Baseball: Physics of Hitting and Pitching

John Lewis Kilgore
10/17/2012
PHY3091-Talk 2

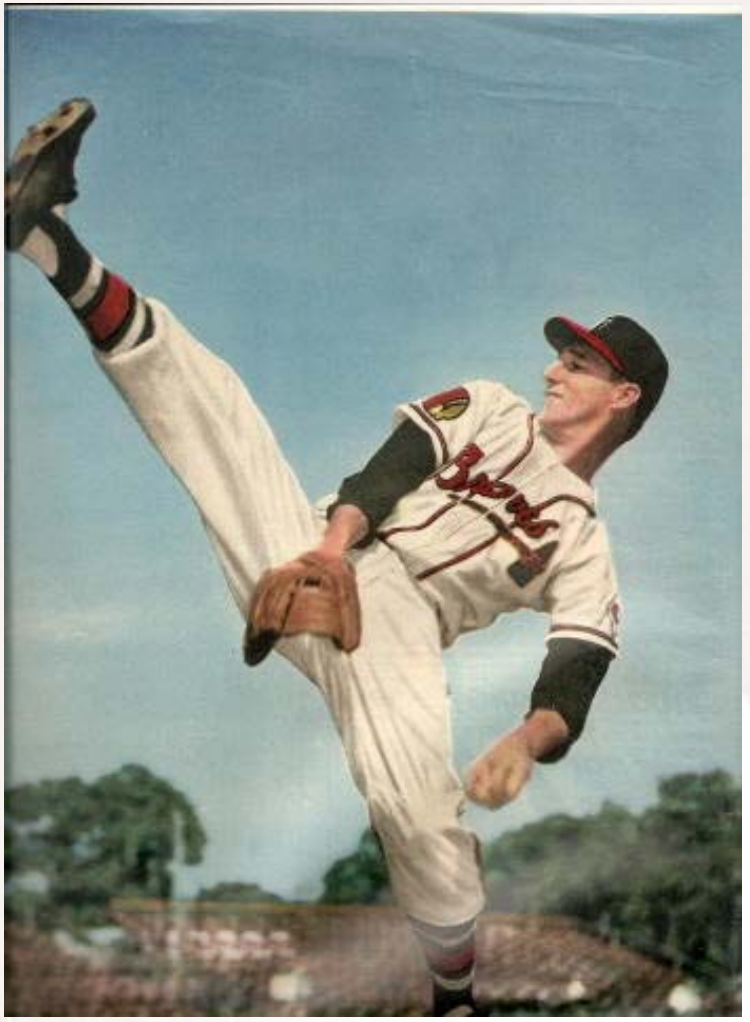
Dimensions of the Game

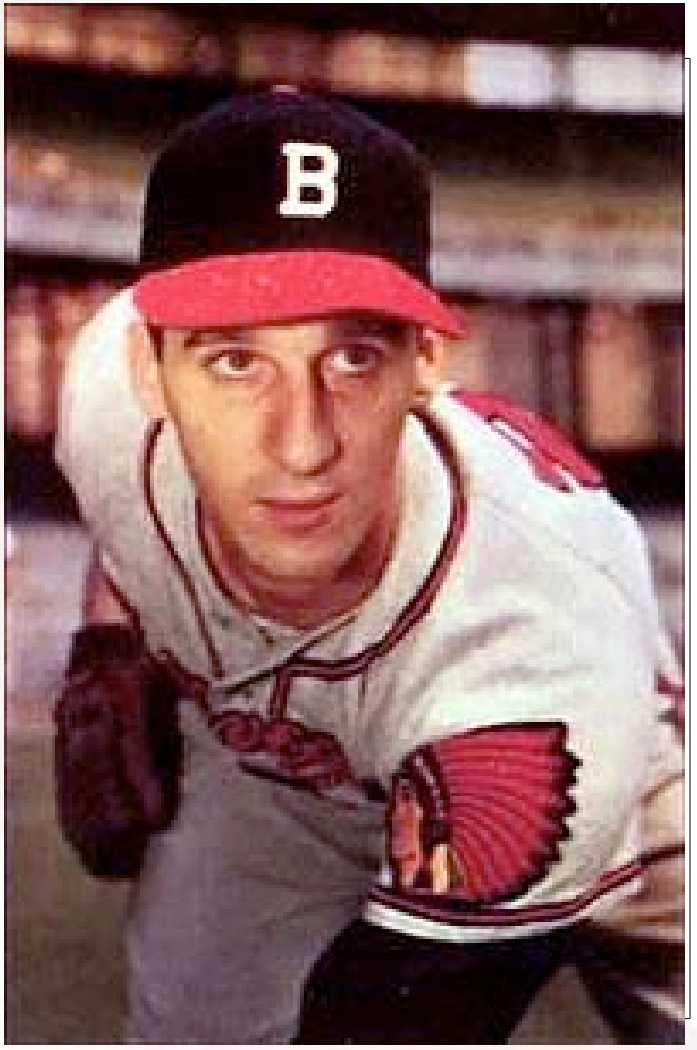
- The distance between the mound and the plate is 60 feet and 6 inches.

