BASEBALL
THE TENTH INNING
A FILM BY KEN BURNS & LYNN NOVICK

Shadow Ball

Grade Level: 6–8

Related Academic Subjects: Mathematics, physical education

Lesson Objectives: (The student will…)

- Learn basic terms and rules for playing baseball
- Identify how different players interact on offense and defense
- Analyze the times, distances and speeds for running, throwing and hitting
- Actively play out the complex interactions of players in a simulated game

Estimated Time for the Lesson: Two or more 50-minute periods (one for generating and collecting data; one for playing the game of Shadow Ball)

Materials Needed:

- Student handouts
  - Shadow Ball Stats Charts
  - Playing Shadow Ball
- Stopwatches or timepieces with second hands
- Set of dice
- Baseball game board (a diagram of a baseball field) and tokens for base runners (not included) if playing the game in the classroom.

Overview: Shadow ball is pantomiming the game of baseball, going through well-timed and believable motions that give the illusion of actually playing the game. In the first half of the 20th century, players in the Negro League would warm up by playing shadow ball, to the delight of crowds. In Ken Burns' *Baseball*, narrator John Chancellor remarks, "They threw an invisible ball around the infield so fast, hit, and fielded imaginary fly balls so convincingly, and made close plays at first and diving catches in the outfield so dramatically that fans could not believe it was not real."

The game of baseball is made up of numerous movements of objects—bats, balls, players—all moving at different and varying velocities and traveling different distances, all at the same time. Sometimes the convergence of these objects makes for some very acrobatic and entertaining movements that transcend the fundamentals of baseball and give fans great memories of that "incredible play." In *Baseball* Bob Costas considers the "I see it but I still don't believe it" nature of plays like the famous Willie Mays over-the-shoulder catch in the first game of the 1954 World Series. Costas sums up the mental game that makes shadow ball so realistic:

> [T]his is one of the great things about baseball, where you calculate so many things simultaneously. A ball is hit into the gap ... how good is the fielder's arm? ... Where is the cutoff man? ... A quick look and a glance ... the runner is between first and second ... How fast is that runner? ... How many outs? ... Should he try for third? ... Is this history that he is daring? ... Will he try for third? ... What is the third base coach doing? And you take all of these things with depth perception ... You try to calculate in those fleeting seconds ... What are the possibilities?

In this lesson, students will first collect data on their physical movements when playing the game of baseball—running times between bases and the time it takes to hit and throw the ball various distances. Students will integrate the data into a game of shadow ball—analyzing baseball's essential elements by calculating the varying forces of movement to understand motion, velocity and force.

Activity/Procedure:

Opening Activity
Review Newton's three laws of motion and the different motions that take place in the game of baseball. On one side of the white board or overhead, write Newton's basic laws of motion:

- Every object in a state of uniform motion tends to remain in that state of motion unless an external force is applied. Every object that it stationary will remain stationary unless an external force is applied.
- An object with a certain velocity maintains that velocity unless a force acts on it to cause a change in the velocity.
- For every action there is an equal and opposite reaction.

Review these with students to check for understanding. Then have student briefly meet in pairs to write down the different movements they see in baseball (players running, balls thrown, bats hitting balls, etc.). Have them identify which baseball movements best align with the different Newtonian laws of motion and report their findings to the class.

Main Activity
Part 1. Gathering Data
In this activity, students record data of their running times between bases and the time it takes them to hit and throw the ball various distances. This activity is best conducted outdoors on a baseball diamond, where students can get accurate times. (TEACHER NOTE: The chart includes many variations for throwing the ball. To save time, students can agree on some realistic times and distances to fill out the stats chart, rather than actually measuring and timing. Two formulas figure prominently in this effort: (1) *force = mass x acceleration* and (2) *distance = rate x time*. Data can also be recorded by timing activities in taped games or TV broadcasts of major league games.

Divide the class into pairs and distribute the handout "Shadow Ball Stats." Review the directions.

Have students go out to the baseball diamond and take turns filling out their charts. When all students have completed their charts, they're ready to play the game. You can have them play

outdoors in true shadow ball style or indoors on the baseball game board. Students will need the dice and their charts to play in either location.

Part 2. Play Ball!
Divide the class into teams of nine players. More than two teams can play in a double elimination playoff tournament where two losses eliminate a team from competition. The team with the most wins is the champion. The players on the teams not playing will facilitate the game. Nonplaying students can be in the following roles:

- Dice rollers (2)
- Play-by-play announcers (2)
- Calculators (8) (2 for each of the four possible ball hits; see below)

A single die can be rolled to simulate random play situations. Use the following chance rolls for different plays:
Number 1 = bunt

Number 2 = infield
Second roll: 1 = pitcher; 2 = 1st base; 3 = 2nd base; 3 = third base; 4 = shortstop; 5 = catcher; 6 = foul ball.

Number 3 = hit to shallow outfield
Second roll: 1-2 = left outfielder; 3-4 = center fielder; 5-6 = right outfielder

Number 4 = hit to deep outfield
Second roll: 1-2 = left outfielder; 3-4 = center fielder; 5-6 = right outfielder

Number 5 = ball

Number 6 = strike

Make sure that the calculators have the stat sheets for all student players. They should have the defensive players' and batters' stat sheets in front of them.

Starting Play:

1. Have the dice rollers roll the die to determine which team starts on offense. The highest number wins.
2. Have the teams take the field (a real baseball field or the game board).
3. Have the dice rollers roll for the first pitch and all subsequent pitches.
4. The play-by-play announcers announce the results of the pitch (a bunt, a hit, a strike or a ball). The dice rollers roll again if the pitch is a hit, to determine where the ball lands in the field of play (infield or outfield and location).
5. If the pitch is a hit, the announcers call where the ball is in the field of play (infield or outfield); after the second dice roll, they call where the play can be made (which base or part of the outfield). The defensive player where the ball is in play should be identified.
6. The batter calls out the base he or she is going to run to.
7. The calculators determine the results of the play by referring to the players' stat charts: adding the batter's hitting distance and the defensive player's throwing time, then

subtracting the batter's running time to the chosen base. If the difference is a positive number, the batter is safe. If the difference is a negative number, the batter is out.

