AIM

To study the effect of intensity of light (by varying distance of the source) on a LDR (Light Dependent Resistor).

APPARATUS AND MATERIAL REQUIRED

LDR, two power supplies (12 V each), key, milliammeter (0-500mA), voltmeter (0-10V), a resistance of 47 Ω, a 12 V lamp, connecting wires.

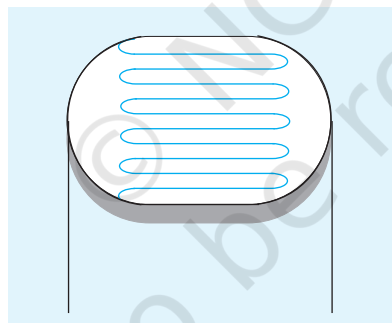# PRINCIPLE

Fig. A 7.1 *A Light Dependent Resistance (LDR).*

Light dependent resistor or a photoresistor is a device that is sensitive to light. Its resistance varies according to the intensity of light incident on it. It is made from a semiconductor material with light resistors to have light sensitive properties, one such materials is, cadmium sulphide. Snake–like tracks are made of cadmium sulphide on thin metal films [Fig. A 7.1]. LDR has a high resistance due to the fact that majority of electrons are locked into the crystal lattice and not free to move. As light falls on the lattice, some of the electrons get sufficient energy to break free the crystal lattice to conduct electricity. A typical LDR has a resistance of 1 MΩ in total darkness and a few hundred ohm resistance in bright light.

PROCEDURE

1. Assemble the circuit as shown in Fig. A 7.2.

2. First keep the lamp switched off. Plug in the key K.

3. Observe and record voltmeter and milliammeter readings.

4. Calculate the reference measurement of LDR resistance R′.

5. Add this value of resistance to all further measurements. This ensures that background illumination has been taken into account.

6. Set up a 12 V lamp on a fixed stand in vertical position facing LDR. Adjust LDR normally below the lamp at about 10 cm (say).

7. Observe milliammeter and voltmeter readings.

8. Changing the distance between lamp and LDR by 15 cm (say) repeat step 7. Record your observation and calculate resistance of LDR at different distances of the lamp.
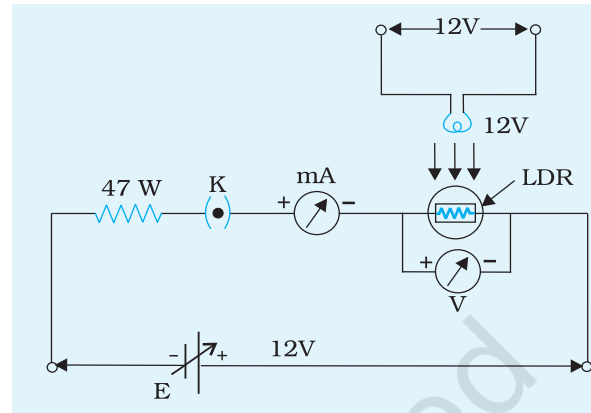

Fig. A 7.2 *Circuit to study the effect of intensity of light on a LDR.*

OBSERVATIONS AND CALCULATIONS

Range of voltmeter = 0 V to …V

Least count of voltmeter = …V

Range of milliammeter = 0 mA to …mA

Least count of milliammeter = …mA

Table A 7.1 : Variation in resistance of LDR with distance

Sl. No.	Distance between LDR and the source d cm	Voltmeter Reading V (V)	milliammeter Reading I (mA)	$R = \dfrac{V}{I} \Omega$	Actual value of resistance $(R + R') \Omega$
1					
2					
--					
5					

RESULT

As distance increases, intensity of incident light decreases and resistance of LDR increases.

PRECAUTIONS

1. LDR is placed normally to the light source so that angle of incidence of light rays remain constant and normal throughout the experiment.

2. All the connections should be made tight.

SOURCES OF ERROR

Background illumination is a source of error in this activity.

DISCUSSION

1. Calculate the product $R.d^2$ in each case. What do you infer?

2. LDRs are used especially in light or dark sensor circuit. It is used in automatic lighting, street light, smoke alarm etc.

3. A suitable resistance is connected in series with LDR to prevent it from damage.

SELF ASSESSMENT

Why does the resistance of LDR not remain constant?

SUGGESTED ADDITIONAL EXPERIMENTS/ACTIVITIES

1. Perform the above activity in totally dark room. Compare and discuss the result with that obtained with normal light in the laboratory.

2. Study the effect of intensity of light on an LDR by using bulbs of different power, keeping the distance same.

3. Provide variable voltage values to power up the light bulb and observe variations in resistance with intensity keeping the distance between LDR and bulb same.

4. Study the effect of intensity of light on LDR of different specifications.

ACTIVITY 8

AIM

To identify a diode, a LED, a transistor, an IC, a resistor and a capacitor from a mixed collection of such items.

APPARATUS AND MATERIAL REQUIRED

Multimeter, a collection of diode, LED, transistor, IC, resistor and capacitor.

PRINCIPLE

A diode is a two terminal device. It conducts when forward biased and does not conduct when reverse biased. It does not emit light while conducting.

A LED (light emitting diode) is also a two terminal device. It conducts when forward biased and does not conduct when reverse biased. It emits light while conducting.

A transistor is a three terminal device. The terminals represent emitter (E), base (B) and collector (C).

An IC (integrated circuit) is a multi-terminal device in the form of a chip. But some may have only three terminals, e.g. 7805, 7806, 7809, 7912.

A resistor is a two terminal device. It conducts equally in both directions.

A capacitor is a two terminal device. It does not conduct but stores some charge when dc voltage is applied.

PROCEDURE

1. Check the physical appearance of the component.

    (a) If it has four or more terminals and has the appearance of a chip (black rectangular block), then it is an IC.

