EE 236: Experiment 4
I/V Characteristics of Solar Cell

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1 Aim

To find I/V characteristics of a Solar Cell corresponding to varying illuminations of light applied to it, to plot its power curve, and also to find its fill factor.

2 Prelab Simulations

2.1 NGSPICE Code for IV Characteristics of Solar Cell

```
.include 'solar_cell.txt'

*Rohan Rajesh Kalbag
*20D170033
*Plot IV Characteristics of Solar Cell

v1 0 1 dc
x1 1 2 solar_cell
vsolar 2 3 dc 0
r1 3 0 100

.dc v1 -2 2 0.01
.control

run
let id = i(vsolar)
let vd = {v(1) - v(2)}
plot id vs vd
.endc
.end
```

2.2 NGSPICE Code for finding $V_{OC}, I_{SC}, I_{MP}, V_{MP}$
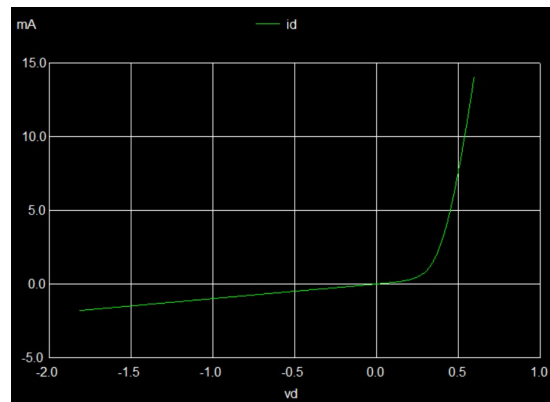
```
.include 'solar_cell.txt'

*Rohan Rajesh Kalbag
*20D170033
*Find Fill Factor

x1 1 2 solar_cell
vsolar 3 1 dc 0
r1 2 3 100

.dc r1 0.001 10k 0.1
.control

run
let power = {i(vsolar)*(v(1) - v(2))}
let id = i(vsolar)
let vd = {v(1) - v(2)}
plot id vs vd power vs vd
.endc
.end
```
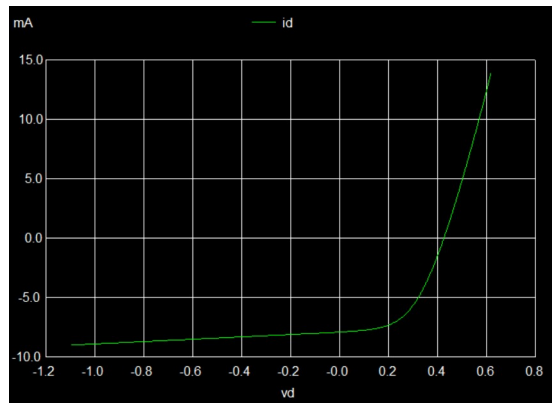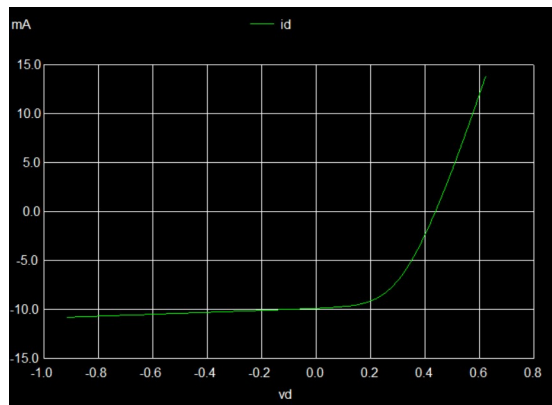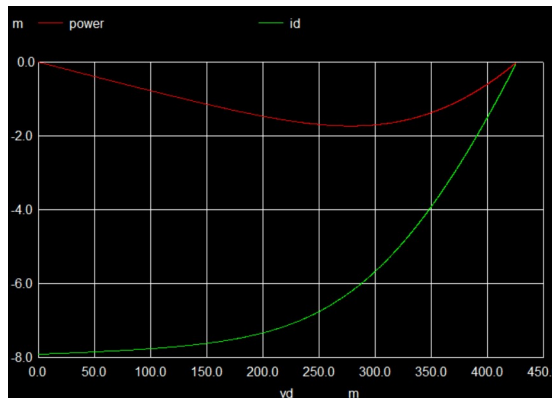
2.3 Simulation Results

