

Lab 5: Week 4 - Sending Cellphone Alerts

Purpose

Imagine the not too far-fetched scenario: COVID-19 vaccines must be kept cold during transit and storage. To ensure this, continuous monitoring of temperature seems like a good idea. Having a system that sends an alert in case of unsuitable storage conditions would be even better.



Figure 1: *Credit: NYC National Guard, via Flickr, CC-BY-ND 2.0*

In this fourth part of the thermocouple lab you will add to your Python script to send a notification to your cell phone if a specific temperature threshold has been crossed. You will also add to the Python code to activate an LED in flashing mode if the temperature is approaching the threshold value and to remain turned on (not flashing) if the threshold temperature has been exceeded.

Learning Goals

The goals of this portion of the Lab are to:

- Become familiar with Python programming used to control sensors and physical systems

- Activate the LED warning system when critical parameters are being reached or exceeded
- Notify the user's cell phone when warnings are happening and action is needed

Background

COVID-19 spurred many technological advances. One of those advances, the mRNA-based vaccine, promises to revolutionize modern medicine and help humans rapidly respond to new and emerging infectious agents. The vaccines can be adapted rapidly to new pathogens and are easy to mass produce. Distribution, however, was a major challenge – as the mRNA vaccines need to be kept cold as soon as they are produced, throughout the entire global distribution process, and right up until they are administered to a patient. Both UPS and FedEx had to make major accommodations to ensure the vaccine was kept cold while in transit – and this transition was not easy. Hundreds of thousands of doses of the new mRNA COVID vaccine were known to have spoiled due to excessive temperature exposure. Many more vaccine doses are likely to have failed due to excessive temperature exposure, but without continuous monitoring, went unnoticed.



Figure 2: Vaccine Transport Chain

In this Lab, we will be simulating an mRNA vaccine shipment that must be kept below 8°C. We will use the thermocouple temperature setup we have been developing but will be adding a few key features.

1. The temperature monitoring system will run continuously instead of creating a known number of samples.
2. The temperature monitoring system will activate a flashing LED alert staff BEFORE a critical temperature is reached.
3. The system will send an SMS message to the staff's cell phone to alert them that action is needed.
4. The system will inform staff if the threshold both by cell phone and a steady LED light if the critical temperature has been exceeded and the vaccine has been compromised (and thus should not be used).