(a)

(b)

(c)

(d)

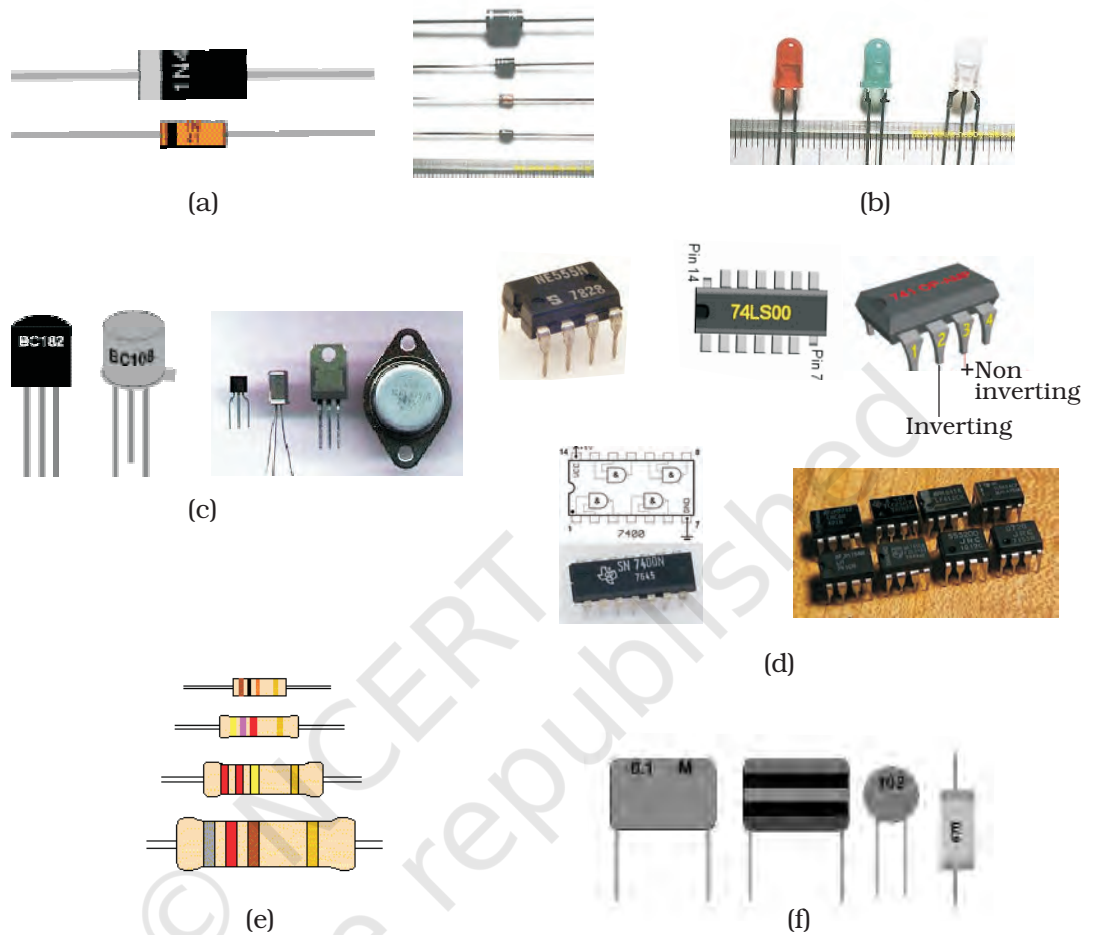+Non inverting

Inverting

(e)

(f)

Fig. A 8.1 (a) Diode (b) LED (c) Transistor (d) IC (e) Resistor (f) Capacitor

(b)   If it has three terminals, the component may be a transistor. To confirm, set-up the multimeter in resistance mode (highest range). Connect its black or common terminal to one of the extreme legs of the component and the second terminal (red or positive) to the central leg. Check the multimeter deflection. If a deflection is observed, interchange the multimeter terminals. If no deflection is observed, the component is a transistor. Repeat this test by connecting the multimeter terminals to the central leg and the other extreme leg. If a similar behaviour is observed, the component is a transistor.

(2)   If the component has two terminals, it could be a resistor, a capacitor, a diode or a LED.

(a) Look for colour bands, if it has a typical set of three colour bands followed by a silver or gold band, the component is a resistor.

(b) Connect the multimeter terminals (in resistance mode-highest range) to the component terminals and watch for multimeter deflection. Also repeat by reversing the component terminals.

(c) If the multimeter shows an equal deflection in both the directions, the component is a resistor.

(d) If the deflection is accompanied with emission of light, in one direction and a much less or zero deflection in the other direction the component is a LED.

(e) If the multimeter does not show any deflection in one direction and shows deflection with no light emission in the other direction then, the component is a diode.

(f) If the multimeter does not show any deflection on connecting its terminals either way to the component, it is a capacitor. But if capacitance of capacitor is large, multimeter may show a momentary deflection.

(g) Record your observations in Table A 8.1 and A 8.2.

Note to teachers

(i) Avoid giving an IC with three terminals.

(ii) Preferably use analog multimeter and not the digital multimeter.

(iii) In case of digital multimeter, the term "deflection" in the instructions may be read as "reading".

(iv) Label each component by a different alphabet e.g., A, B, C, D, E...

OBSERVATIONS

Table A 8.1 : Checking for the number of terminals

Sl.No.	No. of terminals	Alphabet marked on the device	Name of the Device
1	Two		
2	Three		
3	More than three		

Table A 8.2 : Checking for the state of conduction

Sl.No.	State of conduction	Device Code	Name of the device
1	Conducts in one direction only without any emission of light		
2	Conducts in one direction only with emission of light		
3	Three terminal device; conducts in one direction only between central terminal and either of the remaining two terminals		
4	Conducts in both directions		
5	Does not conduct, gives an initial deflection which decays to zero		

RESULT

A diode, a LED, a transistor, an IC, a resistor and a capacitor are identified respectively from a mixed collection.

PRECAUTION

While obtaining resistance of any component, clean its leads properly.

