MIT-WPU

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Pledge

I solemnly affirm that I am presenting this journal based on my own experimental work. I have neither copied the observations, calculations, graphs and results from others nor given it to others for copying.

Signature of the student

Experiment 7: Characteristics of Solar Photovoltaic Cell

Aim: To plot I-V characteristics of solar cell, to determine its fill factor and corresponding optimum load

Apparatus: Solar cell/solar panel, current and voltmeters (OR DMM), variable load and source of light

Significance of the experiment: *Solar cell is a specially designed PN junction which converts light in to electrical power. The ability of the solar cell to deliver optimum power to the optimized load is signified in terms of it's fill factor. The present experiment aims at calculation of the fill factor and corresponding optimum load for a given solar cell.*

Theory: Solar cell is a specially designed PN junction diode that converts light into electrical power. This conversion occurs in three stages. When the PN junction is exposed to light, electron hole pairs are generated in P and N regions. These are then separated across opposite electrodes due to emf at the junction. (refer Fig.7.1). The separated carriers accumulate across the metal contacts and thus generate a potential difference (p.d). This p.d. can drive the optically excited minority carriers in circuit. Thus solar cell, when exposed to light, behaves as a battery that can deliver power to a load. The typical voltage and current from one junction is around 0.6 volts and a few micoramp, however this can be increased by cascading the solar cells in series and parallel (solar panels). Solar cells generate electricity from inexhaustible, freely available sunlight and without pollution, without accidents and need less maintenance. Further, an option of decentralized production can decrease transmission losses. However the low efficiency (10%), high production cost and dependence on sunlight limit its applications to remote areas (such as satellites and villages in deserts, forests) & low power accessories (such as calculators, wrist watches, street lights and solar water pumps). If efficiency is improved, solar power may find uses in solar automobiles, solar houses and many other areas.