8. The announcers call the results of the play—if the batter is safe, he or she goes to the base.
9. The next batter steps up to the plate and steps 3–8 are repeated.

After going through the sequence a few times, students will understand some of the strategy of baseball by determining how far they can run and still remain safe, what defensive play to make to tag a runner out, and the different ways they can put players on base and eventually score a run.

Assessment:
Assessment material can include the running, throwing, and hitting charts, participation in the discussion, and the actual shadow ball play.

Resources:

- Baseball Web site (http://www.pbs.org/ baseball)
- Baseball: The Tenth Inning (http://www.pbs.org/tenthinning)
- PBS Teachers: Mathline, "Fantasy Baseball Parts I and II" (http://www.pbs.org/teachersource/mathline/lessonplans/msmp/fantasy/fantasy_procedure.shtm)
- PBS Teachers: Mathline, Sports and Mathematics, "Batting Averages and More" (Part 3) (http://www.pbs.org/teachersource/mathline/concepts/sportsandmath/activity3.shtm)

Academic Standards:
Standards: This lesson fits the following academic standards set by the National Council of Teachers of Mathematics (NCTM) (http://www.nctm.org).

Number and Operations
Understand and use ratios and proportions to represent quantitative relationships.

Algebra
Represent, analyze and generalize a variety of patterns with tables, graphs, words and, when possible, symbolic rules.
Model and solve contextualized problems using various representations, such as graphs, tables and equations.

Geometry
Recognize and apply geometric ideas and relationships in areas outside the mathematics classroom, such as art, science and everyday life.

Measurement

Select and apply techniques and tools to accurately find length, area, volume and angle measures to appropriate levels of precision.

Solve simple problems involving rates and derived measurements for such attributes as velocity.

Data Analysis and Probability
Formulate questions, design studies and collect data about a characteristic shared by two populations or different characteristics within one population.
Find, use and interpret measures of center.
Use observations about differences between two or more samples to make conjectures about the populations from which the samples were taken.

Communication
Communicate mathematical thinking coherently and clearly to peers, teachers and others.
Analyze and evaluate the mathematical thinking and strategies of others.

Connections
Recognize and apply mathematics in contexts outside mathematics.

Physical Education
Standard 1. Uses a variety of basic and advanced movement forms

Level III (Grades 7-8) 1. Uses intermediate sport-specific skills for individual, dual, and team sports

Standard 2. Uses movement concepts and principles in the development of motor skills

Level III (Grades 7-8) 3. Uses basic offensive and defensive strategies in a modified version of a team and individual sport

IV (Grades 9-12) 4. Uses offensive and defensive strategies and appropriate rules for sports and other physical activities

About the Authors:
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Shadow Ball Stats Charts

Directions: In this activity, you and your partner will record your running times between bases, and your hitting times and throwing times for various distances.

RUNNING TIMES	Player 1	Player 2
Home plate to first base		
Home plate to second base		
Home plate to third base		
Home plate to home plate		
First base to second base		
First base to third base		
First base to home plate		
Second base to third base		
Second base to home plate		
Third base to home plate		

HITTING TIMES	Player 1	Player 2
Time until a bunt stops rolling		
Time until a ground ball gets to the infielders		
Time until a ground ball gets to the outfielders		
Time until a line drive gets to the infielders		
Time until a line drive gets to the outfielders		
Time until a pop fly gets to the infielders		
Time until a pop fly gets to the outfielders		

THROWING TIMES	Player 1	Player 2
Home plate to first base		
Home plate to second base		
Home plate to third base		
Home plate to the pitcher		
First base to second base		
First base to third base		
First base to home plate		
First base to the pitcher		
Second base to first base		
Second base to third base		
Second base to home plate		
Second base to the pitcher		
Third base to first base		
Third base to second base		
Third base to home plate		
Third base to the pitcher		
Left field to first base		
Left field to second base		
Left field to third base		
Left field to the cutoff man		
Left field to home plate		
Left field to the pitcher		
Center field to first base		
Center field to second base		
Center field to third base		

Center field to the cutoff man		
Center Field to home plate		
Center field to the pitcher		
Right field to first base		
Right field to second base		
Right field to third base		
Right field to the cutoff man		
Right field to home plate		
Right field to the pitcher		

Playing Shadow Ball

Directions:

1. Roll the die to determine what team starts on offense. Highest number wins.

2. The teams take the field—on a real baseball field or on the game board.

3. The dice rollers roll for the first pitch and all subsequent pitches.

4. The play-by-play announcers announce the results of the pitch (a bunt, a hit, a strike or a ball). The dice rollers roll again if the pitch is a hit, to determine where the ball lands in the field of play (infield or outfield and location).

5. If the pitch is a hit, the announcers call where the ball is in field of play (infield or outfield); after the second dice roll, where the play can be made (which base or part of the outfield). The defensive player where the ball is in play should be identified.

6. The batter calls out the base he or she is going to run to.

7. The calculators determine the results of the play by adding the batter's hitting distance and the fielders' throwing times, and then subtracting the batter's running time to the chosen base. If the difference is a positive number, the batter is safe. If the difference is a negative number, the batter is out.

8. The announcers call the results of the play—if the batter is safe, he or she goes to the base.

9. Then the next batter steps up to the plate and steps 3–8 are repeated.