SOURCES OF ERROR

1. When the metal ends of a multimeter leads are touched, the multimeter should show zero resistance. If it does not show it, bring the pointer to zero using 'Zero Adj knob' on the multimeter. If it is not done, the resistance measurements are not reliable.

2. While checking resistance of a component, avoid touching either of the metal ends of the multimeter leads. Body resistance in parallel with component resistance can affect the resistance measurement.

Studies of the basic circuit components such as resistor, capacitor may be undertaken on the following lines:

1. Resistors

Types of resistors

(a) *Wire wound resistors:* These are made by winding a specified length of wire of some conducting material. The material may be any alloy like mangnnin, constantan, nicrome etc.*

(b) *Carbon resistors:* They are made of a mixture of graphite (a form of carbon) and a good insulator like shellac in a specified proportion. The mixture is pressed and moulded onto rods by heating. By varying this proportion, carbon resistors are made for a very wide range of values. The stability of such resistors is poor but they are cheap and small.

(c) *Carbon film resistors**:* Carbon resistors are cheap and easily available. A thin film of carbon is deposited onto a small ceramic rod. The resistive coating is spiralled on it to get the desired value of resistance.

(d) *Thin film resistors:* These are made by depositing a very thin film of a conducting material on some insulating base. The thin film provides a very small cross-sectional area. Hence a large resistance. The films may be made from a metal or an alloy.

Tolerance of a resistor

The actual resistance value of a certain resistor may be different from its specified value. This may be due to external influences like changes in temperature, humidity etc. or due to the inherent limitation in manufacturing a given precise value. Deviations in the resistance value due to later cause is known as tolerance.

Wattage of a resistor

Every resistor has a maximum safe current that it can carry. Currents larger than that will produce excessive heat and may damage it. This is usually measured not in terms of the current, but in terms of maximum watt of power that can be dissipated in the resistor without causing any damage. It is known as its wattage. Common wattages for carbon resistors are 1/8, 1/2, 1 and 2 watts. Higher wattages are also available.

Colour code for resistor

Most common colour code used for resistor consists of three colour bands at one end.

* Wire wound resistors have more undesirable inductance than the other types of resistors.
**See appendix 3 for details.

The colour and their numerical meanings are:

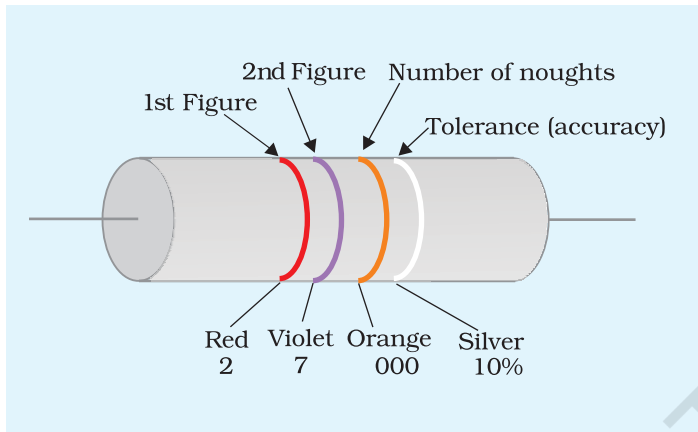|			
Black – 0	Orange – 3	Blue – 6	White – 9
Brown – 1	Yellow – 4	Violet – 7	
Red – 2	Green – 5	Grey – 8	

Fig. A 8.2 *A carbon resistor with colour code marking*

This colour code could be remembered easily by the term BBROY GB VGW (B B ROY Great Britain Very Good Wife). To read the resistance of a colour coded resistor, start with the strip nearest to the end. The colour of the first strip gives the first digit in the resistance value. The colour of the second strip stands for the second digit. The colour of third strip indicates the value of multiplier or the number of zero following second number.

Resistors with only three bands have a tolerance of 20%. Its actual value may vary 20% up or down from its indicated value. If a fourth band is added separated from the first three, then the tolerance of the resistor is known from the colour of the fourth band. If the colour of the fourth band is silver, then tolerance is 10%. Gold colour represents 5% tolerance red represents 2% and brown represents 1%. The ohmic values are often printed on 2% and 1% resistors.

2. Capacitor

Capacitor is a device that stores electrical charge. A capacitor blocks the passage of dc while it allows ac to flow through it.

There are many types of capacitors having different types of dielectrics in general use. These are

(i) Air capacitor (variable gang capacitors)

(ii) Mica capacitor (low capacitance)

(iii) Ceramic capacitor (very low capacitance)

(iv) Paper capacitor (low capacitance)

(v) Plastic capacitor

(vi) Electrolytic capacitor (medium capacitance)

(vii) Oil filled capacitor (high capacitance)

3. Diode

In some semiconductor junction diodes, a silver ring is shown on one of its end. This end of the diode is n-side and the other end is p-side [Fig. A 8.3(a)]. In some diodes, the symbol of the diode is painted on the body of the diode. The direction of arrow is the direction of current flow. Hence, the side from which the arrow starts is p-side and the side towards which the arrow ends is n-side [Fig. A 8.3 (b)]. Some diodes are bullet shaped in which case the flat side is p-side and the cylindrical side is n-side [Fig. A 8.3 (c)]. In case of a light emitting diode (LED), usually the shorter pin is n-side and the longer pin is p-side [Fig. A 8.3 (d)].
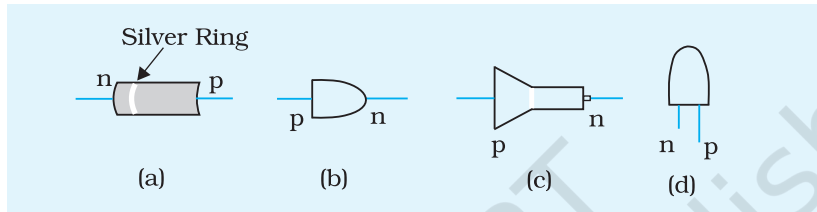

