ECEN204	**Lab 2**

Diode Characteristics: Report

Name: Daniel Eisen Student Number 300447549

Complete a short report on your Lab 2 by providing the following results from your measurements and adding your conclusions where requested. Also add graphs and tables as appropropriate.

This should be handed in at the start of Lab 3.

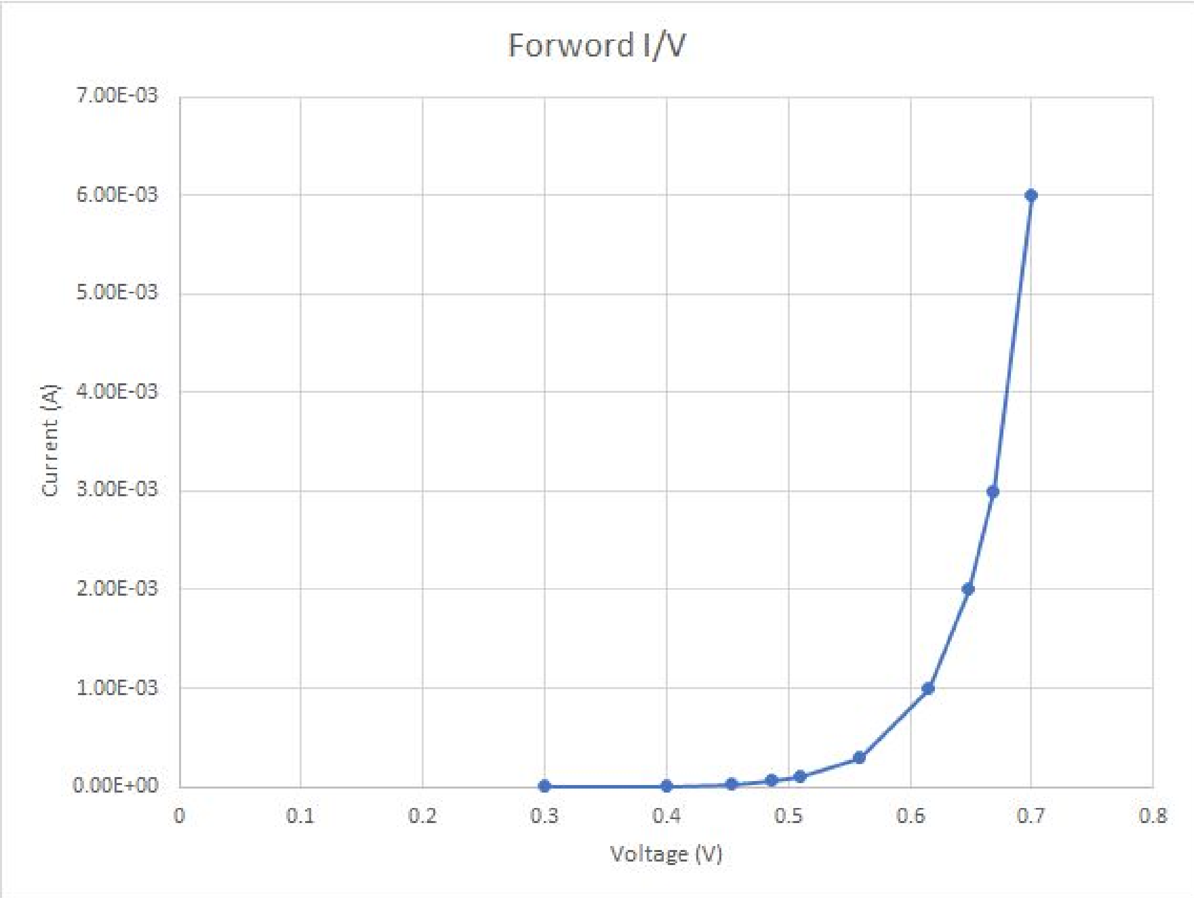
1. Data sheet characteristics of the 1N4148 diode (Section 2)

