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LAB MANUAL

B.Sc. (Physiscs)

SEC-II

RENEWABLE ENERGY RESOURCES

LIST OF EXPERIMENTS

1. **Study of characteristic properties of the solar cell.**
2. **To design the prototype of different renewable energy resources.**
3. **To study the photoelectric effect.**

Experiment- 1

Study of characteristic properties of the solar cell

OBJECTIVE: To study the characteristics of solar cell, the following studies can be carried out.

1. Illumination Characteristics.
2. Current Voltage Characteristics.
3. Power Load Characteristics.
4. Area Characteristics.
5. Spectral Characteristics.

OPTIONAL

1. Distance Vs Open Circuit Voltage.
2. Distance Vs Short Circuit Current.
3. Measurement of Short Circuit Current (IESC) with biasing the solar cell and compare it with the theoretical value obtained from current voltage characteristics curves.

THEORY:

Solar cells are basically solid-state devices. It is basically a p-n junction, which converts sunlight (solar energy) into electrical energy through a three-step process:

1. Generation of carrier pairs (electron hole pairs)
2. Separation of electrons and holes
3. Collection of separated carriers

The details of each of the three processes are beyond the scope of this manual. Pl see text books. When a solar cell is illuminated, the photons incidents on the cell generate electrons-hole pairs. By diffusion in the material the electron and holes reach the junction. At the junction the barrier field separates the positive and negative charges carriers. Under the action of the electric field, the electrons (minority carriers) from p region are swept into n region. Similarly, the holes from n region are swept into p region. It leads to an increase in the number of holes on the p side and of the electrons on the n side of the junction. The accumulation of charges on the two sides of the junction produces an emf, which is called a photo emf. The photo emf is known as open circuit voltage. It is proportional to the illumination (mW/cm^2 or $lumen/cm^2$) and on the size of the illuminated area. When an external circuit is connected across the solar cell terminals, the minority carriers return to their original sides through the external circuit, causing the current to flow through the circuit. Thus the solar cell behaves as a battery with n side as the negative terminal and p side as positive terminal. The photo emf or voltage can be measured with a voltmeter. The process of generation of photovoltaic voltage is shown in Fig.

(1) The conversion of optical energy is known as photovoltaic effect. Hence a solar cell is also called a photovoltaic cell.

All solar cell materials used till date are semiconductors in crystalline or amorphous forms. A common characteristic of these materials is that they posses a band gap i.e. a discontinuity or rather a range of forbidden values in the energy spectrum. Mostly, solar cells are fabricated from silicon single crystals; Silicon is not transparent for visible light. Therefore, the surface layer of the cell, which is of p type, is made extremely thin to enable maximum light to penetrate the junction. It is desired the absorption of light takes place at the junction region such that the generated electron holes pairs can be separated by the junction fields before they are lost by recombination. To enhance the transmission of the light into the material an anti reflection coating is given over p type layer. Thin metallic films vacuum deposited suitably on both the sides of the cell act as electrodes. An open circuit voltage of peak value of 0.6 V is generated by a solar cell. Silicon wafer of 1”dia to 4”dia are used too fabricate solar cells. In order to enhance the total voltage and current out put, a number of P-n junction are formed on a wafer, using a mesh type or finger like electrode structure. To increase power output, solar cells are arrayed into a series chain or parallel chain and are interconnected. Such an arrangement is called a solar panel. In normal use single solar cell is rarely used, as its output is very low.

(i) Illumination Characteristic

The Illumination Characteristic of a solar cell is shown in the Fig. (2). It is seen that the current through the solar cell increases as the intensity of the light falling on the solar cell increases.

(ii) Current Voltage Characteristic

The out put characteristic (current voltage characteristics) of a solar cell is shown in the Fig. (3) it is seen that in the open circuit, the out put voltage of the cell is $\approx$ 0.6 V and the current is zero. If the panel is short circuited, the current is maximum while the output voltage of the cell becomes zero. In both the cases, the output power is zero. It is seen from the curve that the voltage varies depending on the current drawn.

(iii) Power Load Characteristics

To derive maximum power from the panel, an appropriate load is to be connected across it. The value of the load that allows the cell to give maximum output power is obtained by drawing a power load characteristics, as shown in the Fig. (4). It is seen that a load other than (RL)max will produce less power.

