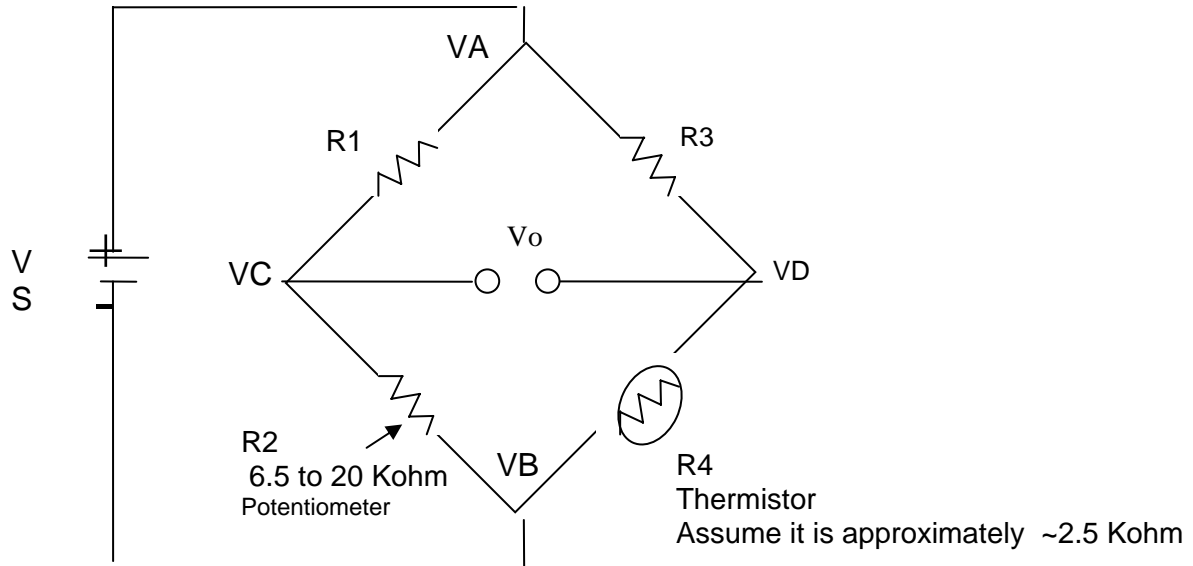


**Laboratory Exercise 1: Wheatstone Bridge and Thermistors**  
**BME 698 Physiological Measurement PreLaboratory Assignment**  
**Prelab due at the start of lab class**

1. Read through entire Lab
2. For the following circuit:



Assume that  $R_2$  and  $R_4$  have the same resistance. Derive the relationship between  $R_1$  and  $R_3$  so that the output voltage  $V_o$  is zero ( $V_C - V_D = 0$ ). Show all work on a separate piece of paper (per person not group) to be handed in at the beginning of the lab (10 points individual grade).

You will need the 10K potentiometer from the BME Kit which will be  $R_2$  and a pair of resistors  $R_1$  &  $R_3$  which you choose based on your derivation above.

Components provided for Lab:

BreadBoard

Multimeter

Resisters

10K potentiometer

All other components will be given to you during class

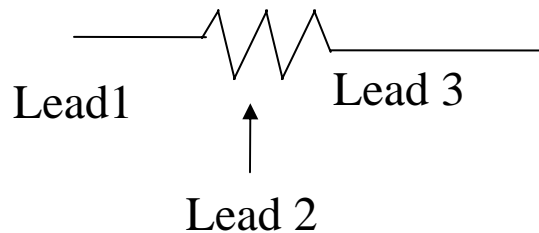
## Laboratory Exercise 1: Wheatstone Bridge and Thermistors BME 698 Physiological Measurements

### OBJECTIVE:

The goal of this lab is to design a Wheatstone Bridge, determine the resistive value of a thermistor, and calibrate the thermistor to measure water temperature.

### INSTRUCTION

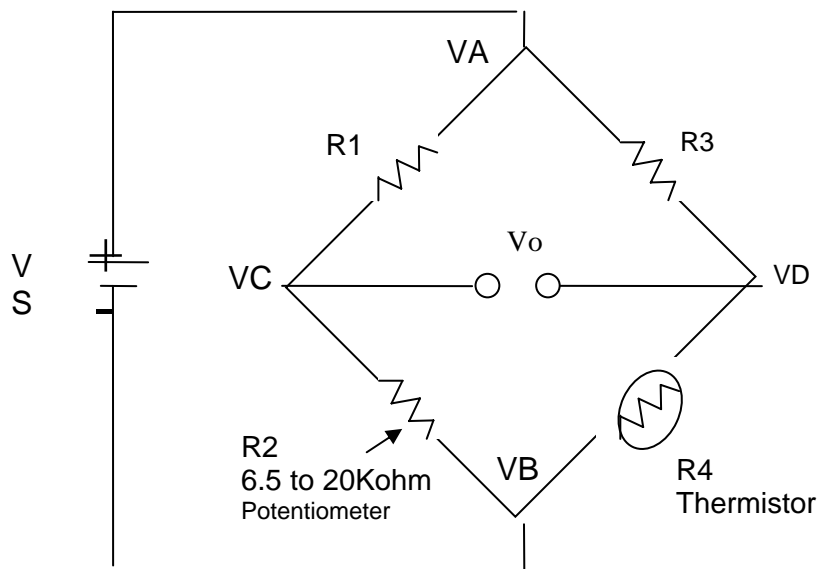
1. Measure the resistance of your thermistor.
  - a) Measure the resistance using an ohmmeter
  - b) Switch the multimeter to the label  $\Omega$ . Insert the 2 leads of the thermistor into the breadboard in different columns. Apply the 2 leads of the meter to the leads of the thermistor.
  - c) The resistance value = \_\_\_\_\_
  