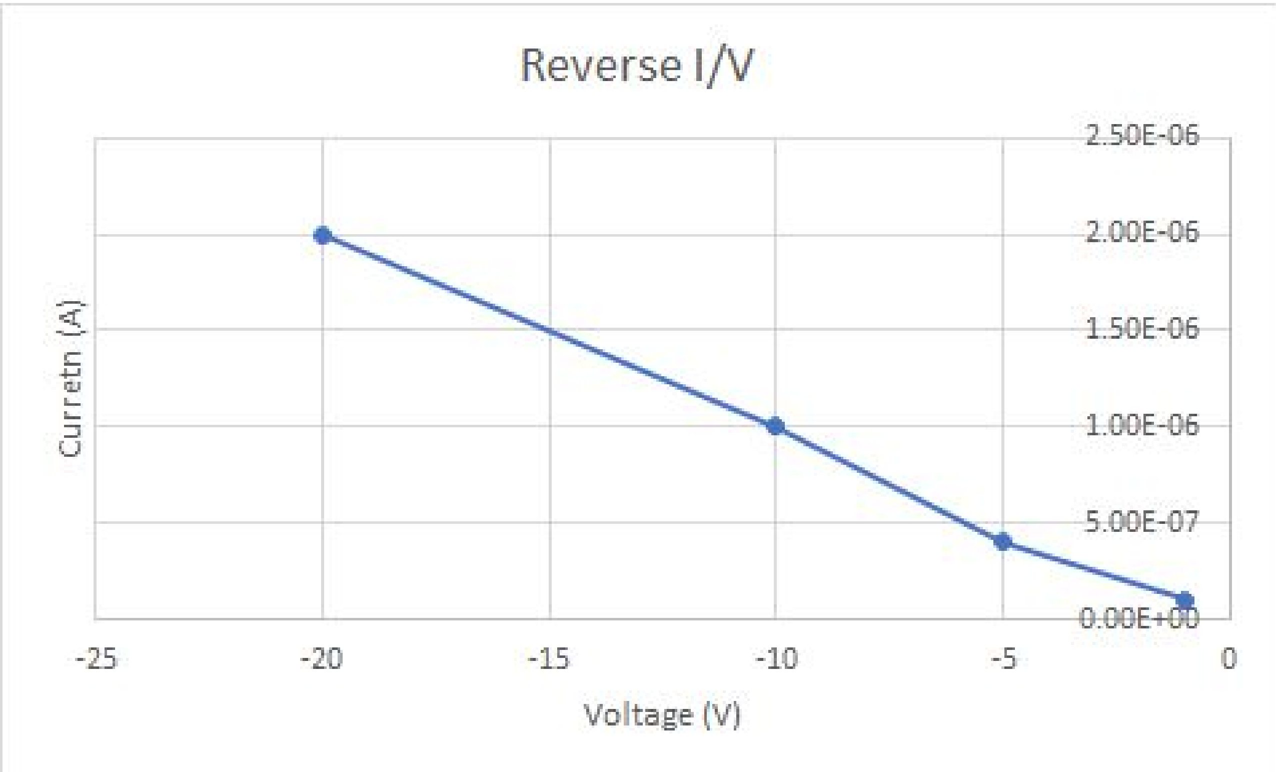
Tabulate the data sheet values that you have obtained for the various diode parameters in Section 2.

Characteristic	**Value from datasheet**
The maximum constant (DC) forward current.	300mA
The peak forward current surge lasting no more than 1 second.	2A
The operating temperature range of the device.	-65 to +150 C
The maximum power dissipation of the diode assuming a 25 ºC environment.	500mW
The reverse breakdown voltage with a reverse current of 5 µA.	100V
The worst case recovery time of the diode	4ns

2. Diode I-V curve and characteristics for Si diode (Section 3.1)

Show your plot(s) of measured diode current and voltage for the forward bias and reverse bias regions for the diode operating at room temperature. From these graph(s) determine:


Forword I/V
7.00E-03
6.00E-03
5.00E-03
4.00E-03
3.00E-03
2.00E-03
1.00E-03
0.00E+00
Current (A)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Voltage (V)


Reverse I/V
2.50E-06
2.00E-06
1.50E-06
1.00E-06
5.00E-07
0.00E+00
Curretn (A)
-25
-20
-15
-10
-5
0
Voltage (V)