- Average MLB fastball takes 0.30 to 0.45 seconds to arrive at plate.

- Ball is made of yarn wound around cork center with a cowhide shell.
  - -108 stitches
  - -Mass: 5 ounces
  - -Circumference: 9 inches

“Hitting is timing. Pitching is upsetting timing.”
-Warren Spahn





Hitting Physics

- There is a +/- 7 millisecond difference between and fair and foul ball.
- The bat-ball collision last about 1/1000th of a second.
- A 8000 lb force compresses the ball to about ½ of its original diameter.
- Bat speed and bat weight key factors in determining distance of batted ball.

  -Around 7 feet for each additional mph

Hitting Physics-Cont.

- Goal is to hit the “sweet spot” of the bat.

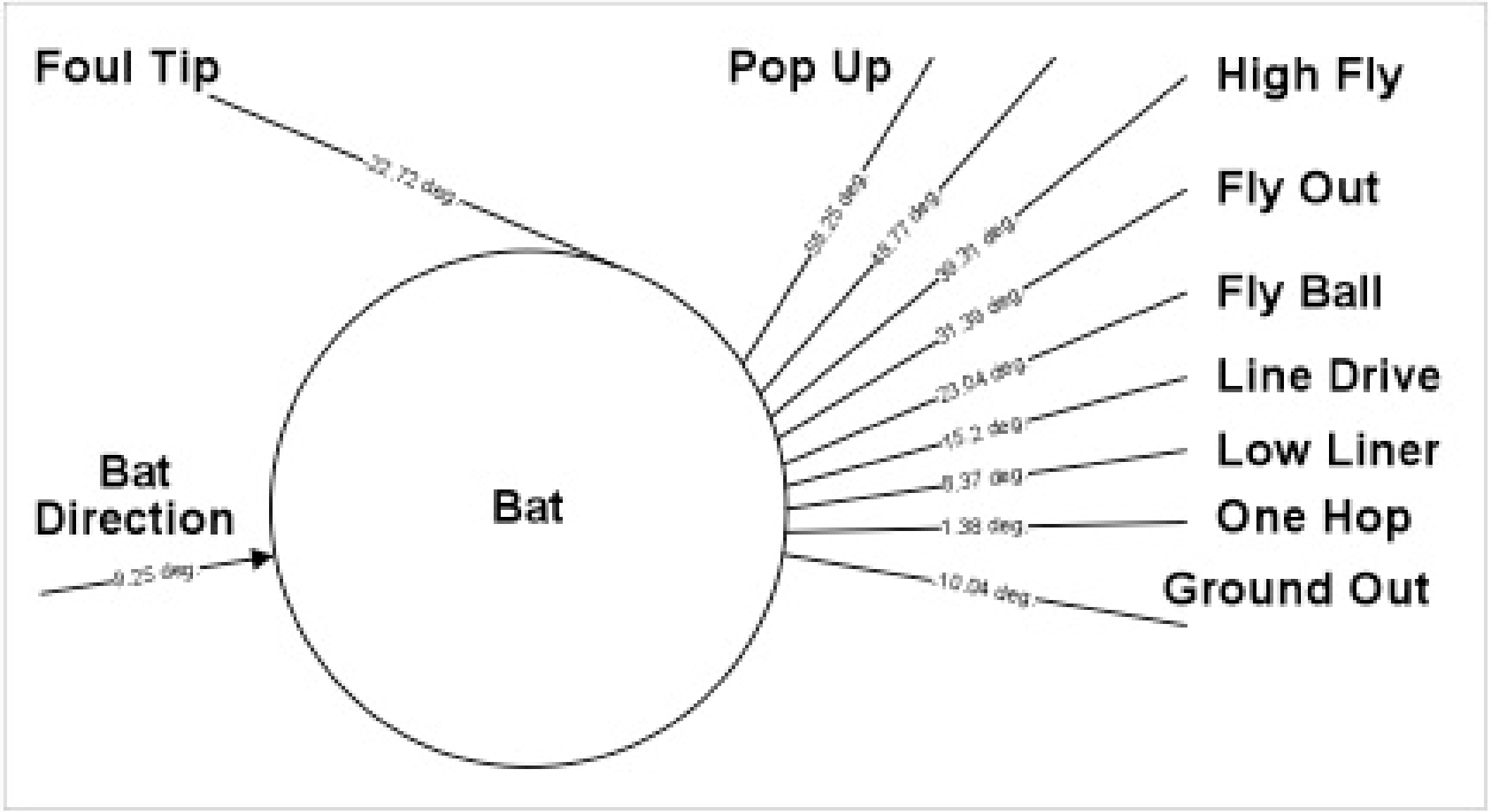
  -Most efficient transfer of energy

- The point of collision between a round ball and a cylindrical bat leads to a sensitive range of launch angles.

  -Ideal Launch Angle ~30-35 degrees

  (Home Run!)

Launch Angle Diagram



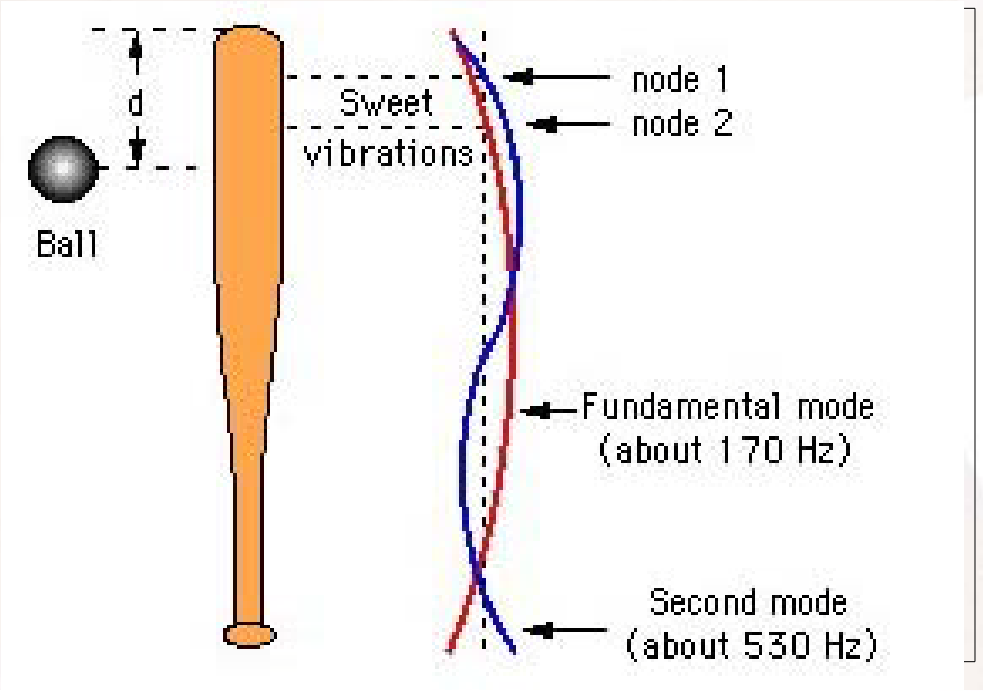
The "Sweet Spot"

