BASEBALL HOME RUN

Performance Standard (7B/8C/9D).J

Use parametric equations to describe the path of a hit baseball, determine whether the hit is a home run, and evaluate the importance of angles and the minimum velocity needed to hit a home run accordingly:

- *Mathematical knowledge*: know how to explain and apply relationships of x, y, and t in parametric equations; know how to solve problems using vectors,
- *Strategic knowledge*: use appropriate strategies to solve the problem, and
- *Explanation*: explain completely and clearly what was done and why it was done.

Procedures

1. Provide students with sufficient learning opportunities to develop the following skills in order to (7B) estimate measurements and determine acceptable levels of accuracy, (8C) solve problems using systems of numbers and their properties, and (9D) use trigonometric ratios and circular functions to solve problems:
   - Analyze precision, accuracy, and approximate error in measurement situations,
   - Describe the relationship of a model of a problem to the real problem,
   - Model and solve real problems using mathematical functions and relations,
   - Explain and apply relationships of x, y, and t in parametric equations,
   - Solve problems using vectors, and
   - Simplify expressions and solve problems using trigonometric identities.
2. Provide each student a copy of the "Baseball Home Run" task sheet and the rubric. Have students review and discuss the task to be completed and how the rubric will be used to evaluate it.
3. Ask students to solve the following problem. Encourage students to reason and experiment with values on the graphing calculator to answer the questions. Students are to show their work and write what they did and why they did each step.

   It's the bottom of the ninth inning, the Cubs are behind 6-3 and the bases are loaded. Sammy Sosa is at bat. He swings and makes contact with the ball 3 feet above the plate at an angle of 20 degrees from the horizontal at a velocity of 150 feet per second. He hits straight toward center field where there is a fence 400 feet from home plate and 20 feet high. At the moment the ball is hit, there is a wind blowing straight in from center field at 6 miles per hour (8.8 feet per second). Does Sammy hit a grand slam and win the game? The path of the ball is given by the following equations: $X_{1T} = 150\ T \cos 20° - 8.8T$ and $Y_{1T} = 150T \sin 20° + 3 - 16T^2$
   (1) Identify from the description what each of the numbers represents in the equations. Note: $-16T^2$ is the term representing gravity.
   (2) Graph and sketch on one set of axes the results of the two original equations, the two equations representing the path of the ball if there were no wind, and the two equations representing a wind of 12 miles per hour. Decide if any would result in a home run.
   (3) Decide which is a more important factor: velocity or angle. Explain your choice with specific numerical examples using the above equations for a foundation. Use different values for angle and velocity in your determination. Take into account real-world issues of factors that affect velocity and angle.

4. Evaluate each student's work using all 3 dimensions of the rubric and its guide to determine the performance level. Major calculation errors would include entering the wrong equations, which would result in incorrect graphs. Minor calculation errors would include coming within 2 degrees or 5 feet per second of the successful (home run) angles and velocity. A4 in mathematical knowledge would require correct answers of:
   - 150 initial velocity, 20° angle of impact, 3 feet above ground, $16T^2$ gravity component, and $-8.8T$ wind component.
   - Accurate parabolic graphs; none are home runs.
   - Specific examples need to show the argument for either angle or velocity, but at certain angles no sensible velocity will make a home run.

   A4 in strategy requires correct interpretation of #1 and appropriate changes in the equations as wind velocity and angle vary.

Examples of Student Work not available

Time Requirements

- One class period

Resources

- Copies of the "Baseball Home Run" task sheet
- Grid paper
- Graphing calculator
- Mathematics Rubric

Name _____ Date _____

BASEBALL HOME RUN

Student Task Sheet

It's the bottom of the ninth inning, the Cubs are behind 6-3 and the bases are loaded. Sammy Sosa is at bat. He swings and makes contact with the ball 3 feet above the plate at an angle of 20 degrees from the horizontal at a velocity of 150 feet per second. He hits straight toward center field where there is a fence 400 feet from home plate and 20 feet high. At the moment the ball is hit, there is a wind blowing straight in from center field at 6 miles per hour (8.8 feet per second). Does Sammy hit a grand slam and win the game?

The path of the ball is given by the following equations:

$X_{1T} = 150\ T \cos 20° - 8.8T$

$Y_{1T} = 150T \sin 20° + 3 - 16T^2$

(4) Identify from the description what each of the numbers represents in the equations. Note: $-16T^2$ is the term representing gravity.

(5) Graph and sketch on one set of axes the results of the two original equations, the two equations representing the path of the ball if there were no wind, and the two equations representing a wind of 12 miles per hour. Decide if any would result in a home run.

(6) Decide which is a more important factor: velocity or angle. Explain your choice with specific numerical examples using the above equations for a foundation. Use different values for angle and velocity in your determination. Take into account real-world issues of factors that affect velocity and angle.

Show all work and write in words what you did and why you did each step for each question.

Adapted from Demana, Waits, Precalculus, A Graphing Approach, Menlo Park, Addison-Wesley, 1997, pp. 575-576.