Katherine Aho
NSF GK-12 Vibes and Waves in Action
Honors and CP Physics
Lesson 6: First R Program and Kinetic energy

Summary of Lesson

This was the first program that the students were given the opportunity to write on their own. Because they were covering kinetic energy in their class, they were given the kinetic equation and asked to change the velocity using two different methods: the c() command and the seq(), and then plot the results. The students were asked to compare which command gave them a smoother curve for the plot. Since this was their first program, they were given several instructions on how to navigate through RStudio. A brief explanation of variables, arrays and basic plotting were also given. After writing the program, the students were asked questions related to kinetic energy and programming.

Honors and CP Physics Lesson Plan

Text: Conceptual Physics, Paul G. Hewitt
Chapter: Ch 9, Kinetic Energy (Section 9.5)
Objectives: Compute kinetic energy with varying velocity and plot a graph vs velocity using different computing techniques in R
Essential Question: What is relationship between kinetic energy and velocity?
Frameworks: Conservation of Energy and Momentum; SIS1, SIS2, SIS3, SIS4

L-Side Activities: Teacher	R-Side Notes: Students
At the Bell: Open RStudio and save a new file. **Agenda:** 1. Reinforce importance of programming and why we are using R 2. Explain how to comment a program and ask the students to write a comment in their program based on the objective 3. Variables 4. Arrays 5. Plotting 6. Run programs and check for errors 7. Questions 8. Relate back to kinetic energy **Working It Out:** 1. What is R? 2. What is a computer program? 3. What is the purpose of commenting a program? 4. How do you define variables? 5. How do you create and vector and how do they differ from variables? 6. What would you do if you wanted to create and array with a sequence of values? 7. Describe the two different methods to compute kinetic energy. Which do you prefer and why? 8. Describe the relationship between kinetic energy and the velocity. 9. Explain why programming is a valuable tool. **Class Activity:** Students will extend the code already written using the seq() command to create a sequence of velocity values and plot on the same graph with the lines() command **Homework:** None	I. What is R? 1. R is a programming language used for computing and statistics II. Program 1. Sequence of instructions written for a computer to perform specific tasks III. Variables 1. Name that represents information or data for the computer to process 2. Like “boxes” that contain information that can be stored or processed by the computer IV. Arrays 1. An arrangement of elements that each contain variables or values 2. Can be multiple dimensions (a) one-dimensional arrays are called vectors 3. Use the c() command or seq() command in R

```
# COMPUTE AND PLOT THE KINETIC ENERGY WITH VARYING VELOCITY
# BY: KATHERINE AHO
##################################################


# FIRST CASE: CHANGE VELOCITY USING SPECIFIC VALUES
m <- 10  # mass, kg
v1 <- c(0,5,10,15,20,25,30,35,40)  # velocity, m/s
k1 <- 0.5*m*v1^2   # kinetic energy equation, Joules

# plotting points
plot(v1,k1,main="Kinetic Energy vs. Velocity",xlab="Velocity (m/s)",ylab="Kinetic Energy (J)")


# SECOND CASE: CHANGING VELOCITY WITH A SEQUENCE OF VALUES
v2 <- seq(0,40,0.1)   # sequence of velocity values at every 1/10th of a second
k2 <- 0.5*m*v2^2   # kinetic energy equation
lines(v2,k2)   # plotting a line of kinetic energy vs. velocity; will be on same graph as points
```

R Programming Activity #1

Objective: Compute the kinetic energy equation with varying velocity and plot a graph with changing velocity using different techniques in R.

What is R? R is a **programming** language used for computing statistics. A **program** is sequence of instructions written for a computer to perform specified tasks. Our first task is to compute the kinetic energy equation by with varying velocity values.

> **Step 1:** Open **RStudio.** Then select **File > New > R Script**
> **Step 2:** Save and name your file by going to **File > Save As…**
> **Step 3: Comment** the beginning of your program with your name and a brief description of what the program is supposed to do

ALWAYS REMEMBER TO SAVE YOUR WORK!!!!

Most computer programs start by defining **variables**. A **variable** is a name that represents information or data for the computer to process. They are like "boxes" that contain information that can be stored or processed by the computer.

> **Step 4:** Define a **variable** for the mass. Set the mass equal to 10 kilograms. Add the appropriate comment for the mass and it's units.

We want to look at what happens to the kinetic energy as the velocity changes. There are several different ways the velocity values can be changed using R. The first is creating an **array.** An **array** is an arrangement of **elements** that each contain variables or values. Arrays can be multiple dimensions. For now, we will only use **one-dimensional arrays.** In programming, these are called **vectors.**

In the **vector** (boxes) below, fill in the following values for the velocity: 0, 5, 10, 15, 20, 25, 30, 35, 40 (m/s).

V =

These boxes are similar to how the values are stored in the computer. How do we write this in R?

> **Step 5:** Write a **vector** of the velocity values that are defined in the boxes above. Add the appropriate comment for the velocity

and it's units.

EXAMPLE: numbers <- c(1,2,3,4,5,6,7,8,9,10)

Note: In R, c() means **combine**. The function c() takes the numbers inside the parenthesis and creates a **vector**.

Step 6: Write the kinetic energy equation using the R language. Add the appropriate comments for the kinetic energy equation and it's units.

$$K = \frac{1}{2} m v^2$$

Step 7: Plot the kinetic energy versus velocity using the plot command.

EXAMPLE: plot(x,y)

Note: You want to put the variable on the x-axis first, then the variable on the y-axis.

Step 8: Add labels to the plot, so you know what's being plotted. Inside the plot command, add a title, xlabel, and ylabel.

EXAMPLE: plot(x,y,main="Title",xlab="x axis",ylab="y axis")

We looked at how you can calculate an equation and plot the results with a vector of specified values. What if we wanted to look at a **sequence or range of values**?

ASSIGNMENT: Write another piece of code which uses a sequence of velocity values from 0 to 40 m/s, every 0.1 seconds. Plot a line graph of the results on the same plot as the first case.

Hints: Most of the steps will be the same as for the first. You may use any commands or techniques that were used in previous R exercise. The command **lines(x,y)** will allow you to plot a line graph of the results on the same plot.

QUESTIONS:

1.) Describe the two different methods that you used to compute the kinetic energy. Which method did you prefer and why?

2.) Describe the relationship between the kinetic energy and the velocity.

3.) Explain why programming is a valuable tool.