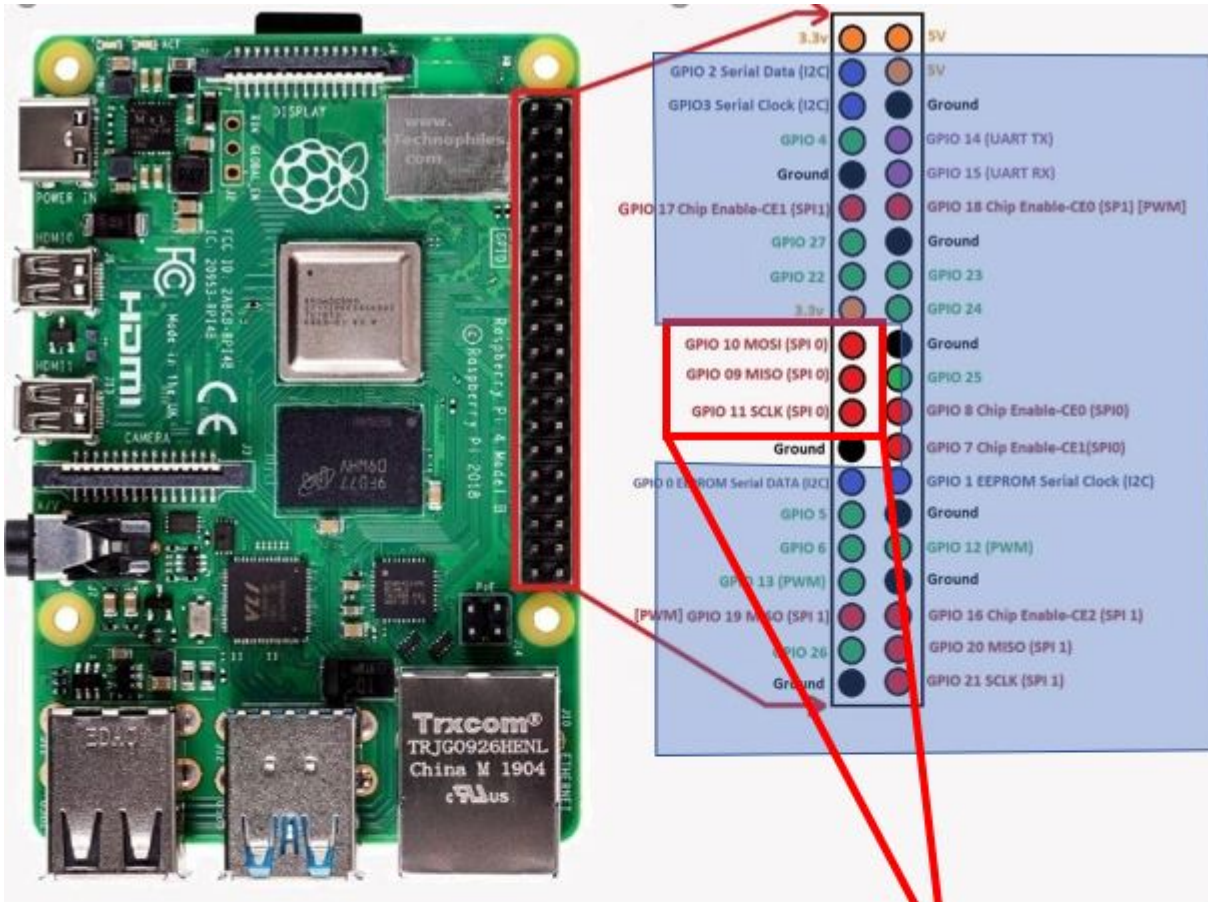
Methods

Methods - Step 1: Thermocouple Hardware Connections

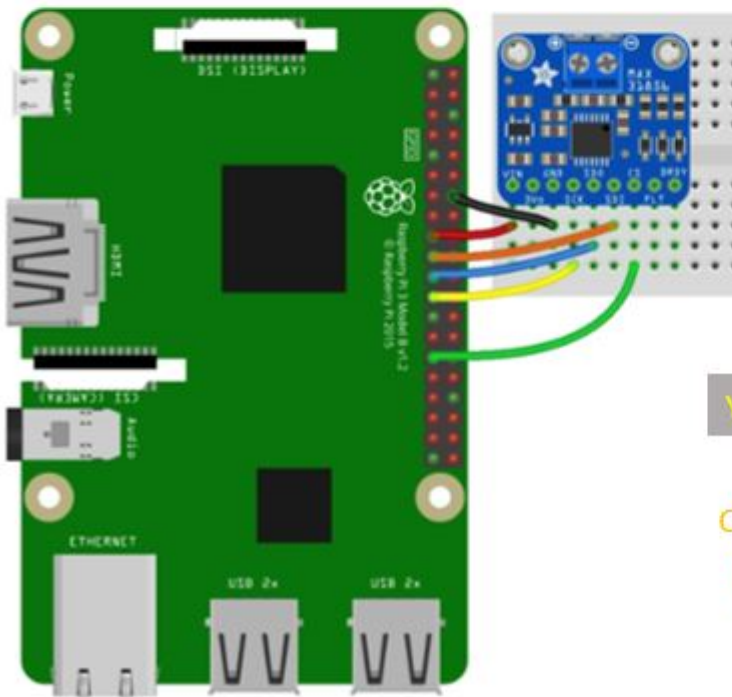
! Important

Shut down the RPi before making the connection and ask an instructor to get the wiring checked before turning it back on!

Connect the RPi to the MAX31856 as shown in the diagram below.



These are the SPI pins we will connect to



- Red** Pi 3V to sensor VIN
- Black** Pi GND to sensor GND
- Yellow** Pi SCK to sensor SCK
- Blue** Pi MISO to sensor SDO
- Orange** Pi MOSI to sensor SDI
- Green** Pi D5 to sensor CS (or any other free digital I/O pin)

Figure 3: MAX31856 Wiring Instructions

Methods - Step 2: Physical Connection for the LED

Connect the LED like in week 2. You might want to connect a second LED to activate if temperatures are too high (this is optional).