(iv) **Area Characteristics**

The power delivered is proportional to the surface area of the solar panel exposed to the light. It is governed by the relation,

$$P = K A$$

Where, P is the total power available

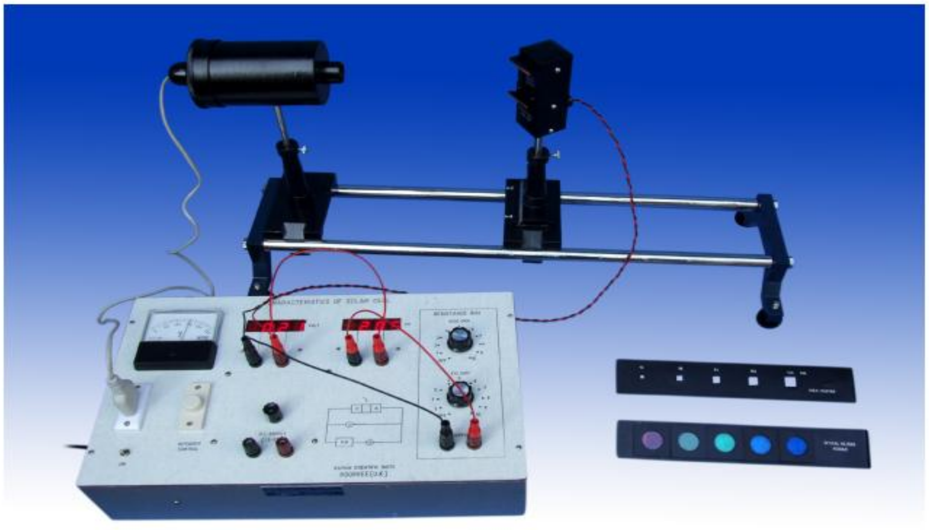
A is the area of the Cell

K is a constant.

The dependence of P on A is shown in the Fig. (5)

(v) Spectral Characteristics

The response of a solar cell to light depends on the wavelength of the incident light also. In the sunlight, different colors have different intensities. The variation of power on wavelength is shown in the Fig.(6)



PROCEDURE

(a) Illumination Characteristics

1. Make the circuit as shown in fig. 7. A 100 W lamp is arranged over the solar cell such that the light falls on it at normal. The intensity control is kept at its minimum say at 50 volts and the lamp is switched on.

2. Adjust the resistance box at zero ohm (i.e. both the knobs marked X10 and X100 ohm must be set at off position) note the short circuit current and make table as shown below.

3. Increase the intensity of the lamp in steps say 100, 150, 200 volts and note the corresponding current for each setting of the voltage, record these readings in the table.

Note: Intensity is taken as proportional to the A.C. voltage given to the lamp

a. Plot a graph between Current and the Intensity.

Table 1:

S.No	Intensity (volts)	Current (mA)

(b) Current Voltage Characteristics

1. The intensity of the lamp is kept at the minimum say 100 V. disconnect the load resistance (i.e. R.B. is at infinity) and note the open circuit voltage.

2. Adjust the resistance box (R.B.) at zero ohm (i.e. both the knob of the resistance box marked X10 and X100 ohm must be set at off position) and note the short circuit current.

3. Set the load dial at 100 ohms. Note the corresponding voltage and current make the table as shown below and record these readings in the table. Vary the load in steps up to 1100 ohms and note the corresponding voltage and current for each setting of the load in table

4. The intensity of the lamp is increased say 150 V. The load is again varied from 100 to 1100 ohms and note the corresponding voltage and the currents, record the value in the table. The open circuit voltage and the short circuit current are also determined and recorded.

5. The intensity of the lamp is set at 200 V, and repeat step 4. Record these readings in the table

6. Plot a graph for Current Vs Voltage

Table 2:

S.NO	R_L (Ohms)	Intensity, I_1		Intensity, I_2		Intensity, I_3	
		Voltage(V)	Current(mA)	Voltage(V)	Current(mA)	Voltage(V)	Current(mA)
1	100						
2	200						
3	……						

(c) Power Load Characteristics

1. Using the sets of the reading obtained in the table 2 above, calculate the output power of the cell. Make table as shown below and record the readings in the table.
2. Plot a graph for Power Vs Load. Measure the value of the optimum load that draws maximum power from the cell.

Table-3

S.NO	R_L Ohms	Intensity, I_1= 100 V	Intensity, I_1= 150 V	Intensity, I_1= 200 V
		Power mW	Power mW	Power mW
1. 2. 3.	100 200 …….			

(d) Area Characteristics:

1. Set the intensity of the lamp at a convenient level say 200V. Adjust the load at the optimum value.

2. Place the chopper plate having different slot areas, in front of the solar cell in the grove provided.

3. Adjust one of the slot say 16 mm2 over the solar cell; it reduces the surface area, which is illuminated. The voltage and the current readings are noted in the table. Note the corresponding voltage and current readings make table as shown below and record the readings in the table.

4. Adjust the other slots say 36, 64, 100, 144 mm2 over the solar cell and note the corresponding current and voltage for each slot area and record the readings in the table.

5. Plot a graph for Power Vs Area. Measure the slope of the curve.

Table -4

S.NO	Slot Area mm^2	Voltage, V volts	Current, I amp	Power P = VI mW
1. 2. 3. 4.				

