Introduction to Processing – Jason Hwang and Daniel DuBrow

Purpose

The activity introduces the use of processing to simulate a physical system using physics equations learned in class. In this we build upon the three way relationship between experiment, theory and simulation. For this particular activity, we are using both theory and observation to construct a set of rules for the simulation.

We chose Processing for several reasons. Processing does not require any files to be installed, which leads to a much faster and less problematic set up. Processing is also free to use and available for download so any students interested in doing work outside of class have easy access to the program.

Overview

The activity consists of three main parts and will require at least two periods to complete depending on how many preparation activities were run.

Part 1: Introduction to programming techniques and syntax

Assuming that this activity is the first programming activity the students have seen there are several concepts that must be covered.

-It may be best to have sections of the code that have nothing to do with the physics be shown as something that the students merely copy down.

-Review how to declare variables. Relating the concept to naming variables in excel can help.

-Go over Processing syntax, specifically the placement of semi-colons brackets and capitalization.

-Emphasize that the code will go through each command from top to bottom and have the students think logically about how the code would run.

Part 2: Review of physics equations

The physics equations required for this activity are the force equations and the relations between acceleration, velocity and position. Illustrate how to convert one of these equations into a segment of code on the board.

$$F = m a$$

$$\Delta v_x = a_x \Delta t$$

$$\Delta v_y = a_y \Delta t$$

$$\Delta x = v_x \Delta t$$

$$\Delta y = v_y \Delta t$$

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Part 3: Running the activity
At this point the worksheet for this activity should be handed out and the instructor should give the students a few minutes to read over the instructions. The instructor should go through the first few steps on the worksheet in front of the students on their own computer before turning the students loose to work on their own.

The students' progress on this activity will be heavily influenced by their previous experiences with programming. More attention must be given to students that have less programming experience as they will have a steep learning curve in the beginning with the coding syntax.

The activity inherently scales well with the students stronger in computational programming able to naturally add their own modules to the given program.

Student Outcomes

1) Introduction to computational thinking
2) Review of force equations
3) Review of equations of motion
4) Understanding how to simulate a system
5) Changing initial conditions to fit a problem

Illinois state science standards met:
Apply scientific inquiry and scientific habits of mind 11A/13A/13Bl.I
How the scientists really work 13A/12A-F/13B.J
Gravitational factors 12D/11B/13A.H

Time

The activity should take at least two class periods with preparation activities strongly encouraged. Such activities include a lab to introduce excel or other spreadsheet type tools.

Level

The physics required for the activity requires the students to be in a high school physics class. The programming aspect can be scaled based on the prior experiences of the students.

Materials and Tools

A computer lab with internet required to download and run Processing. A whiteboard or blackboard is useful for keeping track of the variables required for the program as well as showing a suggested organization scheme for the code. A projector attached to a computer proved to be useful in giving step by step instructions.

A worksheet with the instructions for the activity should be handed out after the introduction to the activity.

Preparation

The teacher should write the program and become familiar with both the logic and syntax behind each line. The teacher should note parts of the program that could potentially give the students problems. By bundling the required files into one folder and hosting it on a personal web storage for download time may be saved.

Prerequisites
While no activities are required as a prerequisite, running the excel projectile activity will give the students an idea of how to convert physics equations into a computational model. Emphasis on naming cells, applying equations and organization of data is especially important in the excel activity.

Background
Students should be familiar with the equations of motion and how to apply them in their program. Familiarity with naming variables in excel and understanding basic computational thinking concepts will help with the coding.

Teaching Notes
The students will work at different paces based on their prior experienced. Be sure to go around the room to ensure that a student is not stuck on a particular step for too long. If the problem is related to coding syntax rather than a physics concept, showing them the correct method/pointing out the issue is fine. Some students will grasp the concept very quickly and finish much faster. If this happens, urge the student to add on their own improvements to the activity. Suggestions include adding in extra forces and including walls.

Assessment
This activity is meant to mainly be an introduction to computational thinking and the assessment will come mostly in the form of answering conceptual questions asking the students to think about why the program code is constructed in the way it is.

Any question underlined in the worksheet should be answered by the students in their lab books. The last few steps are meant to challenge the students that finish early and do not have associated questions.

Additional Information
-A computer lab with at least one computer per student is recommended but groups may be formed for places with less computer resources. Keep in mind if groups are used a strong student may dominate the work.
-While most of the students finished near the end of the period, those with programming experience finished almost 30 minutes early. Because they usually have an interest in the topic guiding them to add additional modules to the code is not a problem.
-This activity uses Java syntax so further activities with Java could be applicable.