DELHI PUBLIC SCHOOL

PHYSICS INVESTIGATORY PROJECT

Variation of Current in an LDR Circuit

A study of how the current through a Light-Dependent Resistor changes with the power and the distance of the illuminating lamp

SUBMITTED BY

Aakrati Billaiya

CLASS

Class XII – B

SUBJECT

Physics

SUBMITTED TO

Mrs. Mini Gupta

ACADEMIC SESSION

2026 – 27

CERTIFICATE OF COMPLETION

Certificate

This is to certify that

Aakrati Billaiya

a student of Class XII – B, has successfully completed this Physics Investigatory Project entitled

“Variation of Current in an LDR Circuit — a study of the effect of source power and distance on the current through a Light-Dependent Resistor”

during the academic session 2026 – 27, in partial fulfilment of the AISSCE Physics practical examination. The work is original and was carried out under my guidance and supervision.

Mrs. Mini Gupta
Subject Teacher (Physics)

Principal
School Seal & Signature

SECTION · 01

Acknowledgement

I would like to express my deep and sincere gratitude to my Physics teacher, Mrs. Mini Gupta, whose expert guidance, constant encouragement and patient supervision made this investigatory project possible. Her thoughtful suggestions at every stage — from the choice of the topic to the final analysis of the readings — have been invaluable, and her enthusiasm for the subject has been a continual source of inspiration to me.

I am sincerely grateful to our respected Principal and to the school management for providing me with a well-equipped physics laboratory and the apparatus needed to carry out this experiment. I also wish to thank the laboratory staff for their kind cooperation in arranging the various components and instruments used in the project.

My heartfelt thanks go to my parents, whose constant support and encouragement gave me the confidence to undertake and complete this work, and to my friends and classmates for their helpful discussions and suggestions, which made this project a genuinely enjoyable learning experience.

Finally, I thank the Almighty for granting me the health, strength and perseverance needed to see this project through to completion.

— Aakrati Billaiya, Class XII – B

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SECTION · 02

Introduction

A Light-Dependent Resistor (LDR), also known as a photoresistor or photoconductive cell, is a passive two-terminal electronic component whose electrical resistance changes with the intensity of the light falling on it. Unlike an ordinary resistor, whose resistance is fixed, the resistance of an LDR is very high in the dark and becomes low in bright light — a property that makes it one of the most widely used light-sensing elements in electronics.

An LDR is made from a thin, zig-zag strip of a high-resistance semiconductor, most commonly cadmium sulphide (CdS), deposited on an insulating base and sealed inside a transparent case. In darkness the semiconductor contains very few free charge carriers, so it conducts poorly and its resistance is extremely high — often several mega-ohms.

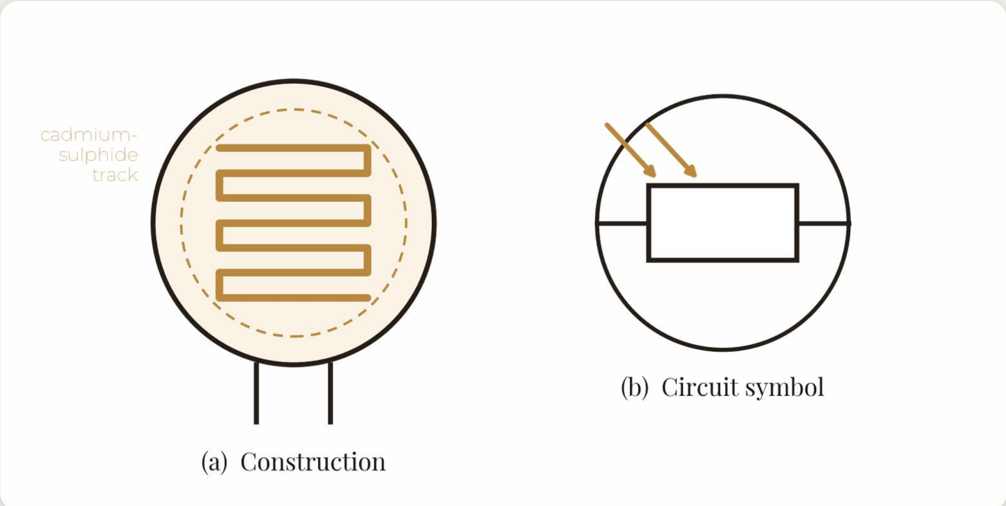


Fig. 1 — A Light-Dependent Resistor: (a) its construction, with a meandering cadmium-sulphide track, and (b) its circuit symbol (the arrows denote light).