2. Measure the resistance of your potentiometer, which will give you the precise resistance needed to balance your bridge. A potentiometer has three leads. The middle lead is the sweep, which allows you to turn the screw to get the precise resistance needed.



Lead 1 to Lead 3 will give you the entire resistance. In this lab, a  $10\text{K}\Omega$  pot will give 10 K resistance (some potentiometers will be a bit more or less which varies due to manufacturing differences.)

- a) Using your ohmmeter what is the resistance of the potentiometer from Lead 1 to Lead 3.  $R = \underline{\hspace{2cm}}$
  - b) Using your ohmmeter what is the resistance of the potentiometer from Lead 1 to Lead 2  $R = \underline{\hspace{2cm}}$
  - c) Using your ohmmeter what is the resistance of the potentiometer from Lead 2 to Lead 3  $R = \underline{\hspace{2cm}}$
- 
3. Turn the screw of your potentiometer approximately 90 deg clockwise or counterclockwise
    - a) Using your ohmmeter what is the resistance of the potentiometer from Lead 1 to Lead 3.  $R = \underline{\hspace{2cm}}$
    - b) Using your ohmmeter what is the resistance of the potentiometer from Lead 1 to Lead 2  $R = \underline{\hspace{2cm}}$
    - c) Using your ohmmeter what is the resistance of the potentiometer from Lead 2 to Lead 3  $R = \underline{\hspace{2cm}}$

4. Turn on your DC power supply and set one side to 5V. Use your voltmeter by switching your multimeter to the Label of V with a straight line.
5. What value does your voltmeter read if you measure from the '+' to the '-' output of the DC power supply?  $V_s =$  \_\_\_\_\_
6. Use alligator clips to connect the 5 V source to your bread board.
7. From your prelaboratory assignment obtain resistors for R1 & R3. What did you choose for R1 & R3?  $R_1 =$  \_\_\_\_\_  $R_3 =$  \_\_\_\_\_
8. Now you are ready to build the Wheatstone bridge. Use the schematic discussed in class:



9. Measure the voltage across  $R_2$  ( $V_C - V_B$ ) and across  $R_4$  ( $V_D - V_B$ ).

$$V_{CB} = \text{_____} \quad V_{DB} = \text{_____}$$

As part of your write up you will need these values.

10. Balance the bridge so that the output voltage ( $V_o$ ) as depicted in class is approximately zero volts. Adjust the potentiometer so that voltmeter reads approximately zero volts.
11. Establish an ice waterbath and put your thermometer in the ice water. Record a voltage difference between the Voltage divider reading immediately when you place the thermistor in the ice water. Take another measurement after one minute.

Voltage = \_\_\_\_\_ (immediate)

Voltage = \_\_\_\_\_ (after 1 minute)

Are these values the same or different? If they are different describe what error you are observing.

12. Place a thermometer in a glass of ice water. Be sure to have the temperature reach close to ~32 deg F. Fill in the calibration table and add hot water to your glass. Record the temperature on the thermometer and the voltage difference. Increase the temperature to ~90 deg F. Note if you cannot obtain these exact temperatures it is okay just try to attain approximately a 50 Deg range in temperature values.

Temperature on Thermometer	Voltage Difference between Voltage Dividers

13. With your thermistor in the hot/warm water gradually add ice until it reaches close to freezing point (~32 F).

Temperature on Thermometer	Voltage Difference between Voltage Dividers


Questions to be answered in report:

1. Why did you use a waterbath instead of ambient air?
2. What is a Wheatstone bridge? Why is this useful when used with a transducer?
3. Describe a few biomedical applications for a Wheatstone Bridge.
4. What other transducers can be used in a Wheatstone Bridge configuration.
5. In step 1, you measured the resistance of your thermistor. In step 3, you measured the resistance of your pot. Using the resistor values you choose for R1 & R3, calculate what  $V_{CB}$  and  $V_{DB}$  should be. How do these values compare to the values you measured for  $V_{CB}$  and  $V_{DB}$  in step 9?
6. Derive the output voltage between the two voltage dividers.
7. Is a thermistor linear or nonlinear over all temperatures? Is a thermistor linear or nonlinear over a limited range?
8. Plot your calibration curve starting from a cold to warm waterbath and then from a warm to cold waterbath. Are the curves the same? If the curves are different what behavior are you observing?
9. Give an example of a voltage difference you would expect for a temperature value that you did not experimentally obtain within the range of temperatures you measured.
10. Discuss your calibration device. Is this the best instrument for calibration?