtual image formed by concave and convex
   mirrors?
   In a concave mirror, virtual image is always enlarged. In a convex mirror, virtual
   image is always diminished.

3. Can a concave mirror form same sized real image?
   If yes, when? If no, Why?
   Yes. When the object is at the centre of curvature.

4. Name one common use of a concave mirror.
   As a reflector in vehicle head lights, (As a shaving mirror, dentists use concave
   mirror to get enlarged virtual image of the teeth).

5. Which type of mirror is used by dentists? Why?
   Concave mirror. Because concave mirror forms virtual enlarged image when teeth
   lies within the focus.

6. A mirror like reflector is placed behind the bulb inside the head light of vehicles.
   Which type of mirror is it?
   Concave mirror.

7. In a concave mirror, object distance is decreased. What happens to the image
   distance?
   Increases.
Experiment-11

FOCAL LENGTH OF A CONVEX LENS

Aim: To determine the focal length of a convex lens by drawing u-v graph.

Apparatus and material required: Optic bench, two pins, convex lens, metre scale.

Principle: When parallel rays are incident on a convex lens, after refraction they meet at a point. The point is called focus. Distance between the pole and the principal focus of convex lens is called focal length.

Formula:

Focal length of the lens (in m), \( f = \frac{OA + OB}{4} \)

where \( OA = OB = 2f \)

Procedure

1. Light from distant object (like a tree) is incident on convex lens. The distance between screen and lens is adjusted to get a clear image on screen. The distance between lens and screen is approximate focal length of lens.

2. Distance of object pin \( P_1 \) from the lens is object distance ‘\( u \)’. It is adjusted such that \( 2f > u > f \).

3. An inverted image of object pin is observed, by suitable adjustment of distance between lens and screen.

4. The distance between screen \( P_2 \) and Lens is measured as image distance ‘\( v \)’.

5. Experiment is repeated for different values of ‘\( u \)’ and each time the value of ‘\( v \)’ is tabulated.

6. A graph of ‘\( u \)’ along negative x-axis and ‘\( v \)’ along positive y-axis is drawn. The graph is a rectangular hyperbola. (Same scale is chosen in both the axes).

7. A line OZ making an angle of 45° with negative x axis is drawn. Lines AZ and BZ are drawn as shown in the graph.

8. \( OA = OB = 2f \) are measured. Focal length is calculated using the above formula.
### Observation

<table>
<thead>
<tr>
<th>Trail Number</th>
<th>Object distance, ( u ) (m)</th>
<th>Image distance, ( v ) (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<tr>
<td>4</td>
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</tbody>
</table>
Calculations:

From the graph,

\[ OA = \quad \text{m} ; \]
\[ OB = \quad \text{m} \]

Focal length of the lens, \( f = \frac{OA + OB}{4} = \quad \text{m} \)

Result: Focal length of the convex lens = \( \quad \text{m} \)

Viva-Voce Questions with Answers

1. What is focal length of a lens?
   Paraxial rays incident on a lens, after refraction meet at point. Distance from this point to the optic centre of a lens is called focal length.

2. What do you mean by focal point of a lens?
   Paraxial rays incident on a lens, after refraction meet at point. This point is called focal point.

3. A lens made of glass is diverging parallel rays of light in air. What type of lens is it?
   Concave lens.

4. A lens made of glass is converging parallel rays of light in air. What type of lens is it?
   Convex lens.

5. Name one common use of a convex lens
   Convex lens is used as a simple microscope (reading lens). Convex lens is used in microscopes, telescopes.

6. A kid holds a lens in front of sun and burns a paper kept on the other side of the lens. Which lens must he be using?
   Convex lens.

7. A man is wearing convex lens as spectacle. What type of eye defect has he?
   Hypermetropia

8. For what position of object, will a convex lens produce virtual image?
   Objects within the focus.
Experiment no 12

REFRACTIVE INDEX OF GLASS

Aim:

To determine refractive index of glass slab using a travelling microscope.

Apparatus and materials used:

Travelling microscope, glass slab, reading lens, chalk powder, paper with ink mark.

Principle:

Objects kept inside a denser medium appear to be shifted up when viewed from a rarer medium. The amount shift is called normal shift and it depends on the refractive index of the medium and its thickness (or depth).

Refractive index of glass with respect to air is the ratio of real thickness of slab to its apparent thickness.