When light falls on the material, photons whose energy exceeds the band-gap energy of the semiconductor are absorbed. Each absorbed photon raises an electron from the valence band into the conduction band, creating a free electron and a positive hole. These extra charge carriers allow the material to conduct far more easily, so its resistance drops sharply — to only a few hundred ohms in bright light. This increase of conductivity on exposure to light is called photoconductivity, and it is the central idea of this project.

The fall in resistance depends on how strongly the LDR is illuminated, and the illumination depends both on the power of the source and on its distance. In this project the LDR is connected in a simple series circuit with a source of EMF and a milliammeter, and the current is measured as the illumination is varied in two independent ways — first by changing the power of an incandescent lamp at a fixed distance, and then by changing the distance of a lamp of fixed power — so that the response of the LDR can be studied.

SECTION · 03

Aim & Objectives

Aim

To study the variation in the current flowing through a circuit containing a Light-Dependent Resistor (LDR), caused by a variation in:

- (a) the power of the incandescent lamp used to illuminate the LDR, keeping the lamp at a fixed distance; and
- (b) the distance of an incandescent lamp of fixed power used to illuminate the LDR.

Objectives

1. To understand the working principle of an LDR and the phenomenon of photoconductivity.
2. To set up a series circuit containing an LDR, a milliammeter and a source, and to measure the current under different conditions of illumination.
3. To study how the circuit current varies with the power of the illuminating lamp at a constant distance, and with the distance of the lamp at a constant power.
4. To relate the observed behaviour to the inverse-square law of illumination and to the photoconductive nature of the LDR.

Variables Studied

- Independent variables — the power of the lamp (Part A) and the distance of the lamp (Part B).
- Dependent variable — the current flowing in the circuit, read on the milliammeter.
- Controlled variables — the EMF of the source, the particular LDR used, the rheostat setting, the surrounding light, and whichever of distance or power is held fixed in each part.

SECTION · 04

Importance of the Study

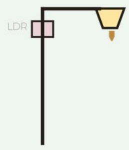
Although it is performed with very simple apparatus, the study of an LDR is important for a number of reasons that range from fundamental physics to everyday technology:

- It provides a clear and direct demonstration of photoconductivity — the increase in the conductivity of a semiconductor when it is illuminated — and so brings to life the band theory of solids studied in the Class XII syllabus.
- It shows how the illuminance of a surface depends on the power of a light source and on its distance, the latter obeying the inverse-square law of illumination, and allows these relationships to be examined experimentally.
- LDRs are used in a great many practical devices — automatic street lights that switch on at dusk, the light meters of cameras, burglar and fire alarms, automatic door systems and industrial light-sensing equipment — so an understanding of their behaviour has real engineering value.
- It develops important laboratory skills, including the construction of an electrical circuit, the careful control of variables, the accurate reading of a meter and the graphical analysis of recorded data.
- It links the abstract theory of the classroom to a tangible, low-cost and easily repeatable experiment, helping to build genuine scientific understanding.

SECTION · 05

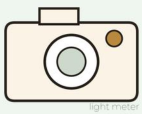
Applications of LDRs

The light-sensing behaviour of the LDR is put to use in a great many everyday and industrial devices. Four important applications are shown below.



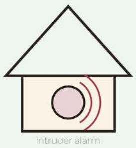
Automatic Street Lights

An LDR switches the lamp on at dusk and off at dawn as the daylight fades, saving electricity.



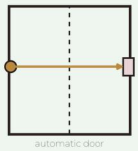
Camera Light Meters

An LDR measures the available light so the camera can set the correct exposure automatically.



Burglar & Fire Alarms

A beam of light is kept on an LDR; interrupting the beam changes the current and triggers the alarm.



Automatic Doors & Counters

Breaking a light beam on an LDR opens a door or advances a counter on a production line.

