ECE 476/676 - Homework #7

Temperature, Text Files, Speed Control of a DC Motor - Due Monday, October 21st

How Good is My Coffee Cup?

Determine the thermal time constant of your favorite cup (your pick) along with the 90% confidence interval.

Problem 1) Write a Python program to measure temperature using a DS18B20 digital thermometer

Use your program to determine the tempeature of

- Ice water
- Cold water from the tap 13.125C
- Hot water from the tap 44.8125C
- Room tempeature (Tamb) 20.625C

Code:

```
# Problem #1

import onewire, ds18x20
from machine import Pin, ADC, Timer
from time import sleep, sleep_ms
import LCD

ds_pin = Pin(0)
ds_sensor = ds18x20.DS18X20(onewire.OneWire(ds_pin))

roms = ds_sensor.scan()
print('Found DS devices: ', roms)

LCD.Init()
White = LCD.RGB(250,250,250)
Yellow = LCD.RGB(250,250,0)
Green = LCD.RGB(100,250,150)
Black = LCD.RGB(0,0,0)
LCD.Clear(Black)
LCD.Box(5,5,475,315,White)
LCD.Text2('Probem #1', 150, 50, White, Black)

while(1):
    ds_sensor.convert_temp()
    sleep_ms(750)
    Temp = ds_sensor.read_temp(roms[0])
    msg = 'Temperature = ' + str(Temp) + ' C     '
    LCD.Text2(msg, 50, 100, Yellow, Black)

    print(Temp)
```

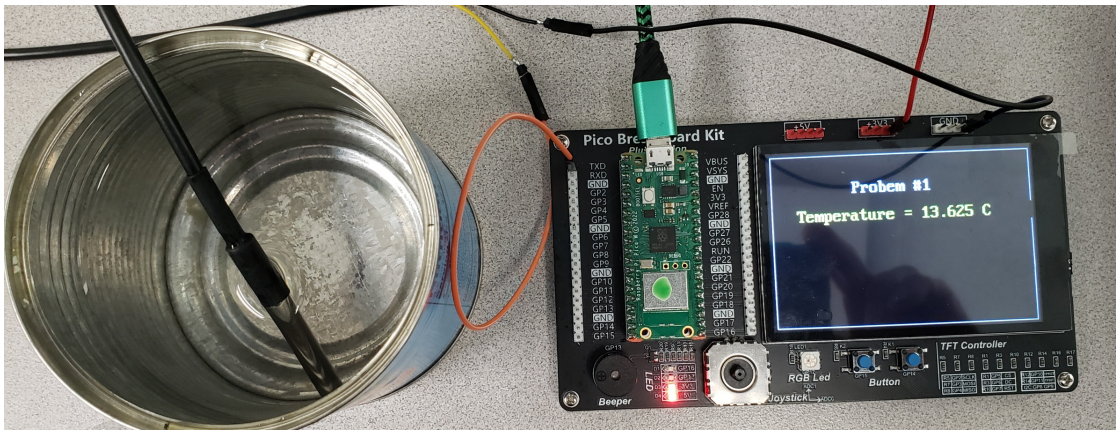
Problem 2) Write a Python program to measure and record the temperature of a hot cup of water

- Sampling rate = 1 second
- Duration = 2 minutes (120 samples)

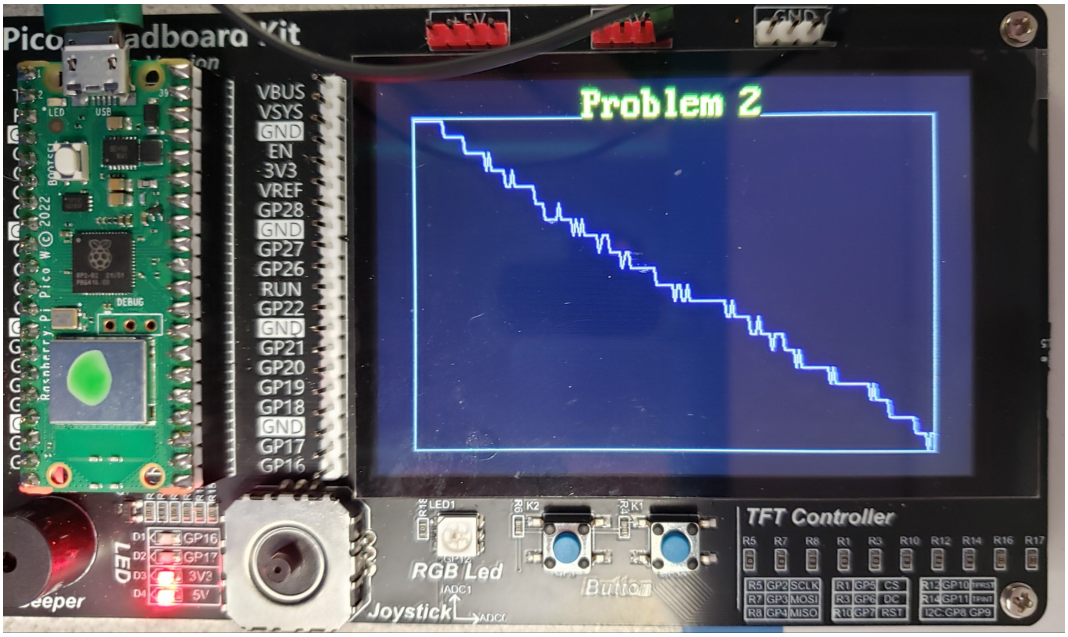
Plot your data vs. time on the graphics display.