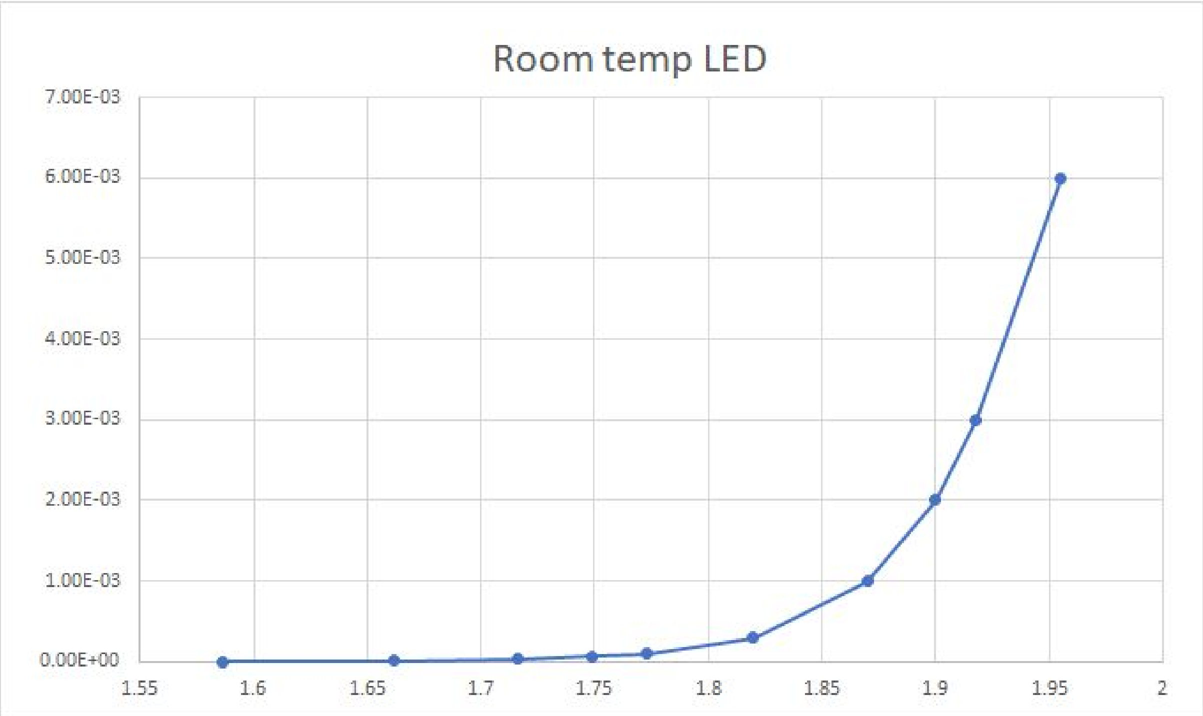
The voltage drop over the diode in forward bias, the resistance of the diode when on.

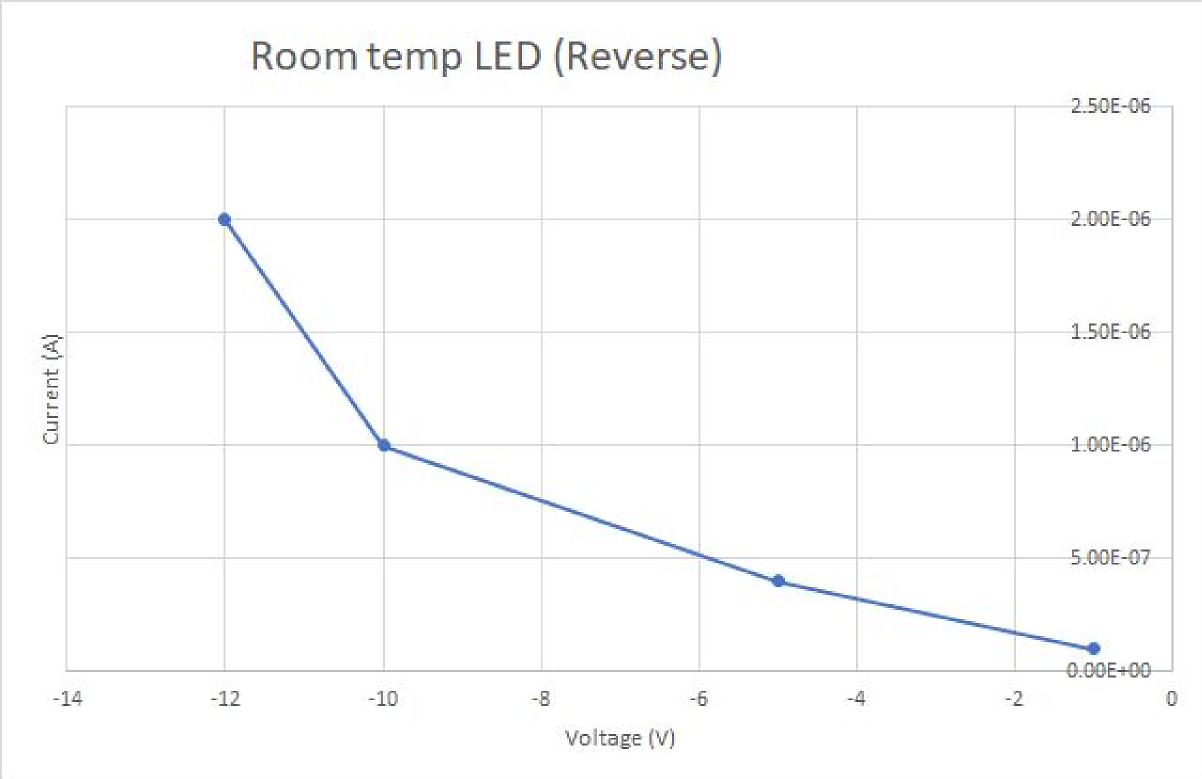
Voltage _ V	Resistance _ Ω
0.7	1.17E+02
0.668	2.23E+02
0.648	3.24E+02
0.615	6.15E+02
0.559	1.86E+03
0.509	5.09E+03
0.486	8.10E+03
0.453	1.51E+04
0.4	4.00E+04
0.3	1.00E+05

