"Galileo's Principles"

Reference to Tennessee Science Standards:

- ✓ Physical Science – Motion: Investigate the relationships among speed, position, time, velocity, and acceleration. (CLE 3202.3.1); Investigate and apply Newton's three laws of motion (CLE 3202.3.2)
- ✓ Physical Science – Embedded Mathematics: Understand the mathematical principles behind the science of physics (CLE 3202.Math.1); Utilize appropriate mathematical equations and processes to solve basic physics problems. (CLE 3202.Math.2)

Common Core Standards

- ✓ CCSS.ELA-Literacy.RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

Materials:

Pencil, baseball, stopwatch

Before the Game:

Using the charts on the following page, find the rule or formula used in each chart. Allow students to experiment with formulas determined from the tables with a baseball.

Time & Velocity of Falling Objects	
Total Time of Fall (seconds)	Velocity of Object (feet per second)

Time of an Object's Fall & Distance Travelled during Fall	
Total Time of Fall (seconds)	Distance (feet)

Total Time & Velocity Object Was Thrown	
Total Time in Air (seconds)	Velocity Thrown (miles/hr)

Total Time in Air & Maximum Height Reached if Thrown Vertically	
Total Time in Air (seconds)	Height Reached (feet)

1	32
2	64
3	96
4	128
5	160
6	
7	
8	
9	

1	16
2	64
3	144
4	256
5	400
6	
7	
8	
9	

1	11
2	22
3	33
4	44
5	55
6	
7	
8	
9	

1	4
2	16
3	36
4	64
5	100
6	
7	
8	
9	

At the Game:

1. Using your stopwatch, collect sample data from the following:
   a) Total time in air of fly balls.
   b) Total time of the descent of a fly ball.
   c) Estimate the height and the distance travelled by each fly ball.

Beyond the Game:

1. Using the sample data collected at the game; does your data support the theories from the tables above?
2. What outside forces may have affected your findings (in relation to the charts)?

"The Coefficient of Restitution"

Reference to Tennessee Science Standards:

- ✓ Physical Science – Embedded Inquiry – Apply qualitative and quantitative measure to analyze data and draw conclusions that are free of bias. (CLE 3203.Inq.4); Compare experimental evidence and conclusions with those drawn by others about the same testable question. (CLE 3202.Inq.5); Communicate and defend scientific findings (CLE 3202.Inq.6)
- ✓ Physical Science – Embedded Technology & Engineering: Explain the relationship between the properties of a material and the use of the material in the application of technology (CLE 3202.T/E.3)
- ✓ Physical Science – Motion: Investigate the relationships among speed, position, time, velocity, and acceleration. (CLE 3202.3.1); Investigate and apply Newton's three laws of motion (CLE3202.3.2); Examine the Law of Conservation of Momentum in real world situations. (CLE 3202.3.3)

Materials:

3 Baseballs, 3 Golf Balls, 1 Tennis Ball, freezer, calculator

Before the Game:

Students, with the assistance of their teacher, will dissect a baseball, a golf ball, and a tennis ball to determine their construction. They will then compare the three types of balls. Create a chart with three columns. List the characteristics and descriptions of each ball (i.e. circumference, diameter, material, etc.) Discuss the coefficient of restitution (The measure of elasticity of the collision between ball and bat). Freeze one baseball and one golf ball. Drop one frozen ball and one room temperature ball of each type to show the effect of temperature on the coefficient of restitution. Discuss how weather and temperature may affect a baseball game

At the Game:

Students will note the game time temperature and then take notes based on the travel of the ball as it relates to the temperature. Does the distance change as the day gets warmer or cooler?

Beyond the Game:

Students will participate in a class discussion based on the transfer of kinetic energy from the bat to the ball. Where else does energy transfer other than the ball? What assumptions may be made if you replaced the baseball with a golf ball

"The Greatest Distance is Sound"

Reference to Tennessee Science Standards:

- ✓ Physical Science – Embedded Inquiry: Use appropriate tools and technology to collect precise and accurate data (CLE 3202.Inq3); Apply qualitative and quantitative measures to analyze data and draw conclusions that are free of bias (CLE 3202.Inq.4); Compare experimental evidence and conclusions with those drawn by others about the same testable question (CLE 3203.Inq.5); Communicate and defend scientific findings (CLE 3202.Inq.6)
- ✓ Physical Science – Matter: Investigate chemical and physical changes (CLE 3202.1.4)
- ✓ Physical Science – Energy: Investigate the Law of Conservation of Energy (CLE 3202.2.5)

Materials:

Hammer or piece of wood the size of a hammer, Baseball bat (aluminum and/or wooden bat), and ruler

Before the Game:

Hold the bat horizontally with one hand. With your other hand, pick up a hammer or piece of wood. Strike the bat at points that are one inch (2.5 cm) apart. Start at the heavier end of the bat. Listen to the sound the bat makes each time you hit it. (Note all changes of sound as you move from one end to the other.)

1. What did you notice about the sound of the bat each time you hit it?
2. Where is the spot that makes the clearest, most solid sound?
3. Measure how far this spot is from the thick end of the bat (inches or cm).
4. Why do you think this spot is called the "center of percussion"? (Hint: Which band instruments are called percussion instruments?)

At the Game:

1. Observe the sound that Redbirds players' bats make. Are these sounds different from the sounds of your bat? Do ground balls sound different than fly balls?
2. Have various students close their eyes for one half inning of the game. Have these students attempt to determine the distance that the ball travelled based on the sound off the bat. Have your students track the difference between their "guess" and the actual distance of the ball.

Beyond the Game:

1. Experiment with other sports equipment (e.g. tennis racquet, racquetball racquet, hockey stick, etc.) to find the "center of percussion." Graph your findings.
2. Why do professional players use wooden bats whereas collegiate players down through little league use aluminum bats? Note that collegiate baseball players are now slowly being required to switch from aluminum bats to wooden bats. Why?