Katherine Aho
NSF GK-12 Vibes and Waves in Action
Honors Physics
Lesson 15: Free fall on other planets

Summary of Lesson

In this lesson, students took their previous free fall program and modified it to include other scenarios on the other nine planets. An example of the IF-ELSEIF-ELSE structure in R was shown before the students began writing their programs. The program was to be designed to ask the user for which planet they would like to use as the location and ask for the initial velocity. The challenge for students was to set up the program such that program makes only one calculation at the end, after the correct value for gravity it chosen.

Honors 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 on different planets
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: Brainstorm about the logic required to include the extra planets
 	
Agenda: 1. Explain the IF-ELSEIF-ELSE structure in R
       2. Explain the objective of the program
       3. Write the program
       4. Answer the follow up questions
 	
Working It Out:
1. What would be the difference in time of flight of the same object on two different planets? Why does this question have no physical basis in reality?
2. What is the ratio of the time of flight on Earth to the time of flight on Mars?
 	
Class Activity: Students will modify the program they created that calculates how long it takes an object that is thrown upwards to return to its starting height (on Earth and on the Moon). The new and improved program will allow the user to select any planet in our solar system as a location and will recognize input that it not a valid selection.
 	
Homework: None	

R Studio

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 (on Earth and on the Moon).

Background
Using $v = v_o + at$, you can calculate how long it will take the object to return. 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

$$v = v_o + at$$

$$-v_o = v_o + gt$$

$$t = -2v_o / g$$

Note that $g = -9.8$ m/s^2 for Earth and -1.6 m/s^2 for the moon.

Requirements: The program must meet the following requirements.

The program must:
- use a minimum of three (3) appropriate comments that are helpful in understanding code
- apply the velocity equation shown above.
- prompt the user for the initial velocity of the object equal (in m/s).
- prompt the user to select a location (Earth or moon)
- only calculate the result for that location, not both.
- display a single-line message in the console with an appropriate statement and solution with units.

EXTRA CREDIT
- Round your answers for the time of flight to two decimal places and use in the output. (2 pts)
- Have the program create a graph of velocity vs. time for the object at that location. The graph must only include the time interval from being thrown to being caught and plot blue points at intervals of .25 seconds. (5 pts)

Rubric

Expectation / Requirement	3	2	1	0
A minimum of three comments are used	-	Meets standard.	Uses only two comments.	Uses one or no comments.
Applies the given equations to the solution	-	Approp equation is used and is correctly entered in R to calculate the time of flight.	An attempt to used equation is evident; equation is not entered in R correctly or does not calculate correct value.	No evidence of the equation.
Prompts user for initial velocity	The prompt works correctly and also includes the as.numeric command.	Prompt works but does not convert to a number using as.numeric.	An attempt to include the prompt is shown but unable to use proper syntax.	No evidence of prompt or program sets a static value.
Prompts for location (Earth or Moon)	-	Prompt is present and works correctly.	An attempt to include the prompt is shown but unable to use proper syntax.	No evidence of prompt or program sets a static value.
Calculates the time of flight for that location only.	Program properly uses if/else statement to calculate for that location only.	Program includes an attempt to use if/else but fails to correctly control program.	No evidence of if/else or student calculates both.	No time of flight is calculated.

Results displayed in console	Message includes clear statement with results and units using command to allow for single-line output.	Message includes clear statement with results and units using multiple print commands.	Output exists but does not meet full requirements.	No output in console.

Quiz Follow Up – Free Fall Using IF/ELSE

Objective
Students will modify the program they created that calculates how long it takes an object that is thrown upwards to return to its starting height (on Earth and on the Moon). The new and improved program will allow the user to select any planet in our solar system as a location and will recognize input that it not a valid selection.

Background
The program you have already created prompts the user for an initial velocity and a location (Earth or moon). Using $t = -2v_o / g$, you calculated how long it would take the object to return to its starting height. Your if/else statement controlled which value was used for *g*.

Requirements
The program must meet the following requirements.

The final program must:
- use a minimum of eight (8) appropriate comments that are helpful in understanding code
- prompt the user for the initial velocity of the object equal and to use m/s
- prompt and provide instructions to the user to select a location
    (any of the eight planets and Pluto)
- recognize if user input an invalid selection and display the message "Your selection is not valid."
- correctly calculate the time of flight only for the location selected
- only have one calculation for the time of flight (not for each planet individually)
- round the time of flight to two decimal places (to be used in the output)
- display a single-line message in the console with an appropriate statement and solution with units

NOTE: Pay attention to details when interacting with the user. Prompts and output should be clear and use proper grammar/spelling.

Acceleration Due to Gravity on the Planets

Location	g (m/s^2)
Mercury	3.8
Venus	8.8
Earth	9.8
Mars	3.7
Jupiter	23.1
Saturn	9.1
Uranus	8.7
Neptune	11.0
Pluto	.60

EXTRA CREDIT
If the user makes an invalid selection, the program should return to the beginning and run again. You may have to research how to do this. (3 pts)

Follow Up Questions
Record all your results from the program as part as the answers. Show all calculations and include units.
Ignore any effects due to air resistance.

1) While visiting the moon, Neil Armstrong throws a hammer straight up at 20 m/s. Jim Lovell throws his hammer straight up at 15 m/s. What is the difference in the times of flight between the two hammers? Why does this question have no physical basis in reality?

2) A person on Earth throws a 5 kg stone straight up at 14 m/s. An astronaut on Mars tosses a 1 kg stone straight up at 20 m/s. What is the ratio of the time of flight on Earth to the time of flight on Mars?

3) A volcano on Venus ejected a large boulder straight up at a speed of 85 m/s. How long did it take for the boulder to reach its highest point?

Scoring Rubric

Expectation / Requirement	3	2	1	0
A minimum of eight comments are used	-	Meets standard.	Uses only 5-7 comments.	Uses less than 5 comments.
Program responds correctly to user input for location	-	.	An attempt to used equation is evident; equation is not entered in R correctly or does not calculate correct value.	No evidence of the equation.
Prompts user for initial velocity	The prompt works correctly and also includes the as.numeric command.	Prompt works but does not convert to a number using as.numeric.	An attempt to include the prompt is shown but unable to use proper syntax.	No evidence of prompt or program sets a static value.
Prompts for location (Earth or Moon)	-	Prompt is present and works correctly.	An attempt to include the prompt is shown but unable to use proper syntax.	No evidence of prompt or program sets a static value.
Calculates the time of flight for that location only.	Program properly uses if/else statement to calculate for that location only.	Program includes an attempt to use if/else but fails to correctly control program.	No evidence of if/else or student calculates both.	No time of flight is calculated.

Results displayed in console	Message includes clear statement with results and units using command to allow for single-line output.	Message includes clear statement with results and units using multiple print commands.	Output exists but does not meet full requirements.	No output in console.