Solar PV: Sun Angle, Cloud Cover and Technologies

During this lab we are going to explore how the angle of the sun can affect the output of our solar panels, along with the idea of "cloud cover", before comparing the output of monocrystalline and polycrystalline solar panels (more on these technologies later)

Sun angle and cloud cover

On any particular day of the year, the solar irradiance available at a particular location can vary to a large extent, and frequently. This is due to the earth rotating around the sun (seasonal changes), the earth spinning (daily changes) and changes in the weather (like cloud cover).
To explore this concept, we will use our solar panel and light to emulate the sun travelling across the sky, as it does on a typical day.
Connect the circuit shown in figure 1, where we will be measuring the voltage across the load.
Remember:

$$P = VI = \frac{V^2}{R} \quad \text{Because} \quad I = \frac{V}{R}$$

So, we are going to measure the value of the resistor before we start (make a note of it) and during the experiment we will just measure voltage (rather than voltage and current), using the above equation to calculate the power output.

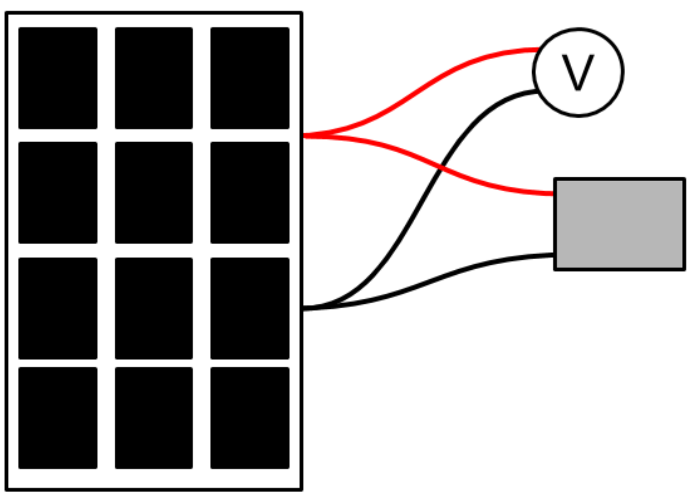

Figure 1: Circuit layout

Core 1: (20 marks)
Once connected, set up the light directly above the middle of your panel at a height of 30cm. Now, use the protractor to alter the angle of the panel in steps of 10 degrees, from 0 to 90 degrees, making a table that displays each angle and the power output.
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Angle	Voltage (V)	Power Output (W)
0	5.93v	0.130

10	5.32	0.104
20	4.80	0.085
30	4.14	0.063
40	3.59	0.004
50	3.20	0.037
60	2.70	0.027
70	2.25	0.018
80	1.88	0.013
90	0.80	0.002

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Core 2: (10 marks)
Now plot the power output vs the angle, what can you conclude from the shape of the graph?
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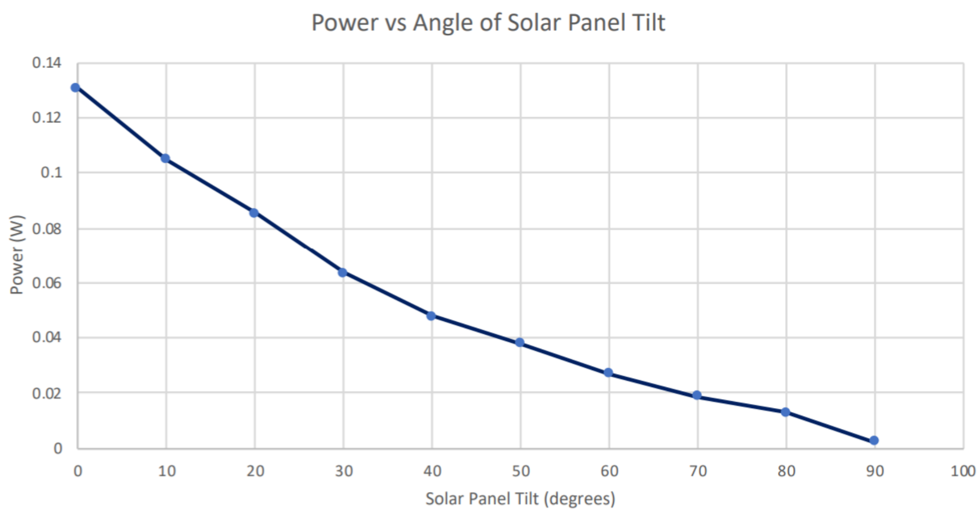

