Thrown For A Curve, Part 2

What makes a curve ball curve or a knuckleball dance unpredictably? It's not just how you hold the ball, but also how you move your body.

Pitcher Annabelle Lee, Fort Wayne southpaw, hurled only perfect game (no opponent reached first) in league history.

Some Background

The first "perfect game" in the history of the AAGPBL (All-American Girls Professional Baseball League) was pitched by Annabelle "Lefty" Lee, a knuckleball pitcher. The knuckleball pitch creates a trajectory in which the baseball moves erratically and is nearly impossible to hit. As John Kruk said when asked how he felt about trying to hit a knuckleball, "I'd rather have my leg cut off than do that all day. You just hope it hits your bat in a good spot."

A curve ball, when thrown well, is also a very difficult pitch to hit. A well-thrown curve ball will do most of the "curving" in the last 15 feet of the trip to the batter. Considering that it takes less time for the ball to travel that distance (about 1/6 of a second) than it takes for the batter to swing the bat (about 1/5 of a second), hitters must begin their swings before the ball has started to show much curve. No wonder curveballs are so challenging to hit.

Attached are two photographs taken of a pitcher throwing a baseball. When these photos were taken, blinking LED lights were attached to various parts of the pitcher's body: his finger (blue), wrist (white), upper arm (white), and ankle (white). Two blinking LED's were also attached to the either side of the baseball (red and white). The time between each blink of the lights was constant, and equal to 0.01 (1/100th) second.

In one photograph, the pitcher is throwing a curve ball – a pitch in which the baseball will deviate in one direction from its straight-line path by as much as 17 inches. The other photograph shows the same pitcher throwing a knuckleball – a pitch in which the baseball moves in a highly unpredictable way.

In both photographs, a meter stick was hung above the pitcher to give a sense of scale.

Materials Needed

• the attached photographs
• a calculator
• a ruler

To Do

Compare the two photographs at the end of this activity carefully. In particular, examine the following:

1. Which pitch is faster after the ball leaves the pitcher's hand, the curveball or the knuckleball?

2. Which pitch produces a faster spin on the baseball, the curveball or the knuckleball?

3. In the curveball, which is faster after the ball leaves the hand, the wrist or the ball? Or are the speeds about the same?

4. In the knuckleball, which is faster after the ball leaves the hand, the wrist or the ball? Or are the speeds about the same?

5. Compare the motion of the "pitching arm" after the curve ball and the knuckleball are released. In what ways are the arm motions of the two pitches different?

To Notice

1. Which pitch is faster after the ball leaves the pitcher's hand, the curveball or the knuckleball?

In both photos, the top line of red and white blinking lights is the path of the ball.

Qualitative answer: The light blinks every 0.01 seconds, the distance between the blinks is the distance the ball travels in 0.01 s. In the photo notice that the distance between the blinks is greater is the curve ball so the speed of the curve ball is faster than the knuckleball.

Estimate: Note that the curve ball travels the length of the meter stick in 4 blinks for an approximate speed of $s = d/t = 1m/0.04\ s = 25\ m/s$ or 56 mph.

The knuckle ball takes about 8.5 blinks to move 1 m. this one is half the speed of the curve ball. $S = d/t = 1,/0.85 = 12\ m/s$ or 27 mph.

2. Which pitch produces a faster spin on the baseball, the curveball or the knuckleball?

The baseball has two lights mounted on it: a blinking red light and a blinking white light. The lights are mounted on opposite sides of the ball pointing in opposite directions. For you to see a red light vanish and a white light appear the ball has to rotate one half of a turn.

For the curve ball, there are about 3 red flashes between the white flashes. This means that one rotation takes 0.06 sec, or about 17 revolutions per second, or 1000 revolutions per minute.

For the knuckle ball there are about 12 white blinks between the disappearance of the red flashes and their reappearance. This means that one full rotation takes 0.24 second and that the ball spins 4 revolutions per second, or 240 revolutions per minute.

3. In the curveball, which is faster after the ball leaves the hand, the wrist or the ball? Or are the speeds about the same?

The white and red flashing lights on the ball are just above the flashing blue light on the pitcher's forefinger. Below the flashing blue light of the finger is a flashing white light on a wrist. Analyzing the curve ball, the distance between the blinks on the ball is greater than the distance between the blinks for the wrist. The baseball travels at a higher speed than the wrist.