Fig. A 8.3 *Shapes of some diodes*

4. Transistors

In this activity, a method to distinguish between n-p-n and p-n-p type transistors has been given, provided the pin diagram of the transistor is known. In case, if no pin diagram is known, one can still determine the type (n-p-n or p-n-p) of the given transistor. This can be done by measuring the resistance values between different terminals of the given transistor [(Fig. A 8.4) (a) and (b)]. Table A 9.5 (p.181) summarises the nature of resistance values for n-p-n and p-n-p transistors.
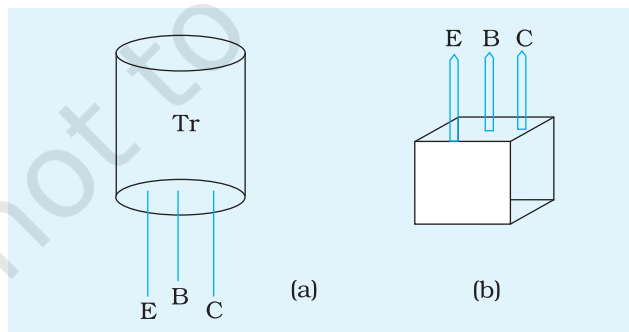

Fig. A 8.4 *Different transistor terminals*

A_{IM}

Use of Multimeter to

(A) check whether the diode is in working order and to check unidirectional flow of current in a diode; (B) identify emitter, base collector of a transistor; (C) distinguish between n-p-n and p-n-p transistors and check whether the transistor is in working order.

A_{PPARATUS AND MATERIAL REQUIRED}

A multimeter, a diode, a transistor (whose base diagram is known), plug key, a battery, resistance box, connecting wires and sand paper.

P_{PRINCIPLE}

Analog multimeter used in resistance mode

In this selection a circuit with a battery and resistors come into play. The circuit diagram below (Fig. A 9.1) indicates the main circuit components: a 3V battery (provided in the multimeter), a fixed resistance, a rheostat and a galvanometer G. Red and black leads are connected at fixed resistance ends B and A respectively.
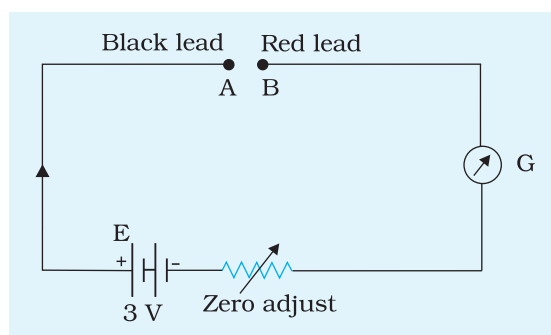

Fig. A 9.1 *Multimeter in resistance mode*

The deflection is adjusted to full scale deflection (zero mark on the scale), using the rheostat (zero adjust) by first shorting the red and black leads. Any resistance which has to be tested/evaluated is placed between A and B. The deflection due to current in the circuit is calibrated to read the resistance.

You will notice that the black lead is actually connected to the positive and red to the negative of the internal 3 V battery. While measuring values of resistances, it is immaterial how they are connected across A and B. However, it becomes important when this battery also provides the bias for a diode or a transistor junction.

(A) Checking whether a diode is in working order and whether flow of electric current is unidirectional through it

A semiconductor junction diode, when connected (or biased) in the forward direction, offers a low resistance. However, when it is biased in the reverse direction, it offers a very high resistance. Therefore, the working of a junction diode can be examined by measuring its resistance in the forward and reverse bias conditions. The functioning of junction diode can also be examined by checking the unidirectional flow of current in a circuit as shown in Fig. A 9.2. For a diode in proper working order, a substantial current (of the order of few mA) will flow in the

Fig. A 9.2 *A semiconductor junction diode in the forward bias*

forward bias condition. If the polarity of the bias is reversed (i.e., diode in reverse bias condition), negligible current (of the order of few μA) will flow.
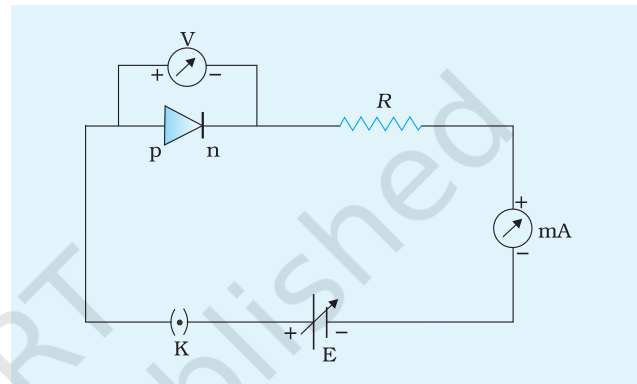
(B) Identification of emitter, base and collector of a transistor

In general, each transistor has three pins of the same size. In some transistors a dot or mark is put on the body near one of the pins. This pin is the emitter. The Emitter (E), Base (B) and Collector (C) of a transistor can be identified using its pin diagram. Fig. A 9.3 shows the base diagram of a typical metal capped cylindrical transistor. This has been drawn by keeping the pins of transistor pointing upwards. In fact, there is no universal pin diagram for the transistors. One can find the pin
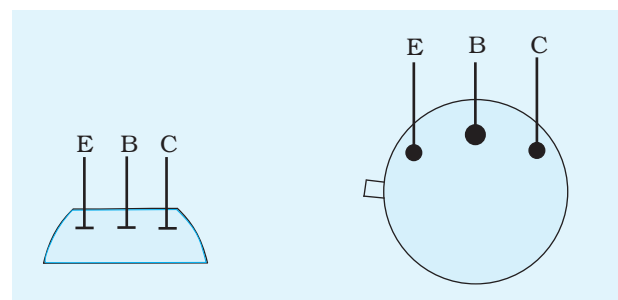

Fig. A 9.3 *Base diagram of a typical metal-capped cylindrical transistor. Note that the pin connections may be different for different transistors. It is advisable to refer to the manufacturer's data sheet.*

diagram of a given transistor (transistors have code numbers AC 127, BC548, 2N3055HL 100 etc.) in most transistor manuals.