(e) Spectral Characteristics:

1. Set the intensity of the lamp to a convenient level say 200 V. Adjust the load at the optimum value.
2. Put the different colors filter over the solar cell and for each filter the note voltage and the current and record these readings in the table.
3. The wavelength corresponding to each color is noted and calculate the output power
4. Plot a graph for Power Vs Wavelength.

Table -5

S.NO	Filter Colors	Peak Wavelength Transmitted, A^o	Voltage, V volts	Current, I amp	Power P = VI Mw
1. 2. 3. 4.					

OPTION

Distance Vs Open Circuit Voltage:

Repeat step 1 of the current voltage characteristics and vary the distance between the source and the photocell and not the open circuit voltage for each position of the cell from the source say at 15, 18, 21, 24, 27, 30 cm.

Distance Vs Short Circuit Current:

Repeat step 2 of the current voltage characteristics and vary the distance between the source and the photocell and note the short circuit current for each position of the cell from the source say at 15, 18, 21, 24, 27, 30 cm.

Experimental Measurement of Short Circuit Current: Make the circuit as shown in the fig. 7(b) using R_2 and the multimeter. Set the lamp voltage say at 100 volts. Adjust the supply voltage at 1.5 volts and vary R2 till the voltmeter V reads Zero voltage. In this position the cell and the battery try to send current through R.B. and when both currents are equal no current will pass through R.B. and thus no voltage drop across it as measured by the voltmeter. In this case, the current obtained through multimeter gives the short circuit current. Repeat the experiment for different values of lamp voltage say150, 200 volts and note the corresponding short circuit current. Make table as shown below.

Table – 6

Compare the Experimental value of Short Circuit Current I_{ESC} with the Theoretical value

S.NO.	Lamp Voltage	Experimental value of Short circuit current I_{ESC}	Theoretical value of Short circuit current obtained from V-I characteristics curve.
1. 2. 3.			