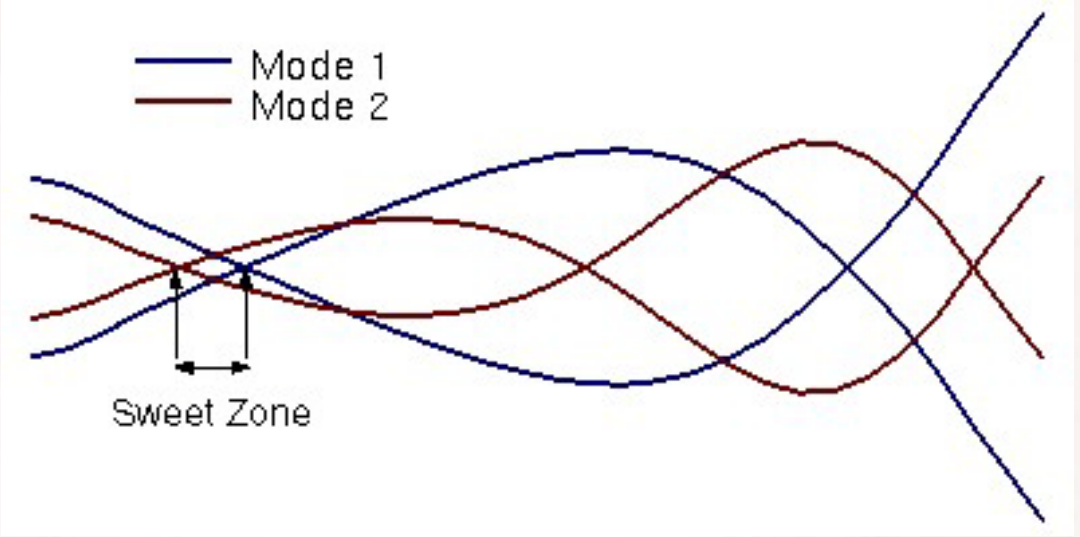
- This is the area of the bat where the the most efficient energy transfer to ball occurs.
- It is the between the nodes of the first and second vibrational modes of the bat.

  -Node for 1st mode is about 6" to 7" from end of bat.(Center of Percussion)

  -Node for 2nd mode is about 4" to 5" from end of bat.

The "Sweet Spot" Cont.





Coefficient of Restitution

- Measure of the ratio of speeds before and after a collision.
  - Elastic collision has COR=1
- The “bounciness” is a bat determines the BBCOR(Bat-Ball Coefficient of Restitution.
- Aluminum bats are easier to control the BBCOR.

$$C_R = \frac{v_b - v_a}{u_a - u_b}$$

Wood vs. Aluminum?

- Aluminum bats decouples length and weight.(More weight towards handle)
- Lighter bats are easier to generate more bat speed.
- BBCOR:

  -Wood is about 0.5 or slight greater

  -Aluminum is set at limit of 0.5

  - Hoop Modes
  - “Trampoline Effect”

Pitching Physics

- Wind-up is important in generating power transferred to the ball.

  -Sequential summation of momentum

- As ball flies through air it is subject to:

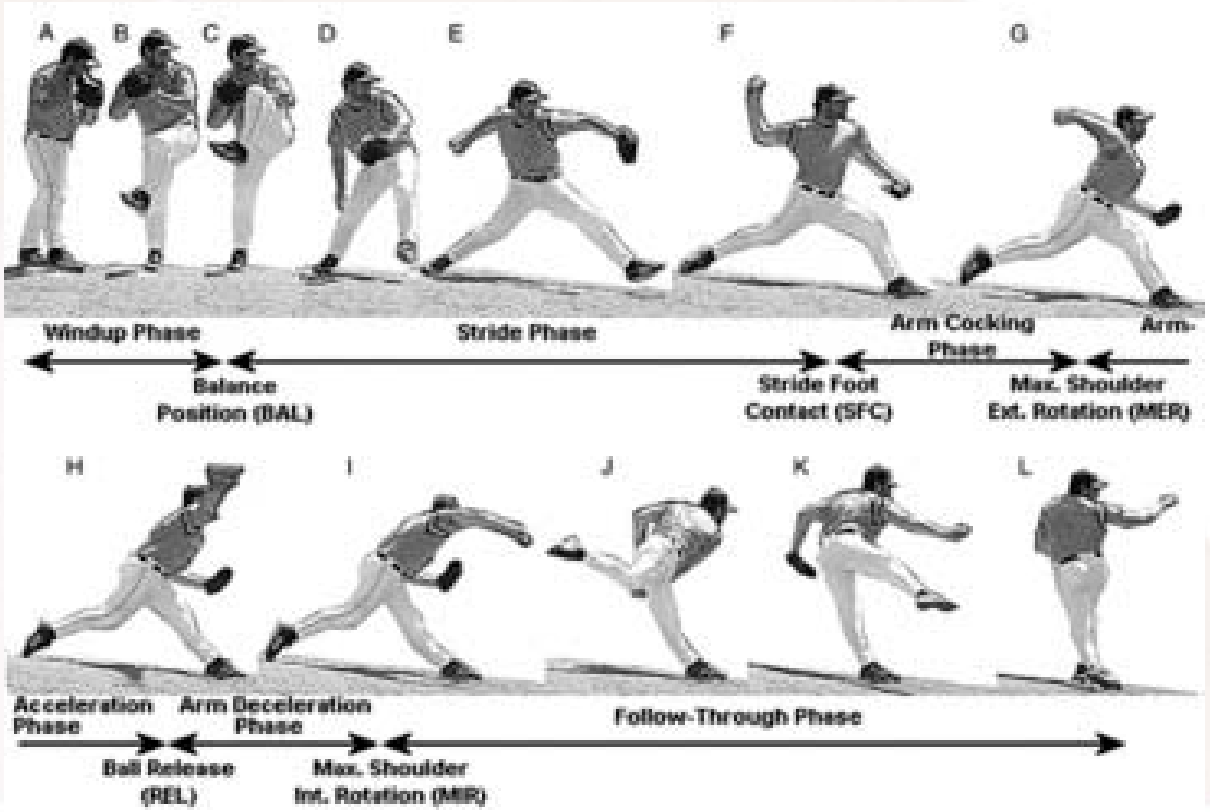
  -Gravity

  -Air Drag

  -Magnus Force

Upsetting timing

- Repeatable wind-up motion
- Same arm trajectory angle
- Same release point
- Grip on the ball to change spin of ball and orientation of the seams.



