Measuring with the naked eye.

Author(s): Edwin Pacheco

Date Created: August 2018

Subject: Chemistry/Physics/General Science

Grade Level: High School

Standards: Next Generation Science Standards (www.nextgenscience.org)

HS-PS4-5. **Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy**

PS4.C: **Information Technologies and Instrumentation**

Schedule: It can be done in 3/4 days.

CCMR Lending Library Connected Activities:

Objectives:	**Vocabulary:**
• Help student to visualize very small measurements and carry out such measurements. • Help students to identify ways to carry out measurements of smaller structures such as cells and atoms.	• Wavelength • Diffraction • Nanometer
Students Will: • Be able to carry out measurements of under a mm. • Be able to develop a methodology to measure very small structures. • Students will carry out metric unit conversions	**Materials:** • Laser pointers (blue, green and red). • Metric ruler. • White paper 8x11. • Paper clips and cardboard 8x11. • Wire mesh of different sizes.
Safety	The laser pointers used can damage the eye. Care must be taken to assure that laser light is aimed only at the targets intended in this activity.

Science Content for the Teacher:

Measurement: An Introduction

At any given time, you will find yourself in the need to perform a measurement. Almost any occupation some type of measurement is required: carpenters, mechanics, nurses, tailor engineers, marketing strategies, just to mention a few. Don't be surprised finding yourself utilizing measurement of some kind in your chosen career. In science, measurements play a rather large role in an experiment. Scientists measure the concentration of solutions, the growth of populations of different organisms under various conditions, the speed of biochemical reactions, the

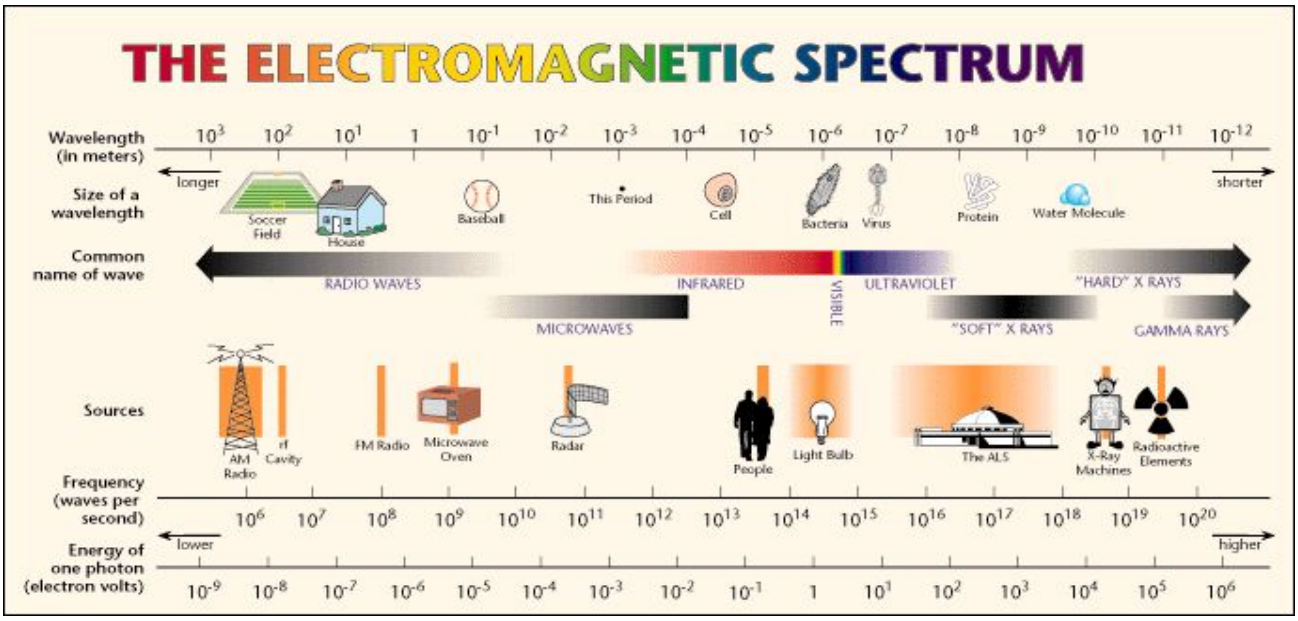
distances between celestial bodies in the universe, the distance between atomic particles and great number of other things.