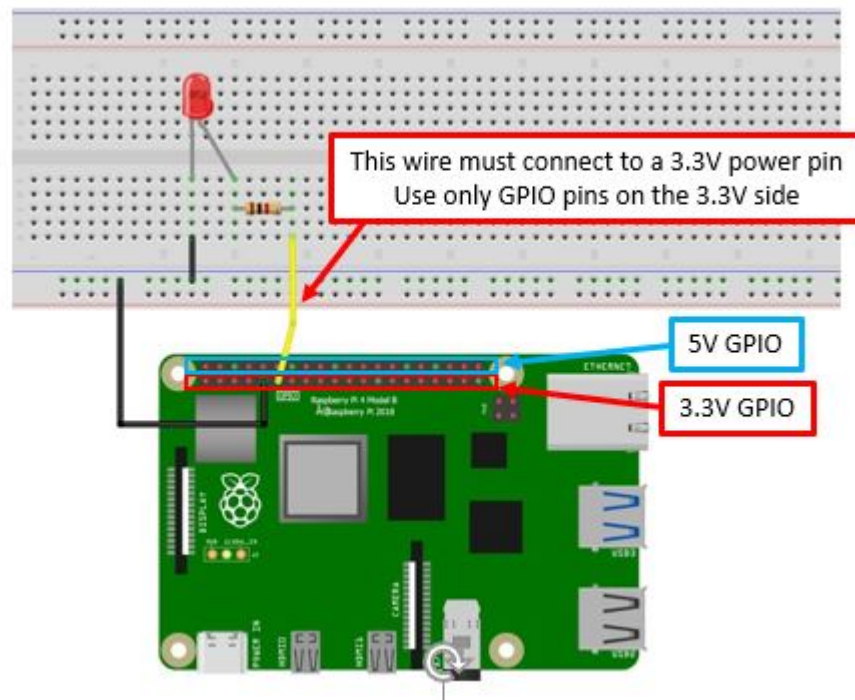


Figure 4: Wiring diagram to connect the LED to the RPi for automated control

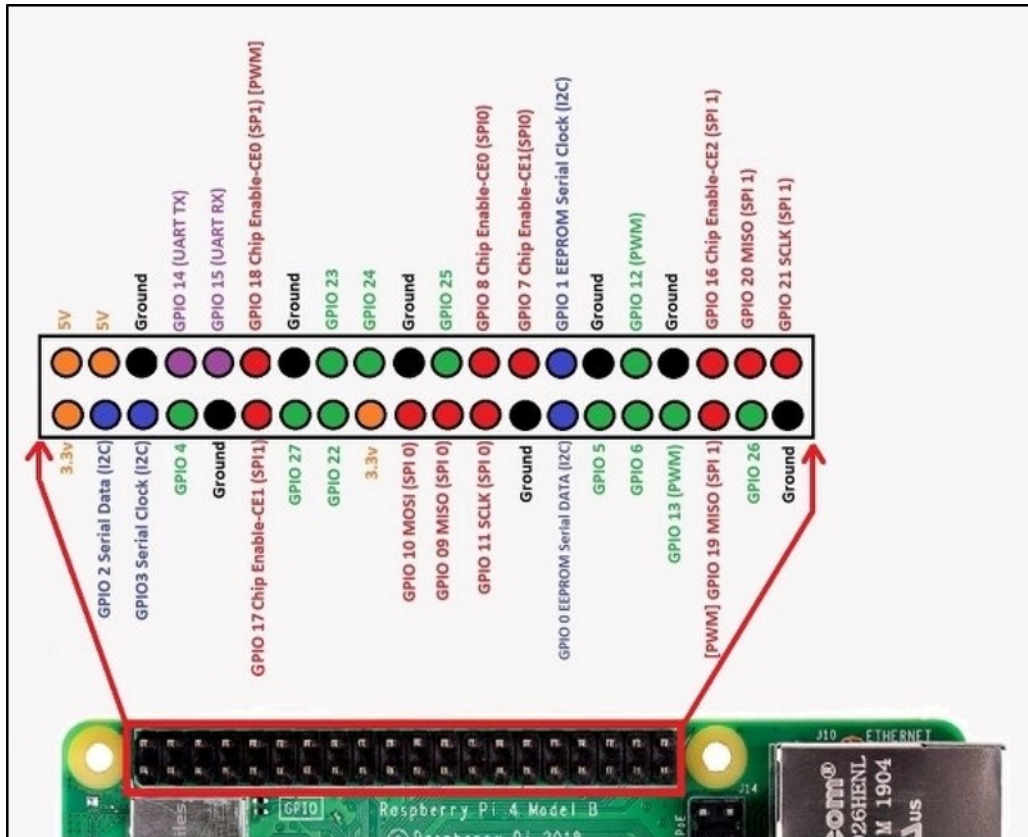


Figure 5: GPIO Overview

Methods - Step 3: Installing the Pushover notifications App

The Raspberry Pi can connect to external devices through hardware, WiFi, and Bluetooth - but it cannot connect directly to the SMS messaging system that is used by cell phones to transmit text messages via cell towers. To do this, we will be using a third-party Application called Pushover. We will then need to use their API to obtain security permissions to allow our Raspberry Pi to connect