Mathematics Governor's Institute 2003
Problem-in-a-Bag Template

Title of Project: "Rip and Roll"

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Grade Level and/or Course: Grades 6-8

Concept(s) Used: Solving equations, Formulas, Graphing, Problem-Solving, Prediction, Means of Central Tendencies, Data Collection, Recording, Writing,

PA Standard(s) Addressed:

MATH

Numbers, Number Systems and Number Relationships	2.1.8 B, D
Computation and Estimation -	2.2.8 A, B
Measurement and Estimation-	2.3.8.B, D
Mathematical Reasoning and Connections	2.4.8 A
Mathematical Problem Solving and Communications	2.5.8 B, C, D
Statistics and Data Analysis	2.6.8.A, F
Probability and Predictions	2.7.8 B, E
Algebra and Functions	2.8.8 C, J

SCIENCE

Inquiry and Design	3.2.7 A, B, C
Physical Science, Chemistry, and Physics	3.4.10 C

HISTORY

Historical Analysis and Skills Development	8.1.9 C
	8.1.6 C
United States History	8.3.9 C
World History	8.4.6 C

READING, WRITING, SPEAKING, AND LISTENING

Reading Critically in all Content Areas	1.2.8 A
Reading, Analyzing, Interpreting Literature	1.3.8 C, D F
Speaking and Listening	1.6.8 B, D, E

NCTM Standard(s) Addressed:

NUMBER AND OPERATIONS
- Understand meaning of operations and how they relate to one another.
- Compute fluently and make reasonable estimates

MEASUREMENT
- Apply appropriate techniques, tools, and formulas to determine measurements.

DATA ANALYSIS AND PROBABILITY
- Formulate questions that can be addressed with data and collect, organize, display relevant data to answer them.
- Select and use appropriate statistical methods to analyze data
- Develop and evaluate inferences and predictions that are based on data

PROBLEM SOLVING
- Build new mathematical knowledge through problem solving
- Solve problems that arise in mathematics and in other contexts
- Apply and adapt a variety of appropriate strategies to solve problems
- Monitor and reflex on the process of mathematical problem solving

COMMUNICATION
- Organize and consolidate their mathematical thinking through communication
- Communicate their mathematical thinking coherently and clearly to peers, teachers, and others
- Use the language of mathematics to express mathematical ideas precisely

CONNECTIONS
- Recognize and use connections among mathematics idea
- Understand how mathematical ideas interconnect and build on one another to produce a coherent whole
- Recognize and apply mathematics in contexts outside of mathematics

REPRESENTATION
- Create and use representations to organize, record, and communicate mathematical ideas

Introduction / Applications:

Collecting data from bowling results will provide practical application of Newton's Second Law of Motion. During a bowling field experience, and classroom follow-up activity, each student must apply the following formulas and constants:

- $1N = 1kg * m/s^2$
  A Newton (N) is equal to the amount of force required to give 1kg. of mass an acceleration of 1 meter per second squared
- $F = m * a$
  Force is equal to mass times acceleration
- $A = d/t$
  Acceleration is equal to distance divided by time
- 1 lb. = .45 kg
  Mass conversion of pounds to kilograms
- 1 ft. = .31 m
  Length conversion of feet to meters
- 18.3 meters
  Length of alley
- 1.53 kg
  Mass of pin

Question:

Is there a relationship between the force exerted by the bowling ball and the number of pins knocked down?

Model:

Students will collect mass and acceleration data during a bowling field experience to later determine if a relationship exists between the force exerted by the bowling ball and the number of pins knocked down.

It is understood that the students bring the following knowledge to the field experience:

- Practice solving problems for force and acceleration.
- Read and participate in discussion regarding Sir Isaac Newton and Newton's laws of motion and gravitation.
- Practice using a stopwatch.
- Practice converting English to metric units.
- Basic understanding of bowling.

