

Making a model out of a sensor

پیمائشی آلے کے لیے ماڈل بنائیں

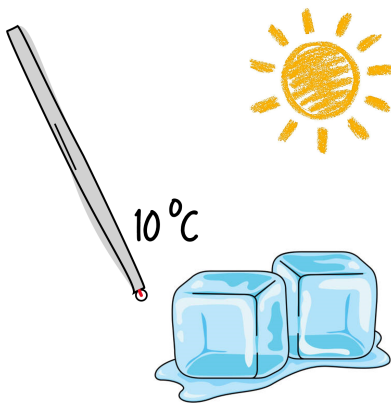
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Have you ever thought how do household devices, such as refrigerators, air conditioners, electric irons and water heaters sense a change in temperature? This is realized by a tiny electronic component, a thermistor.

Thermistor is a specialized semiconductor resistor and is temperature sensitive. Unlike a traditional mercury thermometer, which respond linearly to temperature changes, the thermistor resistance changes non-linearly with a change in temperature.

In this lab investigation, you will go a step beyond measurements. You will learn how a thermistor's behavior can be described using a mathematical model. What begins as a simple measurement becomes an interesting exploration of curves, and the connection between measurement and models. So let's get started.



کیا آپ نے کبھی سوچا ہے کہ گھریلو آلات جیسے ریفریجریٹر، ایئر کنڈیشنر، استری اور واٹر ہیٹر درجہ حرارت میں تبدیلی کو کیسے محسوس کرتے ہیں؟ یہ کام ایک چھوٹے سے الیکٹرانک جزو کے ذریعے کیا جاتا ہے جسے تھرمسٹر کہا جاتا ہے۔

تھرمسٹر ایک خاص قسم کا نیم موصل ہوتا ہے جو درجہ حرارت کے لیے حساس ہوتا ہے۔ روایتی پارہ والے تھرمامیٹر کے برعکس، جو درجہ حرارت میں تبدیلی کے ساتھ خطی انداز میں رد عمل دیتے ہیں، تھرمسٹر کی مزاحمت درجہ حرارت میں تبدیلی کے ساتھ غیر خطی انداز میں تبدیل ہوتی ہے۔

اس لیبل تحقیق میں آپ پیمائش سے ایک قدم آگے بڑھیں گے۔ آپ یہ سیکھیں گے کہ تھرمسٹر کے طبعی رویے کو ایک ریاضیاتی ماڈل کی مدد سے کیسے بیان کیا جا سکتا ہے۔ جو عمل ایک سادہ پیمائش سے شروع ہوتا ہے، وہ آگے چل کر منحنی خطوط کے ایک دلچسپ مطالعے میں تبدیل ہو جاتا ہے، اور اس کے ذریعے طبیعیات اور ریاضی کے درمیان تعلق کو سمجھا جا سکتا ہے۔ تو آئیے، کام شروع کرتے ہیں۔

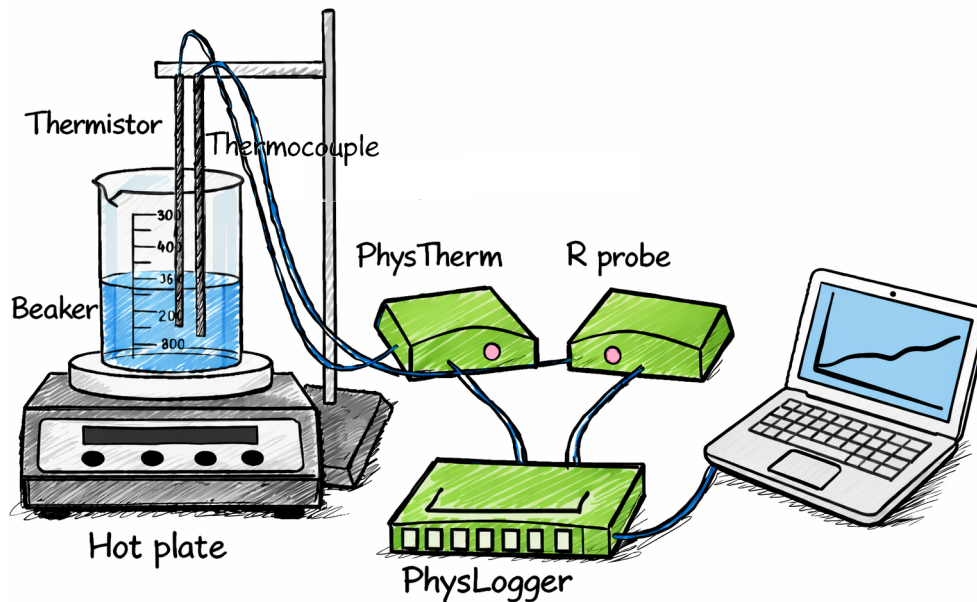


Figure 1: Scheme of the experiment to model the response of a thermistor.

Let's make sure we have everything we need to make our setup which is shown in Fig. 1.