to their servers (just as we did with Google's API last week). Once the proper security tokens have been obtained, we will add them to our Python script and insert the necessary code to enable the RPi to send messages to the cell phone via SMS text messaging.

Pushover

Figure 6: Pushover App

i Pushover free trial

The Pushover App is free to install on Android phones (free for 30 days – then \$4.99 for unlimited use after that).

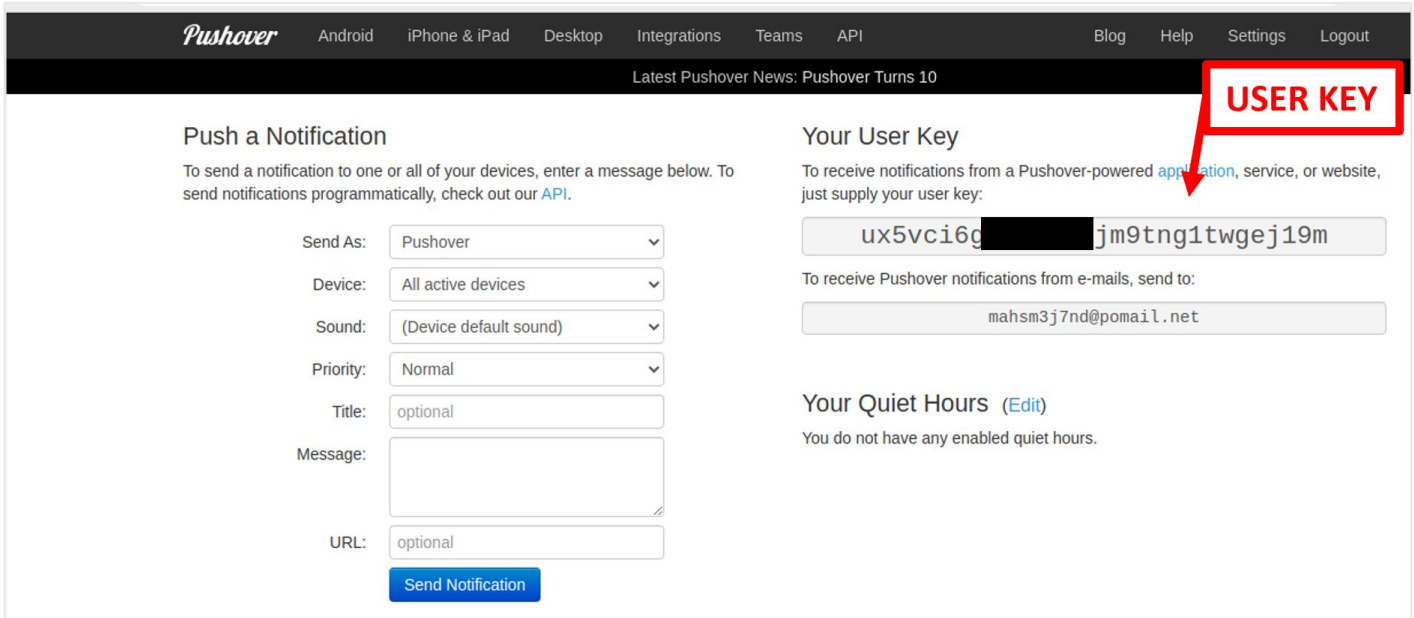
! Important

Before the lab: Please have one team member install the app on their cell phone!
Record the Username and Password; these will be needed for the API.

