

## Can a MaxChill™ sports bottle really cool a drink to below ambient temperature without adding ice?

### Introduction



Figure 1 Sensing the temperature of a *MaxChill™* sports bottle with *LabQuest*

Normal bicycle sports bottles are just plastic containers in which you keep your drink. To keep it cool for as long as possible you will have filled it with drink from the refrigerator or added ice to it.

**Q1** What would happen to the temperature of water in a normal sports drinks bottle with time?

The *MaxChill™* sports bottle shown in Figure 1 is rather different. The slip-on outer cover has within it a special polymer which absorbs up to thirty times its own weight in water. After filling the bottle with drink this cover is soaked in water at the ambient temperature (that of the local environment) and, according to the advertisement, should then cool the drink to quite a few degrees below that temperature. But does it do what it says?

To simulate the effect of air flow over the sports bottle as one cycles a fan will blow air, again at ambient temperature, past the bottle. To measure the effect on the temperature of the bottle's contents, water, you will use the stainless steel temperature probe which can measure temperatures in the range  $-40^{\circ}\text{C}$  to  $+135^{\circ}\text{C}$ . However, this sensor is fairly massive, has a relatively high thermal capacity, and so responds slowly.

## Your task

- To check that the *MaxChill™* sports bottle really can cool a drink to below the ambient temperature without the addition of ice.

## The physics of the temperature sensor

The stainless steel temperature probe consists of a thermistor, a thermally sensitive resistor. Such thermistors are made from mixtures of powdered oxides, selenides and sulphates of cobalt, copper, iron, manganese, nickel or uranium. There are two types of thermistor: ntc (negative temperature coefficient) and ptc (positive temperature coefficient), with the former having a resistance which falls with rising temperature and the latter increasing with rising temperature. This probe uses a ntc thermistor. There are many other types of electronic temperature sensor including a thin film platinum resistance sensor, a thermocouple, a band-gap sensor and even a simple diode can do the job.



Figure 2 Three types of temperature sensor

In simple terms the heating of such a thermistor allows it (i) to release more electrons to flow and (ii) for these electrons to flow more easily. The result is a larger current flow with a rise in temperature.

Computers can only sense voltages and do so via an Analogue to Digital converter (A to D). So, to sense any change in the resistance of the thermistor, a circuit is set up in which a fixed voltage is applied across a resistor and thermistor combination. As the thermistor's resistance changes so also does the current flowing through it and the resistor. Changes of current through the resistor will then result in changes of voltage across it which are then fed into the A to D converter.

## Setting up your investigation

Plug the temperature probe into Channel 1 on the rear of *LabQuest*. If mains power is available connect the power adaptor to the *LabQuest* and then switch **ON** by pressing the silver **ON/OFF** button in its top left-hand corner. You should then see displayed a screen similar to that of Figure 3 overleaf.

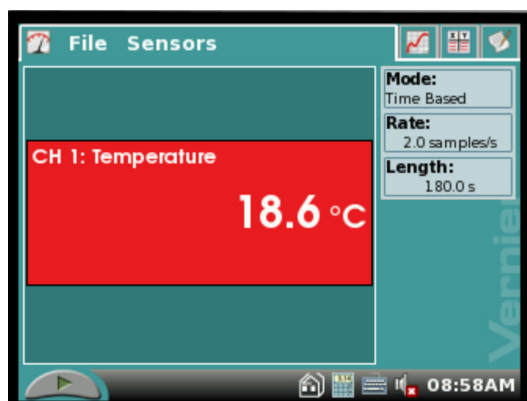


Figure 3 Opening screen

Unscrew the drinks bottle cap and place the cylindrical spacer inside the bottle. This will reduce the amount of liquid in the bottle and so make any effect that is produced show up more quickly. Pour 350ml of water at ambient temperature (you should be provided with a beaker of such water) into the drinks bottle to nearly fill it. Screw the bottle cap back on. Carefully insert the temperature probe through the hole in the edge of the bottle cap and down into the water.