I/V Characteristics for Solar Cell in Dark (Illumination Current of 0 mA)
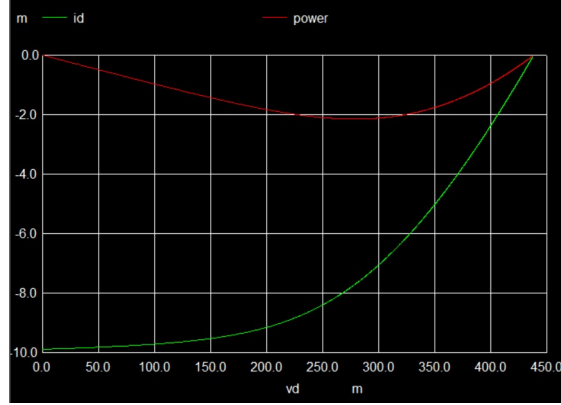
I/V Characteristics for Illumination Current of 8 mA

I/V Characteristics for Illumination Current of 10 mA

Power Curve and IV Characteristics for Cell as Power Source for 8 mA

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Power Curve and IV Characteristics for Cell as Power Source for 10 mA

From the two above two power curves we obtain the following values shown in the bottom table and hence can evaluate the value of Fill Factor

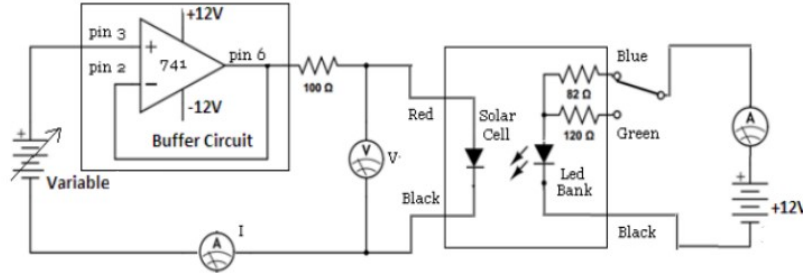| Illumination Current (mA)	V_{MP} (V)	I_{MP} (mA)	V_{OC} (V)	I_{SC} (mA)
10	0.28	-7.64	0.44	-10
8	0.277	-6.23	0.43	-8

Thus the values of fill factors can be obtained using this equation

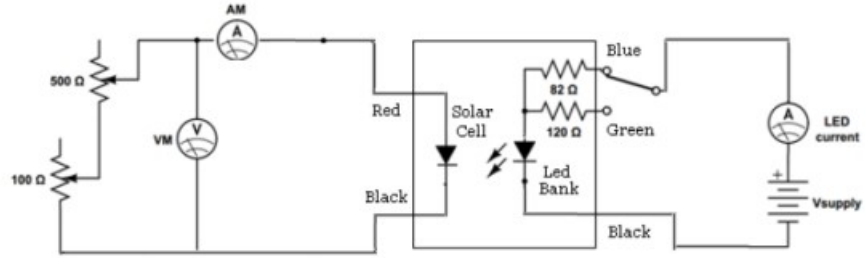$$Fill\ Factor = \frac{V_{MP} \cdot I_{MP}}{V_{OC} \cdot I_{SC}}$$

Thus fill factor for illuminations of **8 mA** is **0.486** and **10 mA** is **0.501**.
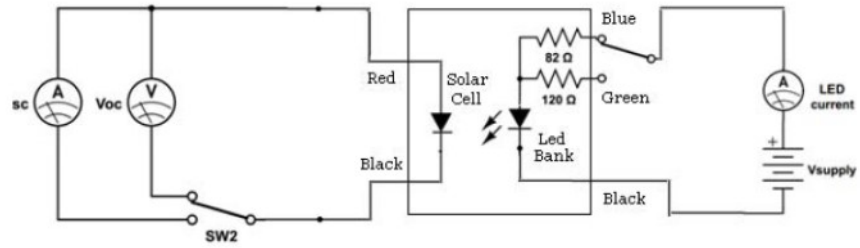
3   Lab Experiment