(C)   Distinguishing between n-p-n and p-n-p transistors and checking whether the given transistor (p-n-p or n-p-n) is in working order
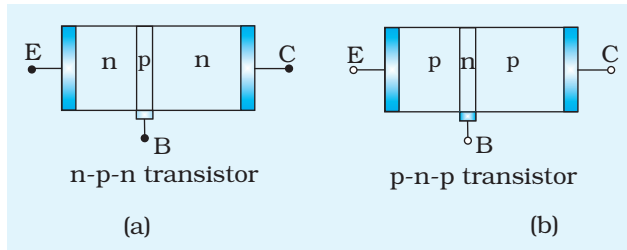

Fig. A 9.4 *Schematic representation of (a) n-p-n, and (b) p-n-p transistors*

The base B of an n-p-n transistor is p-type material whereas emitter E and collector C are of n-type materials (Fig. A 9.4 a). Therefore, the forward resistance between the base B and the emitter E (or collector C) should have a low value. In case of a p-n-p transistor (Fig. A 9.4 (b) (whose emitter E, base B, and collector C are p-, n- and p-type materials respectively), the forward resistance between the emitter and base should be low.

The resistances between the base-emitter, and base-collector are measured. For a transistor in working order, resistance values follow the results as shown in Table A 9.1.

Table A 9.1 : Resistance values between different terminals of n-p-n and p-n-p transistors

Sl.No.	One of the transistor terminals (B, C or E) connected to negative lead (black) of the multimeter	Transistor terminal connected with positive (red) lead of the multimeter	Bias	Resistance

A. For n-p-n transistor

1	E	B	Forward	Low
2	C	B	Forward	Low
3	B	C	Reverse	Very high
4	B	E	Reverse	Very high

B. For p-n-p transistor

1	B	E	Forward	Low
2	B	C	Forward	Low
3	E	B	Reverse	Very high
4	C	B	Reverse	Very high

Any deviation from the results shown in Table A 9.1 would indicate that the given transistor is not in working order. For example, for an p-n-p transistor, a low resistance value between terminal E (when connected with the negative lead of the multimeter) and terminal B (when connected with positive lead of the multimeter) indicates that the transistor's terminals E and B are short-circuited. For a working transistor, it should have shown very high resistance, being reverse biased.

PROCEDURE

1. The diodes, transistors, and connecting wires may have some insulating layers on their surface if they are not used for a long time. Therefore, clean their ends using a sand paper till they shine.

(A) Checking whether a diode is in working order and whether flow of electric current is unidirectional through it

2. Set the multimeter in resistance measuring mode.

3. Connect the diode terminal 1 with the positive lead of the multimeter and terminal 2 with the negative lead of the multimeter. Measure the diode resistance. Reverse the diode connections and again measure the diode resistance. Record your observations in Table A 9.2. Also conclude whether the given diode is in working order or not.

Note: A low value of diode resistance (ranging from few Ω to kΩ) indicates that the diode is connected in forward bias. While a very high value of resistance (of the order of MΩ), indicates that the diode is connected in reverse bias.

If both the resistance values, i.e., in reverse and forward directions, are low then it means that the diode is short-circuited. On the other hand if both the resistance values are very high, then the diode junction may be considered as discontinuous or open. Thus, in both the conditions, the diode condition may be concluded as not in working order.

4. Identify the p-and n-terminals of the given diode from the observations.

5. Connect the diode with the cell and resistance box in a series circuit (without key ON) as shown in Fig. A 9.2. Set the multimeter in current measuring mode at a suitable range (mA, start from high current range).

6. Take out a suitable resistance R from the resistance box in the circuit to restrict the current within the current range chosen (in the multimeter). Put the key ON and measure the current flowing through the circuit. Record your observations in Table A 9.3.

7. Repeat step 6 for a few more values of resistance R in the circuit.

8. Reverse the polarity of diode (now the diode is reverse biased) and repeat steps 6 and 7.

(B) and (C) Identifying n-p-n and p-n-p transistors and checking whether the given transistor (p-n-p or n-p-n) is in working order

9. Identify the emitter E, base B, and collector C of the given transistor by observing dot or a mark on the body of transistor near one of its pins. Draw the base and schematic diagrams of the given transistor in your notebook.

10. Set the multimeter in 'resistance measuring mode'.

11. Connect the positive (red) lead of the multimeter with the base and negative led (black) with emitter (or collector) terminal and measure the resistance. Record the observations in Table A 9.4.

12. Reverse the connections of the multimeter and again measure the resistance values between the transistor's base B and emitter E (or collector C) terminals. Record observations in Table A 9.4.

13. From Table A 9.4, check whether the given transistor is in working order or not.

14. For a transistor that is in working order, using the information given in Table A 9.1, infer the nature of the given transistor (n-p-n or p-n-p).