Setup:

- Add hot water to a tin can (what I could scrounge up)
- Wait 30 seconds for temperatures to settle out
- Start recoding temperature every second



After 200 seconds, plot the temeprature vs. time on the graphics display



Problem #2: Code:

```
import onewire, ds18x20
from machine import Pin, ADC, Timer
from time import sleep, sleep_ms
import LCD

ds_pin = Pin(0)
ds_sensor = ds18x20.DS18X20(onewire.OneWire(ds_pin))

roms = ds_sensor.scan()
print('Found DS devices: ', roms)

flag = 1

def tick(timer):
    global flag
    flag = 1

Time = Timer()
Time.init(freq=1, mode=Timer.PERIODIC, callback=tick)

file1 = open("HW7p2.txt", "a")
file1.write('----------------------\n')
file1.write('Seconds  Degrees C\n')

Navy = LCD.RGB(0,0,5)
LtGreen = LCD.RGB(100,250,50)
Yellow = LCD.RGB(250,250,0)
Orange = LCD.RGB(250,150,50)
Red    = LCD.RGB(250,50,50)
White = LCD.RGB(250,250,250)

LCD.Init()
LCD.Clear(Navy)
LCD.Box(2,2,478,318,White)
LCD.Title('HW7 Prob2', White, Navy)
LCD.Text2('Seconds',30,60, LtGreen, Navy)
LCD.Text2('Degrees C',30,100,Yellow,Navy)
#LCD.Text2('a',30,140,Orange,Navy)
#LCD.Text2('b',30,180,Red,Navy)
time = 0

while(time < 200):
    while(flag == 0):
        pass
    flag = 0
    ds_sensor.convert_temp()
    sleep_ms(750)
    Temp = ds_sensor.read_temp(roms[0])
    print(time, Temp)

    file1.write(str('{: 4.0f}'.format(time)) + " ")
    file1.write(str('{: 7.4f}'.format(Temp)) + " ")
    file1.write("\n")

    LCD.Number2(time, 9, 1, 200, 60, LtGreen, Navy)
    LCD.Number2(Temp, 9, 3, 200, 100, Yellow, Navy)
    time += 1

file1.close()
```