3.1   Circuits Used

Circuit To Obtain IV Characteristics

Circuit for Solar Cell as Power Source and Power Curve

Circuit to find V_{OC} and I_{SC}

3.2 Observations and Plots Obtained

3.2.1 Part 1(a): Values Obtained for Dark I-V Characteristics

V_{supply}	I_D (mA)	V_D
-2	-1.1	-1.8
-1.5	-0.7	-1.44
-1	-0.4	-0.96
-0.8	-0.32	-0.76
-0.5	-0.19	-0.48
-0.3	-0.12	-0.32
-0.1	-0.07	-0.14
0.1	0.03	0.09
0.5	1.42	0.37
0.8	3.19	0.41
1	5.27	0.44
1.5	9.35	0.46
2	14	0.48
3	21.2	0.5
4	21	0.5

3.2.2   Part 1(a): Plot Obtained for Dark I-V Characteristics
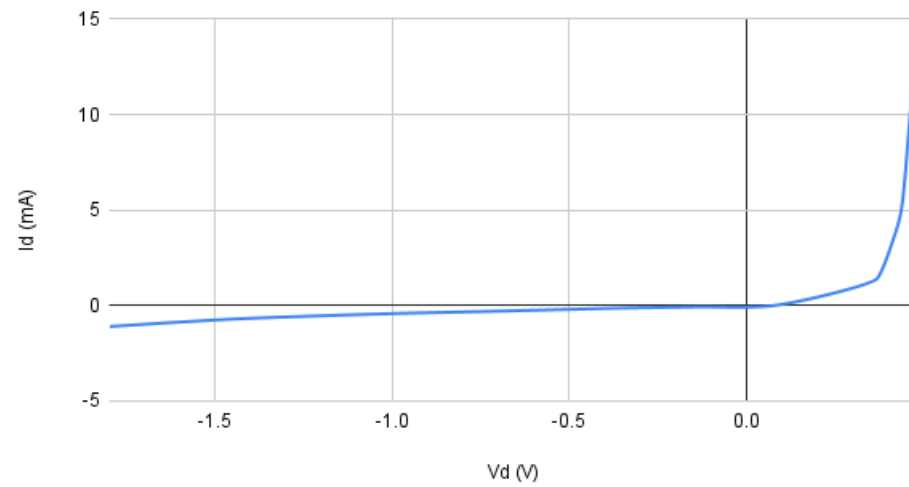
IV Characteristics Obtained for Solar Cell in Dark

3.2.3   Part 1(b): For Illumination 1 (Connected to "Green")

| Vsupply	Id(mA)	Vd
-2	-6.64	-1.28
-1.8	-6.5	-1.02
-1.5	-6.37	-0.8
-1	-6.15	-0.32
-0.8	-6.1	-0.15
-0.5	-5.95	0.13
-0.3	-5.5	0.29
-0.1	-4.6	0.36
0	-3.45	0.4
0.3	-1.9	0.42
0.5	0.86	0.45
0.8	3.2	0.46
1	4.5	0.47
1.5	9.1	0.49
1.8	11.5	0.5
2	13.4	0.5

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IV Characteristics for I1 (Green)
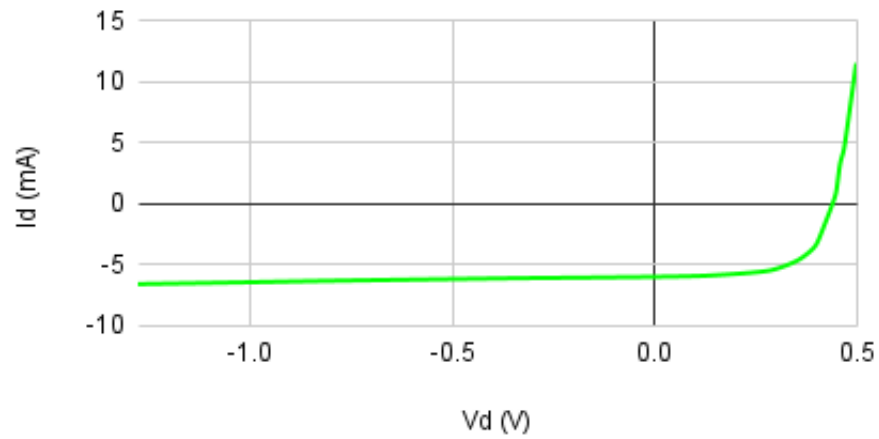
IV Characteristics Obtained for Illumination 1 (Green)