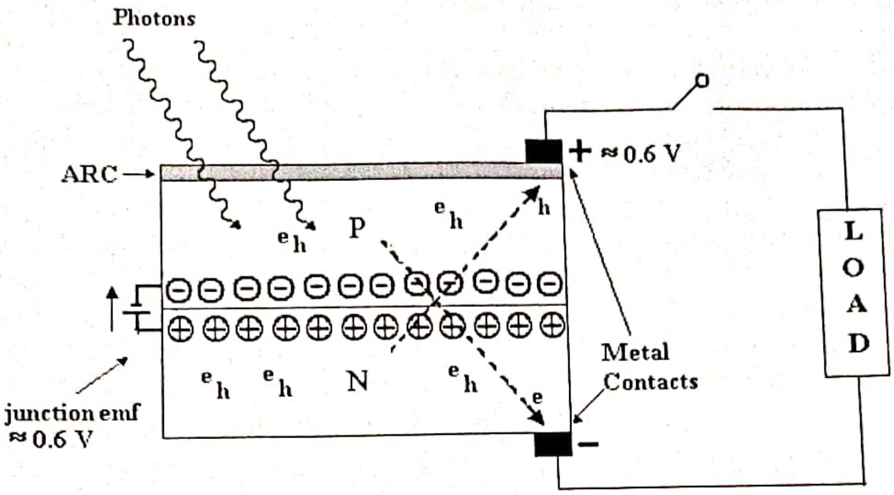

Fig. (7.1): Solar cell and its working

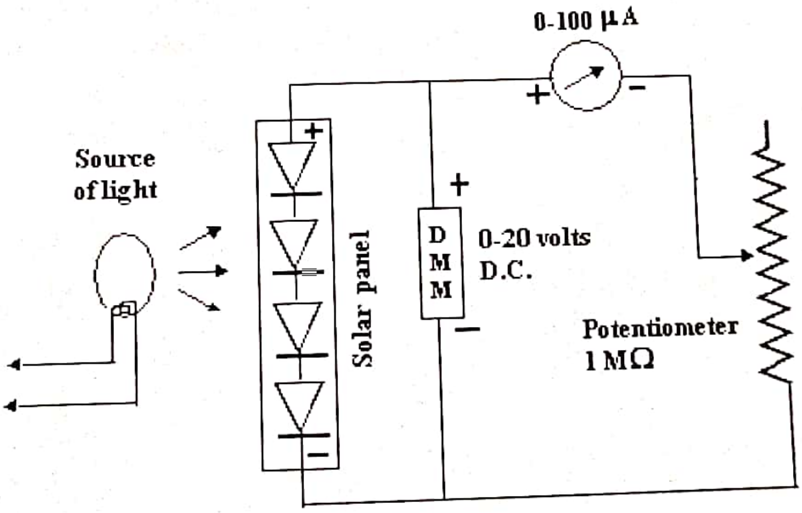

Figure (7.2): Circuit diagram

Procedure:

1. Connect the circuit as shown in the diagram (Fig.8.2) and get it checked. Connect DMM as a 0-20 voltmeter in parallel and DMM and 0-200 µA in series across the 1 MΩ variable load.
2. Make the light source ON and keep it to optimum intensity.
3. Take as many as possible current and voltage readings by varying the load. The readings corresponding to minimum and maximum load must be taken. Tabulate your observations as per table 8.1

4. Plot the graph of current Vs voltage. This represents characteristics of solar cell (refer Fig 8.3).
5. Extrapolate the graph on current and voltage axis. While extrapolating the curve keep the slope same. Calculate I_{SC}(Short circuit current) and V_{OC}(Open circuit voltage) from the intercept of the curve on current and voltage axis respectively. Draw perpendiculars at I_{SC} and V_{OC}. Intersection of these two lines defines a point P_I (I_{SC}, V_{OC}). The product $P_I = I_{SC} \times V_{OC}$ signifies ideal but unachievable power (refer Fig.8.3). The ideal power is unachievable because short circuit condition and open circuit condition cannot be obtained simultaneously.
6. An intersection of a line joining origin (0, 0) to P_I (I_{SC}, V_{OC}) on the curve gives a point, P_W (I_W, V_W), where current and voltage are simultaneously optimum. The product $P_W = I_W \times V_W$ thus signifies the optimum and realizable and hence workable power. Measure I_W and V_W and calculate workable power (P_W)
7. Calculate the fill factor $\left(f = \frac{P_W}{P_I} \times 100\ \%\right)$. The fill factor signifies the extent to which workable power is close to ideal power. Alternatively, it signifies the extent to which workable power rectangle 'fills' the ideal power rectangle.
8. Calculate the workable load $R_W = \frac{V_W}{I_W}$. R_W signifies the workable load at which solar cell can deliver optimum/workable power.
9. Tabulate your calculations and results as per the table (8.2)

