SCPY 394: Advanced Physics Laboratory II
Lab 5: Long-time data collecting using LabVIEW

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September 13, 2022

1 Objective

To use LabVIEW to do long-time automatic data acquisition to measure liquid temperature and observe the water melting and the water cooling phenomena.

2 Measuring temperature using thermistor

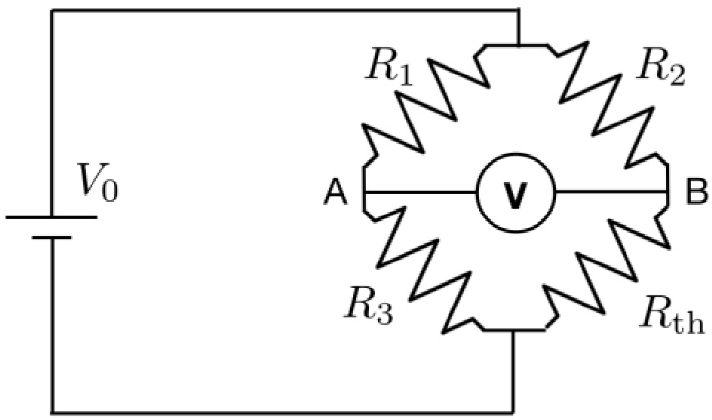

Figure 1: Circuit used in the experiment to measure the temperature

Using electric signal obtained from the bridge circuit in figure 1, voltage between the thermistor is

$$V = V_A - V_B = V_0 \left(\frac{R_3}{R_3 + R_1} - \frac{R_{th}}{R_{th} + R_2} \right) \tag{1}$$

For each thermistor voltage V_{th} obtained from the automatic data acquisition, the temperature T can be determined by applying equation (1) to solve for thermistor resistance R_{th} and then using the below fitted function from the table in the appendix to compute the temperature T.

$$T = A + B \ln(R_{th}) + C \ln^3(R_{th}) \tag{2}$$

where $A = 347.8 \pm 0.6$, $B = -41.1 \pm 0.1$ and $C = (7.21 \pm 0.06) \times 10^{-2}$ are parameters from the thermistor data.