In each case the LDR acts as a light-controlled switch or sensor — exactly the behaviour examined in this project.

Theory — Photoconductivity

Photoconductivity

A semiconductor such as cadmium sulphide has a moderate energy gap between its valence and conduction bands. In the dark only a very few electrons can cross this gap, so there are few free charge carriers and the resistance is very high. When light falls on the material, a photon whose energy hf exceeds the band-gap energy is absorbed by an electron, lifting it into the conduction band and leaving behind a positive hole. Both are then free to carry current, so the brighter the light, the more carriers are produced and the lower the resistance becomes. This is called photoconductivity.

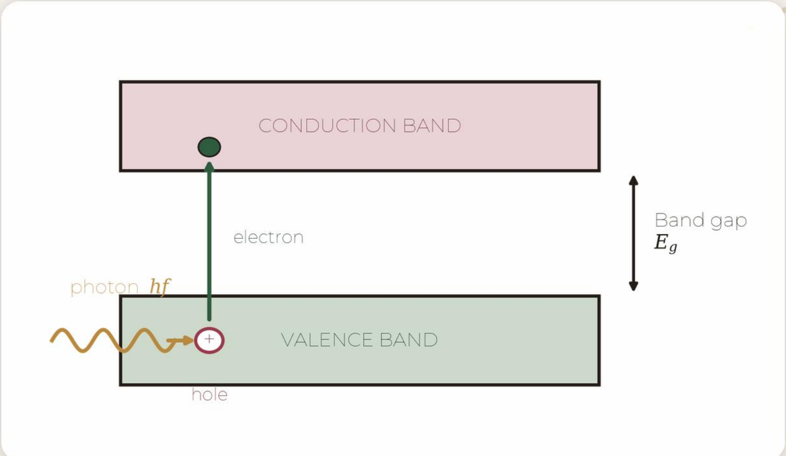


Fig. 2 — A photon raises an electron across the band gap, leaving a hole and raising the conductivity.

How the Resistance Depends on Light

The resistance of an LDR does not fall in simple proportion to the light; it follows an approximate inverse power law, with an index of about 0.7 to 0.9. In darkness it may be several mega-ohms, while in bright light it falls to only a few hundred ohms.

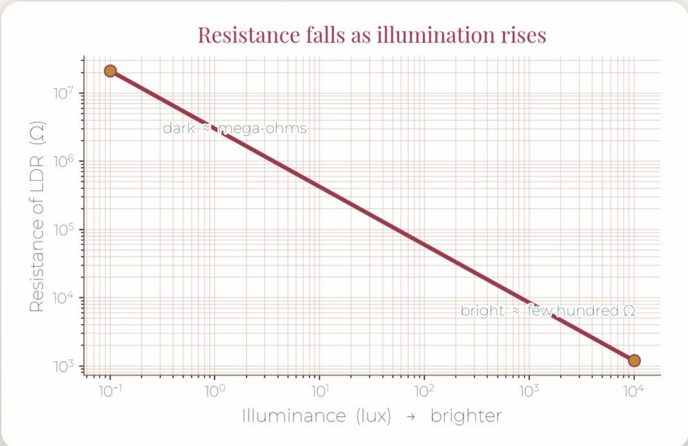


Fig. 3 — Resistance of the LDR against illuminance (logarithmic scales).

Theory — Circuit & Inverse-Square Law

Current in the Circuit

When the LDR is joined in series with a source of EMF E and a milliammeter, the current that flows is given by:

$$I = E / (R_{LDR} + R_{series})$$

where E is the EMF of the 6 V source, and the two resistance terms are the resistance of the LDR and the fixed series (rheostat) resistance. As the illumination increases, the resistance of the LDR falls and the current rises.

The Inverse-Square Law of Illumination

Light from a small source spreads out over a sphere whose area grows as the square of the distance, so the illuminance on the LDR is proportional to the lamp's power and inversely proportional to the square of its distance.