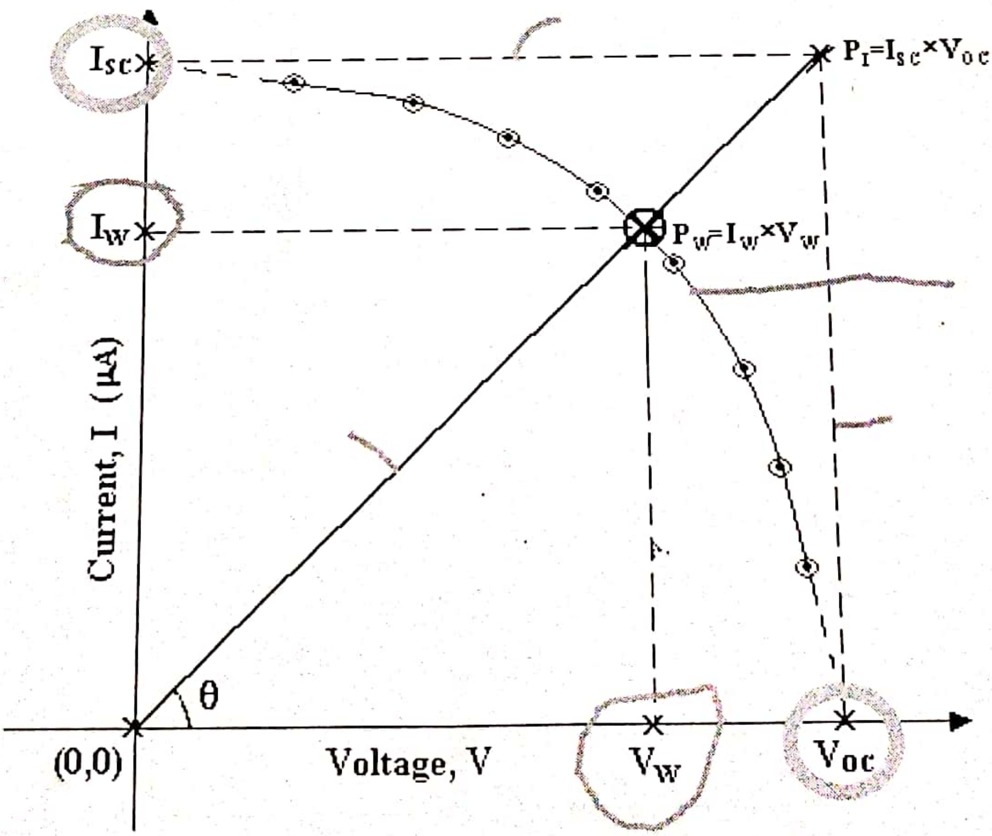

Figure (7.3): Characteristics of solar cell and calculations

ROUGH WORK

Table 7.1 Observations

Sr. No.	Current (μA)	Voltage (volts)
1	(Minimum)	(Maximum)
2	0	2.38
3	8	2.21
4	19.4	2.12
5	24.5	2.02
6	36.3	1.96
7	45.8	1.87
8	58.7	1.79
9	66.5	1.72
10	78.2	1.63
11	88.7	1.59
12	97.8	1.47
13	111.2	1.39
14	119.7	1.31
15	129.8	1.27
16	138.5	1.22
17	151.1	1.1
18	158.2	1.01
19	168.5	0.84
20	181.2	0.46
21		
22		
23		
24		
25	(Maximum)	(Minimum)

Table 7.2: Calculations and results

Sr. No.	Quantity	Symbol and Formula	Value	Unit
1	Short circuit current	I_{SC}	190	μA
2	Open circuit voltage	V_{OC}	2.38	Volts
3	Ideal power	$P_I = I_{SC} \times V_{OC}$	452.2	μW
4	Workable current	I_W	111	μA
5	Workable voltage	V_W	1.39	Volts
6	Workable power	$P_W = I_W \times V_W$	154.29	μW
7	Fill factor	$F = \frac{P_W}{P_I} \times 100\ \%$	34.11	%
8	Workable load	$R_W = \frac{V_W}{I_W \times 10^{-6}} \Omega = \cdots k\Omega$	12.52	kΩ