3 Using LabVIEW (LV)

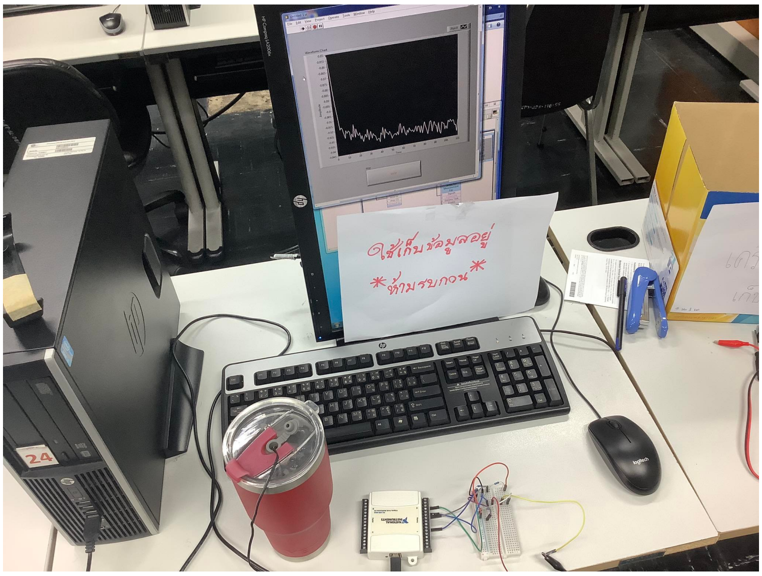

Figure 2: The experimental setup

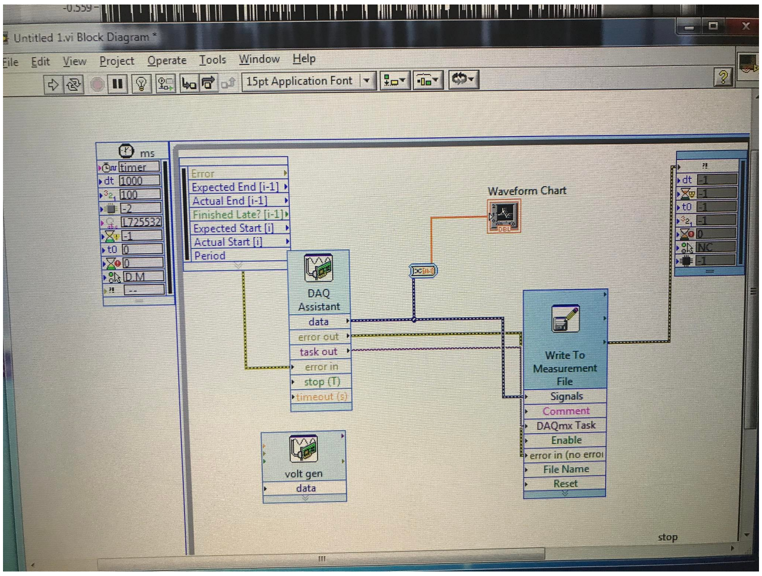

Figure 3: LV code used in the experiment

LabVIEW (LV) is a simple programming language using visual code (figures) instead of typical alphabetical code. In the experiment, LV is used for long-time data collecting. By connecting the USB-6009 with the circuit connected same as figure 1 with $R_1 = R_2 = R_3 = 3.3$ kΩ to a personal computer. The complete setup is shown in figure 2. LV code is implemented, shown in figure 3, to collect the data of voltage. Voltage will be transformed to thermistor resistor by using equation (1) and temperature afterward by using table in the appendix.

4 Comparative result with Newton's Law of Cooling

A system with time-dependent temperature is governed by Newton's law of cooling, where temperature T evolves as time t passes by:

$$\frac{dT}{dt} = A(T_R - T) \tag{3}$$

where T_R is a surrounding temperature, and A is constant depending on the system.

In this experiment, there are two data sets, one with the cooling of hot water and another one with the melting of iced water. Both systems are in an insulated container. The data from the system is collected using LV and then compared with a numerically exact solution of Newton's law of cooling.

4.1 Cooling of hot water in an insulated container

Using hot water along with the circuit set as in figure 1, the data is collected and shown as a graph below. The graph also contains a numerical result from Newton's law of cooling (3). The obtained result is consistent with

