### **Sequence**

1. Activity 1 - Demo/Discussion - diffusion of dye in hot and cold water
2. Worksheet 1 - storyboard of water.
3. Lab 1 - Temperature scales - Fahrenheit and Celsius
4. Worksheet 2 - Working with Expressions
5. Worksheet 3 - Working with Functions
6. Pyret Activity 1 - Temp Converter Program
7. Follow-up - Create the inverse
8. Worksheet 4 - Working with Images
9. Pyret Activity 2 - Thermometer Program

**Background**

*A function is a model, a mathematical model*—it has elements, operations, relations and rules. We need to explicitly **build** it, test and **refine** it and prepare students to **deploy** it in a variety of contexts. The Pyret code and the simulation it produces are *representations of the* *function model.* In physics, we regard a function is a representation of a model, but in math, it IS the model, so we need to engage in a Modeling Cycle that enables students to build it, test and refine it, and deploy it.

It will be a short Modeling Cycle, to be sure, but an essential pre-cursor for what is to come. Once we have this model we can circle back to it whenever we need to…we can also diagnose problems with student thinking about mathematizing the model better. Typically we ask students to represent a model “algebraically” and we get them to develop an equation in *y = mx + b* form—for computational modeling in Pyret we need to shift our use of language to having them represent the model *‘functionally’* (rather than saying *‘algebraically’*)--as a function (of which an equation is a specific expression). The words we use matter, as you are coming to realize, and this is an opportunity to begin to use the word ‘function’ purposefully.

The development of the concept of function is a big deal in the math education research. It turns out that one reason it’s hard for students to develop a coherent concept of function is because in math it is taught in a “context-free” way. Students end up with a procedural knowledge of functions and their use, but no conceptual model that enables them to apply functions more generally. If we can help students build a strong function model at the start of 9th grade physics, not only will they be better computational modelers they may be better mathematical thinkers and learners as well.

### **Activity 1 - Demo/discussion: diffusion of dye in hot and cold water**

In this demonstration, obtain two large beakers or flasks. Fill one with cool to cold water and the other with very warm water (not boiling). Allow the water to become still on a demo table before beginning the demonstration. Add 1-2 drops of a dark food dye to the water in each flask and observe the diffusion of the dye in the water. Using two different colors, such as red and blue, makes it easier to keep track of which beaker is hot and cold during discussion.

Students are asked to describe what they saw macroscopically, and then explain their observations in terms of the particle model we have developed so far (small, separate particles in motion that move randomly by collision). The discussion should draw students to explain the observed behavior in terms of the effect that adding energy to the system of particles has on temperature and the speed of the particles.

An important aspect of our model of matter that is being developed in this unit is that particles interact via collision to change motion and transfer energy from particle to particle. This feature of our model provides a mechanism for understanding energy transfer by both heating and working (introduced in Unit 3) and for understanding reactions beginning in Unit 7. It is helpful to students to explicitly identify these features of our model following these activities.

### **2. Worksheet 1 - Storyboard**

Students will prepare two storyboard sequences, one each for the hot water and cold water diffusion observations. To contrast the difference in rate, each storyboard sequence should contain the same number of frames at the same time intervals. These can be prepared individually as a homework assignment, however, ideally as class time allows, prepared in groups on whiteboards for discussion.

### **3. Lab 1 - Temperature scales - Fahrenheit and Celsius**

Outline: multiple containers at various temperatures to be measured in both Celsius and Fahrenheit and create a data table.

|  |  |
| --- | --- |
| Celsius | Fahrenheit |
|  |  |
|  |  |
|  |  |

Graph: Fahrenheit vs Celsius

BFL: F = (1.8 \* C) + 32

Discuss slope meaning…

Discuss intercept meaning...

Discuss the FUNCTION (remember to emphasize the term ‘function’) with its input and output parameters, and constant values.

### **4. Worksheet 2 - Working with Expressions**

Simple calculations….

* 2 + 3
* 3 \* 5
* 2 + (3 \* 5)
* (2 + 3) \* 5
* Etc.

### **5. Worksheet 3 - Working with Functions**

Simple functions…

* Perimeter-square
* Perimeter-rectangle
* Area-square
* Area-rectangle
* Area-triangle
* Perimeter-triangle (optional)

### **6. Pyret Activity 1 - Temp Converter Program**

Students will use the ‘function’ they developed through the lab to write a program that will convert the temp in Celsius (input) to the temp in Fahrenheit (output).

### **7. Follow-up - Create the inverse**

Students should reverse their data table…

|  |  |
| --- | --- |
| Fahrenheit | Celsius |
|  |  |
|  |  |
|  |  |

Graph: Celsius vs Fahrenheit (reverse the axes from the previous assignment)

BFL: C = (0.55 \* F) - 17.8

Discuss slope meaning…

Discuss intercept meaning...

Discuss the FUNCTION (emphasize the term ‘function’) with its input and output parameters, and constant values.

Students should then program the inverse function… a temp converter from Fahrenheit to Celsius.

### **8. Worksheet 4 - Working with Images (Optional)**

Simple images…

* Circle
* Square
* Rectangle
* etc.

### **9. Pyret Activity 2 - Thermometer Program (Optional)**

Students incorporate their functions for temp converter from C to F, and have the computer display a thermometer that matches it.

**include** image

background = rectangle(10, 100, “outline”, “black”)

**fun** therm(C):

overlay-align(“bottom”, “middle”, rectangle(10, C, “solid”, “red”), background)

**end**

Culminating discussion/whiteboard -

* Model So Far - What is a Function?
* Model So Far - How would you use a Function?
  + Concepts in programming come in pairs -- how to create, and how to use
  + Numbers go with arithmetic
  + Booleans go with ifs (conditionals)
  + Functions...go with function calls