Formula:

1. Refractive index of glass with respect to air is,

\[ n_{oa} = \frac{\text{real thickness}}{\text{apparent thickness}} = \frac{R_3 - R_1}{R_3 - R_2} \]

Where \( R_1 \) is the microscope reading corresponding to ink mark without glass slab.

\( R_2 \) is the microscope reading corresponding to shifted image if ink mark.

\( R_3 \) is the microscope reading corresponding to the surface of glass slab.

2. Total reading in the microscope, \( R_1 = MSR + (CVD \times LC) \)

MSR-Main Scale Reading

CVD-Coinciding Vernier Scale Reading

LC -Least Count

Procedure:

1. Find the least count of the microscope scale, being used.

2. Put a mark on sheet of paper.

3. Place the paper on the horizontal platform of the microscope. Adjust the microscope in such a way that its lens system is vertically above the mark.

Focus the microscope on the mark and record the reading \( R_1 \)

4. using main scale reading(MSR) and vernier scale reading(VSR) of its coinciding division as shown in the table.

5. Next, place the glass slab over the mark on the sheet of paper.

Move the microscope upward until mark on the paper, seen through the glass slab is sharp and clear. Take the reading \( R_2 \)
6. with the main scale and coinciding division of the vernier scale.

7. Spread a little chalk dust over the top surface of the glass slab.

   Raise the lens system of the microscope and focus the microscope to see some of their particles clearly and record reading $R_3$.

8. Refractive index of glass is calculated using the formula,

$$ n_{ga} = \frac{\text{real thickness}}{\text{apparent thickness}} = \frac{R_3 - R_1}{R_3 - R_2} $$

Diagram:

![Diagram of Travelling Microscope setup](image)

Observations:

Value of one main scale division, $S = \ldots \ldots \text{cm}$

Number of divisions on the vernier scale, $N = \ldots \ldots \text{div}$

Least count of the travelling microscope, $LC = \frac{s}{N} = \ldots \ldots = \ldots \ldots \text{cm}$

<table>
<thead>
<tr>
<th>Trial no</th>
<th>Microscope reading corresponding to Ink mark</th>
<th>Microscope reading corresponding to image of ink mark with glass slab on ink mark</th>
<th>Microscope reading corresponding to image of Chalk Powder</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MSR</td>
<td>CVD</td>
<td>TR in cm</td>
</tr>
<tr>
<td>1</td>
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</table>

Calculations: $R_1 = MSR + (CVD \times LC)$  $R_2 = MSR + (CVD \times LC)$  $R_0 = MSR + (CVD \times LC)$
Refractive index of the glass \( n_{\text{glass}} = \frac{R_3 - R_1}{R_3 - R_2} \)

**Result:** Refractive index of the glass = ...........

**Viva-voce questions with answers**

1. What do you mean by refractive index of medium?
   Ratio of velocity of light in air to the velocity of light in medium.

2. Refractive index of a medium ‘A’ is more than that of ‘B’. In which medium does light travel comparatively faster?
   In B. (More the speed of light lesser will be the refractive index)

3. What is the refractive index of vacuum?
   One.

4. Bottom of a swimming pool appears to be nearer when seen from air. How does a coconut tree look when seen from a point inside water?
   Looks taller than in air.

5. Name the material which has high value of refractive index among water, glass and diamond.
   Diamond.

6. In which medium does light travel with maximum speed? What is its value?
   In vacuum. \( c = 3 \times 10^8 \text{ms}^{-1} \)

7. On what factors does the apparent depth depend?
   Real depth, refractive index of the medium in which the object is kept and refractive index of the medium from where the object is viewed.

8. In this experiment why is the apparent depth lesser than real depth?
   Because the object is in denser medium and the observer is in rarer medium.

9. Can apparent depth be more than the real depth?
   Yes. (When the object is in rarer medium and the observer is in denser medium)

10. What is the formula for real depth in the experiment?
    \( R_3 - R_1 \)

11. What is the formula for apparent depth in the experiment?
    \( R_3 - R_2 \)

12. Can you find the normal shift in the above experiment? How?
    Yes. By calculating \( R_2 - R_1 \).
Experiment no 13

FORWARD BIAS CHARACTERISTIC OF SEMICONDUCTOR DIODE

Aim:
To draw the I-V characteristic curve for a p-n junction diode in forward bias and hence to find cut in voltage.

Apparatus and materials required:
Semiconductor diode, milliammeter, plug key, connecting wires, voltmeter, rheostat, battery.

Principle:
When the positive terminal of the battery is connected to p-side of the diode and negative terminal of the battery is connected to n-side, the diode is said to be forward biased. Diode offers very low resistance during forward bias and current of the order of milli ampere flows through it.