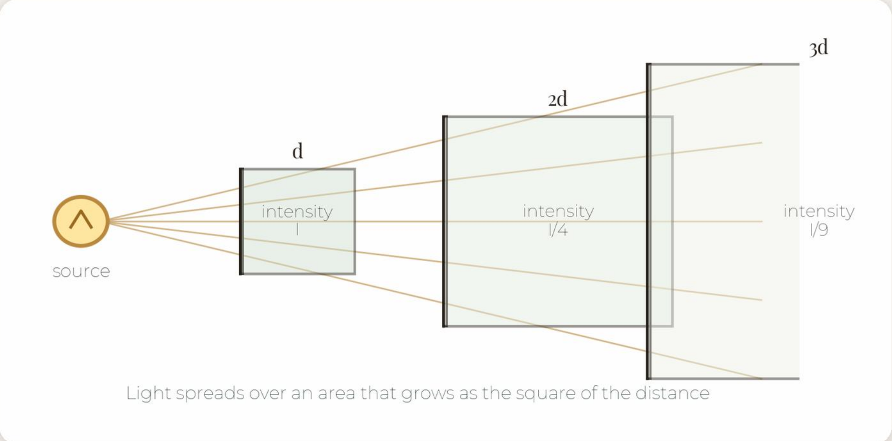


Fig. 4 — As the distance doubles and trebles, the light is spread over 4 and 9 times the area, so the illuminance falls as $1/d^2$.

While the illuminance obeys this inverse-square law, the current does not vary as $1/d^2$: because the LDR's resistance changes only as a fractional power of the illuminance, the current is a non-linear, sub-proportional function of the illumination.

SECTION · 08

Methodology & Apparatus

Apparatus Required

The following apparatus is required to perform the experiment:

- Light-Dependent Resistor (CdS type) • Plug key / switch
- Milliammeter (0 – 3 mA) • Rheostat for current control
- Regulated D.C. source / 6 V battery • Incandescent lamps (15, 25, 40, 60, 100, 200 W)
- Lamp holder and stand • Metre scale (to measure distance)
- Connecting wires, and a dark enclosure to exclude stray light.

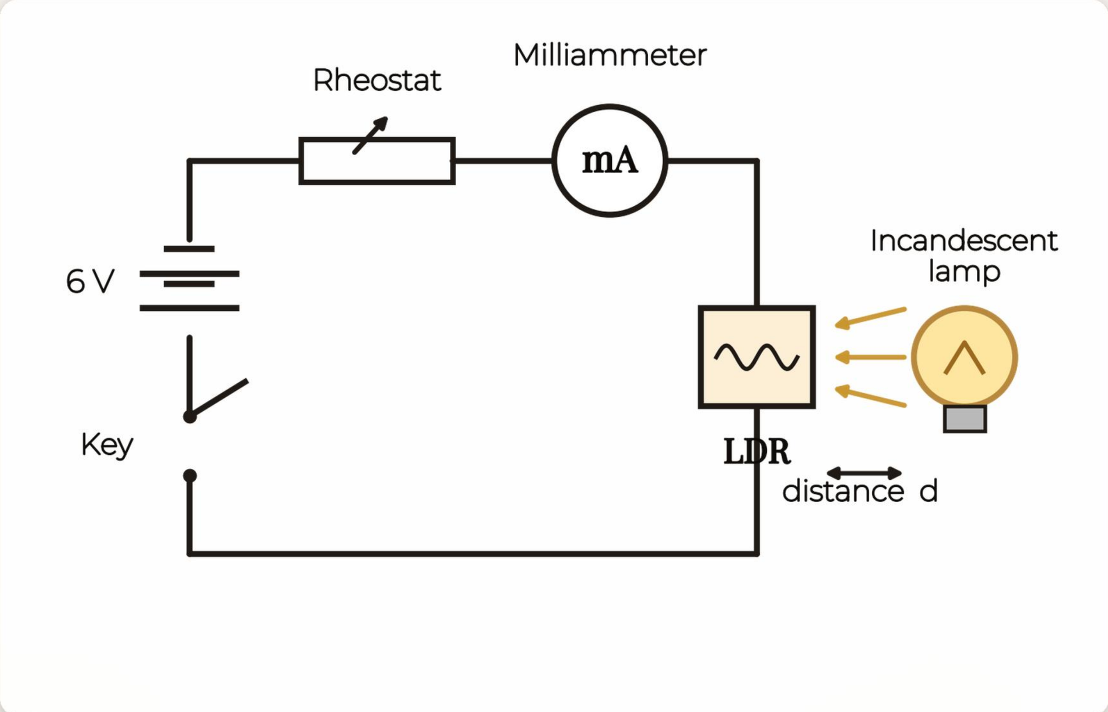


Fig. 5 — Circuit arrangement: the LDR in series with a key, rheostat and milliammeter, illuminated by an incandescent lamp at distance d.