FAIR WORK

Table 7.1 Observations

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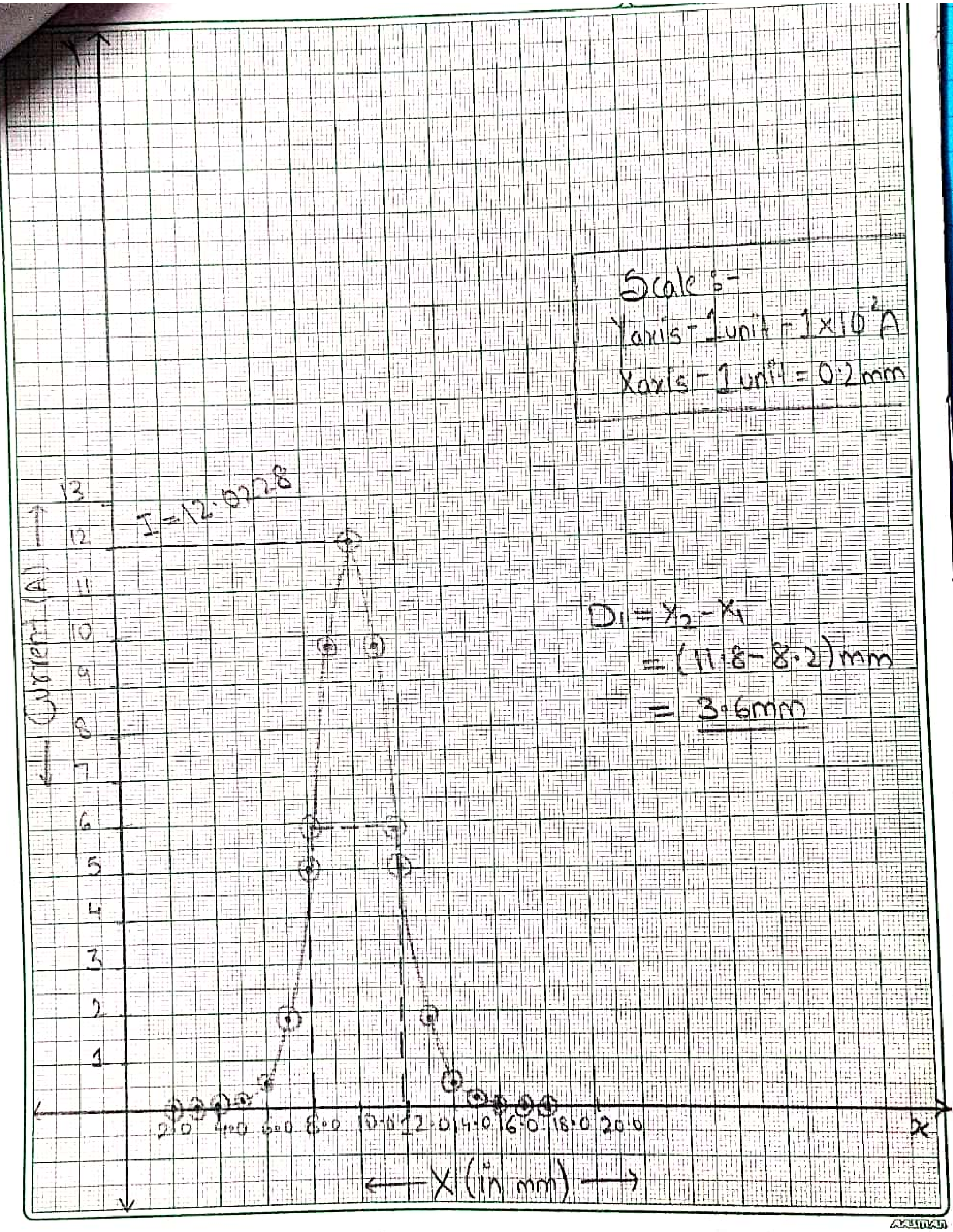