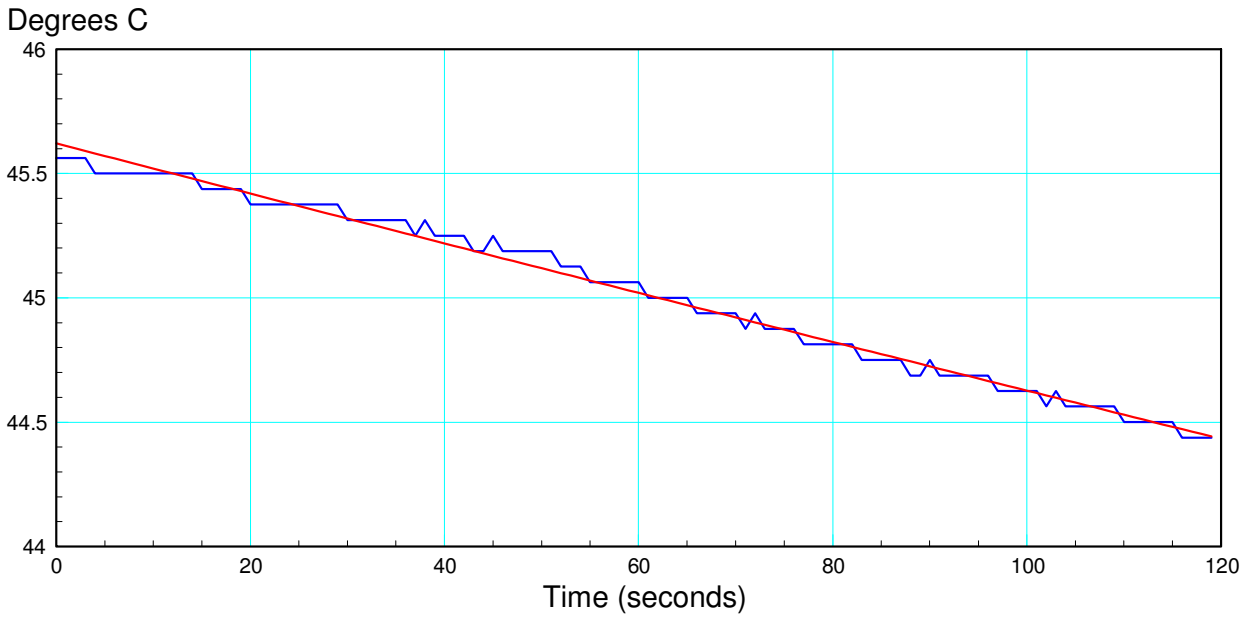
Problem 3) Using you data from problem #2 and Matlab, determine the thermal time constant of your cup using least-squares curve fitting and

$$T = be^{-at} + T_{amb}$$

time constant = 1/a

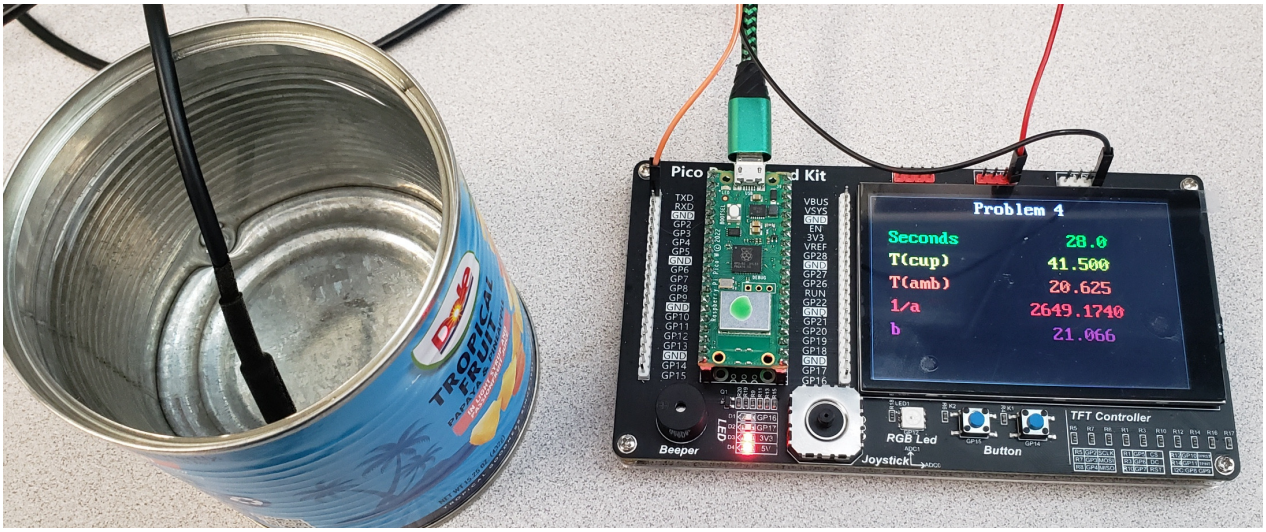
In Matlab

```
>. Data = [  <paste data> ];
>> t = Data(:,1);
>> C = Data(:,2);
>> T = Data(:,2);
>> Tamb = 20.625;
>> Y = log(T - Tamb);
>> B = [t, t.^0];
>> A = inv(B'*B)*B'*Y

   -0.0004
    3.2187

>> -1/A(1)

  2.4641e+003

>> a = A(1);
>> b = exp(A(2));
>> plot(t,T,t,b*exp(a*t) + Tamb)
```



Problem 4) Write a Python program which uses recursive least squares to determine the thermal time contant of a coffee cup in real time

