Out of the Park: The Physics of Baseball

Watch it online http://www.kqed.org/quest/television/view/397
TV story length 11:00 minutes

QUEST SUBJECTS

Life Science Biology, Health, Environment

Earth Science Geology, Weather, Astronomy

Physical Science **Physics**, Chemistry, Engineering

CA SCIENCE STANDARDS

Grades 8

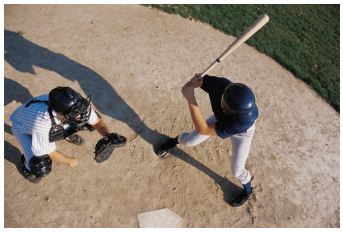
Physical Science
1. The velocity of an object is the rate of change of its position. (d, e)
2. Unbalanced forces cause changes in velocity. (b, d, e, f)

Grades 9-12

Physics
1. Newton's laws predict the motion of most objects. (c, d)
2. The laws of conservation of energy and momentum provide a way to predict and describe the movement of objects.(f)

PROGRAM NOTES

Why does a curve ball curve? Where is the best spot on a bat to hit a baseball? At UC Berkeley, a team of undergrads is experimenting with velocity, force, and aerodynamics. But you won't find them in a lab – they work on a baseball diamond, throwing fast balls, sliders and curve balls. QUEST discovers how the principles of physics can make the difference between a strike and a homerun.



In this segment you'll find…

- how basic physics principles can explain the techniques used by baseball players.
- how and why a curve ball curves.
- information on the physics of hitting a ball.

TOPIC BACKGROUND

The origins of American baseball reach back to the early 1800s. By the 1960s the sport was considered "America's "pastime." American baseball appears to be an offshoot of the English sport of rounders, a type of cricket played in the Colonies as early as the mid-18th century. Alexander Joy established the modern baseball field in 1845, when baseball was a leisure activity played only by the wealthy. But after soldiers returned from World War I, where they had played the sport behind the battle lines, baseball was enjoyed by members of every social class.

Baseball can be used as a vehicle to teach physics. Newton's second law states that an object will move with constant velocity until a force is exerted on it. The force at which the baseball hits the bat depends on the mass of the ball and how fast the speed of the ball changes. A pitched ball is going fastest when it leaves the pitcher's hand, because air friction slows it down as it approaches the batter. Newton's third law states that whenever one object exerts force on a second object, the second exerts an equal and opposite force on the first. When the ball hits the bat, the bat applies a force on the ball that equals that of the ball on the bat. Even though these forces are equal and opposite, there is a net force on the ball because the forces act on different bodies.

Objects tend to vibrate at their natural frequency when disturbed. When traveling waves interfere with each other they can form standing waves. Standing waves have alternating nodes and antinodes. Nodes on a standing wave are the regions where there is little to no amplitude, so there is no vibration. Batters want to hit the ball on the node of the bat, so there is little vibration and maximum energy is transmitted to the ball, causing it to travel farther.

Momentum is another important aspect of physics that applies to pitching. The momentum of an object depends on both its speed and mass. When pitchers move their legs and hips first (slow-moving and massive), that momentum is transmitted up the body, through the torso and into the arms and fingers as they pitch the ball. If a pitcher tried throwing a ball just from the momentum of the fingers, it wouldn't go very far, because fingers have very little mass. The large mass of legs and hips creates the momentum needed to pitch a fast ball.

Media Enhance Education

Video and audio can be powerful tools for meaningful learning. It all depends on you, the educator. The key to using media effectively is preparation. Make the most of learning opportunities by encouraging students to become active viewers and listeners. Pick and choose from the suggested questions and activities to offer an engaging media experience.

Questioning

Oftentimes, teachers and students become frustrated during a media segment when students can't find the answers to a long list of questions. Provide a limited number of questions or topics for students. This focuses their attention during a media segment, helps to keep them engaged and generally results in higher quality answers. QUEST Ed. has provided a number of options for focus questions ranging from fact based to opinions, as well as "big picture" ideas.

PRE-VIEWING

- State how Newton's three laws apply to baseball.
- What physics principles are used when throwing or hitting a baseball?
- How do pitches differ, such as a curve ball or fast ball?
- When and where did baseball start?
- How does gravity affect a baseball after it's been pitched and after it's been hit?
- What has more momentum, a slow-moving baseball or a fast-moving Ping-Pong ball?

VIEWING FOCUS

NOTE: You may choose to watch the television segment twice with your students: once to elicit emotional responses and get an overview of the topic and again to focus on facts and motivate students to express their opinions.

- Record any facts you find interesting while you watch.
- Baseball can be used to teach what principles of physics?
- Where do some of the physics students do their "field" work?
- How does Linda's body dictate her momentum?
- How does Newton's second law of physics relate to throwing a baseball?
- What two things determine the force that a bat has when it hits a ball?
- Why does a batter want to hit the ball on the node or "sweet spot"?