3.2.4   Part 1(b): For Illumination 2 (Connected to "Blue")

Vsupply	Id(mA)	Vd
-2	-8.79	-1.05
-1.8	-8.7	-0.88
-1.5	-8.5	-0.55
-1	-8.33	-0.06
-0.8	-8.25	0.08
-0.5	-7.7	0.28
-0.3	-6.63	0.37
-0.1	-4.6	0.41
0	-3.7	0.42
0.3	-1.8	0.44
0.5	0.41	0.46
0.8	3.07	0.47
1	4.8	0.48
1.5	9.32	0.49
1.8	12.15	0.5
2	13.6	0.5

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IV Characteristics for I2 (Blue)
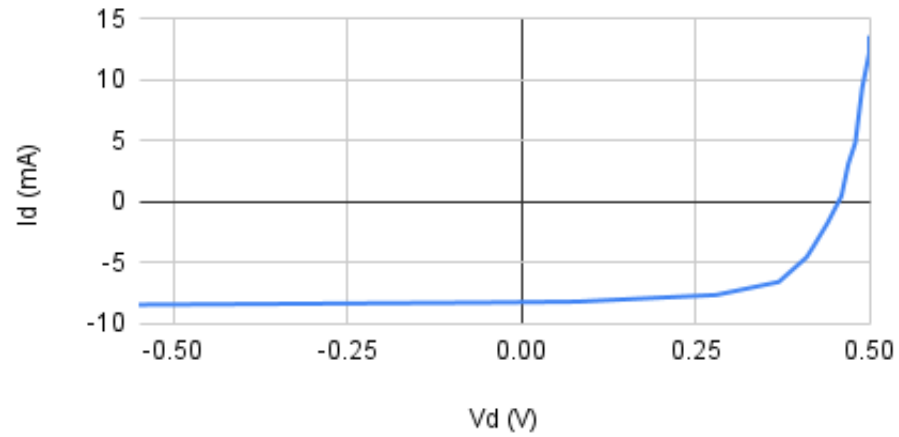
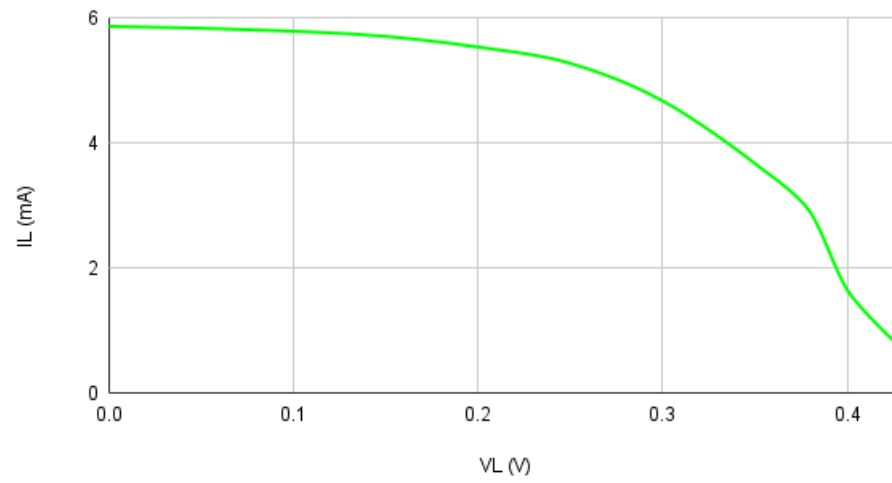*IV Characteristics Obtained for Illumination 2 (Blue)*

3.2.5   Part 2: For Illumination 1 (Connected to "Green")

The value of current flowing through the LED bank to illuminate the solar cell was measured as **44.3 mA**

The values obtained for V_L, I_L and $P = V_L \cdot I_L$

V_L (V)	I_L (mA)	P (mW)
0	5.86	0
0.05	5.83	0.2915
0.11	5.77	0.6347
0.15	5.7	0.855
0.2	5.53	1.106
0.25	5.27	1.3175
0.3	4.67	1.401
0.35	3.67	1.2845
0.38	2.89	1.0982
0.4	1.65	0.66
0.43	0.7	0.301