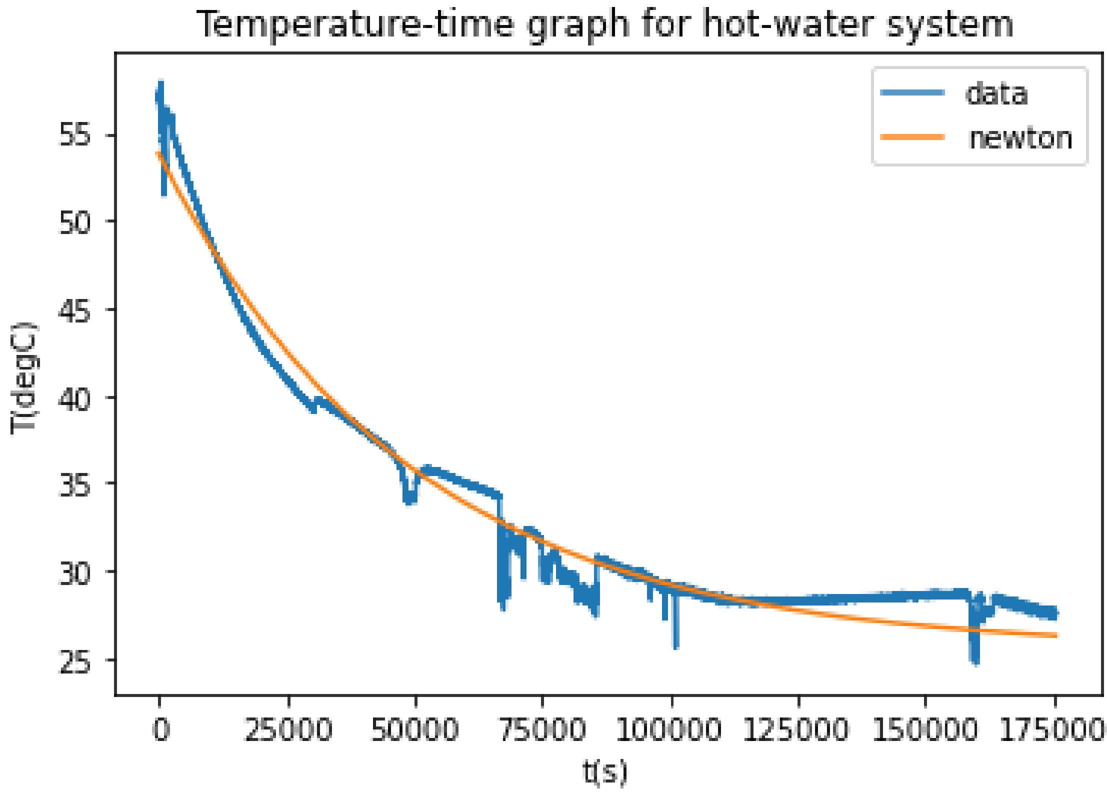

Figure 4: Temperature-time graph of the hot water system

Newton's law of cooling with $A_{hot} = (2.031 \pm 0.004) \times 10^{-5}$s^{-1}

4.2 Melting of iced water in an insulated container

Using iced water along with the circuit set as in figure 1, the data is collected and shown as a graph below. The graph also contains a numerical result from Newton's law of cooling (3). Considering at temperature-changing

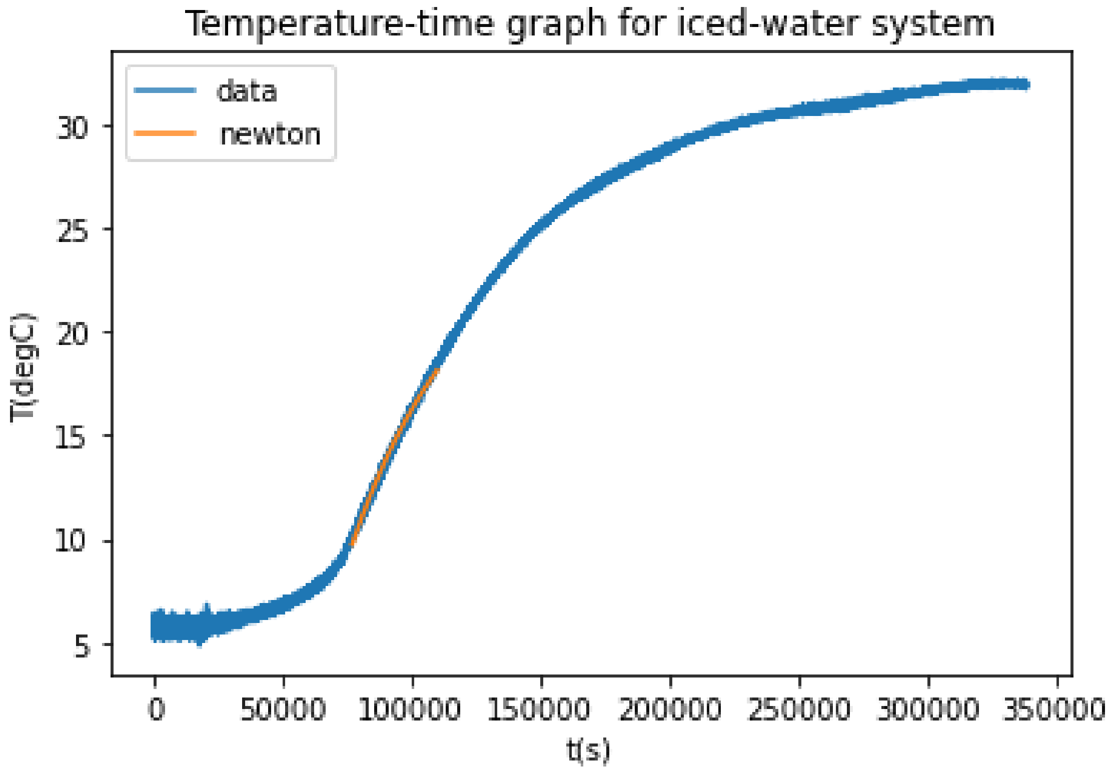

Figure 5: Temperature-time graph of the iced water system

phase, the obtained result is consistent with Newton's law of cooling with $A_{ice} = (2.479 \pm 0.004) \times 10^{-5}\text{s}^{-1}$

5 Conclusion

The experiment is to observe the cooling and melting phenomena. LabVIEW is used for long-time data acquisition in the experiment. For the cooling of hot water, the constant of Newton's law of cooling is $A_{hot} = (2.031 \pm 0.004) \times 10^{-5}\text{s}^{-1}$ whereas A for the melting of iced water is $A_{ice} = (2.479 \pm 0.004) \times 10^{-5}\text{s}^{-1}$