POST-VIEWING – Links to activities mentioned can be found on the following page.

- **Review** students' answers to the Viewing Focus Questions.
- **Explore** the science of baseball with the Exploratorium Web site. Learn why a curve ball curves and how much reaction time a batter has to hit a ball going 90 miles per hour.
- **Role play** how force and friction affect a baseball between the time it leaves the pitcher's hand and when the batter hits it. Explore the many activities available on the 108 Stitches Web site.
- **Find out** how bouncy a baseball is. On the Exploratorium Web site, do the bouncing ball activity and learn about gravity and different types of energy.
- **Invent** your own sports game using physics techniques. How can force, momentum and torque be applied to your new game? You might want to discuss how physics principles apply to different games, such as baseball, football and tennis.

"You see, you spend a good piece of your life gripping a baseball, and in the end it turns out that it was the other way around all the time."

-- Jim Bouton

LESSON PLANS / ACTIVITIES

Science of Baseball The Exploratorium
http://www.exploratorium.edu/baseball/

- This site has educational material on the science of baseball, including exhibits, articles, activities and online interactive games, all with baseball themes.

Learning from Baseball
http://www.teachersfirst.com/baseball.htm

- Here you'll find tons of resources for teachers on using baseball to teach math, statistics and physics.

108 Stitches: The Physics in Baseball
http://www.pbs4549.org/baseball/index.htm

- This teacher's guide has activities on teaching physics through baseball. The Web site also has baseball links and online videos.

ARTICLES / READING

The Physics of Baseball
http://webusers.npl.uiuc.edu/~a-nathan/pob/

- This is an extensive Web site put together by a University of Illinois professor. It has articles explaining the physics of baseball, with topics that include the effect of spin on the flight of a baseball, how to hit a home run and vibration analysis of a baseball bat.

The Sweet Spot The Physics of Baseball
http://www.physics.usyd.edu.au/~cross/baseball.html

- Find information on hitting the sweet spot, a baseball's bounce and bat and ball collisions.

The Physics Behind Baseball
http://ffden-2.phys.uaf.edu/211_fall2002.web.dir/Jon_Drobnis/index.html

- Find great information on the history of baseball, the forces that are applied in baseball, the curve ball and what exactly happens when the ball meets the bat.

Look for the **indicating resources from QUEST partner organizations**

QUEST QUAD

FIELD NOTES

Go outside and...

- Hit the ball on its sweet spot
  - With a friend, practice hitting the ball at different positions on a bat.
  - Can you find the node or sweet spot? What reaction does that have on the ball? Is it easier to hit the ball or harder? How does the bat vibrate when you hit the ball in different places on the bat?
- Observe how physics applies to other aspects of your life
  - Take note of things around your house, in your yard or in your community, such as towing a car or building a freeway. How is physics being applied?

FIELD TRIP

Visit...

- A baseball game
  - While watching the game, write down the ways you see physics used in the sport.

FIELD RESEARCH

Find out more about...

- Newton's three laws
  - What are the three laws? How do they apply to baseball?
  - What other sports use Newton's three laws?
- Another sport that can be explained with physics techniques
  - Which sports players use physics to improve their technique?
  - Explain how physics applies to tennis, basketball or golf.

FIELD TEST

Experiment with...

- Your fast ball reaction time
  - On the Web site below, see if you can react quickly enough to hit the ball out of the park.
    http://www.exploratorium.edu/baseball/reactiontime.html
- Designing your own bat
  - After reading the Web site below, design your own bat and explain your reasoning behind your design.
  - Would you make it out of wood or aluminum? Why?
  - How do nodes and vibrations affect your design?
    http://www.kettering.edu/~drussell/bats.html

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www.calacademy.org

Chabot Space and Science Center
www.chabotspace.org

East Bay Regional Park District
www.ebparks.org

Exploratorium
www.exploratorium.edu

Girl Scouts of San Francisco Bay Area
www.girlscoutsbayarea.org

Golden Gate National Parks Conservancy
www.parksconservancy.org

Lawrence Berkeley National Laboratory
www.lbl.gov

Lawrence Hall of Science
www.lawrencehallofscience.org

Oakland Zoo
www.oaklandzoo.org

The Tech Museum of Innovation
www.techmuseum.org

UC Berkeley Natural History Museums
http://bnhm.berkeley.edu/

OTHER WAYS TO PARTICIPATE IN QUEST

LOG ON

kqed.org/quest

LISTEN

KQED 88.5 FM San Francisco &
89.3 FM Sacramento
Fridays at 6:30am and 8:30am

WATCH

KQED Channel 9
Tuesdays at 7:30pm

CREDITS

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