Remove the outer cover on the drinks bottle

Position a fan about 20cm from the bottle but do not switch on at this stage. It should now look much like the photograph of Figure 4 below although the bottle will now be without its outer cover.



Figure 4 Setup of *LabQuest* with the temperature probe and the *MaxChill™* sports bottle

Tap the stylus on the **Rate** box to display the initial Data Collection screen much like that shown in Figure 5.

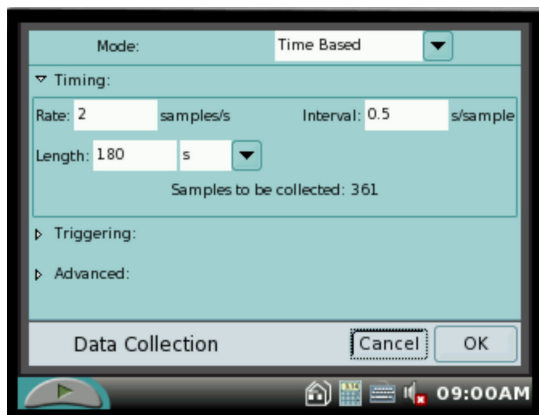


Figure 5 Initial Data Collection screen

Keep in Time Based mode but change the **Rate** to 1 samples/s which automatically indicates an interval of 1 s/sample. A temperature probe of the type being used here is not quick to respond to changes so there is no point in trying the sample more quickly.

Set the **Length** (time over which data will be collected) to 2100 s. Use the stylus with the on-screen keyboard to do this so that it is as shown in Figure 6.

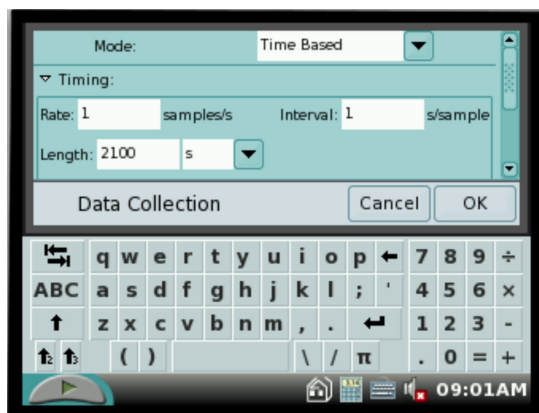

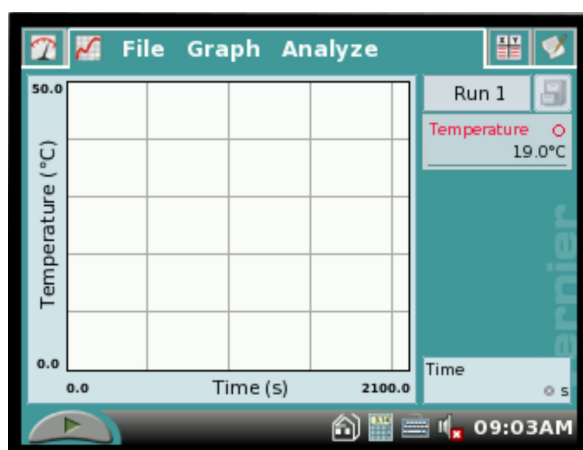


Figure 6 Data Collection screen

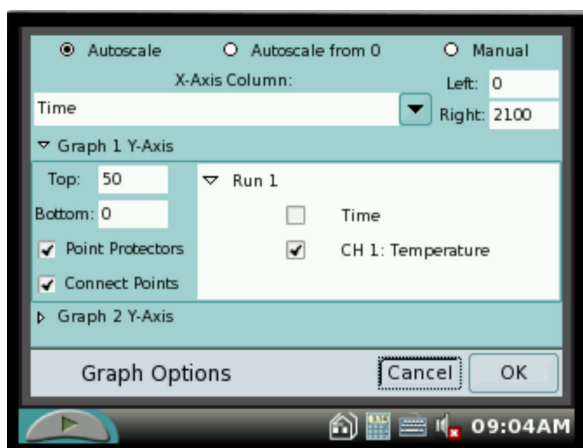
Tap the **OK** button. You should now obtain a screen display similar to that of Figure 3 but with a different Rate and Length.