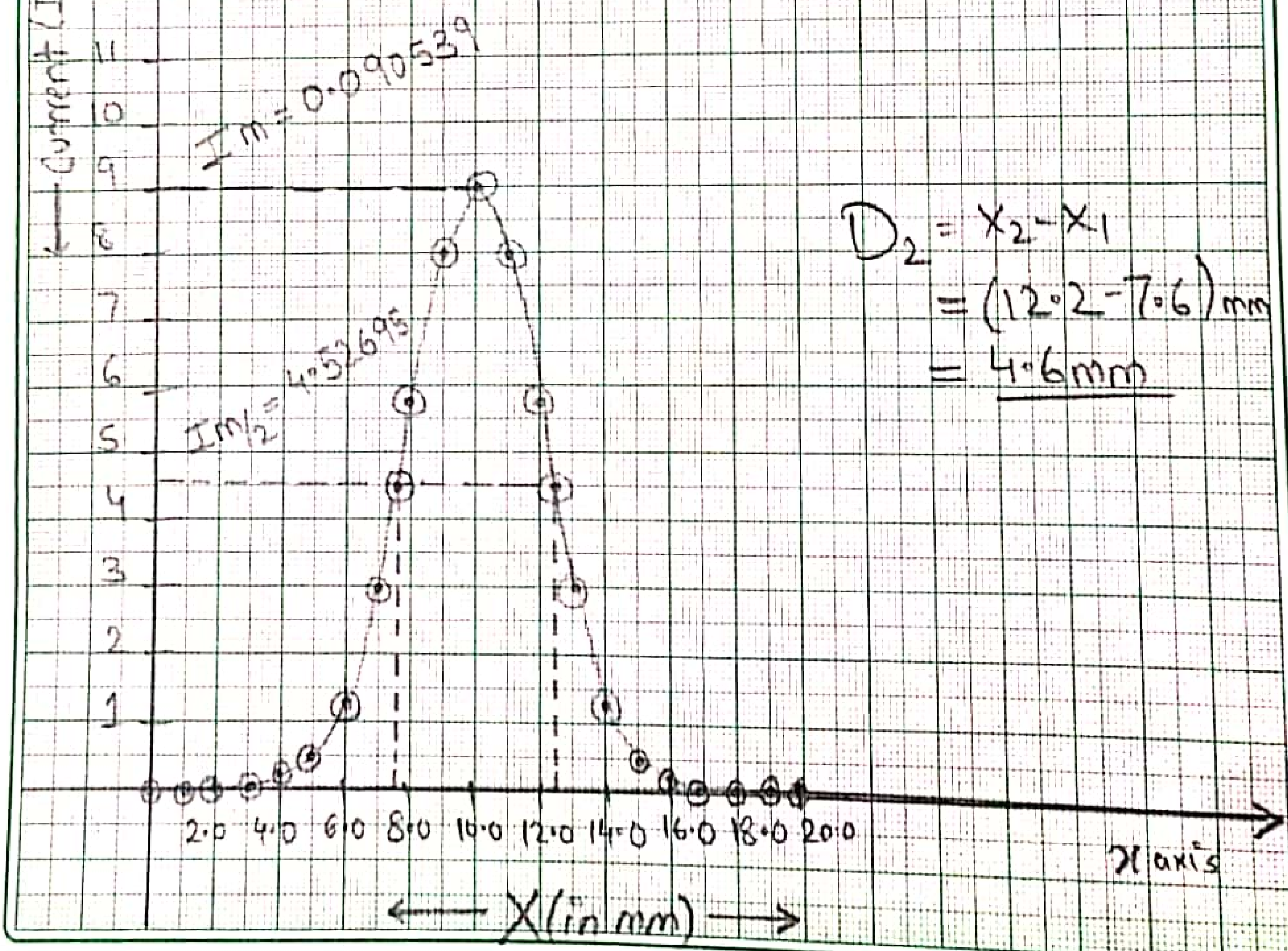
Scale :-
Y axis - 1 unit = 1×10^{-2} A
X axis - 1 unit = 0.2 mm

