WAMC Lab Template

Math Concept(s): Nonlinear Equations

Source / Text:

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Attach the following documents:

- Lab Instructions: See attached
- Student Handout(s)
- Rubric and/or Assessment Tool

Short Description (Be sure to include where in your instruction this lab takes place):

This activity has the students collect data to help them create a graph showing the relationship between the drop height of a ball and how long it bounces. This lab takes place at the end of instruction on "Nonlinear Relationships." This hands-on activity provides students an opportunity to apply their knowledge about nonlinear relationships through the process of collecting data, graphing their data, and identifying if the relationship between two variables is linear or nonlinear.

Lab Plan

Lab Title: Height and time of bouncing ball

Prerequisite skills: Students should have basic knowledge of nonlinear equations and creating and graphing data involving nonlinear equations.

Lab objective: The objective of this lab is to help students apply their knowledge of nonlinear equations to explain the affect drop height has on how long a racquetball bounces.

Standards: *(Note SPECIFIC relationship to Science, Technology, and/or Engineering)*

Mathematics K–12 Learning Standards:

- HSF-IF.A: Understand the concept of a function and use of function notation
- HSF-IF.B: Interpret functions that arise in applications in terms of the context
- HSN-IF.C: Analyze functions using different representations
- HSF-ID.B: Summarize, represent, and interpret data on two categorical and quantitative variables

Standards for Mathematical Practice:

- Make sense of problems and persevere in solving them
- Reason abstractly and quantitatively
- Model with mathematics
- Use appropriate tools strategically

K-12 Learning Standards-ELA (Reading, Writing, Speaking & Listening):

- Speaking and listening. Comprehension and Collaboration
- Work with peers and set rules for collegial discussions and decision making
- Propel conversations by posing and responding to questions that relate to the current information

K-12 Science Standards

- HS-PS2-1. Motion and Stability

Technology

- 5.b Students collect data or identify relevant data sets, use digital tools to analyze them and represent data in various ways to facilitate problem solving and decision making.

Engineering

- HS-ETS 1-3. Engineering Design

Leadership/21st Century Skills:

21st Century Interdisciplinary themes (Check those that apply to the above activity.)

☐ Global Awareness ☐ Financial/Economic/Business/Entrepreneurial Literacy ☐ Civic Literacy
☐ Health/Safety Literacy ☐ Environmental Literacy

21st Century Skills (Check those that students will demonstrate in the above activity.)

LEARNING AND INNOVATION

Creativity and Innovation
☐ Think Creatively
☒ Work Creatively with Others
☐ Implement Innovations

Critical Thinking and Problem Solving
☐ Reason Effectively
☐ Use Systems Thinking
☒ Make Judgments and Decisions
☒ Solve Problems

Communication and Collaboration
☐ Communicate Clearly
☐ Collaborate with Others

INFORMATION, MEDIA & TECHNOLOGY SKILLS

Information Literacy
☐ Access and Evaluate Information
☐ Use and manage Information

Media Literacy
☐ Analyze Media
☐ Create Media Products

Information, Communications and Technology (ICT Literacy)
☐ Apply Technology Effectively

LIFE & CAREER SKILLS

Flexibility and Adaptability
☐ Adapt to Change
☐ Be Flexible

Initiative and Self-Direction
☒ Manage Goals and Time
☐ Work Independently
☐ Be Self-Directed Learners

Social and Cross-Cultural
☒ Interact Effectively with Others
☐ Work Effectively in Diverse Teams

Productivity and Accountability
☐ Manage Projects
☒ Produce Results

Leadership and Responsibility
☐ Guide and Lead Others
☒ Be Responsible to Others

Teacher Preparation: (What materials and set-up are required for this lab?)

Materials

- Rubber ball such as a racquetball
- Tape measure
- Timer
- Calculator
- Paper and pencil
- Chairs (to help with dropping the ball from the maximum height)

Set-Up Required:

- Classroom or another room that has a floor surface where a ball is able to bounce for a period of time.

