UNIVERSIDADE da MADEIRA

Experimental Science
P4: Calibration

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1. Purpose

- Present a measurement device as a transducer.
- Perform the calibration of an electronic thermometer.
- Estimate the device's scale zero and sensitivity.
- Work on the concepts of weighted mean and percentage.

2. Introduction

A transducer is a device that converts one type of energy (or physical quantity) into another different one. It can be represented by the following diagram:

where *x* is the input quantity e *y* is the output quantity.

A transducer can be used as an actuator (e.g., a loudspeaker converts electric energy into acoustic energy) or as a sensor (e.g., a microphone converts acoustic energy into electric energy). In the latter case (if we know the dependence between *x* and *y*) a transducer may be used as a measurement device.

The process of determining the dependence between *x* and *y* (*y = y(x)*) is a calibration.

On this particular lab activity, the input variable will be water temperature and the output variable will be voltage. Since the voltage produced by the transducer is very low, a transducer cannot be used as an electrical generator and is just a sensor. That is, our transducer will operate as electronic thermometer. Let's calibrate it.

3. Experimental activity

3.1 Material

1 temperature transducer, 1 multimeter, 1 GLX, 1 graduated cylinder (50 or 100 ml), 1 beaker, 1 calorimeter, 2 thermostats, 1 heating plate, connection wires, 1 towel, liquid water, ice.

3.2 Setup and experiment plan

3.2.1. Getting familiar with the GLX

The Explorer GLX is a multifunction device. It can be use as a thermometer, a voltmeter, a graphical calculator, a data acquisition system and so on. Check how you can use it as a thermometer (place a temperature sensor into one of the GLX's lateral entries do GLX. Select "home" followed by "digits").

3.2.2 Water preparation for an intended temperature

On this experiment you will be measuring the temperature of 7 different systems. They are: ice, tap water, heated waters, human skin, waters resulting form the mixing of hot water with tap water com (T_{amb}). These last waters will be prepared by the students and should reach pre-defined temperatures.

The starting volume is 100 ml of hot water. The volume, V, of tap water (at a T_{amb} temperature) to be added will have to be derived by the students in advance before the actual liquid mixing. Example: imagine 100 ml of hot water at 80 ºC are mixed with 400 ml of tap water at T_{amb} = 20 ºC. The hot water and tap water mixing percentages are 20% and 80%, respectively. The mixture temperature (T_{mix}) can be determined by a weighted mean: T_{mix} = 0.2 x 80ºC + 0.8 x 20ºC = 32 ºC.

Measure the tap water temperature. (Don't forget to record your measurement result with units and error). Consider the hot water temperature to be 80ºC. Calculate the amount of tap water needed to obtain a T_{mix} of 50 ºC and 40 ºC. Organize you results in a table with the following title line:

T_{mix} (ºC)	% hot water	% tap water	$V_{\text{tap water}}$ (ml)

3.2.3 Getting familiar with the transducer

Identify the transducer's sensor. Identify the transducer output terminals.

3.3 Procedure (please read all the procedure instructions before starting the experiment)

You will have to measure the output transducer voltage for each one of the 7 systems. Place both the transducer sensor and the GLX sensor (as close as possible to each other) on the intended measurement system. Measure in simultaneous the transducer output voltage and the GLX temperature reading.

Attention: All voltmeter measurements should be made at the most sensitive scale. Don't forget ALL measurements should have units and error.

Take note of your transducer number as well as the GLX number.
Record all measurements in an organized fashion on your lab book. In order to do so build in a table with the following title line:

System	U (V)	T (ºC)

The systems are as follows:

(1) Crushed ice
(2) Tap water
(3) Thermostat 1 heated water
(4) Thermostat 2 heated water
(5) Skin
(6) Water mix close to 40 ºC
(7) Water mix close to 50 ºC

Group 1 starts with system 1, then system 2 and ends with system 7. Group 2 starts with system 2, then system 3 and ends with system 1. Group 3 starts with system 3, and so on.

Systems 1 through 4 are already prepared. Check where they are in the lab. You should use a graduated cylinder to transport a sample from one of these systems. Make your measurements as fast as possible as you reach your working area. This way you will minimize system temperature changes.

As far as systems 6 e 7, look for the hot water. Start by measuring 100 ml of hot water and pour it into the calorimeter. Cover it and bring it to your working area. Measure and recorde the hot water temperature. Measure the needed tap water volume with the graduated cylinder and pour it into the calorimeter. Homogenize the mixture with the calorimeter agitator. Make your measurements as fast as possible to minimize system temperature changes.

Each group should add their transducer results to other taken by other groups for the same transducer in an Excel spreadsheet available at the lab computer. The resulting file will then be available at the course's web site (LabInf).

Attention: **Be careful when handling BOILING WATER**. Please wipe clean any spills you may have.