As measurements form the basis of scientific inquiry, they are deserving of in-depth analysis in lab. In a scientific experiment, examining the effects of variations during an experiment, can only be explain if those variations are measured. Therefore, a major part of any experiment is to determine ways in how to measure those changes. Such data is analyzed and used to determine any necessary changes in the experiment.

In everyday life, most measurements are very visible. However, in a class setting we find ourselves trying to make students understand units of measurement at very small scale. Students have a hard time understanding how small a millimeter is. Then we begin to explain concepts like wavelength and atomic radius using units such as nanometers, picometers so maybe they can understand the size of the concept. There is no ruler small enough to make them understand how small or how big these concepts can relate to each other. Moreover, the idea that we can measure them is mind blowing. “How can I measure something that I can’t see?” they ask.

Perhaps if we can use something that they can see and measure, like visible light and show them some of its interaction properties with matter, they might develop a measuring tool which could help them see the “invisible”. Students should be taught or reminded of what a visible light is and properties such as wavelength, frequency and units of measurement as well. They should be explained the reason to use laser as light source.

These series of activity are designed with the intention to help student understand the thinking behind the developing of scientific tools. Prior to these activities, students should also discuss Electromagnetic Spectrum. However, we should focus in the use of Electromagnetic Spectrum as the tool to measurement very small objects. The light property to be discuss before the activity is light diffraction. Students should be taught to carry out unit conversions in the metric system as well. It can be done prior or during the activity at teacher’s discretion. A table of conversion is provided in this module as well as the Electromagnetic Spectrum chart.

CONVERSION TABLE

Multiplication Factor	Prefix	Symbol
$1,000,000,000 = 10^{9}$	giga	G
$1,000,000 = 10^{6}$	mega	M
$1,000 = 10^{3}$	kilo	k
$100 = 10^{2}$	hecto	h
$1 = 1$		
$0.01 = 10^{-2}$	centi	c
$0.001 = 10^{-3}$	milli	m
$0.000001 = 10^{-6}$	micro	μ
$0.000000001 = 10^{-9}$	nano	n

Classroom Procedure:

Prep work:

Students should be already familiar with visible light spectrum and the concepts of wavelength as well as units. An assessment should be performed before the activities.
Optional: Teacher should consider introducing the concept of Standard Deviation.

Activity 1:
Determining Patterns (qualitative activity). Groups should be assigned one color laser for this activity and the observations should be shared between groups with different color.

1. **Groups will use known sizes of wire mesh to observe patterns developed on the white screen by the assigned color laser. Patterns should be recorded on the white screen.**
2. **Laser will place the at various distances and the patterns will be recorder on the white screens.**
3. **Groups of different lasers will get together and exchange results.**
4. **Results must be saved for the next activity.**

Activity 2:
Measuring Patterns (quantitative activity). Using the coarse mesh, students will develop a relationship between the spacing in the coarse mesh and its diffraction pattern.

1. **Every group will measure the distances between points of the patterns generated at different distances for each laser. They must be recorded as "w" in the corresponding data table.**
2. **The different distances for each pattern should be recorded for each laser as "L".**
3. **The spacing of the mesh "d" will be determined by the following:**

$$d = L \times \lambda \div w$$

4. **Each group will determine the average value for each of the tables.**
5. **Students will perform similar study on the finer coarse mesh to determine the spacing size.**

Assessment:

Students will complete the attached student sheets and assessment will be based upon the work submitted on the sheets as well as the participation in the classroom procedure.

Resources:

CCMR Lending Library.

Extra Activities:

Research: How does the electron microscope works?
Research: Limitations of light microscopy.

Acknowledgements:

Nevjinder Singhota
Mark Walsh
CCMR Staff Facility Managers
Cornell University
NSF