Experimental Procedure

The experiment is carried out in two parts. In Part A the power of the lamp is varied while its distance is held constant; in Part B the distance is varied while the power is held constant. The physical arrangement on the laboratory bench is shown below.

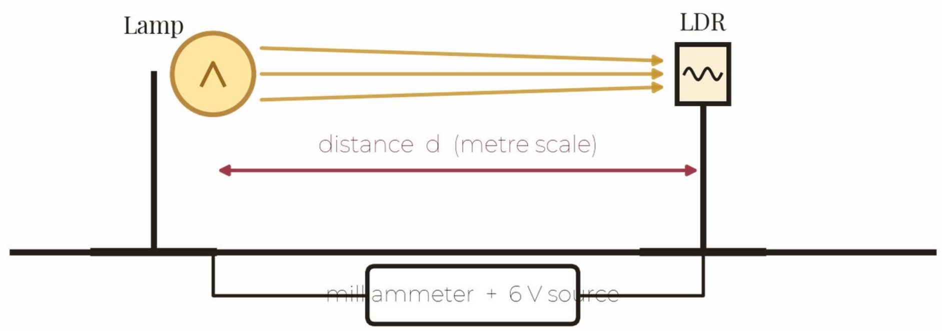


Fig. 6 — Experimental arrangement: the lamp and the LDR mounted facing each other, with the distance measured by a metre scale and the current read on the meter.

Part A — Varying the Power of the Lamp

1. Connect the LDR in series with the plug key, rheostat, milliammeter and 6 V source as shown in Fig. 5, and check every connection.
2. Fix the lamp holder so that the lamp is exactly 25 cm from the LDR, and keep this distance constant throughout Part A.
3. Insert a 15 W lamp, switch on the circuit, allow the meter reading to settle and record the steady current.
4. Replace the lamp in turn with 25, 40, 60, 100 and 200 W lamps, recording the current in each case, and tabulate the readings.

Part B — Varying the Distance of the Lamp

1. Use a single lamp of fixed power (100 W) throughout this part of the experiment.
2. Place the lamp 10 cm from the LDR, switch on and record the steady current.
3. Move the lamp to 15, 20, 30, 40, 50 and 60 cm in turn, recording the current at each distance.
4. Switch the lamp off between readings to prevent heating, and finally plot the required graphs from the two tables.

SECTION · 10

Precautions

The following precautions were carefully observed in order to obtain accurate and reliable readings:

1. All electrical connections were made clean and tight, and the whole circuit was checked once before the current was switched on.
2. The LDR was shielded from stray light from windows and room lamps, so that only the light of the experimental lamp fell on it; as far as possible the experiment was performed inside a darkened enclosure.
3. The lamp and the LDR were kept at the same height and made to face each other directly, so that the light fell squarely on the sensitive surface of the LDR.
4. In Part A only the power of the lamp was changed while the distance was kept exactly constant; in Part B only the distance was changed while the power was kept constant.
5. Each distance was measured carefully with a metre scale, with the eye placed directly above the scale to avoid errors of parallax.
6. The lamp was switched off between successive readings, so that neither the lamp nor the LDR was allowed to heat up appreciably during the experiment.
7. Every current reading was taken only after the meter pointer had come to rest, with the eye held directly in line with the pointer.
8. The rheostat was adjusted so that the current always stayed within the range of the milliammeter, and the meter was checked for zero error before the readings were begun.

SECTION · 11

Data Collection

Table A — Current vs Lamp Power

Distance of lamp from LDR kept constant at d = 25 cm.

S.No.	Lamp Power P (W)	Current I (mA)
1	15	0.22
2	25	0.35
3	40	0.55
4	60	0.78
5	100	1.15
6	200	1.80

Table B — Current vs Distance

Power of lamp kept constant at P = 100 W.