OBSERVATIONS

1. Table A 9.2 : Measurement of diode resistance

Sl. No.	Diode terminal connected with the positive lead of the multimeter	Diode terminal connected with the negative lead of the multimeter	Resistance (Ω)
1	1	2	
2	2	1	

2. Table A 9.3 : Unidirectional flow of current through a diode

(a) When diode is connected in forward bias

Sl. No.	Resistance (Ω)	Current (mA)
1		
2		

(b) When diode is connected in reverse bias

Sl. No.	Resistance (Ω)	Current (mA)
1		
2		
3		

3. Table A 9.4: Resistance values between different transistor terminals

Sl. No.	Transistor terminal connected with the positive lead of the multimeter	Transistor terminal connected with the negative lead of the multimeter	Resistance (Ω)
1	B	E	
2	B	C	
3	E	B	
4	C	B	

RESULT

1. The p- and n-sides of the given diode are identified from Table A 9.2.

2. The given diode is/is not in working order (from Tables A 9.2 and A 9.3)

3. The unidirectional flow of current in a diode has/has not been realised (from Table A 9.3).

4. The three terminals of the given transistor have been identified and the pin diagram has been shown in Fig. A 9.3.

5. The given transistor is n-p-n/p-n-p (from Table A 9.4).

6. The given transistor is/is not in working order (from Table A 9.4).

PRECAUTIONS

1. While obtaining resistance of any component, clean its leads properly.

2. Use the selector switch of the multimeter carefully for various measuring modes.

SOURCES OF ERROR

1. When the metal ends of multimeter leads are touched, the multimeter should show zero resistance. If it does not show this, bring the pointer to zero using 'zero Adj knob' on the multimeter. If it is not done, the resistance measurements are not reliable.

2. While checking resistance of a component, avoid touching both the metal ends of the multimeter leads. Body resistance in parallel with component resistance can affect the resistance measurement.

DISCUSSION

1. In a transistor, the junction joining the base region and the emitter region is called base-emitter junction. The junction joining the base region and the collector region is called base-collector region.

2. When multimeter is in current measuring mode, shunt resistance of different values are introduced in the circuit paralleled with the coil. In voltage measuring mode resistances of different values come in contact with the circuit in series with the coil. When you select the switch of the multimeter for measurement of resistance, different resistances are introduced in circuit in series with the cell of the multimeter.

SELF ASSESSMENT

Find the base of a transistor if pin diagram is not available. You may use the Table A 9.5 for this purpose.

Using the results given in Table A 9.5, it can be determined whether the given transistor is n-p-n or p-n-p type.

Table A 9.5 : Nature of resistance values between different transistor terminals (when pin diagram is not known)

(Note: Here terminal 2 is assumed as the base pin of transistor)

Sl. No.	Transistor terminal connected with the positive lead of the multimeter	Transistor terminal connected with the negative lead of the multimeter	Nature of resistance
A. For n-p-n transistor			
1	1	2	Very high
2	1	3	Very high
3	2	1	Low
4	2	3	Low
5	3	1	Very high
6	3	2	Very high
B. For p-n-p transistor			
1	1	2	Low
2	2	1	Very high
3	1	3	Very high
4	3	1	Very high
5	2	3	Very high
6	3	2	Low

AIM

To observe refraction and lateral deviation of a beam of light incident obliquely on a glass slab.

APPARATUS AND MATERIAL REQUIRED

Drawing board, rectangular glass slab, white sheet of paper, adhesive tape (cello-tape), drawing pins, a metre scale, alpins, protractor, sharp pencil and eraser.

PRINCIPLE

When a ray of light is incident on a rectangular glass slab, it is refracted through it. It emerges out of the slab parallel to the direction of the incident ray. The emergent ray suffers only a lateral displacement. For a given angle of incidence and a pair of media, the lateral deviation is proportional to the thickness of the glass slab.

PROCEDURE

1. Fix a white sheet of paper on the drawing board with the help of cello-tape or drawing pins.

2. Place the glass slab lengthwise symmetrically at the centre of the paper sheet and mark its boundary ABCD (Fig. A10.1) on the paper sheet with a sharp pencil.

3. Draw a normal at a point F on the face AB. Draw a line EF, representing the incident ray, making an angle i the angle of incidence with the normal.

4. Fix two alpins P and Q with sharp tips, about 8 to 10 cm apart, vertically on the line EF.

5. Observe the images of the two pins through the face opposite of the glass slab. Fix two more alpins R and S

about 8 to 10 cm apart, vertically on the white paper sheet carefully with their tips in line with the tips of the images of P and Q. Take care that the tips of all the alpins appear to be on a straight line.

6. Remove the glass slab and mark the pin prick positions of the alpins on the white paper sheet with a pencil. Draw a straight line GH, representing the emergent ray, passing through the points marked R and S, meeting the face CD at G.

7. Draw the line FG to represent the refracted ray. Draw a normal at the point G on the face CD; making an angle of emergence *e* with the normal. Measure the angle of incidence *i* and angle of emergence *e* with a protractor. Write the values of these angles on the white paper sheet. Do you find some relation between ∠*i* and ∠*e*?

Fig. A10.1 *Refraction through a rectangular glass slab*

8. Extrapolate EF forward to meet the face CD of the glass slab at O. Draw the perpendicular OL to the line GH.

9. Check if the emergent ray GH is parallel to the incident ray EF along the original direction. It is laterally deviated by a perpendicular distance OL. Measure the lateral deviation OL = *d* and also the thickness of the glass slab.

10. Repeat steps 2 to 9 by changing the angle of incidence.

11. Repeat the steps 2 to 10 by using glass slabs of different thickness. Measure the lateral deviation and the thickness of the glass slab each time. Also write the values of ∠*i* and ∠*e* on the white paper sheet each time.

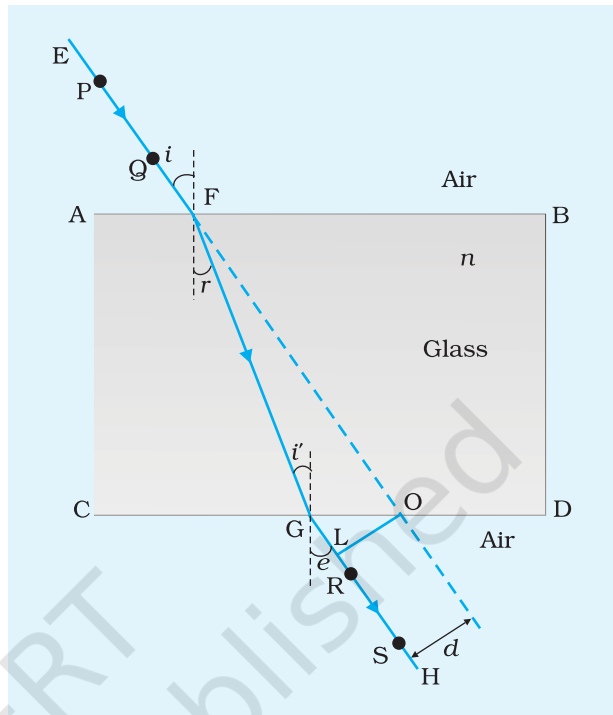12. Record observations in tabular form with proper units. What inference do you draw from your observations?