Methods - Step 4: Activating the Pushover API

The next steps must be done on the Raspberry Pi, so we can download the necessary security keys.

1. Go to: <https://pushover.net>
2. Login using your Pushover username (email) and password. Leave this window open so you can access the user/group key (you will need to copy this into the python script)



The screenshot shows the Pushover website interface. At the top, there is a navigation bar with links for Android, iPhone & iPad, Desktop, Integrations, Teams, API, Blog, Help, Settings, and Logout. Below the navigation bar, there is a header with the Pushover logo and a news item: "Latest Pushover News: Pushover Turns 10". The main content area is divided into two columns. The left column is titled "Push a Notification" and contains a form with fields for "Send As" (Pushover), "Device" (All active devices), "Sound" (Device default sound), "Priority" (Normal), "Title" (optional), "Message" (text area), and "URL" (optional). A "Send Notification" button is at the bottom of this form. The right column is titled "Your User Key" and contains a text input field with the value "ux5vc16g[redacted]jm9tng1twgej19m". A red box with the text "USER KEY" is overlaid on the top right of this section, with an arrow pointing to the user key. Below the user key, there is a section for "Your Quiet Hours" with a link to "Edit" and a note that no quiet hours are currently enabled.

Figure 7: Retrieving your API Key

3. Open the API tab in a new window. Click on *Register your application* in step 1.
4. Enter a name for your Application (e.g. the Lab Name)
5. (*Optional*) Open the browser to find a square image you would like to use for the notifications. Save the image to the RPi. If the image is not already a PNG, simply open it and use *Save As* to make it a PNG. I will be using Duke Dog.
6. Click *Create Application*

Pushover Android iPhone & iPad Desktop Integrations Teams API Blog Help Settings Logout

Latest Pushover News: Pushover Turns 10

Create New Application/API Token


To start pushing notifications with Pushover, you'll need to create an Application and get a unique [API token](#), which you can do here. Each website, service, application, plugin, etc. may only be registered once and each application can send 10,000 messages per month for free. Additional message capacity may be purchased after creating an application. For more on monthly limits, see our [API page](#).

Application Information

Name:
This name should be short (20 character maximum), such as "Nagios", "Adium", or "Network Mon". If messages are sent with no title, this name will be displayed.

Description:

URL:
If this is a public app/plugin, you can include a URL to point to the app's homepage, Github repo, or anything else related to the app.

Icon: DukeDog.png 
To customize your app's notifications, upload a 72x72 icon in PNG format (transparent background preferred). Any images not 72x72 will be resized.

By checking this box, you agree that you have read our [Terms of Service](#) and our [Guide to Being Friendly to our API](#). Only one API token may be registered per source and you agree that this token will not be used to circumvent our free usage allowance.




Figure 8: Setting up the Pushover App

If everything is working correctly, you should see this screen displaying your API Token/ Key.

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Latest Pushover News: Pushover Turns 10

Your application has been created

ISAT300Lab5 (Application)

[Back to Apps](#)

API Token/Key ([Edit](#) or [Delete Application](#))

To begin using our API to send notifications, use this application's API token:

`acijd2y52mxv97idxy6o743zme1igx`




Figure 9: Successful Pushover Configuration

7. Test your system using the *Python* code shown below. It is available on [GitHub: pushover.py](#)

! Important

Note that you will need to enter YOUR User Token/key and YOUR App Token/key

```

1 import http.client, urllib
2
3 conn = http.client.HTTPSConnection("api.pushover.net:443")
4 conn.request("POST", "/1/messages.json",
5             urllib.parse.urlencode({
6                 "token": "enter your App token/key here",
7                 "user": "enter your User token/key here",
8                 "message": "ISAT300 is the best!!",
9             }, { "Content-type": "application/x-www-form-urlencoded" }))
10 conn.getresponse()

```

Enter YOUR App token

Enter YOUR User token

You should receive a notification on your cell phone!

