

Student Name: \_\_\_\_\_

Date: \_\_\_\_\_

## Activity Sheet

### *Calculating the Speed of Light*

<b>Aim:</b>
By melting chocolate in a microwave, you will be able to measure the speed of light.

<b>Background:</b>
<p><b>Watch the following video on how to do the experiment:</b>  <a href="https://www.youtube.com/watch?v=N3a1ufL_EC8">https://www.youtube.com/watch?v=N3a1ufL_EC8</a></p> <p><b>Read the information sheet at the end of this lab!</b></p>

<b>Materials:</b>			
Microwave	Chocolate chips, large piece of chocolate, or marshmallows	Microwavable plate	Ruler

<b>Method:</b>	
1	Take out the turntable out of the microwave so the chocolate chips stay still while being heated.
2	Scatter the chocolate chips (or place the chocolate bar) on a plate
3	Heat the chocolate in the microwave until it begins to melt in a few places. This should take about 20 seconds.
4	<p>Carefully take the plate out of the microwave and use a ruler to measure, in cm, the distance between melted spots (where the chocolate melted). Measure two distances and record them in your results table.</p> <p><i>Note: If you are using a chocolate bar, you might need to use a toothpick or knife to feel for the melted spots.</i></p>
5	Convert your distance into meters (M) by dividing your distance by 100. Show your work and record in your results table.



Text is available under the [Creative Commons Attribution-NonCommercial 4.0 International \(CC BY-NC 4.0\) license](https://creativecommons.org/licenses/by-nc/4.0/).

Student Name: \_\_\_\_\_

Date: \_\_\_\_\_

6	Find out the frequency of your microwave (usually on the back). It will most likely be expressed as <b>gigahertz (GHz)</b> or <u>megahertz (MHz)</u> . To convert the unit to Hertz (Hz) multiply the number by <b>one billion (1,000,000,000)</b> or <u>one million (1,000,000)</u> . Record this in your results table.
7	Use the formula for speed to calculate the speed of light for both measurements and record in your table.  <i>Speed = Wavelength x 2 x Frequency</i> * <b>See reading for why you multiply by 2</b>
8	Look up the answer to the actual speed of light in m/s. Record this in your table.
9	Find out the percent error for your answer by using the following formula. The lower the percent, the more accurate your calculation was.  $\% \text{ Error} = \frac{  \text{Measured Speed of Light} - \text{Actual Speed of Light}  }{\text{Actual Speed of Light}} \times 100$

<b>Results Table</b>					
Distance (cm)	Distance (M)	Microwave Frequency (Hz)	Speed of Light (m/s)	Actual Speed of Light (m/s)	% Error



Text is available under the [Creative Commons Attribution-NonCommercial 4.0 International \(CC BY-NC 4.0\) license](https://creativecommons.org/licenses/by-nc/4.0/).

Student Name: \_\_\_\_\_

Date: \_\_\_\_\_

<b>Calculations</b>			
<b>Distance Conversion</b>	<b>Frequency Conversion</b>	<b>Speed of Light</b>	<b>% Error</b>



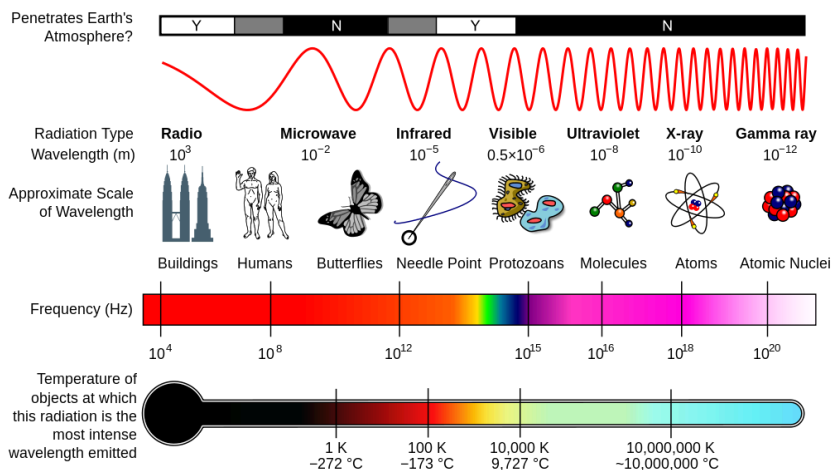
Text is available under the [Creative Commons Attribution-NonCommercial 4.0 International \(CC BY-NC 4.0\) license](https://creativecommons.org/licenses/by-nc/4.0/).

