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NSF GK-12 Vibes and Waves in Action
CP Physics
Lesson 14: Free fall on earth

Summary of Lesson

The students were given a scenario where you are standing at the edge of a tall cliff (on Earth) and throw a rock straight up. The rock will rise and fall, just missing the edge of the cliff on the way down. They were first asked to draw a diagram of the scenario. Then, taking what they understood from the scenario, they were asked to write a program that calculates how long it takes an object that is thrown upwards to return to its starting height and create a graph of its velocity over some time period using R. After a series of follow up questions were given to check the students' understanding in both the physics and the programming.

CP Physics Lesson Plan

Text: Conceptual Physics, Paul G. Hewitt
Chapter: Ch 4- Linear Motion (Sections 4.3, 4.5, 4.6, 4.7)
Objectives: Write a program in R to simulate free fall
Essential Question: How long would it take an object to return to it's original height after it is thrown straight up with an initial velocity?
Frameworks: Motion and Forces- 1.1, 1.2, 1.3; SIS1, SIS2, SIS3, SIS4

L-Side Activities: Teacher	R-Side Notes: Students
At the Bell: Draw a diagram of the given scenario **Agenda:** 1. Review diagram 2. Explain the objective of the program 3. Write the program 4. Answer the follow up questions **Working It Out:** 1. Is the slope of the graph positive or negative? Why? 2. What does the slope of the line represent? 3. By looking at the graph, how can you tell when the object has reached it's maximum height? At what time does this happen? 4. What does the y-intercept of the graph represent? 5. If you wanted to create a graph that only covered the time to come back to the original height, how would you modify the code? **Class Activity:** The first part of the program will just calculate how long it takes the rock to return to its starting height (as it passes you on the way down). In the second part, the students will create a graph of the velocity of the rock each second for 10 seconds. **Homework:** None	

R Coding Activity CP - #3 Name: _____

Scenario
You are standing at the edge of a tall cliff (on Earth) and throw a rock straight up. The rock will rise and fall, just missing the edge of the cliff on the way down.

Objective
Using R, students will write a program that calculates how long it takes an object that is thrown upwards to return to its starting height and create a graph of its velocity over some time period.

Draw a diagram of the scenario.

Background
Using $v = v_o - gt$, you can calculate how long it will take the object to return to its starting height. Through symmetry, the **speed** of the object when it returns to its starting height is the same as when it was thrown (except it's falling) so its **velocity** is negative. Therefore, this equation becomes

$v = v_o - gt$	This is the original equation.
$t = -2v_o / g$	Here, we have solved for t, the time it takes to go up and come down to its original height.

Note that $g = -9.8\ m/s^2$ for Earth.

Requirements: Part 1
The first part of the program will just calculate how long it takes the rock to return to its starting height (as it passes you on the way down). The program must meet the following requirements.

The program must:
- use a minimum of three (3) appropriate comments that are helpful in understanding code
- set the value of g equal to $-9.8\ m/s^2$
- prompt the user for the initial velocity of the object equal (in m/s).
- apply the equation shown above to solve for the time.
- display a single-line message in the console with an appropriate statement and solution with units.

Requirements: Part 2
In this part, you should create a graph of the velocity of the rock each second for 10 seconds.

The graph must:
- display the correct data using a blue line
- include a title
- include labels and units on the x- and y-axes

Follow Up Questions

Run your program using an initial velocity of 40 m/s. Use the graph to answer the following questions.

1) Is the slope of the line positive or negative? Why would it be?

2) Calculate the slope of the line. What does this represent?

3) By looking at the graph, how can you tell when the object has reached its maximum height? At what time does this happen?

4) What does the y-intercept of this graph represent?

Review the code in the program. Answer the following questions.

1) If you wanted to create a graph that only covered the time to come back to the original height, how would you modify the code?