Hardware: Same as before: Connect a temeprature sensor to GP0



Software: Use recursive least squares to determine a and b

```
while(time < 201):
    while(flag == 0):
        pass
    flag = 0
    ds_sensor.convert_temp()
    sleep_ms(750)
    Temp = ds_sensor.read_temp(roms[0])

    x = time
    y = log(Temp - Tamb)

    B = matrix.add(B, [[x**2, x], [x, 1]])
    Y = matrix.add(Y, [[x*y], [y]])

    if(B[1][1] > 3):
        Bi = matrix.inv(B)
        A = matrix.mult(Bi, Y)
        a = -1 / A[0][0]
        b = exp(abs(A[1][0]))

    print(time, Temp, a, b)

    LCD.Number2(time, 9, 1, 200, 60, LtGreen, Navy)
    LCD.Number2(Temp, 9, 3, 200, 100, Yellow, Navy)
    LCD.Number2(Tamb, 9, 3, 200, 140, Orange, Navy)
    LCD.Number2(a, 9, 3, 200, 180, Red, Navy)
    LCD.Number2(b, 9, 3, 200, 220, Plum, Navy)

    time += T
```

Problem 5) With this program, record the thermal time constant for a given cup three times

From your data, determine the 90% confidence interval for the actual thermal time constant

- student t-test

Results: Three trials were run with hot water, resulting in the time constant being

{1823,858, 1580.445, 1680.642} seconds

From this data, you can find the mean and standard deviation:

```
>> Data = [1823,858, 1580.445, 1680.642];
>> x = mean(Data)

x =  1.4855e+003

>> s = std(Data)

s =  430.0223
```

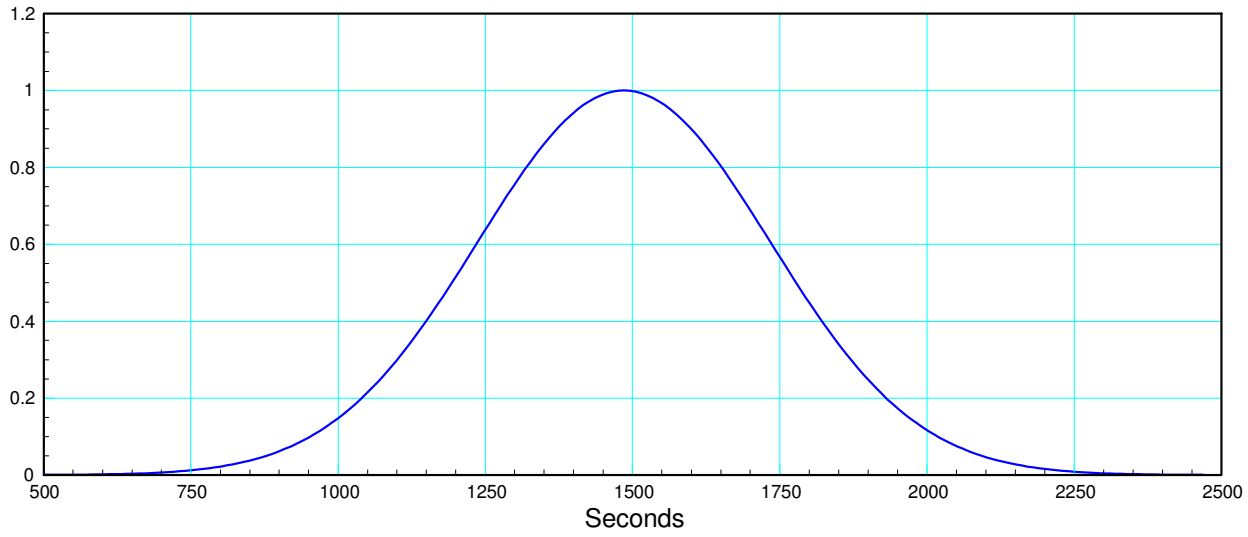
The 90% confidence interval for the actual time constant (population question) is then

- t-score for 5% tails with 2 degrees of freedom = 2.92
- Divide the variance by the sample size (population question)

```
>> x + 2.92 * s / sqrt(3)

ans =  2.2105e+003

>> x - 2.92 * s / sqrt(3)

ans =  760.5632
```

I am 90% certain that the time constant for this cup is in the range of (760.56, 2210.5) seconds

That's a pretty big range - this indicates that the experiment's procedures need to be tightened to reduce the variaions between trials.



pdf for the thermal time constant of a metal can