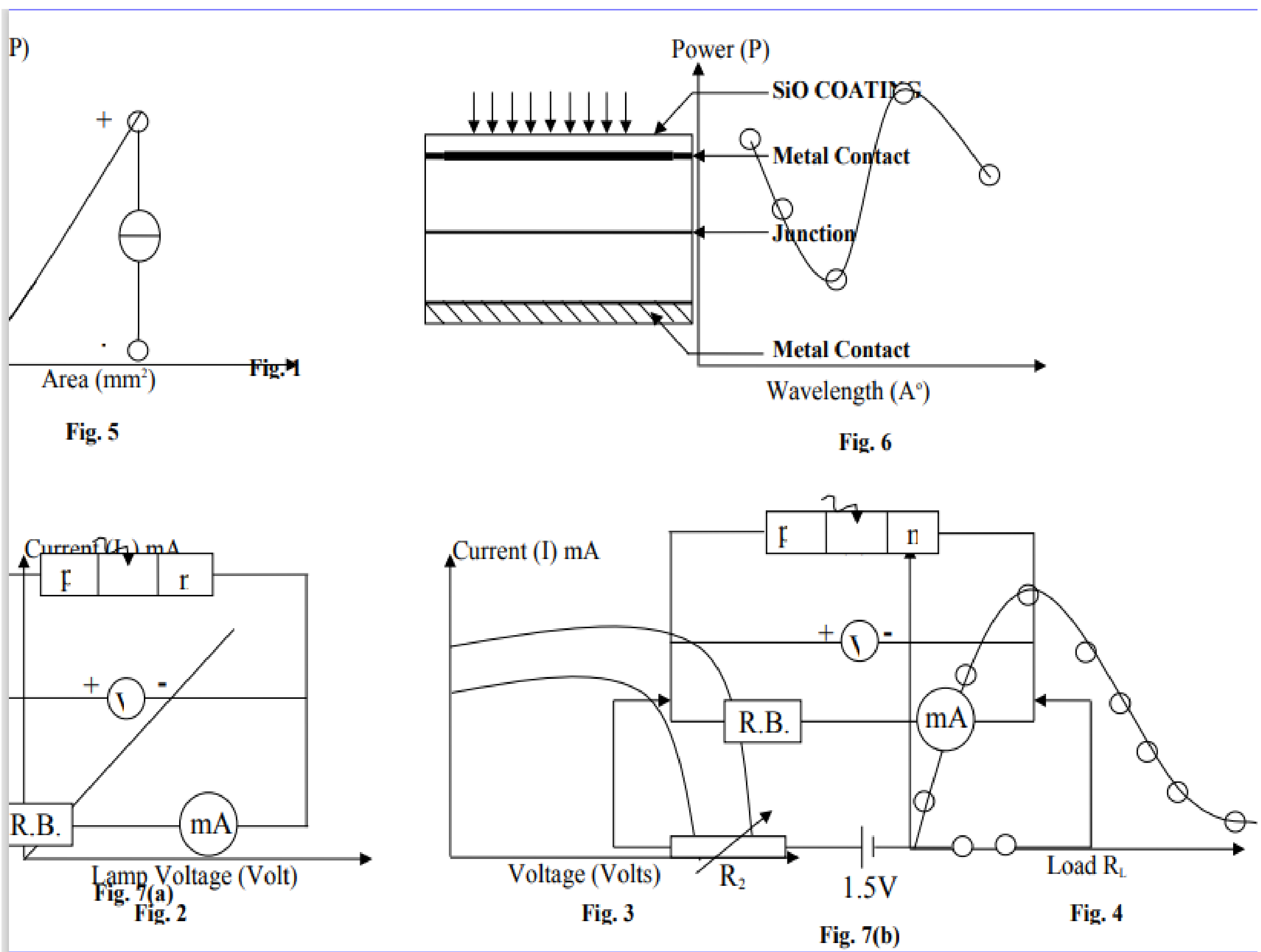


Fig. 5 Fig. 6 Fig. 7(a) Fig. 2 Fig. 3 Fig. 7(b) Fig. 4

Experiment -2

Design the prototype of different renewable energy resources

Aim 1- To Study of Solar Fencing.
Aim 2: To study solar photovoltaic system.
Aim 3: Familiarization with renewable energy gadgets

Aim 1- To Study of Solar Fencing.

Working Principle of Solar Fencing System

The Solar module generates the DC energy and charges the Battery. The output of the battery is connected to Energizer or Controller or Charger or Fencer. The energizer will produce a short, high voltage pulse at regular rate of one pulse per second. The live wire of the energizer is connected to the fence wire and the earth terminal to the Earth system. Animal / Intruder touching the live wire creates a path for the current through its body to the ground and back to the energizer via the earth system and completes the circuit. Thus, the intruder will receive a shock, the greater the shock the intruder receives the more lasting the memory will be avoided in future.

The Energizer has to be set up with its earth terminal coupled to an adequate earthing or grounding system. The live terminal is coupled to the live insulated wires of the fence. Energizer will send an electric current along an insulated steel wire. An animal or intruder touching the live wire creates a path for the electrical current through its body to the ground and back to the Energizer via the earth or ground system, thus completing the circuit. The greater the shock the animal receives the more lasting the memory will be and the more the fence will be avoided in the future. The shock felt is a combination of fence voltage and pulses time or energy. The higher the *joule rating of the energizer the greater the shock and the greater the fence performance.

*JOULE: Unit of energy. One joule is one watt for one second. It is an important measure of the power of an Energizer.

The basic building blocks of a power fence are:

1. Energizer
2. Earthing (Grounding System) and
3. Fence system

ENERGIZER: The heart of the Power fence is the Energizer. The energizer is selected depending on the animals to be controls, length of the fence and number of strands. Main function of the energizer is to produce short and sharp pulses of about 8000 volts at regular intervals. The power input is from the DC energy from battery. The energizer should be protected from 34 children, should be enclosed, free from mechanical damage and away from inflammable material.

EARTHING SYSTEM: The earth or ground system of the Energizer is like the antenna or aerial of a radio. A large radio requires a large antenna to effectively collect sound waves and a high powered Energizer requires a large number of electrons from the soil. The earth or ground system must be perfect to enable the pulse to complete its circuit and give the animal an effective shock. Soil is not a good conductor so the electrons spread out and travel over a wide area, inclining towards moist mineral soils. If possible, select an area for the energizer earth site which is damp all the year.

FENCE WIRE SYSTEMS: They are of two types:

A. All live Wire System and

B. Earth or ground Wire Return System.

Fence wire:

1. 2.5 mm (12.5 gauge) High tensile (H.T) wire is recommended for electric fence systems because of its advantages:

a. It retains its tension far longer than soft wire.

b. It conducts sufficient current for most applications.

c. It is reasonable visible. 35

2. High Conductive Aluminium Coated Wire is best used for long leadouts i.e. several kilometers.

3. Double insulated Leadout Cable is used in building, under gateways and where the soil could corrode exposed galvanized wire.

A. All Live Wire System: The all live wire system should be used where there is relatively even rainfall and where there is some green vegetation most of the year, or in areas with highly conductive soils. The all live wire system should be used as much as possible.

B. Earth or ground Wire Return System: The earth or ground wires return system should be used where there is low rainfall stony and dry soil condition most of the year. The system overcomes the problem of dry, nonconductive, or frozen soils not allowing sufficient current to flow through the animal's feet back to the energizer. The fence should have both live and ground wires. By touching the live and ground wires on the fence, the animal gets the full shock.

Precautions:

1. Never use household electrical cable.

2. Never use copper wire undergate cable because electrolysis problems occur where it is joined to the galvanized fencing wire.

3. Never electrify barbed wire. It is dangerous, has the potential to cause faults and is illegal in some countries.

Aim 2: To study solar photovoltaic system.