IL vs VL (Green) Iled = 44.3mA

I_L vs V_L for Illumination 1 (Green)

Power vs VL (Green) (Pmax = 1.914mW)

P vs V_L for Illumination 1 (Green)

3.2.6 Part 2: For Illumination 2 (Connected to "Blue")

The value of current flowing through the LED bank to illuminate the solar cell was measured as **58.9 mA**

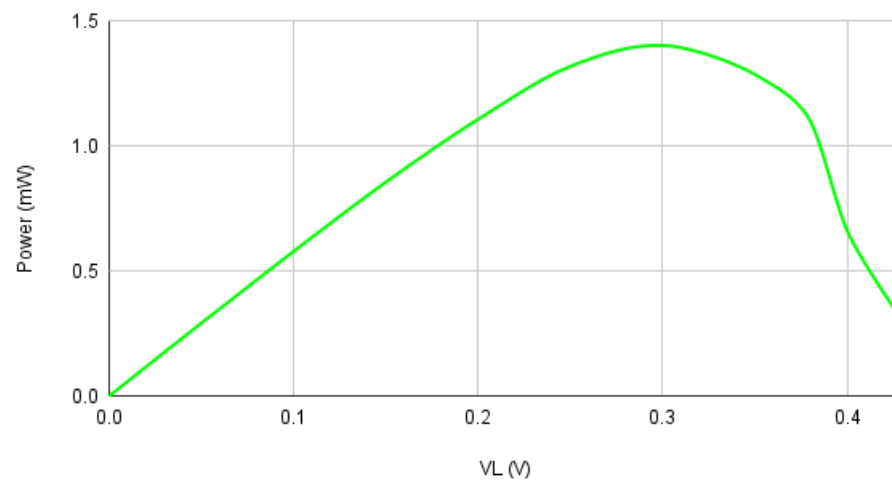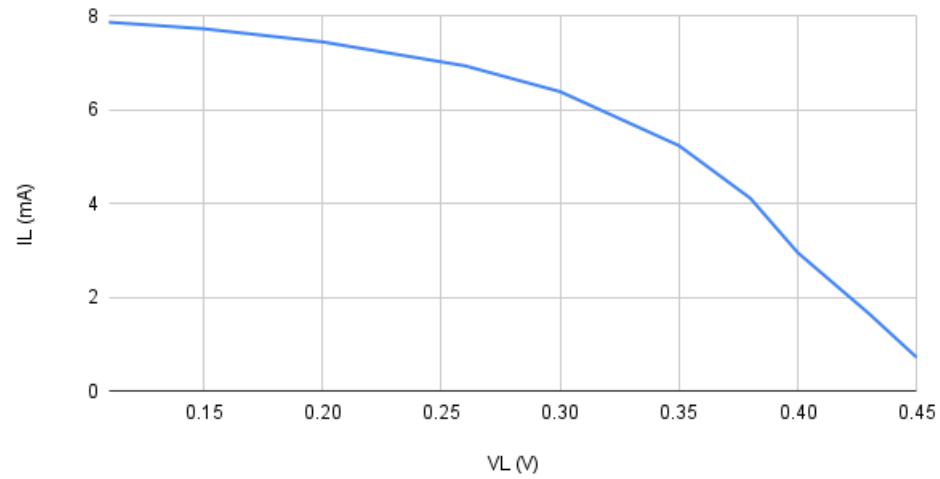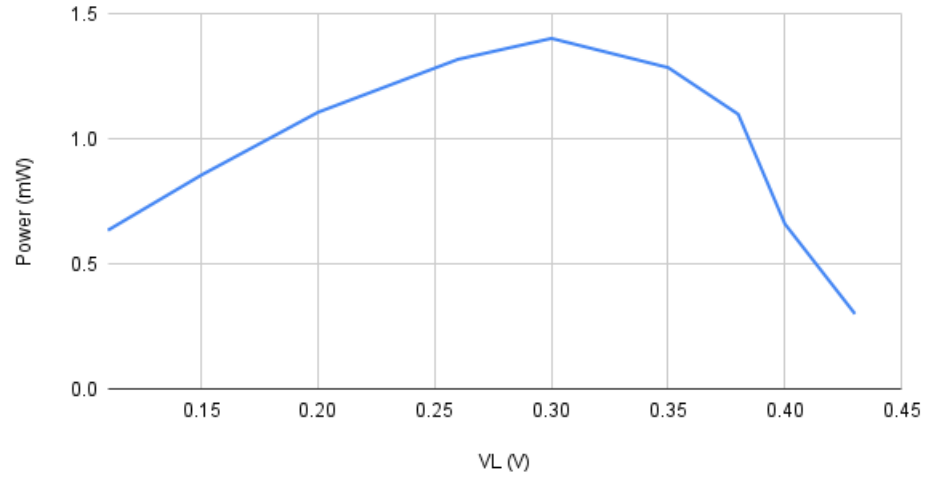The values obtained for V_L, I_L and $P = V_L \cdot I_L$