OBSERVATIONS

Least count of the protractor = ... (degree)

Least count of the metre scale = ... mm = ... cm

Table A 10.1 : Measuring the angle of incidence *i*, angle of emergence *e* and lateral deviation *d*.

Sl. No.	Thickness of the Glass slab, t 10^{-2} m	Angle of incidence i		Angle of emergence e		Lateral devia-tion d 10^{-2} m
		(degree)	(radians)	(degree)	(radians)	
1	t_1					
2	t_1					
--	--					
5	t_1					
6	t_2					
--	--					
10	t_2					
11	t_3					
--	--					

RESULT

1. The ray of light emerging from a glass slab is parallel to the incident ray direction, but is laterally deviated.

2. The lateral deviation of the emergent ray with respect to the incident ray is directly proportional to the thickness of the glass slab.

DISCUSSION

1. The accuracy in the measurement of angles of incidence *i* and emergence *e* and the lateral deviation *d* depends on how sharp the pin tips are, and how careful you are in observing the tips of the pins to lie along the same straight line. Take special care in observing the tips of the pins, marking the pin pricks, drawing the incident, refracted and emergent rays with a sharp pencil, and measuring the angles *i* and *e*, accurately with a protractor.

SELF ASSESSMENT

1. Examine Table 10.1 and interpret the relationship between $\angle i$ and $\angle e$, and between t and d.

2. Plot a graph between lateral deviation d along the y-axis and thickness t of the glass slab along the x-axis using the observed values from Table 10.1 keeping the angle of incidence same. Identify the shape of the graph you have obtained and interpret it.

SUGGESTED ADDITIONAL EXPERIMENTS/ACTIVITIES

1. From the observations with the glass slab placed lengthwise, breadthwise and thicknesswise, find out the refractive index of the material (glass) of the slab. Discuss your result.

   [Hint: Use $\sin i / \sin r = n$ (refractive index of the material)]

2. Measure the angle i' in each case of the above observations. Calculate the ratio $\dfrac{\sin i'}{\sin e} = n'$. What is the relation between $\angle r$ and $\angle i'$ and also between $\angle i$ and $\angle e$? Compare the ratio n' with $\dfrac{\sin i}{\sin r} = n$. Remember that the ray FG is the incident ray on face CD and GH is the refracted ray. Discuss the relation between n and n'.

AIM

To observe polarisation of light using two polaroids.

APPARATUS AND MATERIAL REQUIRED

Two polaroid sheets, source of light/sunlight, card board, a pair of scissors, white paper, glue.

TERMS AND DEFINITIONS

A light wave consists of a varying electric field vector **E** and a varying magnetic field vector **B**, which are perpendicular to each other. Each of these field vectors are also perpendicular to the direction of propagation of the wave.

(i) *Unpolarised light:* The orientation of electric vector is not confined to one direction only but in all directions randomly, transverse to the direction of propagation.

(ii) *Plane or linear polarisation:* Light waves are said to be plane/linearly polarised if the electric field vector **E** is restricted to one direction in a plane normal to the direction of propagation.

(iii) *Polaroid:* A polaroid consists of long chain molecules aligned in a particular direction. The electric vectors (associated with the propagating light wave) along the direction of the aligned molecules get absorbed. Thus, if an unpolarised light wave is incident on such a polaroid, then the light wave will get linearly polarised with the electric vector oscillating along a direction perpendicular to the aligned molecules. This direction is known as the *pass-axis* of the polaroid.

Plastic sheets of synthetic substances are commonly used in sun glasses, calculator and digital watch.

(iv) *Polariser and analyser:* When the passage of light through two polariods is studied, the transmitted fraction of intensity falls between 1 to 0 as the angle between the axis of their transmission varies from 0 to 90. The first polaroid next to the

source being used is called the polariser and the second polaroid used is called analyser.

PRINCIPLE

Natural light is associated with electric vectors normal to the direction of propagation and lying in all possible planes passing through the light beam. However, all these vectors can be resolved along two mutually perpendicular directions.

Every polaroid has an axis of transmission such that when the polaroid is placed normal to the path of an unpolarised light beam, the component of electric vector associated with it and parallel to the axis of transmission is allowed to pass through and the transmitted light is plane polarised. This can be checked by rotating another polaroid placed next to the first polaroid along the beam of light, (Fig. A11.1) a position comes for which the transmitted intensity vanishes. This position corresponds to the situation when the axis of transmission of the two polaroids are perpendicular to each other. When these axes are parallel to each other, the transmitted intensity attains a maximum value. Hence, the fractional intensity ranges between 0 and 1 as the two polaroids in the path of light beam are rotated with respect to each other.
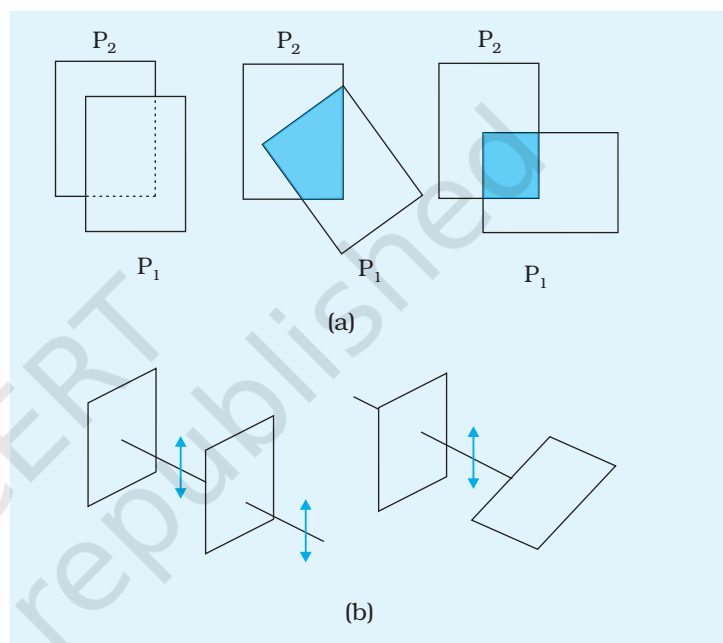

