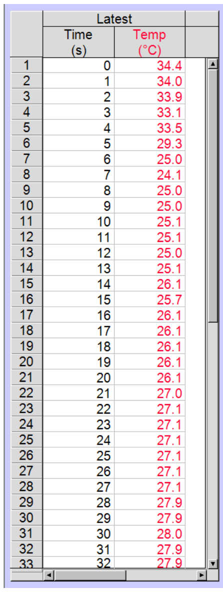
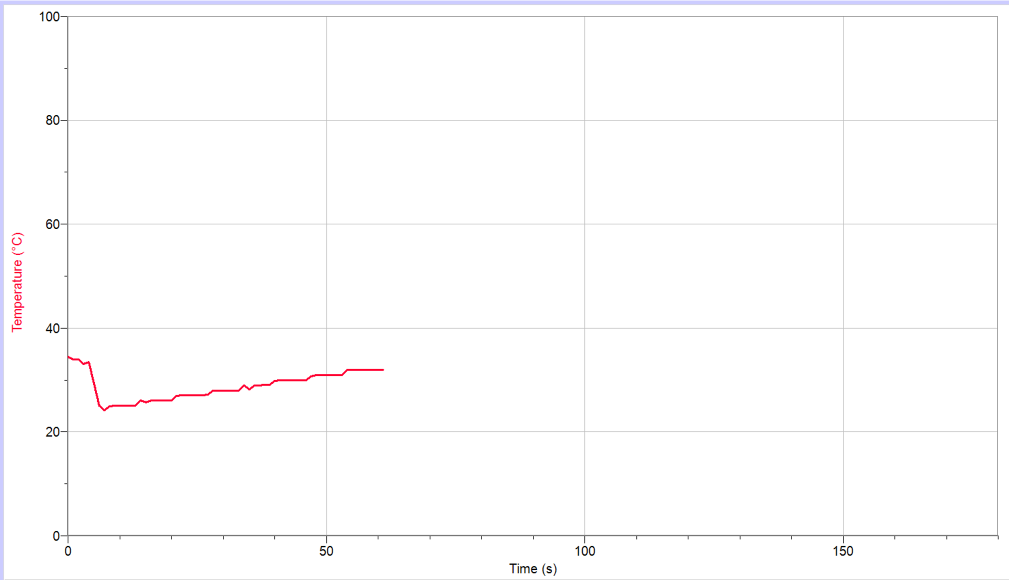
Ethan Wen - Solar Constant Lab

3. Results

To get full credit for this lab, please present your data from Logger Pro (with a plot), and your answers to the following questions:



	Latest	
	Time (s)	Temp (°C)
1	0	34.4
2	1	34.0
3	2	33.9
4	3	33.1
5	4	33.5
6	5	29.3
7	6	25.0
8	7	24.1
9	8	25.0
10	9	25.0
11	10	25.1
12	11	25.1
13	12	25.0
14	13	25.1
15	14	26.1
16	15	25.7
17	16	26.1
18	17	26.1
19	18	26.1
20	19	26.1
21	20	26.1
22	21	27.0
23	22	27.1
24	23	27.1
25	24	27.1
26	25	27.1
27	26	27.1
28	27	27.1
29	28	27.9
30	29	27.9
31	30	28.0
32	31	27.9
33	32	27.9



Flux Calculation

Try 1 (With only the first few seconds included):

$$\frac{\Delta T}{\Delta t} = f \cdot \frac{A}{C \cdot m}$$

$C = 0.89\ J/g°C$, $A = 0.014732\ m^2$, $m = 68.1g$

$\Delta T = 34.4 - 33.9 = 0.5°C$, $\Delta t = 2s$

$$f = \frac{C \cdot m}{A} \cdot \frac{\Delta T}{\Delta t}$$

$$\frac{0.89 \frac{J}{g°C} \cdot 68.1g}{0.014732\ m^2} \cdot \frac{0.5°C}{2s} = 1028.53 \frac{J}{m^2 s}$$

Try 2 (With all data used):

$$\frac{\Delta T}{\Delta t} = f \cdot \frac{A}{C \cdot m}$$

$C = 0.89\ J/g°C$, $A = 0.014732\ m^2$, $m = 68.1g$

$\Delta T = 34.4 - 32.0 = 2.4°C$, $\Delta t = 61s$

$$f = \frac{C \cdot m}{A} \cdot \frac{\Delta T}{\Delta t}$$

$$\frac{0.89 \frac{J}{g°C} \cdot 68.1g}{0.014732\ m^2} \cdot \frac{2.4°C}{61s} = 161.866 \frac{J}{m^2 s}$$

*Note: I know that this value for the solar constant is somewhat inaccurate, but I tried the best with our data. Our data shows a negative change in temperature. Instead, I just tried to ignore the negative; pretty sure that our data didn't get the original "heating up" phase. In addition, because there was no "heating up" phase, I wasn't sure how to do my solar constant calculation, leading to my multiple calculations for the solar constant (one with only the first few seconds, as if it was the "heat up period", and a second that just uses all of the data).

