Peltier Cooler Experiment

In this lab, you will examine the Peltier Effect and the Seebeck Effect. These thermoelectric effects can be thought of as inverses of each other. Each can be observed on the same equipment under different conditions; you will create both sets of conditions in this lab and investigate both effects.

For part 1, you will apply electricity to the Peltier Cooler and measure the cooling effect and the heating effect that is produced (i.e. the Peltier Effect). For part 2, you will measure the voltage difference caused by a temperature difference between two reservoirs (i.e. the Seebeck Effect). For more background on these two effects, see the textbook (pp. 626-627), the class notes, and/or the internet.

Please collect data in groups of 2.

PROCEDURE

Setup, Part 1

1. Check the wires connecting the power supply and the Peltier cooler equipment. The red wires (including the red ports on the cooler and power supply) should be connected; the black wires (including the black ports on the cooler and power supply should be connected).
2. Turn the power supply on (switch is on back of the unit; make sure it is plugged in) and set the voltage to approximately 6.5 V (does not need to be exact). The two stirring rods should start turning. (If the rods are not stirring and everything is connected correctly, please contact your instructor.) Turn off the power supply.
3. Connect your multimeter using the ports on the right side of the Peltier equipment. You will be measuring the current (which will be greater than 1 A). Connect the + probe to the DC10A port on your multimeter and the – probe to the COM port on your multimeter.
4. Check to make sure the water level is at the line (this is approximately 200 mL of water) for each tank.

Procedure, Part 1

5. With everything connected, turn on the power supply (the stirring rods should start turning). Record the initial temperatures of the two tanks (they should be reasonably close if not the same).
6. Turn on your multimeter and set it for DC10A. This will complete the circuit and the Peltier element will start transferring heat from blue tank to the red tank. Every minute, on the minute, record the temperatures of the two tanks and the voltage (read from the power supply and should be relatively stable) and the current (from your multimeter).
7. Take 10 readings (plus the initial reading for a total of 11 temperature pairs).
8. Proceed immediately to Part 2.

Setup, Part 2

1. Leave the power supply on so that the stirring rods will continue turning.

2. Disconnect your multimeter from the Peltier equipment. You will now measure the voltage across the Peltier unit as the temperatures of tank return to room temperature.
3. Change the wire setup on your multimeter to measure voltage. Place the probe connected to COM on the multimeter on the – probe on the right side of the Peltier equipment. Place the voltage probe from the multimeter in the – probe on the left side of the Peltier equipment. Set the settings on your multimeter to DCV.
4. Note: now that the multimeter is not measuring the current through the Peltier element, the circuit is effectively broken and the Peltier element is no longer running (i.e., it is no longer transferring heat from the cold tank to the hot tank). The voltage measured across the Peltier cooler represents the Seebeck effect.

Procedure, Part 2

5. Every minute, on the minute, record the temperatures of the two tanks and the voltage from your multimeter.
6. Take a total of 10 readings.
7. After you are done collecting your data, turn off the power supply using the switch on the back (there may be a delay before it actually shuts off). Be sure to collect your multimeter and the multimeter wires before you leave. Leave the water in the tank for the next group.

LAB MEMO FORMAT

You may team up with one classmate (i.e. form a team of 2) to write this lab memo. The lab memo must be computer generated, except possibly for sample calculations, and will be submitted using the Turnitin.com link on Moodle. The set up should follow this format:

Title Page

Make sure both team members' names are on the front page. Also put the name of the lab, the course and course section, and the due date.

Results Sections

For part 1, create a table in Excel containing the raw data values measured above. Add a column for temperature difference, and one for each Coefficient of Performance (COP_R and COP_{HP}) using the following formulas. ("n" is the row number; the first row will not contain a value of COP_{PC}.)

$$Q_L = c_p m(T_{L\,n-1} - T_{L\,n});\;\; Q_H = c_p m(T_{H\,n} - T_{H\,n-1});\;\; W_e = \left(\frac{V_n + V_{n-1}}{2}\right)\left(\frac{I_n + I_{n-1}}{2}\right)(60s)$$

$$COP_R = \frac{Q_L}{W_e}; \qquad COP_{HP} = \frac{Q_H}{W_e}$$

T_L(°C)	T_H(°C)	$V(V)$	$I(A)$	ΔT(°C)	COP_R	COP_{HP}

Make a scatter plot (X-Y plot with **discrete points**, not lines) with temperature difference on the x-axis, and two data series, COP_R and COP_{HP}, on the y-axis (be sure to have axes labels and units). Add a legend. It is not necessary to add trendlines. Comment on the graph; explain its behavior.

Besides other comments, address the following: Ideally,

$$COP_{HP} = \frac{Q_H}{W_e} = \frac{Q_L + W_e}{W_e} = \frac{Q_L}{W_e} + 1 = COP_R + 1$$

In your data, is the COP_{HP} always 1 greater than the COP_R? If not, discuss possible reasons.

Make a second scatter plot (with **discrete points**, not lines) with temperature difference on the x-axis, and current on the y-axis (be sure to have axes labels and units). It is not necessary to add a trendline. Comment on the graph; explain its behavior.

For part 2, create a table in Excel containing the raw data values measured above. Add a column for temperature difference and one for the Seebeck Coefficient, using the following formula. ("n" is the row number)

$$S_n = \frac{V_n}{T_{H\,n} - T_{L\,n}}$$

T_L(°C)	T_H(°C)	$V(V)$	ΔT(°C)	$S\left(\frac{V}{K}\right)$

Make a scatter plot (with **discrete points**, not lines) with temperature difference on the x-axis, and voltage the y-axis. Label it appropriately. Insert a linear trend line (be sure you put the equation on the graph). Comment on the graph and the linear equation: What does the slope represent? How does the intercept compare with the value you would expect?

Sample Calculations

Without the use of Excel, show you calculations for one data set; i.e. pick one row from each table and show how you computed each COP and S, respectively. **Show the formulas and then show the values you plugged in, with units.** You may neatly write these calculations on white printer paper and scan it into your report or you may use Equation Editor in Word. You may also use a professionally formatted entry MathCad.

In general, consider the following standard for your work: you should not be embarrassed to hand this to your future boss as part of a project report.

Be sure to have page numbers (except the title page) and check for spelling and grammar.

GRADING RUBRIC

Section and Description	Point Total
Title Page	**1**
Results	**55**
Part 1 data table	10
Part 1 graph 1	15
Part 1 graph 2	10
Part 2 data table	10
Part 2 graph (with trendline equation)	10
Discussions	**15**
Comments on part 1 graph 1	5
Comments on part 1 graph 2	5
Comments on part 2 graph	5
Sample Calculation	**20**
Correct equations and values used	16
Correct units used	4
Format	**9**
Spelling, grammar, page numbers, professionalism	10

** Spelling and grammar mistakes anywhere in the report may result in point deductions