Cut in voltage is the characteristic voltage of the diode after which current increases sharply during forward bias.

Procedure:
1. Circuit is constructed as shown in the diagram.
2. A small voltage is applied to the circuit by slight and gentle turning of the power supply knob. The voltmeter reading across the diode and the corresponding milliammeter reading are noted.
3. Gradually, the applied voltage is increased (in steps) in the circuit and the corresponding voltmeter and milliammeter readings are recorded in table.
4. (The value of current flowing through the diode is found to be negligibly small till the voltage across the diode exceeds the value of its cut in or threshold voltage. After the cut in voltage, the variation in current is rapid.)
5. Once the threshold voltage is reached, the diode voltage is varied very slowly noting the corresponding current 'I' flowing through the diode. It is continued till the current reaches the limit of the milliammeter.
6. A graph is plotted with V along X-axis and I along Y-axis.
7. Cut-in voltage (OP) is noted from the graph.
Circuit diagram:
Observations:

<table>
<thead>
<tr>
<th>V in volts</th>
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</thead>
<tbody>
<tr>
<td>I in mA</td>
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</table>

Calculation:

From the graph, OP= .............. Volts.

Result:

Cut-in voltage of the given diode= .............. Volts.

Viva-voce questions with answers

1. What is semiconductor?
   Material having electrical conductivity property between conductors and insulators.

2. How are semiconductors different from conductor in terms of their resistance?
   Resistance of semiconductors is more than conductors.

3. What do you mean by biasing a diode?
   Supplying energy to the junction is called biasing.

   The equilibrium barrier potential of a p-n junction diode can be altered by applying an external voltage across the diode. This is called biasing.

4. How do you forward bias a diode?
   By connecting p-side of the diode to positive of battery and n-side of the diode to negative of battery.

5. Name one application of a diode OR name an electronic circuit where semiconductor diode is used.
   Rectifier.

6. What is the difference between a semiconductor diode and a resistor?
   A resistor offers same resistance when current flows through it in both the directions. But a diode offers low resistance when current flows in one direction and very high resistance when current flows in opposite direction.
7. What do you mean by cut-in voltage?
   The forward voltage of the diode after which current increases sharply is called knee or cut in voltage.

8. What happens to junction resistance of a diode when it is forward biased?
   Decreases.

9. What are the resistance of the diode during forward bias?
   Less.
Experiment-14

ZENER DIODE CHARACTERISTICS

Aim:

To draw I-V characteristic curve for a zener diode in reverse bias and hence to determine its breakdown voltage.

Apparatus and materials required:

Zener diode, connecting wires, voltmeter, rheostat, key, battery.

Principle:

Zener diode is a special purpose diode designed to work in the reverse bias. At the breakdown region the reverse voltage remains constant for a large change in current. Thus zener diode acts as a voltage regulator.

Circuit diagram:
Procedure:

1. Circuit is constructed as shown in the diagram.
2. Rheostat is adjusted for a suitable value of voltage V. The corresponding value of I is noted.
3. Voltage is increased in small steps and each time corresponding value of current is tabulated.
4. A graph is plotted with V along negative X-axis and I along negative Y-axis.
5. Breakdown voltage is noted from the graph.

Observations:

| V in volts |   |   |   |   |   |   |
| I in μA    |   |   |   |   |   |   |

Calculations:

From the graph, breakdown voltage OP = .................Volts.

Result:

Breakdown voltage of the given diode = .................Volts.
Viva-voce questions with answers

1. What is zener diode?
   Zener diode is a special purpose semiconductor diode designed to operate under reverse bias in the breakdown region.

2. Name one common use of voltage regulator.
   As a voltage regulator.

3. What do you mean by zener breakdown?
   It is the condition in the reverse biased zener diode where no change in zener voltage occurs for any change in current.

4. What do you mean by avalanche breakdown?
   A process that occur in a diode when high voltage causes free electrons to travel at high speeds, colliding with other electrons and knocking them out of their orbits. The result is a rapidly increasing amount of free electrons.

5. How is zener diode different from ordinary semiconductor diodes?
   Zener diode is doped more heavily than ordinary diode. Ordinary diodes are not used in breakdown regions whereas zener diode is used in breakdown region.

6. Why do we use series resistance with the zener diode in reverse bias?
   To limit the flow of current.

7. What are the majority carriers in a p-region?
   Holes.

8. What are the minority carriers in a n-region?
   Holes.