The reverse bias current that flow at –5 V: ***(negative) 0.4μA***

3. Diode I-V curve and characteristics for a LED (Section 3.2)

(a) Show your plot(s) of measured diode current and voltage for the forward bias and reverse bias regions for the diode operating at room temperature. From these graph(s) determine:





The voltage drop over the diode in forward bias, the resistance of the diode when on.

Voltage _ V	Resistance _ Ω
1.955	3.26E+02
1.918	6.39E+02
1.9	9.50E+02
1.87	1.87E+03
1.82	6.07E+03
1.773	1.77E+04
1.749	2.92E+04
1.716	5.72E+04
1.662	1.66E+05
1.586	5.29E+05

The reverse bias current that flow at –5 V: ***(negative) 0.4µA***

(b) What was the diode current when light emission was first observed ? What colour is the light from the LED ?

*LED technically started to emit visible light (just barely) at 1.75V, **30µA** but was not what I'd call operating until 1.9V, **2mA**. At which point the light was enough to light up the casing.*

(c) What would be a suitable value for the diode current in order to produce a suitable light level ?

4-5mA+ was bright enough to be usable.

(d) Compare the values of the voltage drop observed for diodes of different colours by exchanging results with other people in the lab who had a different colour LED.

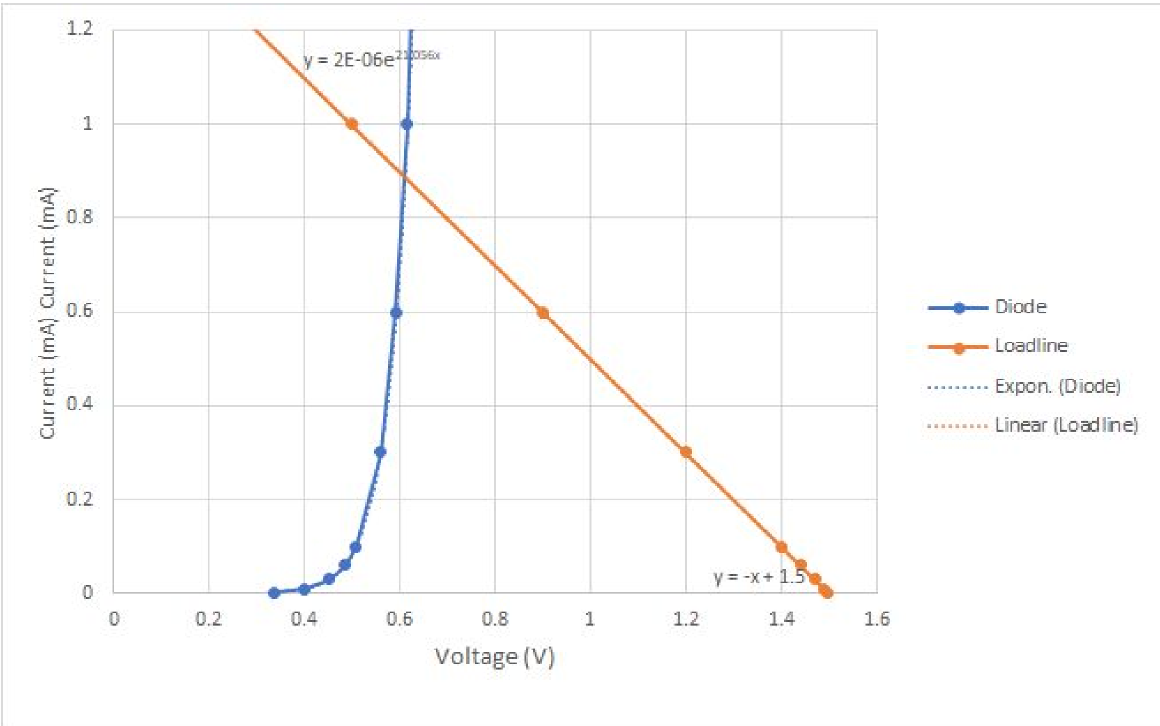
Diode Colour	V_D (V)
red	*1.6*
orange	*1.73*
green	*2.1*