Figure 10: Testing the Pushover App

Methods - Step 5: Finalizing the Python Code

! Important

Remember to activate your Virtual Environment as root, so do the following:

```

sudo su
source lab_env/bin/activate
# CHECK: Your terminal prompt should now start with (lab_env)

```

! Important

Google requires you to re-authenticate every week. This means the `token.json` expires and your program will produce an error.

To avoid this, you need to delete the `token.json` file from your *Lab 5* folder. If you then run the program again. The code will check for the `credentials.json` file and ask you to re-authenticate. Follow the screen prompts to then log back into your *ISAT 300* google account.

1. **Pushover Notification:** Add the Pushover Python script to your Python code in the appropriate location.

You can embed this in the existing LED control loop (twice – once for Max Temp Exceeded, once for Approaching Max Temp.) OR you can create a new loop. In either case, it must come within the main control loop that will run until the temperature exceeds a certain threshold (I recommend 8°C for the main control loop).

i Optional

You can have Pushover send email notifications as well as sounds and images. Visit [Pushover.net](https://pushover.net) for more details if you would like to add these to your Python code.

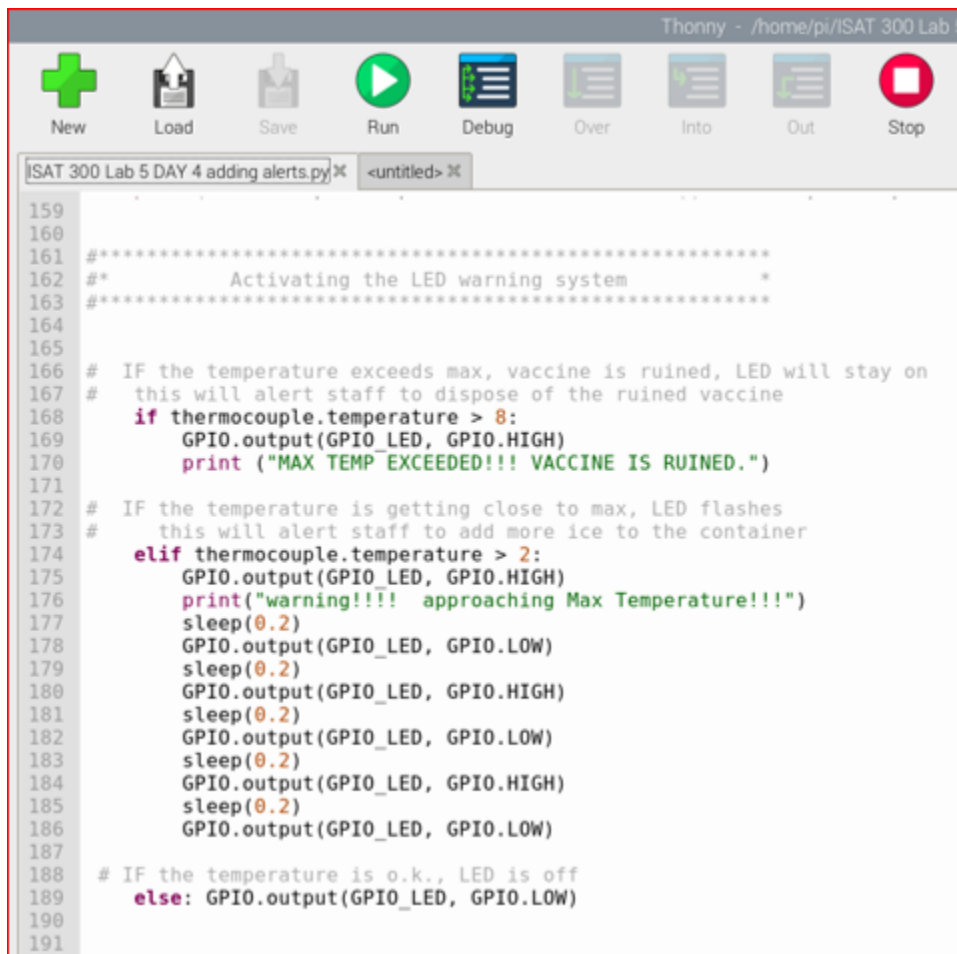
1. Adjusting the temperature thresholds:

We will be sending two different alerts using the same LED. The LED should produce a flashing Warning signal BEFORE our critical temperature is reached, thus alerting staff to take action to cool the vaccine. IF the critical temperature is reached, the vaccine will be compromised and should be disposed of. IF the critical temperature is exceeded at any point in time, the LED should turn on and stay on.

An example code is shown below. Notice that the MAX TEMP EXCEEDED alert comes first in the program - before the flashing alert indicating we are getting close to the maximum temperature. It is necessary to put this first, because anything above 8°C will satisfy both the flashing warning AND the max temp warning.

Add to your Python code to make the LED flash when the temperature is above 2°C and for the LED to remain on for temperatures above 8°C.

The code for the flashing LED (shown below) is available on [GitHub: Lab 5 Day 3 ...](#)



```
159
160
161 #*****
162 #*           Activating the LED warning system           *
163 #*****
164
165
166 # IF the temperature exceeds max, vaccine is ruined, LED will stay on
167 # this will alert staff to dispose of the ruined vaccine
168     if thermocouple.temperature > 8:
169         GPIO.output(GPIO_LED, GPIO.HIGH)
170         print ("MAX TEMP EXCEEDED!!! VACCINE IS RUINED.")
171
172 # IF the temperature is getting close to max, LED flashes
173 # this will alert staff to add more ice to the container
174     elif thermocouple.temperature > 2:
175         GPIO.output(GPIO_LED, GPIO.HIGH)
176         print("warning!!!! approaching Max Temperature!!!")
177         sleep(0.2)
178         GPIO.output(GPIO_LED, GPIO.LOW)
179         sleep(0.2)
180         GPIO.output(GPIO_LED, GPIO.HIGH)
181         sleep(0.2)
182         GPIO.output(GPIO_LED, GPIO.LOW)
183         sleep(0.2)
184         GPIO.output(GPIO_LED, GPIO.HIGH)
185         sleep(0.2)
186         GPIO.output(GPIO_LED, GPIO.LOW)
187
188 # IF the temperature is o.k., LED is off
189     else: GPIO.output(GPIO_LED, GPIO.LOW)
190
191
```

Figure 11: Code with Flashing LED

Merge your program with the provided code and use the ice water provided to test your system and ensure that it is working correctly.

2. Error Handling: Add error handling to ensure that the system keeps running.

Since we are planning to run the alert system over a longer time, we need to ensure that small, temporary network connection issues or other instabilities in the connection don't cause our program to crash and abort.

To do so, we implement two strategies:

- First, we increase the time that the API will try to establish the connection. We can do this by increasing the threshold before the API stops trying to establish a connection.

Add the following two lines near the top of your python program to do this.

```
import socket
socket.setdefaulttimeout(10) # Sets the default timeout to 10 seconds
```

- Secondly, we should also implement some error handling. In general error handling is something that we should always do, since we don't want our programs to fail completely if something goes wrong (or at least we want to know what happened to our program).

Python has a built in method to [handle errors](#) - called exceptions -, which is the `try-except` method.

A `try-except` block works very similar to an `if-else` statement. It will try to do the first thing, and if that does not work it will execute the alternative statement. In our case, we want to wrap our *API*-calls into a `try-except` block.

Modify the code inside the measurement loop, where the API is called, so that the two lines that start with `result =` are wrapped in the `try-except`-block¹:

```
try:
    result = ... #keep the code as is here
    result = ... #keep the code as is here
except socket.timeout as err:
    print("Connection timed out.")
```

Now, the program will try to connect and write to the google sheet. If that fails, rather than crashing, it will execute the print statement to print the error message and then continue with the loop.

3. *Test your system to be sure it is working.*

! Important

Your system will run over the weekend!

Your goal is to be alerted when approaching the threshold temperature and when the threshold has been crossed.