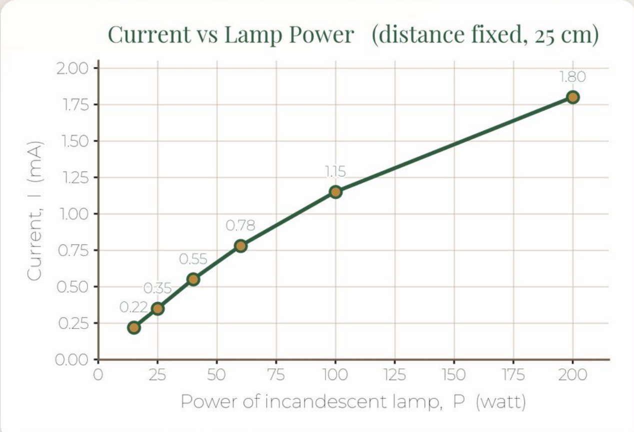
Distance d (cm)	Current I (mA)	$1/d^2$ ($\times 10^{-3}$ cm^{-2})
10	2.40	10.00
15	1.70	4.44
20	1.30	2.50
30	0.92	1.11
40	0.70	0.63
50	0.55	0.40
60	0.46	0.28

Sample Calculation

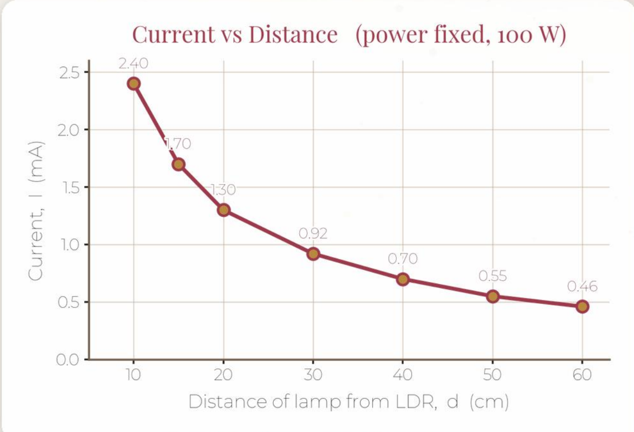
For the third column of Table B the quantity $1/d^2$ is worked out for each distance. For example, at d = 20 cm: $1/d^2 = 1 / (20)^2 = 1 / 400 = 0.0025$ cm^{-2} $= 2.50 \times 10^{-3}$ cm^{-2}. The remaining values in the column are obtained in exactly the same way.

SECTION · 12

Data Analysis & Interpretation

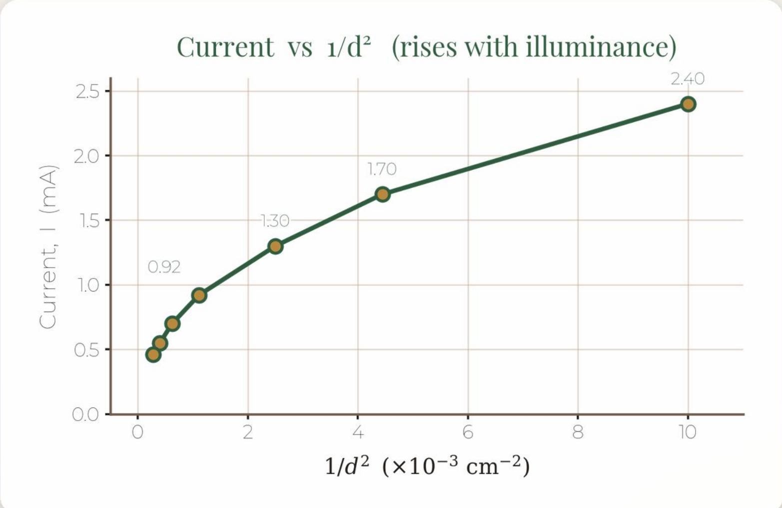


Graph 1 · I increases with lamp power



Graph 2 · I decreases with distance

Graph 1 shows that the current rises as the lamp power increases. A more powerful lamp produces a greater luminous flux, which raises the illuminance on the LDR, lowers its resistance and so increases the current. Graph 2 shows the opposite trend with distance: as the lamp is moved away the illuminance falls, and the current drops sharply.