Lab Organization Strategies:

Leadership (Connect to 21st Century Skills selected):

Cooperative Learning:

- Students will be working in groups of 3-5 people. One person to hold the tape measure, one person to drop the ball, one person to time how long the ball bounces, one person to record the times on paper, and one person to calculate. If groups of 5 people cannot be formed, then a group member may need to double as the timer and recorder.

Expectations:

- It is expected that students will gain an understanding on how nonlinear equations can be created out of data that gathered from hands-on activities. From there, students should be able to brainstorm ideas on how to impact the time the ball bounces outside of changing the drop height.

Timeline:

- This should be a lab that can be completed in 1-2 days. The ball dropping and data collection should take up to half of the first day maximum. This lab can be done in one day if students are highly skilled in plotting data points on a graph. If graphing data is a challenge for students, an extra day may be needed to complete the graphing of data and answer lab questions.

Post Lab Follow-Up/Conclusions:

Discuss real world application of learning from lab

- Students will know they must apply more force to an object in order to have that object return to its initial height. This is very relevant in sports such as basketball.

Career Applications

- Physics, athletics

Optional or Extension Activities

- This lab is very diverse. Students can experiment with a different type of ball such as a tennis ball, ping pong ball, golf ball, basketball, etc. Students can also experiment with a different surface such as marble, carpet, concrete, wood, etc. A “force” (student

pushes/throws ball into ground at the start) can be applied to experiment how that impacts the bouncing time.

STUDENT INSTRUCTIONS

Statement of Problem

When a ball is dropped to the floor from a given height, the time it takes for the ball to stop bouncing depends on the height from which it is dropped. In this activity, you measure the length of time a ball bounces when you drop it from different heights.

Grouping Instructions and Roles

You will be divided into groups of 4-5 people.

One person to hold the tape measure
One person to drop the ball
One person to time how long the ball bounces
One person to record the times on paper
One person to perform calculations on the calculator.
Note: If groups of 5 people cannot be formed, then a group member may need to double as the timer and recorder.

Procedures

1. Locate an area where there is a hard, smooth floor. A tile, wood, or concrete surface should work well.
2. Drop the ball onto the floor from a height of 1 foot. Measure the length of time the ball bounces. Write the drop height and time of bounce (nearest 1/100 second) on a sheet of data paper.
3. Repeat Step 3 four more times.
4. Repeat Steps 2 and 3, using drop heights of 2 feet, 3 feet, 4 feet, 5 feet, and 6 feet.

Outcome Instructions

1. After all the data is collected and recorded, the group gathers to calculate the average time the ball bounces for each drop height. Record the drop height and the average time (rounded to nearest 1/100 second) on a sheet of data paper.
2. Plot a graph of drop height on the horizontal axis and time on the vertical axis. Make sure you select appropriate data intervals for your collected data (you will probably be okay with intervals of “1” for both of your axis).

Assessment Criteria (what will you be assessed on?)

Data collection
Accurate calculations of the average time the ball bounces
Accurate and adequate graph of the data
Correct identification of a linear or nonlinear relationship between height and bouncing time

Student Lab Data Sheet

Name: _____ Date: _____ Class: _____

Lab Title: _____

Write the objective (in your own words) of the lab you are performing.

Data Collection:

Bounce Times (seconds)

Height	Drop 1	Drop 2	Drop 3	Drop 4
1 Foot				
2 Feet				
3 Feet				
4 Feet				
5 Feet				
6 Feet				

Calculations

Height	Avg. Bounce Time (seconds)
1 Foot	
2 Feet	
3 Feet	
4 Feet	
5 Feet	
6 Feet	

Graphing Data

Use your graph paper to plot the data on average bounce time. Height should be you "X-Axis" and Bounce Time should be your "Y-Axis."

Circle the correct answer: The relationship between drop height and bouncing time is…

Linear Nonlinear

Lab Grading Rubric: Height and Time of Bouncing Ball

Name: _____ Date: _____ Class: _____

Topic	Points Possible	Points Earned
Data Collection	15	
Calculations of Avg. Bounce Time	10	
Graph of Data	20	
Correct linear/nonlinear identification	5	