(e) Why would these diodes show different colours in the output spectrum ?

These different LED's will be of differing semiconductor composition so that the band-gap energy corresponds to the energy of the visible light spectrum, with the different values of E_g in each, resulting in differing colors.

4. The diode load line (Section 3.3)

(a) Show the graph of your load line.



(b) Use this load line graph to determine the current through the diode and the voltage drop over the diode at the operating point of the circuit. Compare to the measured values from Section 3.1.

2E-6*e^21.056x `intercept w/` ***-x+1 ⇒ V = 0.62, I = 0.9mA***

This lines up quite well with my measure results.

(c) The load line above was constructed using your experimentally determined diode curve. What would you do if this measured I-V data was not available ? Hint: How would you model your diode behaviour so that you can obtain a best estimate of circuit parameters (I_D, V_D) using ?

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By using a diode mode, to represent an important characteristic of the diode, ie modelling it a reverse polarity source (or plus a resistance) to represent ON at Vo.
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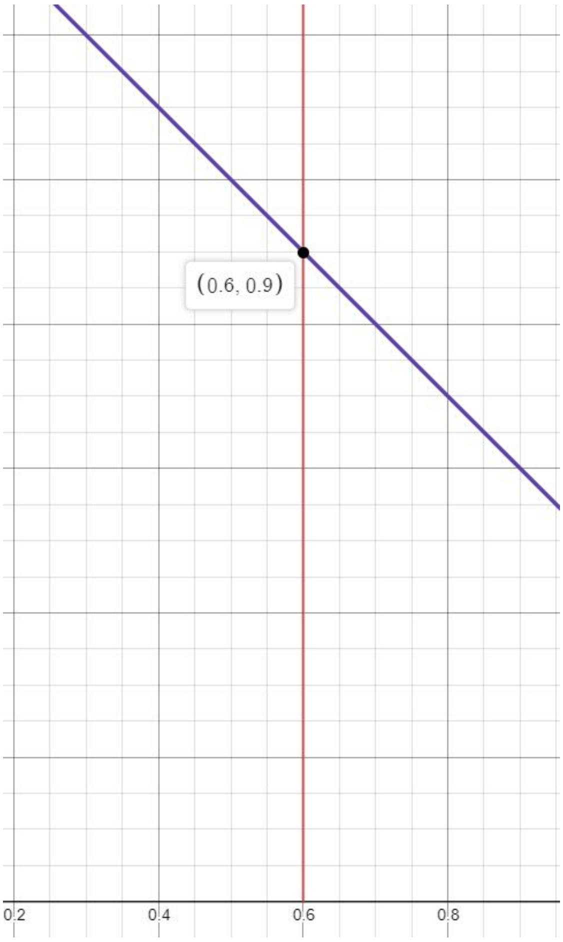
(d) Use this method you suggested in (c) above and sketch an approximate load line (no real I-V data available) and again calculate I_D and V_D. How much do these values differ from the values obtained using the actual diode curve in (a) and (b) ?

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Vo from this simple model yielded very close results to the actual measured results.
Meas: 0.62, I: 0.9
Modl: 0.6,  I: 0.9
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4. Additional Questions

4.1 Temperature dependence of diode behaviour

You repeat your measurements of the diode I-V characteristics, but you also perform these measurements with the diode immersed in liquid nitrogen (-196 oC) and in hot water (90 oC). The data from these measurements are shown in the table below.