3.1 Consideration of Errors

What sources of error may appear in your measurement? Are there any important factors that we might need to consider before we accept our answer as 100% correct?

The plate may have touched the sun earlier than it should have, which would have made the 'rapidly heating' phase of the plate unread, which led to data that doesn't account for the entire span of the plate's temperature. The plate could also have been covered by the shadow of the temperature reader, which would change the temperature of the plate, thus changing the readings in a way that may have messed with the data. Before we accept our answer as correct, we should consider where our data was taken could have an impact on the temperature taken, leading to a possible different flux.

3.2 Questions

1. How would you intuitively expect the measured flux to change if the sun was twice as far away? Explain your reasoning. What if the sun stays in its same position, but fuses twice as much material per second?

   If the sun were to be twice as far from the Earth, I would expect the flux to be half as much as it is, as there is twice the distance the energy needs to travel. This would lead to there being less energy that makes it to the final destination (in our case, this would be the metal plate). If the sun were to fuse twice as much material, the flux should double as well, as the sun is emitting more energy from fusing more material, leading to more energy felt on the final destination (again, this would be our plate).

2. As you can read about in Chapter 5, flux is proportional to temperature to the fourth power:

   $F \propto T^4$

   Say we measured double the flux during our experiment. What would this mean about the temperature of the sun?

   The temperature of the sun would be $\sqrt[4]{2}$ times hotter, as the doubling should make $2F \propto 2 \cdot T^4$. We then distribute a fourth power to 2, making $2F \propto (\sqrt[4]{2} \cdot T)^4$. This shows that temperature should be multiplied by $\sqrt[4]{2}$ to get double the flux.

3. Does it matter if we use a metal plate with a much larger area to do this experiment? Why or why not?
   It should not matter, as the amount of flux should not change when a different sized plate is used to capture data. The area and mass of the metal plate should scale in some way together, meaning that they should always 'cancel out' into the same ratio that our metal plate gave.

4. Brainstorm: The sun goes through active periods and inactive periods on a (roughly) 11 year cycle. During an active period, we sometimes see huge flares, called Coronal Mass Ejections, driven by the sun's magnetic field. During a period of high solar activity, would we measure a different flux of the sun in our experiment? [Hint: in your experience, does the Earth get extra hot every 11 years?] Why or why not? What could be going on here? Does anything change if we do our experiment on Mercury?
   There is no variation in flux that would occur in our experiment, because of the Earth's magnetic field. In the short movie that was shown, we see how the solar storm that was ejected from the sun "curved around" the Earth due to our magnetic field reacting with the storm and curving it around the Earth. As such, there is no real difference here on Earth (other than the Aurora). If we were to look at a planet without a magnetic field, like Mercury, we would see the flux change, as there is no field to keep the flux stable. Instead, the planet would just feel the full force of the CME.

5. Independent research: our sun does fusion through a process called the p-p chain, or proton-proton chain. If you do some research, you'll see the chain of interactions that takes protons and converts them into 4He is actually pretty complex! For credit on this question, please write down all the steps that take us from 4 protons to 4He. You should see some neutrinos and some photons (sometimes called gamma rays) appear!
   Two Hydrogen-1 protons undergo a simultaneous fusion and beta decay, leading to a Hydrogen-2, a positron, and a neutrino to form. This Hydrogen-2 reacts with another Hydrogen-1 proton, leading to a gamma ray and Helium-3 to be formed. Finally, two Helium-3 atoms react, forming two Hydrogen-1 protons and a Helium-4.

   https://www.pas.rochester.edu/~blackman/ast104/ppchain.html

   Bonus: Larger stars are able to fuse heavier elements than Helium. This process is called the CNO cycle. Take a look at it online and appreciate how complex the process is! Why do you think this process is called a "cycle" whereas the proton-proton reaction is called a "chain"?
   I think that the p-p chain is just a sequence of events that lead to a Helium-4, whereas the CNO cycle continues to react and decay and form new

elements in a loop. Because the CNO cycle never has a defined end goal and it can theoretically never end as long as it keeps reacting, it is a cycle. The p-p chain, on the other hand, has a defined end goal of Helium-4, making it a chain that leads to that satisfying end.