# Measuring the Speed of Light With Chocolate

*This lesson can be used as a lab or demonstration to teach students about the speed of light and it relationship to frequency and wavelength. It discusses the equation $c = f\lambda$. The idea for this lesson came from the 2004 NSTA meeting in Atlanta.*

**Primary Learning Outcome:**
After the lesson has been taught students should fully understand the equation $c = f\lambda$ and relate it to things that they use.

**Georgia Performance Standards:**
SPS7. Students will relate transformations and flow of energy within a system
SPS9. Students will investigate the properties of waves

**Total Duration:**
20 minutes

**Materials and Equipment:**
1. Microwave
2. Chocolate chips
3. Paper plate
4. Ruler

**Procedures:**
Remove turntable from microwave
Scatter chocolate chips over paper plate
Place in microwave
Microwave for a few seconds until chocolate starts to melt
Measure the distance between hotspots

**Assessment:**
The lesson will be assessed using students answers to questions and how closely students got to the right answer.

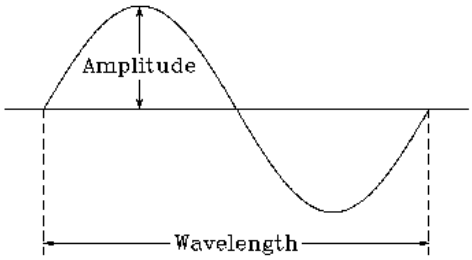
**Accommodation:**
This lesson can be taught as a laboratory or as a demonstration for students who have problems with laboratories.

# Measuring the Speed of Light with Chocolate

Anyone can measure the **speed of light (c)** - with chocolate and a microwave oven! The only equipment you need for this experiment is a microwave, a ruler and chocolate.

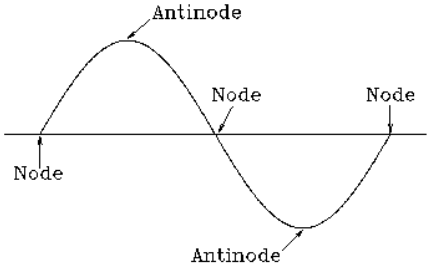
The speed of light is equal to the **wavelength (λ)** multiplied by the **frequency (f)** of an electromagnetic wave (microwaves and visible light are both examples of electromagnetic waves).

$$c=\lambda*f$$




When you turn on your microwave oven, electrical circuits inside start generating microwaves – electromagnetic waves with frequencies around 2.5 gigahertz – 2500000000 Hz. These waves bounce back and forth between the walls of the oven. The size of the oven is chosen so that the peaks and troughs of the reflected waves line up with the incoming waves and form a **"standing wave"**.

The electromagnetic field inside the microwave behaves in roughly the same way as a guitar string except the vibrations are in "the electromagnetic field". Where the vibrations are greatest (the **antinodes**), you will see the greatest heating, but at the **nodes**, the chocolate will only melt slowly as heat diffuses into those areas.



## You do it.

Remove the turntable from the microwave (so the plate does not rotate). Place chocolate scattered on a plate inside the microwave. Heat the chocolate until it just starts to melt - about 20 seconds. There will be some melted hot spots and some cold spots in the chocolate.

The distance between the melted areas is half the wavelength of the microwaves or the distance between the antinodes. So, from this simple experiment, and some easy math, you can work out the speed of light!

$$c=2*x*f$$

Distance between the hot spots _____cm

Wavelength _____cm

Wavelength _____m

Frequency of the microwave _____m

EQUATION _____

Your calculated speed of light _____m/s