- | | |
|-----------------|-----------------|
| 1. Thermistor | 5. R probe |
| 2. Thermocouple | 6. PhysTherm |
| 3. Hot plate | 7. PhysLogger |
| 4. Beaker | 8. Retord stand |

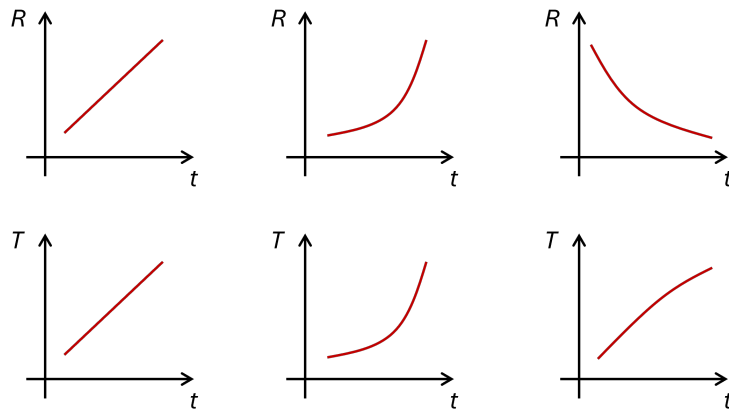
The setup for this experiment consists of a thermistor and a calibrated thermocouple placed in a beaker filled with water. The beaker is placed on a hot plate. A thermocouple that measures temperature T is connected to a PhysTherm to record and transfer temperature data to a desktop using PhysLogger for further analysis.

In parallel, the resistance R of the thermistor is measured using an R-probe connected also to the PhysLogger. We want to build a "model" that tells us the temperature from the resistance, so that we can use the thermistor stand-alone in future experiments, without having to take parallel measurements from a thermistor being used as reference.

What does the data say?

Let's turn on the hot plate, and proceed with settings provided in Appendix to measure change in temperature (T) registered by the thermocouple and resistance (R) of the thermistor, over time.

[Q 1]. Make a sketch of how you predict the R and T behavior with time (t) for present setup. Is your answer one of the following? Or any thing else?



In order to validate your intuition, perform the following tasks.

[Q 2]. Plot the measured T versus t .

[Q 3]. Plot the measured R versus t .

[Q 4]. What kind of graph would you like to make between R and T ?

[Q 5]. For example, how would a graph between $\{1/T\}$ and $\{R\}$ look like?

[Q 6]. Similarly, how would a graph between $\{1/T\}$ and $\{\ln R\}$ look like?

The key idea is that the same data when plotted differently, can provide different shapes of graphs. One shape can be more intuitive than another.

At the outset, your task is to make a model that related the temperature to the resistance. The model is a function taking R to $\{1/T\}$:

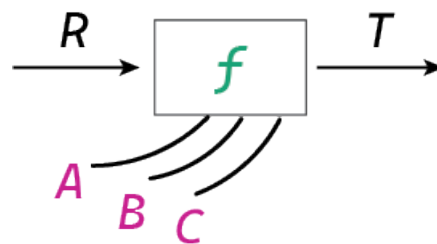
$$\frac{1}{T} = f(R). \quad (1)$$

For example, we propose three models:

$$\frac{1}{T} = B(\ln R), \quad (2)$$

$$\frac{1}{T} = A + B(\ln R) \quad (3)$$

$$\frac{1}{T} = A + B(\ln R) + C(\ln R)^3, \quad (4)$$



where A , B and C are constants determined from nonlinear fitting.

[Q 7]. From your data, estimate coefficients A , B , C in the proposed models using nonlinear curve fitting model the thermistor response. What is your finding? Which one of these, (2), (3) or (4) is a better model?

References

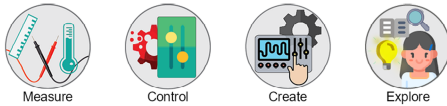
- [1] M. Boleman, Mechanical Equivalent of Heat—Software for a Thermistor, The Physics Teacher **46**, 92–94 Feb. 2008.

Appendix

PhysTherm and R Probe setting

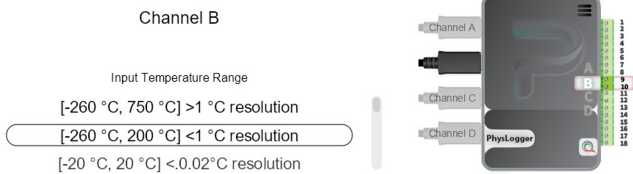
In the PhysLogger desktop application, select **PhysLogger** and then click **Continue**. Go to **Measure**. Ensure **PhysTherm** and **R probe** are connected to analogue input channels of PhysLogger.

I want to

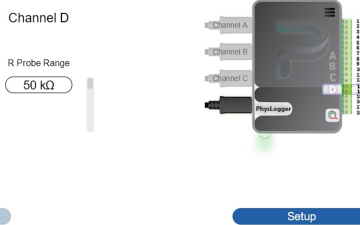


Select **Temperature**, and appropriate temperature range, then **Proceed**.

Measure temperature

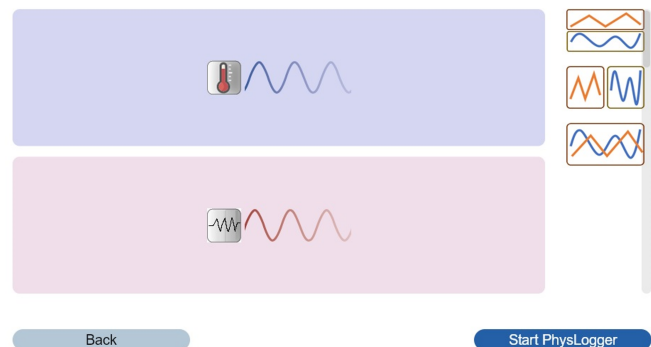


Measure Resistance



Select **Resistance** to interface **R probe** and select mentioned range, and then select **Proceed**.

Select a preferred display layout



Click on **Start PhysLogger**. Here you all set for data visualization using **PhysTherm** and **R probe**.