Graph 3 — As $1/d^2$ increases (the lamp moves closer) the current rises, because the illuminance, which obeys the inverse-square law, increases. The relation is a smooth curve — not a straight line — since the LDR responds non-linearly to light.

SECTION · 13

Findings & Results

Analysis of the observations and of the three graphs leads to the following findings:

- When the distance is kept constant and the power of the lamp is increased, the current in the circuit rises steadily (Table A and Graph 1). A more powerful lamp emits more light, which raises the illuminance on the LDR and lowers its resistance.
- When the power is kept constant and the lamp is moved farther away, the current decreases (Table B and Graph 2). The illuminance falls as the distance increases, so the resistance of the LDR rises and the current drops.
- The fall of current with distance is steep at first and then more gradual, which is in keeping with the illuminance decreasing as the inverse square of the distance.
- A graph of current against $1/d^2$ (Graph 3) rises as $1/d^2$ increases, but it is a smooth curve rather than a straight line through the origin; the current is therefore not directly proportional to $1/d^2$.
- This sub-linear behaviour is expected, because the resistance of the LDR varies as only a fractional power of the illuminance and a fixed series resistance is also present in the circuit.
- Taken together, these results confirm that the resistance of the LDR decreases as the light falling on it increases — that is, the LDR is photoconductive.

SECTION · 14

Conclusion

The experiment clearly establishes that the current flowing in a circuit containing a Light-Dependent Resistor depends strongly on the illumination of the LDR, and that this illumination can be controlled both by the power of the light source and by its distance.

It was found that, at a fixed distance, the current increases as the power of the lamp is increased, and that, at a fixed power, the current decreases as the lamp is moved farther away. Both effects occur because the power and the distance of the source together determine the illuminance reaching the LDR, which in turn controls its resistance through the phenomenon of photoconductivity.

The illuminance on the LDR falls with distance according to the inverse-square law. The measured current follows this fall, but because the resistance of the LDR responds to light in a non-linear way, the current is a sub-proportional function of the illuminance rather than being directly proportional to $1/d^2$.

The aim of the project has therefore been fully achieved: the behaviour of the LDR has been studied quantitatively, and its photoconductive nature has been clearly demonstrated. The experiment provides a simple yet convincing illustration of how a semiconductor device responds to light, and of the physical principles that govern that response.

SECTION · 15

Suggestions & Recommendations

The investigation can be extended and improved in several ways:

- A calibrated lux-meter could be used to measure the actual illuminance on the LDR, so that its resistance could be plotted directly against illuminance and the power law tested numerically.
- Light-emitting diodes (LEDs) of known luminous flux could replace the incandescent lamps, giving cleaner and cooler control of the source power without large changes of temperature.
- The experiment could be performed inside a properly darkened enclosure to remove all errors due to stray ambient light.
- Each reading could be repeated several times and averaged, allowing the LDR to settle before every measurement, so as to improve the accuracy of the results.
- The resistance of the LDR could be measured directly with an ohm-meter as a function of illuminance, instead of being inferred from the circuit current.
- The study could be extended to examine how the response of the LDR depends on the colour (wavelength) of the incident light, or to compare LDRs of different types.

SECTION · 16

Limitations of the Study

Like every experiment, this study is subject to a number of limitations and possible sources of error:

- Incandescent lamps of different powers also differ in their temperature and spectral output, so the power of the lamp is not a perfectly clean independent variable.
- A real lamp is not an ideal point source, so the inverse-square law of illumination holds only approximately, particularly at small lamp-to-LDR distances.
- Stray ambient light, together with the self-heating of the LDR and the lamp, introduces errors into the recorded currents.
- The LDR has a non-linear response and a small time-lag (latency), so its resistance does not settle instantaneously when the illumination changes.
- Distances measured on a metre scale are liable to small errors of parallax and of judgement.
- The milliammeter has a finite least count and a small possible zero error, which limit the precision with which the current can be read.

SECTION · 17

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