Background Information

You know the guy who got hit in the head with an apple? Well, some say he wasn't a very nice man, but he has been called the greatest scientist ever. He is known as the father of modern physical science. It took over 200 years for another scientist, named Einstein, to extend laws established by Newton.

Sir Isaac Newton was an English philosopher, mathematician and scientist born in 1642. Some notable things he achieved during his lifetime were:

- The first to show that seven different colors make up white light
- Credited with inventing the reflecting telescope
- Invented the math techniques now known as calculus
- Developed laws of motion and gravitation

Resources and Materials (estimated cost):

Stop Watch
Approximately $3/student for bowling
Data Tables 1, 2, and 3
Microsoft Excel
Graphing Calculators

Procedures & Activities:

Field Experience

At the bowling alley, lab partners will be assigned a lane. As one partner releases the ball, the other partner clocks the time from the release to the contact with the pins. Time and pins knocked down per frame is recorded on Data Table 1. Students will complete calculations of acceleration and force at school.

Back at School

In class, students will use data collected in Table 1 (see attachments) to calculate acceleration and force.

Then, students will complete Data Table 2 (see attachments). This table is a compilation of data collected from classmates who bowled with balls of the same mass. The students will find the average, range, and median of the acceleration and force of like mass bowling balls. A short essay describing any correlations, or lack of correlations, between acceleration and force will be written. Students will also use Excel to graph results.

Finally, students will complete Data Table 3 (see attachments). This table lists the average forces and accelerations computed with groups from Table 2. Students will use Excel to graph results. Students will also use graphing calculators to plot the results. A comparison of results and a best-fit line will be made to determine if a relationship exists between the force of the bowling balls and the number of pins knocked down. A short essay describing any new relationships found will be written. A short essay predicting the results of using a larger or smaller mass bowling ball will be written.

Cross-Curricular Extensions

English:

Teacher will read Rip Van Winkle by Washington Irving aloud to class.
Students will work in groups to make a dramatic presentation of the adapted poem.
Writing prompt: Imagine you woke up in the year 2023; how would society, your town, and your family have changed?
Discuss historical fiction and the life of Washington Irving. How are his life experiences evident in his writing?

Science:

Students will study Newton's laws of motion and gravitation.
http://www.aloha.com/isaac/3laws/2mid.htm
Students will calculate the force and acceleration of a baseball rolled down the hallway at varying distances (5 meters, 10 meters, 15 meters….) and compare the results. What conclusions can be drawn about force acceleration?
Students will research Isaac Newton and Robert Hooke. Discuss their relationship.
http://starryskies.com/~kmiles/spec/hooks.html
Apply appropriate formulas to determine the resistance between the bowling pins and the ball.

History:

Web quest to explore historic New York, especially the Hudson River Valley.
www.hudsonriver.com/history.htm
Compare Pre-Revolution America to Post-Revolution America.
Create a time line that highlights important dates in American history while Rip Van Winkle slept.