As the angle increases from 0-90 the power collected decreases.
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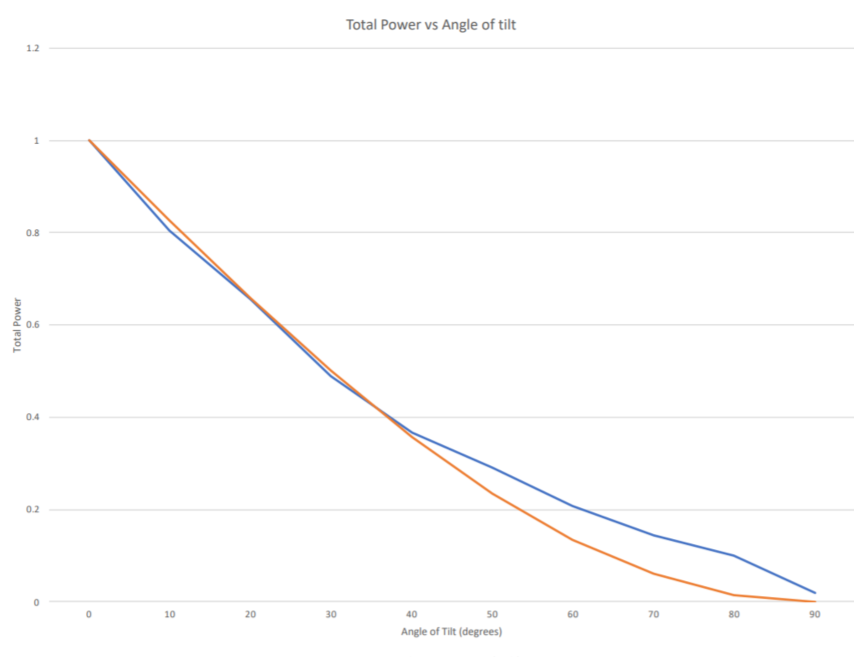
Core 3: (20 marks)
Next, we want to look at the data as a percentage of our highest output for this test condition.
So, divide all the values by the highest power output (should have a range of values between 0

and 1). Now calculate the 1-SIN() of each angle (between 0 and 90 degrees), and plot both data sets on the same plot (percentage vs angle and sin(angle) vs angle).
Is there a correlation between the two graphs? Explain why this might not be perfect.

1 – Sin()

Angle	
0	1
10	0.826
20	0.658
30	0.5
40	0.357
50	0.234
60	0.134
70	0.060
80	0.015
90	0



The graph produced is not perfect due to testing under altered conditions. Light sources around our experiment from other teams affected our results. With the inferring of the lights and the equipment also being possibly faulty these could have been the reason why our results were altered and not perfect.

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Core 4: (10 marks)
With the panel facing directly at the light (still 30cm apart), again, measure the output power. Now, with your hand, cover approximately a quarter of your solar panel and measure the power again. Are you still getting three quarters of your power out?
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The start voltage without any cells covered is 5.93V however when a quarter of the panel was covered the voltage dropped down to 0.14V. Meaning that the power decreases from 0.1302W to 0.0000726W.
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Completion: (20 marks)
In fact, just cover one of the cells on your solar panel and measure the power output again. How much did the power drop? Can you explain why this is? Discuss with your lab instructor.
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5.93v – 2.6v = 3.33v
0.1302W to 0.0412

The solar panels are in series which means a higher resistance when one cell is covered. The increase in resistance in that one cell results in a greater voltage being used therefore a decrease in power.
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Challenge: (20 marks)
In the real world, how might you minimise the impact of the daily and/or seasonal changes in the sun's locations with respect to your solar panels?
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To minimise the impact of the daily or seasonal changes in the sun's location, changing the angle of the module itself so that it's perpendicular to the sun will maximise the power collected. This is achievable through solar tracking.

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<u>**Solar Panel Technologies**</u>

Monocrystalline and polycrystalline are two of the most common solar panel technologies on the market today. Monocrystalline cells are made from an incredibly pure form of silicon, while polycrystalline cells have a lower level of purity. Polycrystalline cells are not cut like monocrystalline, instead they are melted and poured into a mould. The reason both technologies are still very prevalent in the market today, is because they have slightly different advantages and disadvantages. Polycrystalline is less efficient but cheaper than monocrystalline, which means it's applications vary slightly. If you are not bound by physical area, or your application is low power, polycrystalline might be a good option. However, if you have a limited space and you want to extract as much power as possible from this area, monocrystalline might be your preferred option.

You can generally spot polycrystalline as it has a slightly blue sparkly look to it, while monocrystalline is closer to black and generally has cells with the corners missing (due to the manufacturing process).