Magnus Force

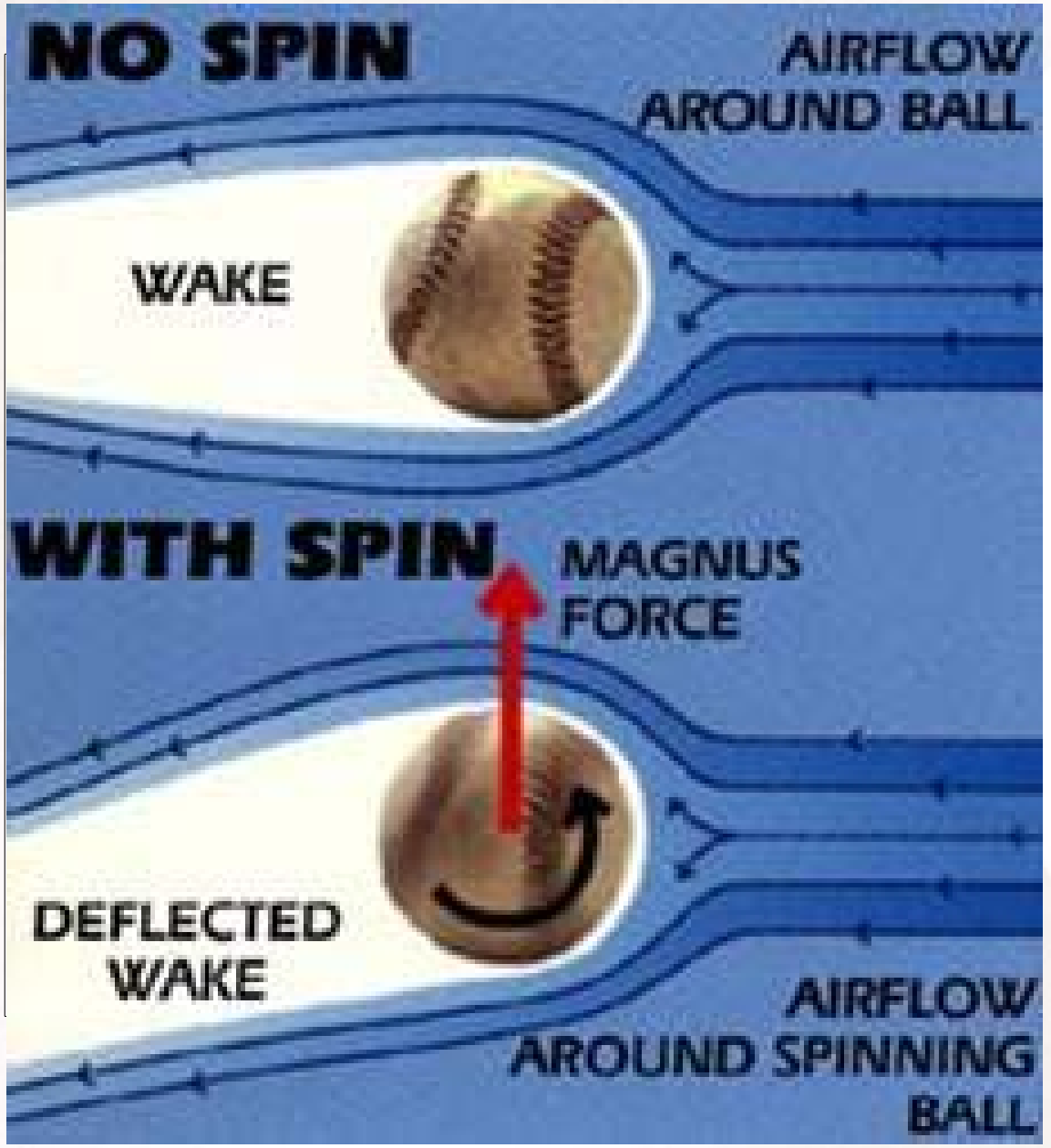
- The rotation of the ball is on an axis perpendicular to direction of travel
- For a ball with back spin(fastball):

  -lower pressure on upper surface compared to lower surface

  -generates a force upwards

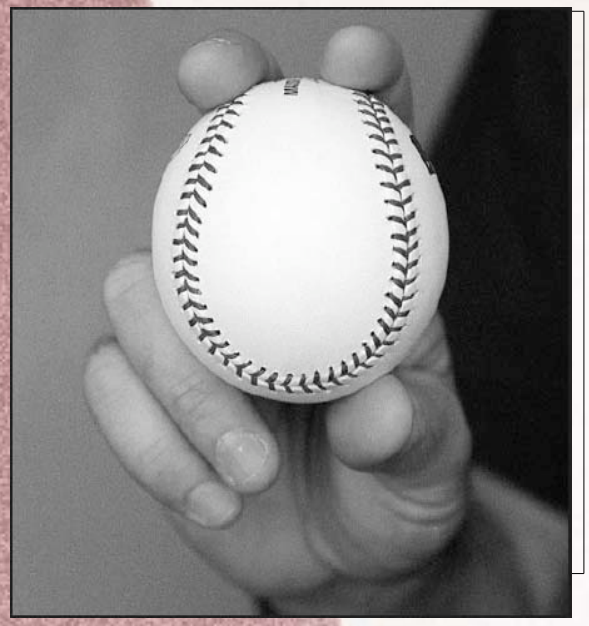
  -force is towards lower pressure

Magnus Force Cont.