Now tap the **Graph** tab  to display the empty graph screen of Figure 7 shown on the following page.



**Figure 7 Initial empty graph screen**

Tap **Graph** and then **Graph Options** in the associated drop-down menu to reveal the Graph Options screen displayed in Figure 8.



**Figure 8 Initial Graph Options screen**

If not already set, use the stylus and on-board keyboard to set the radio button at the very top to Autoscale, the Time X-axis Column Left to '0' and Right to '2100', the Graph 1 Y-axis Top to '50' and Bottom to '0'. Ensure that the box alongside CH 1: Temperature is ticked but leave the box alongside Time unticked.

Tap in the box alongside Point Protectors to untick it, but ensure that the box alongside Connect Points is ticked. It should now appear as in Figure 9 on the next page.

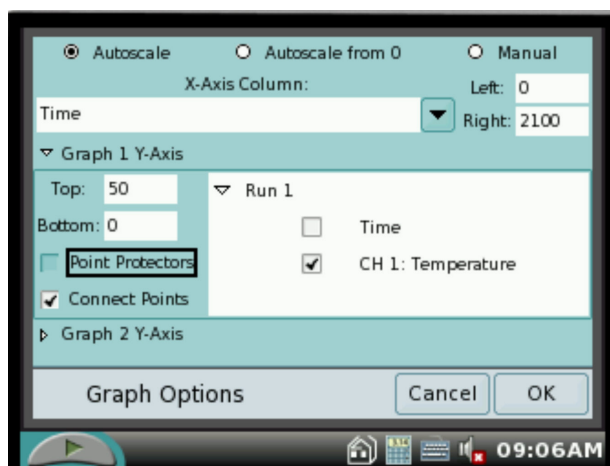


Figure 9 Graph Options setup

Now tap the **OK** button.

You are now ready to conduct the investigation but you need to be aware of the changes that you will need to make during the time that data is being collected. Initially you will collect data for 300s but leave it running. Then you will need to soak the drinks bottle's outer cover in water at ambient temperature and fit that onto the bottle and collect data for a further 300s, but again leave it running. Finally you will need to then switch the fan on and leave it running until all the data has been collected after 2100s.

Tap the **Start/Stop collecting data** button  to commence datalogging. It will stop automatically after 2100s.

When your final graph displays, switch **OFF** the fan.

Now tap **Analyze, Statistics** and tap/tick the box alongside **Temperature** in the drop-down menu. From the Statistics box you will be able to see both the maximum and minimum temperatures attained during the datalogging.

- Q2** How did the temperature of the water in the sports bottle change, if at all, in the first 300s?
- Q3** How did the temperature of the water in the sports bottle change, if at all, in the second 300s?
- Q4** How did the temperature of the water in the sports bottle change, if at all, in the final 1500s? So does the *MaxChill* bottle do what its advertisement says?
- Q5** Explain the effect, if any, in terms of the speeds and kinetic energies of the water molecules.
- Q6** What is the process called by which the water molecules in the bottle's outer cover escape to the atmosphere and explain how this process differs from boiling?

**Q7** What is this same process usually called when we note it cooling our bodies?

### **Deleting datasets and finishing**

To leave things set up for other users tap **File** and **Quit** and then **Discard** in response to 'you have unsaved data. Do you wish to save or discard the data?'.

Remove the temperature probe from the sports bottle and then unplug it from *LabQuest*. Now press the silver **ON/OFF** button to switch *LabQuest* **OFF**.

Carefully empty the water out of the sports bottle, remove its outer cover and leave to dry.