The direct conversion of solar energy in to electrical energy by means of the photo voltaic effect, that is the conversion of light (or other electromagnetic radiation) in to electricity. The photo voltaic effect is defined as the generation of the electromotive force as a result of the absorption of ionizing radiation energy conversion devices which are used to convert sun light to electricity by the use of the photo voltaic effects are called solar cells. A single converter cell is called a solar cell or more generally, a photo voltaic cell, and combination of such cells, designed to increase the electric power output is called a solar module or solar array.

Photo voltaic cells are made of semi-conductors that generate electricity when they absorb light. As photons are received, free electrical changes are generated that can be collected on contacts applied to the surface of the semi-conductors. Because solar cells are not heat engines, and therefore do not need to operate at high temperatures, they are adopted to the weak energy flux of solar radiation, operating at tome temperature. These devices have theoretical efficiencies of the order of 25 percent. Actual operating efficiencies are less than this value, and decrease fairly rapidly with increasing temperature.

The best known applications of photo voltaic cells for electrical power generation has been is spacecraft, for which the Silicon cell is the most highly developed type. The Silicon cell consists of a single crystal of silicon into which a doping material is diffused to from a semiconductor. Since the early day of solar cell development, many improvements have been manufactured with areas 2x2 cm, efficiencies approaching 10 percent, and operating at 28oC. The efficiency is the power developed per unit area of array divided by the solar energy flux in the free space (1.353 KW/m^2).

For terrestrial applications, silicon solar cells have shown operating efficiencies of about 12 to 15 percent. Though Silicon is one of the earth's most abundant materials, it is expensive to extract (from sand, where it occurs mostly in the from SiO2) and refine to the purity required for solar cells. The greater barrier to solar cell application lies in the costs of the cells themselves. Reducing the cost of Silicon Cells is difficult because of the cost of making single crystal. One very promising method is being developed to produce continuous thin ribbons of single-crystal Silicon to reduce fabrication costs.

Cells made from the ribbon have so for shown efficiencies of around 8 percent. Several other kinds of photo cells are in the laboratory stage of development. Cadmium Sulphide cells are 29 other possibilities. So far, efficiencies have been in the range of 3 to 8 percent and these cells have been less durable than Silicon cells owing to degradation with exposure to Oxygen, water vapor and sunlight, especially at elevated temperatures. The active part of the Cadmium Sulphide cds cell is a thin polycrystalline layer of cds, about 10µm. Thick on which a layer of Cu2S compound perhaps 0.1µm thick is grown. These cells can be made by deposition on long sheets of substrates, a process that might be adaptable to expensive mass production.

Photo voltaic cells could be applicable to either small or large power plants, since they function well on a small scale, and may be adaptable to local energy generation on building roof tops. The cost of the energy storage and power conditioning equipment might, however, make generation in large stations the most economical method; solar cells have also been used to operate irrigation pumps, navigational signals high way emergency call system, rail road crossing warnings, automatic meteorological stations, etc; in location where access to utility power lines is difficult.

Aim 3: Familiarization with renewable energy gadgets

RENEWABLE ENERGY

Renewable energy sources also called non-conventional energy, are sources that are continuously replenished by natural processes. For example, solar energy, wind energy, bioenergy bio-fuels grown sustain ably), hydropower etc., are some of the examples of renewable energy sources A renewable energy system converts the energy found in sunlight, wind, fallingwater, sea waves, geothermal heat, or biomass into a form, we can use such as heat or electricity. Most of the renewable energy comes either directly or indirectly from sun and wind and can never be exhausted, and therefore they are called renewable.

Various forms of renewable energy:

1. Solar energy
2. Wind energy
3. Bio energy and Biofuel
4. Hydro energy
5. Geothermal energy
6. Wave and tidal energy

1. Solar energy

Solar energy is the most readily available and free source of energy since prehistoric times. India receives solar energy in the region of 5 to 7 kWh/m^2 for 300 to 330 days in a year. This energy is sufficient to set up 20 MW solar power plant per square kilometre land area.

Solar energy can be utilised through two different routes, as solar thermal route and solar electric (solar photovoltaic) routes. Solar thermal route uses the sun's heat to produce hot water or air, cook food, drying materials etc. Solar photovoltaic uses sun's heat to produce electricity for lighting home and building, running motors, pumps, electric appliances, and lighting.

2. Wind energy

Wind energy is basically harnessing of wind power to produce electricity. The kinetic energy of the wind is converted to electrical energy. When solar radiation enters the earth's atmosphere, different regions of the atmosphere are heated to different degrees because of earth curvature. This heating is higher at the equator and lowest at the poles. Since air tends to flow 2 from warmer to cooler regions, this causes what we call winds, and it is these airflows that are harnessed in windmills and wind turbines to produce power.

3. Bio energy

Biomass is a renewable energy resource derived from the carbonaceous waste of various human and natural activities. It is derived from numerous sources, including the by-products from the wood industry, agricultural crops, raw material from the forest, household wastes etc.