Name:_____ Section:_____

Rubric – Field Experience, Graphs, Tables, and Short Essays

SKILL	4 Points	3 Points	2 Points	1 Point	TOTAL
Field Experience Table 1	Table is completely filled out; including all data for pins knocked down, number of seconds, acceleration, force and averages.	Table is almost completely filled out, including most data for pins knocked down, number of seconds, acceleration, force and averages. Not missing more than 4 entries.	Table is not completely filled out. Does not include enough data for pins knocked down, number of seconds, acceleration, force and averages. Missing more than 4, but less than half the required entries.	Table is less than half completed.	Points **X** Multiplier ____ **X7**
Table 2 – Like mass bowling ball	Table is completely filled out, including student names. Accelerations, forces, averages, ranges, and medians must be calculated correctly.	Table is almost completely filled out, including student names. No more than 1 calculation incorrect.	Table is not completely filled out. No more than 2 calculations incorrect.	Table is not completely filled out. More than 2 calculations incorrect.	Points **X** Multiplier ____ **X2**
Table 2 short answer	Correlations and non-correlations written in sentence form.	Correlations and non-correlations written in sentence form.	Correlations and non-correlations not written in sentence form.	Some explanation but does not answer task.	Points **X** Multiplier ____ **X2**
Table 3 and short answers	Data table filled out completely. Answers correct and written in sentence form.	Data table filled out completely. Answers correct and written in sentence form.	Data table filled out completely. Answer one question correctly. Is written in sentence form.	Data table filled out completely. Answers incorrect May or may not be written in sentence form.	Points **X** Multiplier ____ **X2**
Graph	Title correct, X and Y axis labeled correctly, uniform increments, units labeled, legend, correct bar graph format, name and section on graph	Missing no more than one of the following: Title correct, X and Y axis labeled correctly, uniform increments, units labeled, legend, correct bar graph format, name and section on graph	Missing no more than two of the following: Title correct, X and Y axis labeled correctly, uniform increments, units labeled, legend, correct bar graph format, name and section on graph	Missing more than two of the following: Title correct, X and Y axis labeled correctly, uniform increments, units labeled, legend, correct bar graph format, name and section on graph	Points **X** Multiplier ____ **X 5**
Quality of presentation	Grammar, spelling, and punctuation are correct. Neat.	Small error in grammar, spelling or punctuation. Neat.	Major errors in grammar, spelling, or punctuation. Sloppy.	Hard to read or off task.	Points **X** Multiplier ____ **X 2**

Total Points Earned: _____/84

Comments:

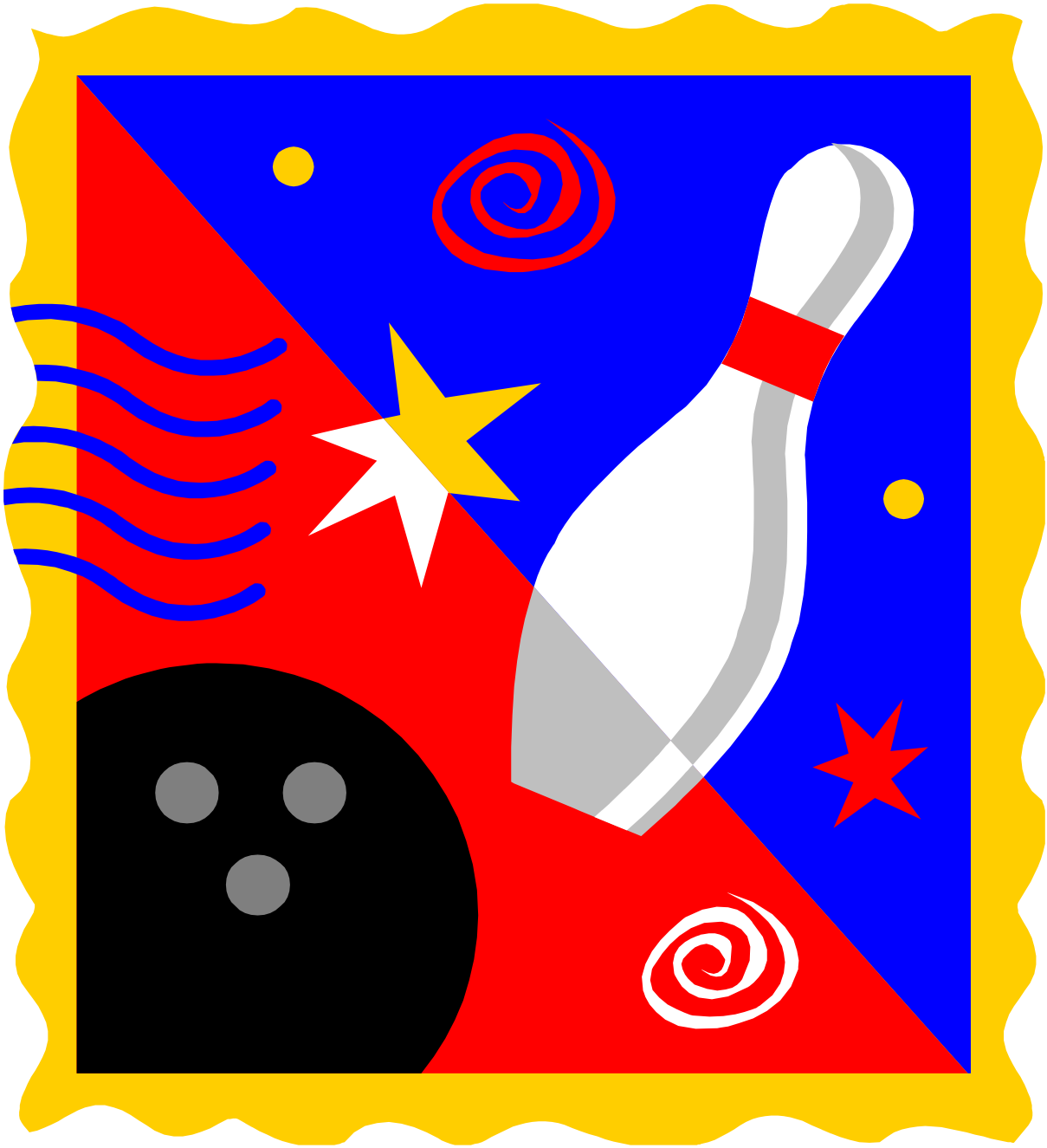
Accommodations/Adaptations

ESL
- Translation into Vietnamese, Cambodian, Laotian, Spanish, Pharsee, and Eritrean and any other language which students need.
- ESL teacher to accompany on field experience and assist as needed.
- Pair students with another student who speaks that language.

Special Ed
- Allow extra time for assignments.
- Partner to write data for student and help read stopwatch time.
- Allow use of adaptive technology.

Enrichment
- Research projects on: Sir Isaac Newton, Washington Irving, Robert Hooke, Albert Einstein, and Liebnitz.
- Plan and arrange field experience.
- Final compilation and display of school-wide data.
- Use graphing calculators to plot data.

Rip & Roll



Name _____

Lab Partner _____

Section _____

TABLE 1

Individual Results

You must use the same weight bowling ball for the entire game. Record the number of pins you knocked down in each frame, Have your partner record how long it takes you from releasing the ball until you hit the pins. Record your time to the nearest tenth of a second. Upon returning to school, you will use the formulas listed below to find the acceleration and force.
The weight of your ball is _____.

FRAME	# pins knocked down	# of seconds	Acceleration	Force
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
Average				

Distance of alley = 18.3 meters
Bowling pin weight = 1.53 kg

Acceleration=Distance/Time
Force = Mass x Acceleration

Name _____

Section_____

TABLE 2

Using Same Weight Bowling Balls

Acceleration and Force

List the names of classmates who used the same weight bowling ball. Record their average acceleration and force from Table 1. Now, find the groups mean, range, and median for acceleration and force.

Student Name	ACCELERATION	FORCE
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
	Average	**Average**
	Range	**Range**
	Median	**Median**

Directions: Answer the question fully, using complete sentences. Be sure to be neat and use correct grammar, punctuation, and spelling.

What correlations from Table 2 do you see with members of your group's answers to acceleration and force?

Name _____
Section _____

TABLE 3
Comparison of Acceleration & Force of Various Weights
of Bowling Balls

Using the information from Table 2, record the average acceleration and force from the various groups that used different weight bowling balls.

Mass of Bowling Ball	ACCELERATION	FORCE
6 lbs		
8 lbs		
10 lbs		
12 lbs		
14 lbs		

Directions: Answer the question fully, using complete sentences. Be sure to be neat and use correct grammar, punctuation, and spelling.

Explain the relationships you observed from Table 3.

What do you think the acceleration and force would be if you used a bowling ball that has a larger mass than 14 lbs. or smaller mass than 6 lbs.?