You can monitor the situation at any time, from any location, using your Google Sheets.

¹Don't change the code the lines that contain the actual *API-call* and that begin with `result =`

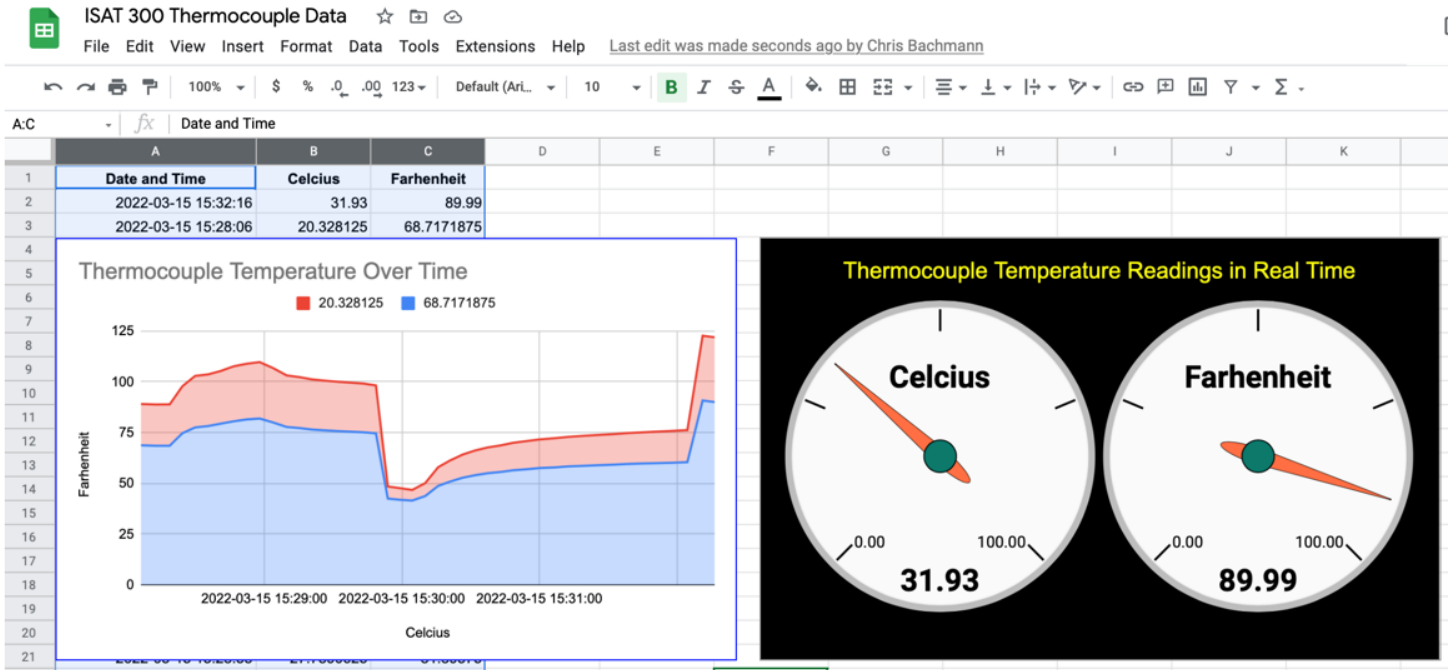


Figure 12: Monitoring temperature with the dashboard

Final Deliverable

We will not be doing a regular lab report for this lab. The final deliverables for the lab are found on the [Lab 5 Overview page](#).

! Important

Before leaving the lab, make sure that you have collected all the data needed to calculate/ estimate all the technical specs needed for the final deliverable.
If you are unsure, ask an instructor what you will need.

Acknowledgements

This Lab was designed by Dr. Chris Bachmann with modifications by Tobias Gerken. Special thanks to Joe Rudmin for helping secure necessary equipment and for providing lab support.

Revision	Description	Author
2025-04-03 (S25)	Error handling for google sheets API was added	Tobias Gerken
2025-03-19 (S25)	Moved deliverables to main page for lab	Tobias Gerken
2024-03-27 (S24)	Updated to Web and updates for clarity	Tobias Gerken
	Initial Version	Chris Bachmann