Fig. A 11.1 *(a) Passage of light through two polaroids P_2 and P_1. The transmitted fraction falls from 1 to 0 as the angle between them varies from 0° to 90°. Notice that the light seen through a single polaroid P_1 does not vary with angle. (b) Behaviour of the electric vector when light passes through two polaroids. The transmitted polarisation is the component parallel to the polaroid axis. The double arrows show the oscillations of the electric vector.*

PROCEDURE

(a) Making a circular scale for angle measurement

1. Take a card board. Paste a white paper on it. Draw a circle of radius 10 cm on the white paper.

2. Cut the circle with a pair of scissors.

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3. Mark angular divisions on the circle as shown in (Fig. A 11.2).

4. Cut a hole at the centre of the circle such that your polariser fits in the circle. Attach the polaroid in the hole (Fig. A 11.3).

5. Prepare a similar scale for analyser.

(b) Observing Polarisation

1. Take a polaroid piece P_1 (also known as polariser) and hold it in front of your eye and observe light from any source.

2. Take the other polaroid (also known as analyser) and put it over the first polaroid P_1 and observe the light through the combined system.
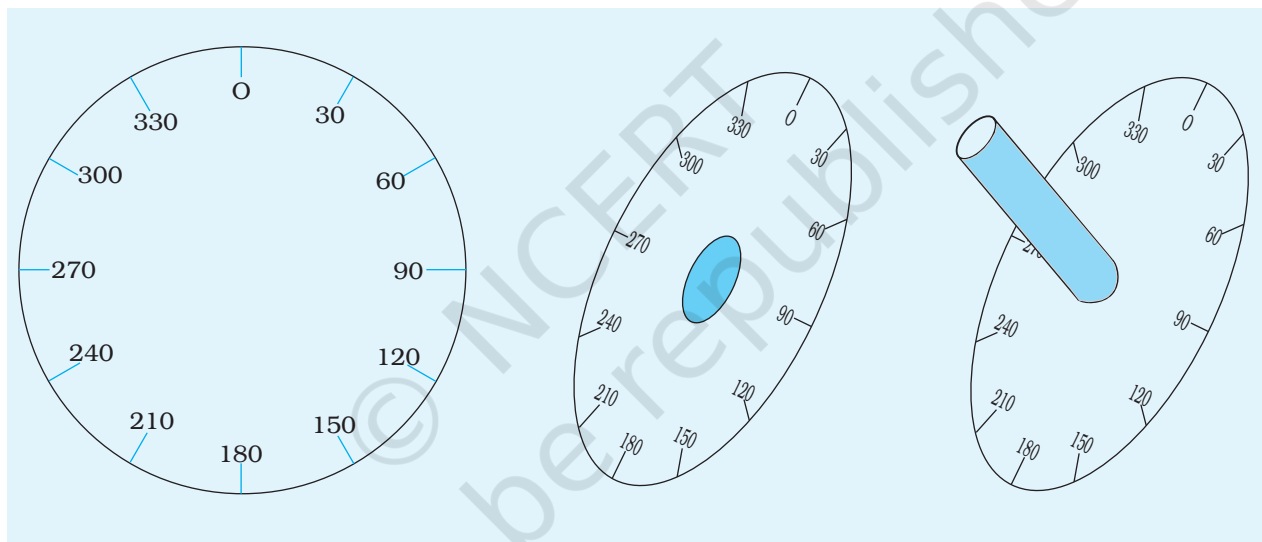

Fig. A 11.2 *Circle with angular division*

Fig. A 11.3 *Circular scale for angle measurement*

3. Rotate analyser to get maximum intensity of emerging light. Note down the difference between scale readings.

4. Now rotate the analyser so that you get zero intensity of emerging light. Note down the difference between scale readings.

OBSERVATIONS

1. Difference between scale readings for maximum intensity, $a = \ldots°$.

2. Difference between scale readings for minimum intensity, $b = \ldots°$.

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3. Rotation of analyser from maximum intensity to minimum intensity
$a - b$ = ... °

RESULT

The angle through which the intensity changes from maximum to minimum =... °

PRECAUTION

Care should be taken to handle the polaroids carefully so as not to leave finger prints.

DISCUSSION

While observing light from some source through a polariser there is no change in the intensity of light. What can you say about its polarisation condition? How does an analyser make it possible to detect polarisation condition?

SELF ASSESSMENT

1. What do you understand by polarisation of light?

2. Can sound waves be polarised?

3. Name the crystals commonly used for polarising light.

4. Name a source of light which directly gives plane polarised light.

5. Study polarisation of sunlight by different methods (polarisation by scattering, reflection).

SUGGESTED ADDITIONAL EXPERIMENTS/ACTIVITIES

1. Take a photodiode for light intensity measurement. Connect it properly with a multimeter so that it glows. By rotating the analyser through different angles, note down the variations in transmitted intensity. Plot appropriate graph to verify Malus law, $I = I_0 \cos^2\theta$
where I_0 is the intensity of light at $\theta = 0°$ and I is the intensity of light at an angle θ.
2. Give a write up to show how this activity can be used to demonstrate transverse nature of light?

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