Biofuel: Unlike other renewable energy sources, biomass can be converted directly into liquid fuels— biofuels— for our transportation needs (cars, trucks, buses, airplanes, and trains). The two most common types of biofuels are ethanol and biodiesel.

Ethanol is an alcohol, similar to that used in beer and wine. It is made by fermenting any biomass high in carbohydrates (starches, sugars, or celluloses) through a process similar to brewing beer. Ethanol is mostly used as a fuel additive to cut down a vehicle's carbon monoxide and other smog-causing emissions. Flexible-fuel vehicles, which run on mixtures of gasoline and up to 85% ethanol, are now available.

Biodiesel, produced by plants such as rapeseed (canola), sunflowers and soybeans, can be extracted and refined into fuel, which can be burned in diesel engines and buses. Biodiesel can also made by combining alcohol with vegetable oil, or recycled cooking greases. It can be used as an additive to reduce vehicle emissions (typically 20%) or in its pure form as a renewable alternative fuel for diesel engines.

4. Hydro energy

The potential energy of falling water, captured and converted to mechanical energy by waterwheels, powered the start of the industrial revolution. Wherever sufficient head, or change in elevation, could be found, rivers and streams were dammed and mills were built. Water under pressure flows through a turbine causing it to spin. The Turbine is connected to a generator, which produces electricity.

5. Geothermal energy

Geothermal energy is heat derived within the sub-surface of the earth. Water and/or steam carry the geothermal energy to the Earth’s surface. Depending on its characteristics, geothermal energy can be used for heating and cooling purposes or be harnessed to generate clean electricity. However, for electricity, generation high or medium temperature resources are needed, which are usually located close to tectonically active regions.

6. Tidal and Ocean Energy

Tidal electricity generation involves the construction of a barrage across an estuary to block the incoming and outgoing tide. The head of water is then used to drive turbines to generate electricity from the elevated water in the basin as in hydroelectric dams.

Oceans cover more than 70% of Earth's surface, making them the world's largest solar collectors. Ocean energy draws on the energy of ocean waves, tides, or on the thermal energy (heat) stored in the ocean. The sun warms the surface water a lot more than the deep ocean water, and this temperature difference stores thermal energy.

Experiment -3
To study the photoelectric effect

Planck's constant (Photo Electric Effect)

Aim:

1**. To determine Planck's Constant and work function using photo electric effect.**
2**. To verify inverse square law of radiation**.

Apparatus used: Light source, Digital voltmeter and ammeter, Vacuum photo tube, filters of different colors.

Formula used:
Stopping potential is given by

$$Vs = \frac{h}{e}\upsilon - \phi$$

where Vs = Stopping potential
e = Electronic charge
υ = Frequency of light used
ϕ = Work function
h = Planck's constant

The slope of straight line obtained by plotting a graph V_s as a function of υ yields *h*/ *e* and the intercept of extrapolated point $\upsilon = 0$ gives the work function of Cesium Antimony film (Cs-Sb)

Theory:

It was observed as early as 1905 that most metals under influence of radiation, emit electrons. This phenomenon was termed as photoelectric emission. The detailed study of it has shown:

1. That the emission process depends strongly on frequency of radiation.
2. For each metal there exists a critical frequency such that light of lower frequency is unable to liberate electrons, while light of higher frequency always does.
3. The emission of electron occurs within a very short time interval after arrival of the radiation and number of electrons is strictly proportional to the intensity of this radiation.

The experimental facts given above are among the strongest evidence that the electromagnetic field is quantified and the field consists of quanta of energy $E= h\ \upsilon$ where is υ the frequency of the radiation and h is the Planck's constant. These quanta are called photons.

Further it is assumed that electrons are bound inside the metal surface with an energy $e\ \phi$, where ϕ is called the work function. It then follows that if the frequency of the light is such that $h \upsilon > e \phi$, it will be possible to eject photoelectron, while if $h \upsilon$ while if $h \upsilon < e \phi$, it would be impossible. In the former case, the excess energy of photon appears as kinetic energy of the electron, so that

$$h \upsilon = \frac{1}{2} mv^2 + e \phi \text{ ......(1)} \qquad \text{or} \qquad \frac{1}{2} mv^2 = h \upsilon - e \phi$$

which is the famous photoelectric equation formulated by Einstein in 1905.