Reverse Bias

T=293 K			T=383 K			T=77 K	
Voltage	I (uA)		Voltage	I (uA)		Voltage	I (uA)
-9.8	-1.0		-10	-0.9		-10.06	-2.6
-7.98	-0.8		-7.99	-0.7		-8.5	-2.3
-7.24	-0.7		-7.3	-0.6		-7.3	-2.0
-5.08	-0.5		-5.9	-0.5		-5.02	-1.5
-3.056	-0.3		-3.6	-0.3		-3.32	-1.1
-1.969	-0.2		-2.43	-0.2		-2.05	-0.8
-0.325	-0.1		-0.85	-0.1		-1.02	-0.5
0	0.0		0	0.0		0	0.0

Forward Bias

T=293 K			T=383 K			T=77 K	
Voltage	I (mA)		Voltage	I (mA)		Voltage	I (mA)
0	0.00E+00		0	0.00E+00		0	0
0.261	5.00E-04		0.121	2.70E-03		0.435	1.00E-04
0.363	3.70E-03		0.207	1.14E-02		0.726	1.00E-04
0.404	8.60E-03		0.27	3.19E-02		0.966	1.20E-03
0.45	2.29E-02		0.302	5.35E-02		0.989	6.60E-03
0.501	6.69E-02		0.415	3.51E-01		1	1.54E-02
0.533	1.33E-01		0.45	6.29E-01		1.016	5.78E-02
0.59	4.47E-01		0.48	1.05E+00		1.035	2.90E-01
0.606	6.26E-01		0.547	3.13E+00		1.041	4.82E-01
0.628	9.20E-01		0.57	4.49E+00		1.05	1.10E+00
0.652	1.41E+00		0.593	6.28E+00		1.066	2.90E+00
0.67	2.00E+00		0.629	1.04E+01		1.081	5.79E+00
0.685	3.13E+00					1.096	9.63E+00
0.696	3.91E+00						
0.704	4.49E+00						
0.712	5.22E+00						

0.722	6.25E+00						
0.735	7.81E+00						
0.752	1.04E+01						

Forward__

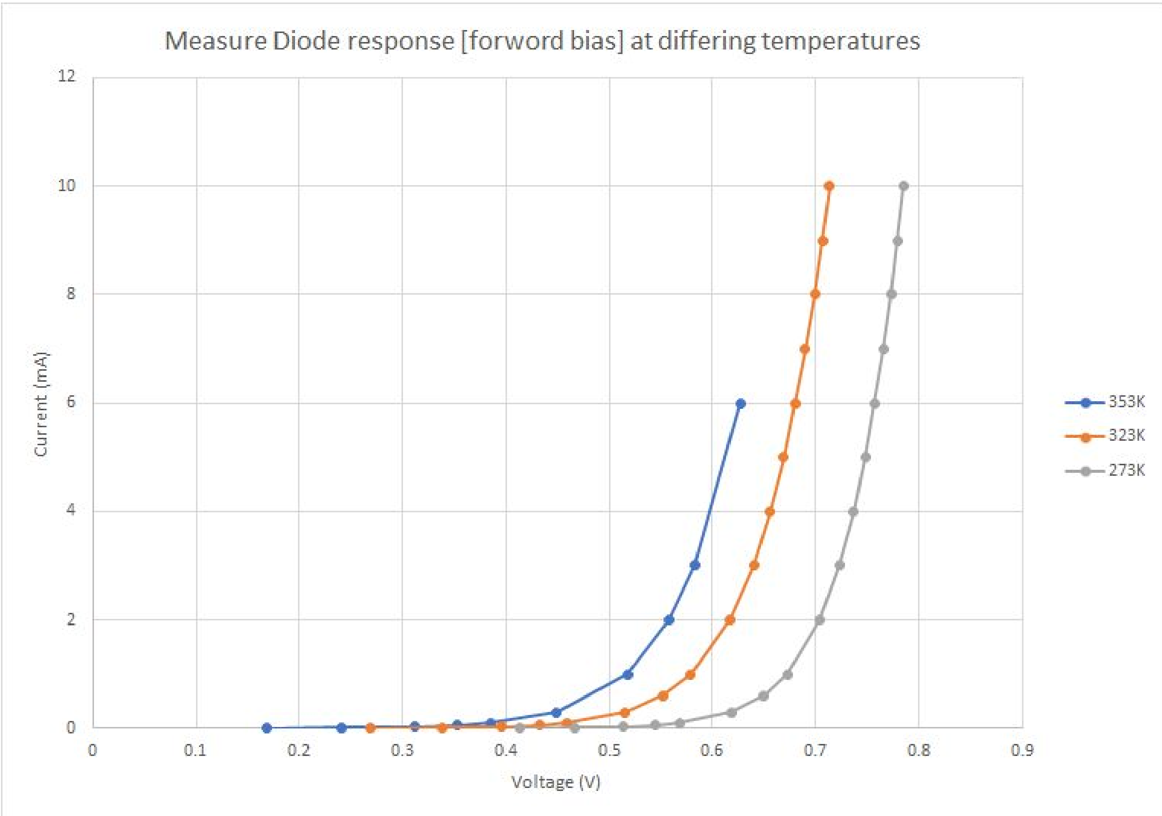
T=353K			T=323K			T=273K	
Voltage	I (mA)		Voltage	I (mA)		Voltage	I (mA)
0.168	0.003		0.269	0.003		0.413	0.003
0.241	0.01		0.338	0.01		0.466	0.01
0.311	0.03		0.396	0.03		0.514	0.03
0.353	0.06		0.433	0.06		0.545	0.06
0.385	0.1		0.459	0.1		0.568	0.1
0.449	0.3		0.516	0.3		0.618	0.3
0.518	1		0.552	0.6		0.65	0.6
0.558	2		0.579	1		0.673	1
0.583	3		0.617	2		0.704	2
0.627	6		0.64	3		0.723	3
			0.656	4		0.737	4
			0.669	5		0.748	5
			0.68	6		0.757	6
			0.69	7		0.766	7
			0.699	8		0.773	8
			0.707	9		0.779	9
			0.713	10		0.785	10