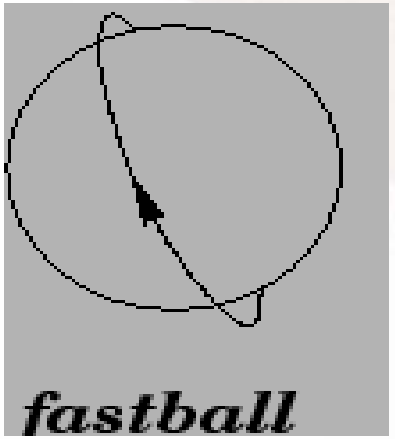
Pitch Types: Fastball

- 85-95 mph
- 1200 rpm backspin
- 8 revolutions from mound to plate
- Two Popular grips:



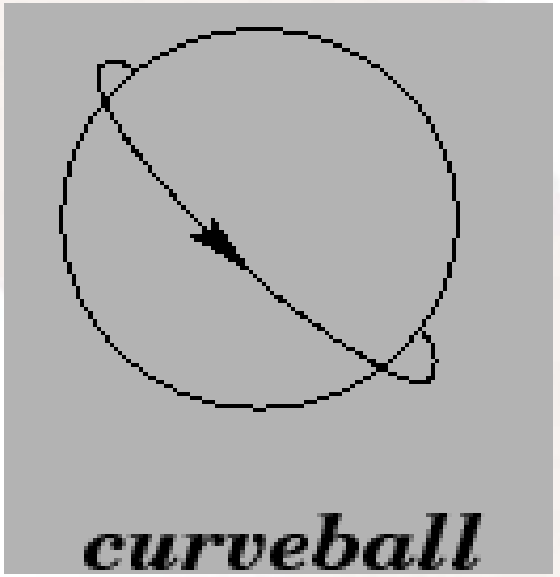
-Two Seam Fastball

-Four Seam Fastball



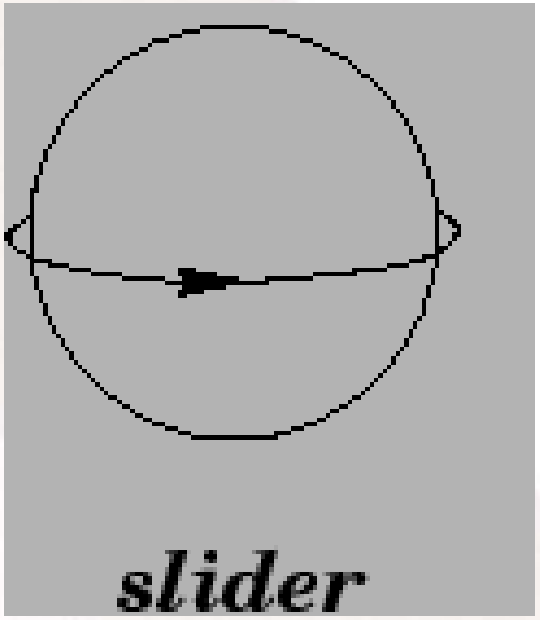
Pitch Types: Curveball

- 70-80 mph
- 1900 rpm top and side spin
- 17 revolutions from mound to plate
- Magnus force downward causes drop



Pitch Type: Slider

- 85 to 90 mph
- 1400 rpm
- 10 revolutions from mound to the plate
- Sweeping breaking ball



Pitch Type: Knuckleball

- Thrown from fingertips rather than knuckles.
- 70 mph
- 400 rpm
- ¼ revolution from mound to plate
- Unpredictable flight
- Slip pitch

References

- http://farside.ph.utexas.edu/teaching/329/lectures/node41.html
- http://en.wikipedia.org/wiki/Warren_Spahn
- http://videos.howstuffworks.com/science-channel/4945-the-physics-of-baseball-hitting-video.htm
- http://www.physics.usyd.edu.au/~cross/baseball.html
- http://www.acs.psu.edu/drussell/bats/bend-sweet.html
- http://www.dubinchiro.com/features/pitcher1.html
- http://math.etsu.edu/multicalc/prealpha/Chap1/Chap1-6/exer.htm
- http://westsidecubs.net/teaching_pitching.htm
- http://www.checkswing.com/forum/topics/teaching-the-curveball
- http://www.thekmiecs.com/tag/knuckle-ball/

Questions/Comments