V_L (V)	I_L (mA)	P (mW)
0	8	0
0.05	7.98	0.399
0.11	7.86	0.8646
0.15	7.72	1.158
0.2	7.44	1.488
0.26	6.93	1.8018
0.3	6.38	1.914
0.35	5.23	1.8305
0.38	4.11	1.5618
0.4	2.95	1.18
0.43	1.65	0.7095
0.45	0.72	0.324

IL vs VL (Blue) Iled = 58.9mA

I_L vs V_L for Illumination 2 (Blue)

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Power vs VL (Blue) (Pmax = 1.401mW)

P vs V_L for Illumination 2 (Blue)

3.2.7 Results Obtained after Calculations for Part 2

The Fill Factors were found using the following relation

$$Fill\ Factor = \frac{P_{max}}{V_{OC} \cdot I_{SC}}$$

Value	Illumination 1 (Green)	Illumination 2 (Blue)
$I_{LED\ Bank}$	44.3 mA	58.9 mA
I_{SC}	5.86 mA	8 mA
V_{OC}	0.45 V	0.5 V
P_{max}	1.914 mW	1.401 mW
I_{MP}	4.67 mA	6.38 mA
V_{MP}	0.3 V	0.3 V
FF	0.5312	0.4785

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3.2.8 Part 3: Values of V_{OC} and V_{SC} for Different Illuminations

V_{LED} (V)	I_{LED} (mA)	I_{SC} (mA)	V_{OC} (V)
6	10	0.8	0.3
7.3	20	2.25	0.37
8.5	30	3.73	0.4
9.7	40	5.27	0.41
10.8	50	6.77	0.42
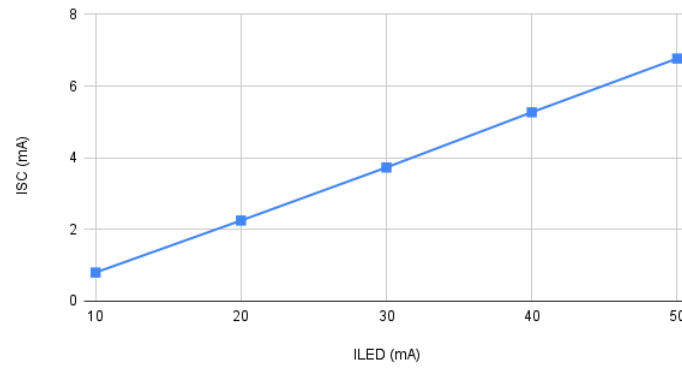
Variation of I_{SC} with I_{LED}
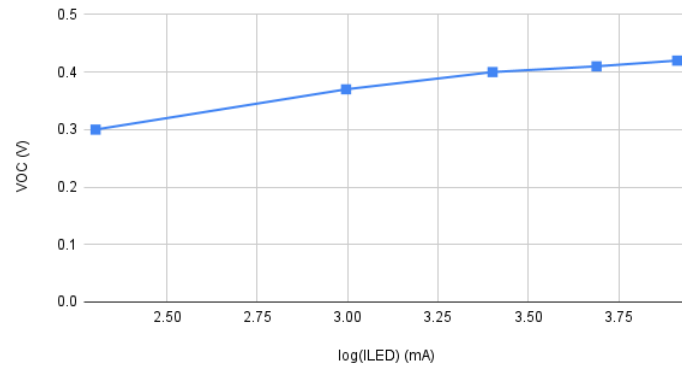
Variation of V_{OC} with $log(I_{LED})$

We notice that both the above plots show **linear behaviour** as we would expect.