6 Appendix: Resistor-temperature table for the thermistor

T (°C)	R (Ω)	T (°C)	R (Ω)	T (°C)	R (Ω)	T (°C)	R (Ω)	T (°C)	R (Ω)
0.0	32624.2	20.0	12492.8	40.0	5323.9	60.0	2483.8	80.0	1251.8
0.5	31804.3	20.5	12214.2	40.5	5217.9	60.5	2439.5	80.5	1231.6
1.0	31007.3	21.0	11942.6	41.0	5114.4	61.0	2396.0	81.0	1211.8
1.5	30232.8	21.5	11677.8	41.5	5013.2	61.5	2353.4	81.5	1192.4
2.0	29479.8	22.0	11419.7	42.0	4914.2	62.0	2311.7	82.0	1173.4
2.5	28747.9	22.5	11168.0	42.5	4817.5	62.5	2270.9	82.5	1154.6
3.0	28036.4	23.0	10922.5	43.0	4722.9	63.0	2230.8	83.0	1136.3
3.5	27344.5	23.5	10683.2	43.5	4630.5	63.5	2191.6	83.5	1118.2
4.0	26671.8	24.0	10449.8	44.0	4540.1	64.0	2153.2	84.0	1100.5
4.5	26017.6	24.5	10222.1	44.5	4451.7	64.5	2115.6	84.5	1083.2
5.0	25381.4	25.0	10000.0	45.0	4365.3	65.0	2078.7	85.0	1066.1
5.5	24762.6	25.5	9783.4	45.5	4280.8	65.5	2042.5	85.5	1049.4
6.0	24160.7	26.0	9572.0	46.0	4198.1	66.0	2007.0	86.0	1032.9
6.5	23575.3	26.5	9365.9	46.5	4117.3	66.5	1972.3	86.5	1016.8
7.0	23005.7	27.0	9164.7	47.0	4038.2	67.0	1938.3	87.0	1000.9
7.5	22451.6	27.5	8968.5	47.5	3960.9	67.5	1904.9	87.5	985.3
8.0	21912.5	28.0	8777.0	48.0	3885.2	68.0	1872.2	88.0	970.0
8.5	21387.8	28.5	8590.1	48.5	3811.2	68.5	1840.1	88.5	955.0
9.0	20877.3	29.0	8407.7	49.0	3738.8	69.0	1808.7	89.0	940.3
9.5	20380.5	29.5	8229.7	49.5	3668.0	69.5	1777.9	89.5	925.8
10.0	19896.9	30.0	8056.0	50.0	3598.7	70.0	1747.7	90.0	911.6
10.5	19426.2	30.5	7886.4	50.5	3530.9	70.5	1718.0	90.5	897.6
11.0	18968.0	31.0	7720.8	51.0	3464.6	71.0	1689.0	91.0	883.9
11.5	18522.0	31.5	7559.2	51.5	3399.7	71.5	1660.5	91.5	870.4
12.0	18087.8	32.0	7401.4	52.0	3336.1	72.0	1632.6	92.0	857.2
12.5	17664.9	32.5	7247.4	52.5	3273.9	72.5	1605.2	92.5	844.2
13.0	17253.2	33.0	7097.0	53.0	3213.1	73.0	1578.3	93.0	831.4
13.5	16852.3	33.5	6950.1	53.5	3153.5	73.5	1552.0	93.5	818.8
14.0	16461.9	34.0	6806.6	54.0	3095.2	74.0	1526.1	94.0	806.5
14.5	16081.6	34.5	6666.6	54.5	3038.1	74.5	1500.8	94.5	794.4
15.0	15711.3	35.0	6529.7	55.0	2982.3	75.0	1475.9	95.0	782.5
15.5	15350.5	35.5	6396.1	55.5	2927.6	75.5	1451.5	95.5	770.8
16.0	14999.0	36.0	6265.6	56.0	2874.0	76.0	1427.6	96.0	759.3
16.5	14656.6	36.5	6138.1	56.5	2821.6	76.5	1404.2	96.5	748.0
17.0	14323.0	37.0	6013.5	57.0	2770.3	77.0	1381.1	97.0	736.9
17.5	13998.0	37.5	5891.8	57.5	2720.0	77.5	1358.5	97.5	725.9
18.0	13681.2	38.0	5772.9	58.0	2670.8	78.0	1336.4	98.0	715.2
18.5	13372.5	38.5	5656.7	58.5	2622.6	78.5	1314.6	98.5	704.7
19.0	13071.7	39.0	5543.2	59.0	2575.3	79.0	1293.3	99.0	694.3
19.5	12778.5	39.5	5432.3	59.5	2529.1	79.5	1272.4	99.5	684.1

Figure 6: Resistor-temperature table of the thermistor. From: SCPY393 Lab Direction