If we apply a retarding potential V_0 so as to stop the photo electrons completely, it is known as stopping potential Vs. At that instant

$$\frac{1}{2} mv^2 = eVs \qquad \text{or} \qquad eVs = h \upsilon - e \phi$$

Or $$Vs = \frac{h}{e} \upsilon - \phi$$

So when we plot a graph V0 as a function of υ , the slope of the straight line yields $h\ e$ and the intercept of extrapolated point at υ =0 gives work function ϕ

<u>To verify inverse square law of radiation using a photoelectric cell</u>

If L is the luminous intensity of an electric lamp and E is the illuminiscence (intensity of illumination) at point r from it, then according to inverse square law.

$$E \alpha L/ r^2$$

If this light is allowed to fall on the cathode of a photo-electric cell, then the photo-electric current (I) would be proportional to E.

$$E = L/r^2 = K.I$$

Hence a graph between $1/ r^2$ and I is a straight line, which verify the inverse square law of radiation.

Apparatus Used : The apparatus consists of the following :

1. Photo Sensitive Device : Vacuum photo tube.
2. Light source : Halogen tungsten lamp 12V/35W.
3. Colour Filters : 635nm, 570nm, 540nm, 500nm & 460nm
4. Accelerating Voltage : Regulated Voltage Power Supply

    Output : ±15 V continuously variable through multi-turn pot

    Display : 3 ½ digit 7-segment LED

    Accuracy : ±0.2

5.Current Detecting Unit : Digital Nanoammeter

It is high stability low current measuring instrument

Range : 1000 [A, 100 [A, 10 [A & 1[A with 100 % over ranging facility]

Resolution : 1nA at 1 [A range]

Display : 3 ½ digit 7-segment LED

Accuracy : ±0.2% .

6. Power Requirement : 220V ± 10%, 50Hz

7. Optical Bench : The light source can be moved along it to adjust the distance between light source and phototube. Scale length is 400 mm. A drawtube is provided to install colour filters, a focus lens is fixed in the back end.

STRUCTURE:

1. Light Source, 12V/35W halogen tungsten lamp.

2. Guide. Move the light source along it, the distance between light source and receiving dark box can be adjusted.

3. Scale, 400mm total length. The center of the vacuum phototube is used as zero point.

4. Drawtube. The forepart is used for installing color filter; a focus lens is fixed in the back end.

5. Cover. Used to cover chamber containing Phototube.

6. Focus lens. Make a clear image of light source on the cathode area of phototube.

7. Vacuum Phototube. The sensitive component.

8. Base for holding the Phototube.

9. Digital Meter. Show current (μA), or voltage (V).

10. Display mode switch. For switching the display between voltage and current mode.

11. Current Multiplier.

12. Light Intensity Switch. Switch for choosing light intensity. Up is of strong, middle is of off; down is for weak.

13. Filter Set. Four pieces.

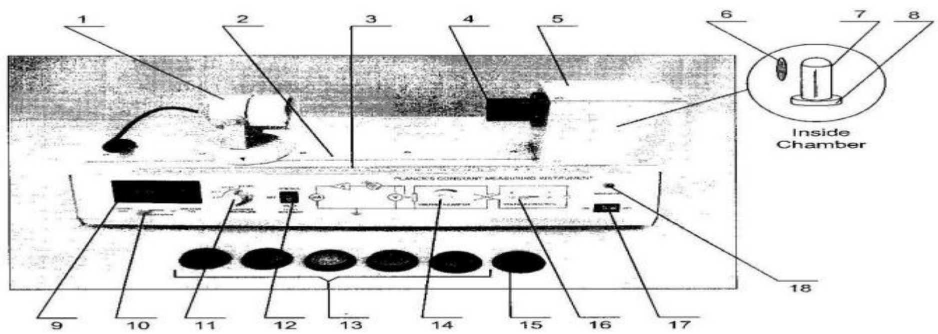
14. Lens Cover. (For protecting the phototube from stray light during ideal period).

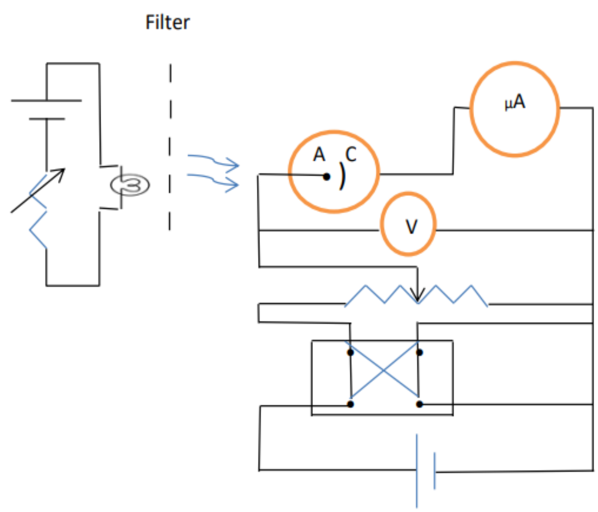
15. Accelerate voltage adjustor. Knob for adjusting accelerate voltage.

16. Voltage direction , switch. Switch for choosing voltage direction. ±15V accelerated voltage is provided

17. Power switch.

18. Power indicator.





Schematic Diagram
(Draw in practical note book)

Procedure:

For determination of Planck's Constant and work function:

1. Insert the red color filter (635nm), set light intensity switch (12) at strong light, voltage direction switch (16) at '-', display mode switch (10) at current display.