$D_1 = X_2 - X_1$
$= (11.8 - 8.2)$ mm
$= \underline{3.6 \text{mm}}$

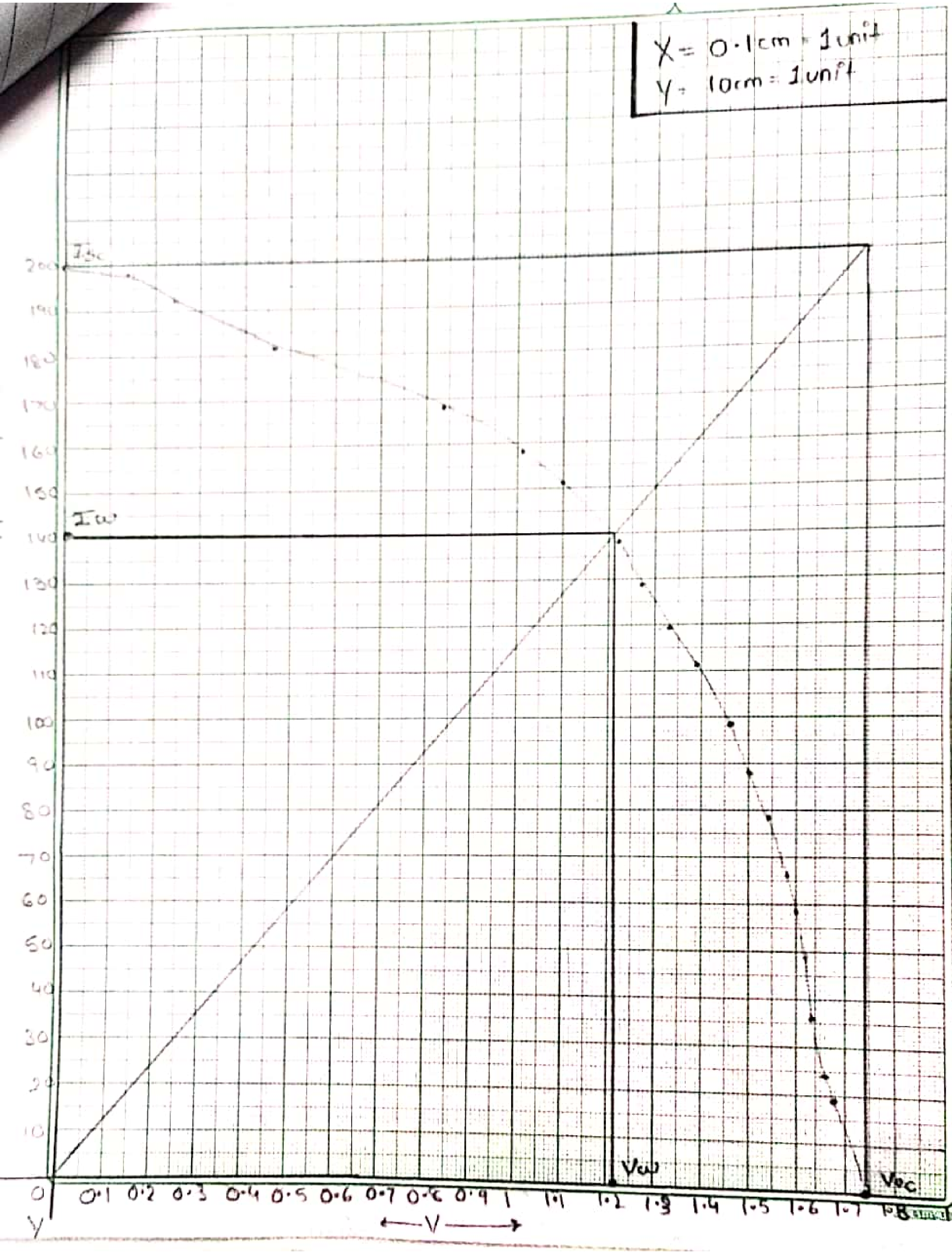
Scales:-

Y axis: 1 unit = 1×10^{-2} A

x axis: 1 unit = 0.2 mm



$$D_2 = X_2 - X_1$$
$$= (12.2 - 7.6)\,\text{mm}$$
$$= \underline{4.6\,\text{mm}}$$



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My understanding to this experiment. 7

This experiment emphasis on working of a solar cell. We determied the optimun load as well as the fill factor of the given photovoltic cell. Also we come to know that solar cells convert light into electric current, as they are specially designed P-N junction diode.