Estimate: The blinking light on the wrist is going 18 m/s or 40 mph compared to the ball, which is moving 25 m/s or 56 mph.

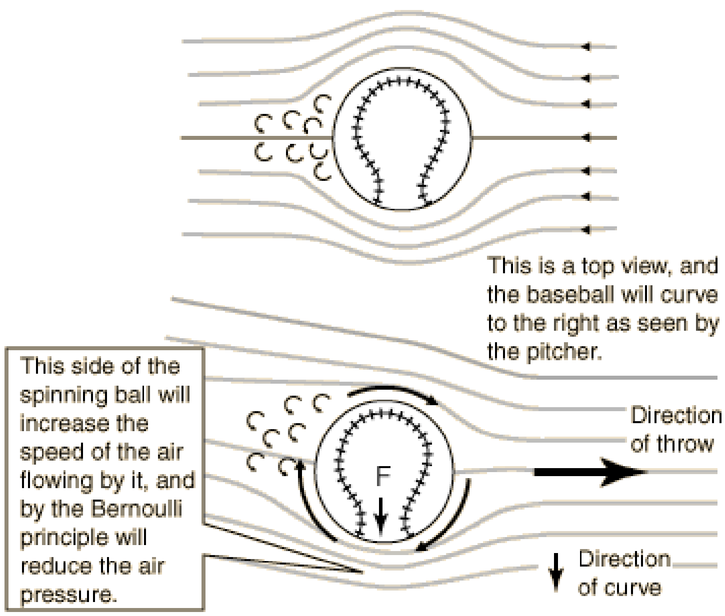
4. *In the knuckleball, which is faster after the ball leaves the hand, the wrist or the ball? Or are the speeds about the same?*

For the knuckleball it travels a meter in 8.5 blinks while the wrist travels a meter in 12 blinks so the knuckleball is also moving faster than the wrist.

5. *Compare the motion of the "pitching arm" after the curve ball and the knuckleball are released. In what ways are the arm motions of the two pitches different?*

In the curve ball the light on the wrist travels in a high speed circular arc follow through. In the knuckleball the motion is at first more linear as if the ball is being pushed toward the plate, The follow through is much slower since the blinking LEDs of light are closer together

What's Going On



A **curveball** spins rapidly as it makes its way from the pitcher to the batter. The ball can spin with rates as high as 1500 rpm and more. When the ball spins, masses of air are shed fro the back of the ball and thrown in the same direction that the <u>*back*</u> of the ball is spinning. By conservation of momentum, if we move a mass of air in one direction, to conserve momentum the ball must move in the opposite direction. *The baseball will curve to in the direction that the front of the ball is spinning.* (See the diagram to the left)

To throw a curve ball, the pitcher must transfer a great deal of rotational energy from his/her body to the ball. Look at the photo of the curveball pitch and notice the motion of the throwing arm after the ball is released. In a curveball, a pitcher quickly snaps his/her wrist and arm downward in a large arc. This transfers a great deal of spin to the ball.

A Knuckleball Pitch

The ideal **knuckleball** rotates only about one and a half revolutions on its way to the plate. The ball is aerodynamically very unstable, and the raised seams create an uneven flow of air over the surface of the ball, pushing it one way or another. The result is a ball that travels to the batter with a motion that is highly erratic. To throw a knuckleball, the pitcher does not want to impart a rotational motion to the ball. Ideally, the ball should simply be released from the pitcher's hand (see the diagram above). Look at the LED photo of the knuckleball pitch and notice that the arm and wrist does not describe an arc (as it did for the curveball) after the ball is released. Nor does the arm move as fast. This ball was released with almost no rotation.

In both cases, the speed of the ball leaves the hand at speeds greater than the speeds of the wrist and fingers. In the case of the curveball, the ball moved about 16mph faster than the wrist. How is that possible?

The answer lies in the elaborate wind -up motion of the pitcher's body. Starting with the leg and hips, a pitcher will rotate his/her entire body. The rotational motion of the body starts with the largest masses (the legs and hips) and proceeds up the torso (somewhat less massive) to the arms and finally the hand (the smallest mass). Since momentum and energy must be conserved, the final speed of the wrist and fingers becomes greater than that of the legs and hips. This transfer of energy – from lower body to the hand) – is what gives a ball its tremendous speed.


Curveball
Meterstick


Knuckleball
Meterstick