2. Adjust to de-accelerating voltage to 0 V and set current multiplier (4) at X0.001. Increase the deaccelerating to decrease the photo current to zero. Take down the de-accelerating voltage (Vs) corresponding to zero current of 635nm wavelength. Get the Vs of other wave lengths, the same way. (Repeat for at least 2 distances say 40cm and 30cm)

For verification of inverse square law:

1. The connection would be same as before except a positive voltage would be applied to the anode with respect cathode.
2. Place a filter in front of the photoelectric cell.
3. Keeping the voltage constant and position of photocell fixed, increase the distance of lamp from photo-cell in small steps. In case note the position of the lamp r on the optical bench and the current I.
4. The experiment may be repeated with other filters (at least 2 filters).

Observation:

Table 1 For determination of Planck's Constant and work function

S.NO.	Filters	υ ($sec^{-1}x10^{14}$)	Stopping Voltage (Vs in Volts)	
			d = 40 cm	d = 30 cm
1 2 3 4	Red (635nm) Yellow I (585nm) Green (500nm) Blue (460nm)	4.72 5.13 6.00 6.50		

Table 2 For verification of inverse square law:

S.NO.	Distance between lamp and photo-cell	$\frac{1}{r2}$ X 10^3	I (μA)	
			Red filter	Green filter
1	18cm	3.09		
2	20cm	2.50		
3	22cm	2.07		
4	24cm	1.74		
5	26cm	1.48		
6	28cm	1.28		
7	30cm	1.11		

Calculations :

From graph (1) Vs vs υ

h = e × slope of graph

$$h = e \frac{\Delta Vs}{\Delta \upsilon}$$

Substituting the values of ΔVs and Δ υ from graph (1)

h can be found, h = ….. Joule– sec.
Standard value of h = 6.62x10-34 Joules-sec
Again from graph (1) intercept at υ = 0.
Work function ϕ = intercept on y axis = ………………volts.

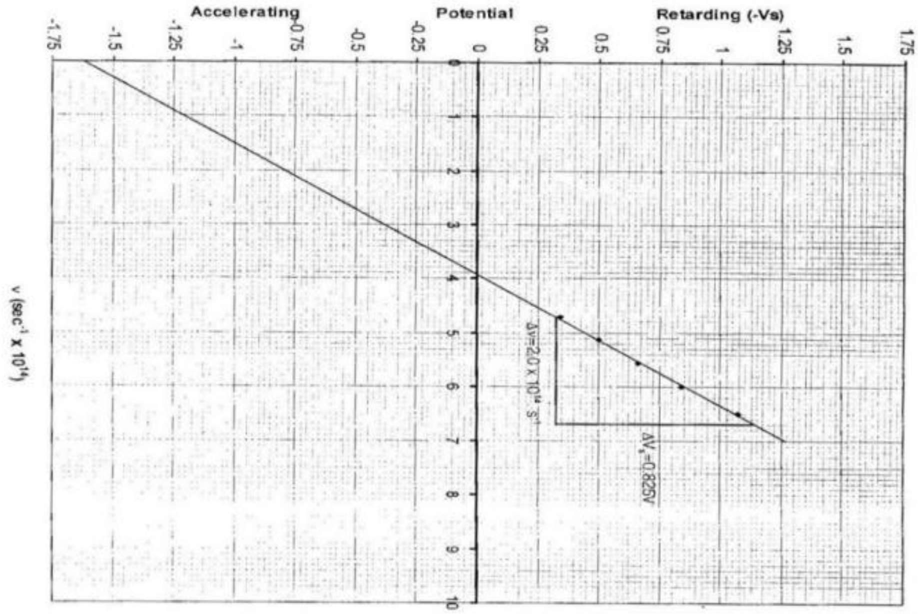
Result: 1.

1. Planck's constant 'h' is found to be work function h = ……..J-sec
   ϕ = ……..V. 2.
2. Graph between $\frac{1}{r^2}$ along X axis and I along Y axis is a straight line hence proves the inverse square law of radiation

Precautions:

1. This instrument should be operated in a dry, cool indoor space.
2. Phototube particularly should not be exposed to direct light, particularly at the time of installation of phototube; the room should be only dimly lit
3. The instrument should be kept in dust proof and moisture proof environment, if there is dust on the phototube, color filter, lens etc. clean it by using absorbent cotton with a few drops of alcohol.
4. The color filter should be stored in dry and dust proof environment.
5. After finishing the experiment remember to switch off power and cover the drawtube (4) with the lens cover (15) provided. Phototube is light sensitive device and its sensitivity decrease with

PLANCK'S CONSTANT MEASURING APPARATUS



Verification of Inverse Square Law
Graph : 1/r² vs I