Student Name: \_\_\_\_\_

Date: \_\_\_\_\_

## Measuring the Speed of Light with Chocolate

Microwaves are a type of electromagnetic radiation, just like light waves.



Microwaves are used to detect speeding cars and to send telephone and television communications. Industry uses microwaves to dry and cure plywood, to cure rubber and resins, to raise bread and doughnuts, and to cook potato chips. But the most common consumer use of microwave energy is in microwave ovens. Microwaves have three characteristics that allow them to be used in cooking: they are reflected by metal; they pass through glass, paper, plastic, and similar materials; and they are absorbed by foods.

Like all electromagnetic radiation, microwaves travel at the speed of light. The speed of a wave is directly related to both its size (*wavelength*) and its *frequency*. In the diagram above, you can see that radiation with small wavelengths has very high frequency (e.g., gamma rays), while radiation with very long wavelengths have much lower frequency (e.g., radio waves). If you know the frequency of a light wave, you can measure its wavelength to calculate the speed of light.

### Wavelength

In this activity, we are using melting chocolate to measure the wavelength of microwaves. A microwave oven forms *standing waves* in which the points halfway between the *crest* (maximum) and *trough* (minimum) of a wave form fixed points called



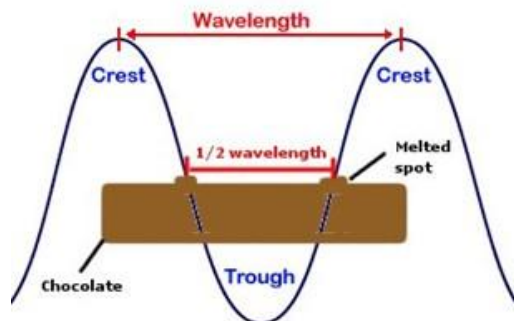
Text is available under the [Creative Commons Attribution-NonCommercial 4.0 International \(CC BY-NC 4.0\) license](https://creativecommons.org/licenses/by-nc/4.0/).

Student Name: \_\_\_\_\_

Date: \_\_\_\_\_

*nodes*. These nodes receive more radiative energy from the microwaves in your oven, so they heat up fastest and that's where the chocolate chips begin to melt first (normally the rotating plate helps your food warm more evenly -- that's why we need to take it out for this experiment!). When you measure the distance between two melted spots you can work out the wavelength of the microwaves.

Measuring the distance between melted spots gave you half a wavelength. You need to multiply the distance by two to get a whole wavelength.



*The distance between two melted spots is half a wavelength*

### Frequency

Now you know the wavelength you need to know the wave frequency. Wave frequency is how many times a wave bounces up and down in one second. Think about shaking one end of a jump rope with the other end fixed: the faster you shake, the higher the frequency. The units of frequency are called 'Hertz' (Hz) with 1 Hz = 1/sec. Most microwaves operate at a frequency near 2.45 gigahertz. This means that a wave will move up and down 2.45 billion times per second.

### Speed

$$\text{Speed of light} = \text{wavelength} \times \text{frequency}$$

#### Citation:

“Measure the Speed of Light Using Chocolate.” *Planet Science*,  
[www.planet-science.com/categories/over-11s/physics-is-fun!/2012/01/measure-the-speed-of-light-using-chocolate.aspx](http://www.planet-science.com/categories/over-11s/physics-is-fun!/2012/01/measure-the-speed-of-light-using-chocolate.aspx).



Text is available under the [Creative Commons Attribution-NonCommercial 4.0 International \(CC BY-NC 4.0\) license](https://creativecommons.org/licenses/by-nc/4.0/).

Student Name: \_\_\_\_\_

Date: \_\_\_\_\_



Text is available under the [Creative Commons Attribution-NonCommercial 4.0 International \(CC BY-NC 4.0\) license](https://creativecommons.org/licenses/by-nc/4.0/).