Reverse__

T=353K			T=323K			T=273K	
Voltage	I (uA)		Voltage	I (uA)		Voltage	I (uA)
-1	-0.3		-1	-0.1		-1	-0.1
-5	-1		-2	-0.2		-2	-0.2
-10	-1.9		-3	-0.3		-3	-0.3
-15	-2.8		-4	-0.4		-4	-0.3
-20	-3.7		-5	-0.5		-5	-0.4

	-6	-0.6		-6	-0.5
	-7	-0.7		-7	-0.7
	-8	-0.8		-8	-0.8
	-9	-0.9		-9	-0.9
	-10	-1		-10	-1

(a) You must now compare the behaviour of this diode at the three different operating temperatures. Plot the three forward bias regions on one graph and the three reverse bias regions on another graph.



(b) From your forward bias graphs comment on the temperature behaviour of the forward bias voltage drop. Calculate an approximate value for the temperature variation of this voltage. Also discuss the observed trend in the forward bias voltage drop with temperature in more detail using your knowledge of semiconductors and the device physics of a p-n junction. **Hint:** Look the equation describing V_o (from your class notes) and see what the temperature dependence is of this equation.

The higher the temperature, the higher the thermal energy on the charge carriers. Ie they have more available energy to jump the band gap 'faster' or at a lower voltage.

(c) From your reverse bias graphs discuss the temperature behaviour of the reverse bias current. Can you suggest a reason for the temperature behaviour of this diode parameter ?

As temperature decreases the speed of breakdown increases. This could be due to less intrinsic charge carriers resulting in a weaker junction field.

4.2 Design of an LED circuit

You must design a circuit for a light emitting diode. The circuit must be powered by a 3.3V power source and you need a current of at least 2 mA through the diode to ensure sufficient brightness. At the same time you would also like to limit the diode current to no more than 5 mA to limit your power consumption. Calculate a suitable value of the current limiting resistor for this circuit if it is given that the LED will have a forward voltage drop of 2.1 V over it. Show your reasoning and calculations.

V_s = 3.3V, V_{LED} = 2.1V, V_R = 1.2V (voltage loop law)
we want: 2mA < i < 5mA, so take i = 4mA
R = 1.2 / 4e-3 = 300ohm
Assume a +-10% tolerance on the resistor and check current variance
270ohm: i = 4.4mA
330ohm: i = 3.6mA

This falls with range, and towards upper end so a nice brightness level.