A great book to read…. 

“Our goal is not to reform the game but to understand it.”
A more advanced book…
...and if you really want a challenge

Corked bats, juiced balls, and humidors: The physics of cheating in baseball

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Three questions of relevance to Major League Baseball are investigated from a physics perspective. Can a baseball be hit farther with a corked bat? Is there evidence that the baseball is more lively today than in earlier years? Can storing baseballs in a temperature- or humidity-controlled environment significantly affect home run production? These questions are subjected to a physics analysis, including an experiment and an interpretation of the data. The answers to the three questions are no, no, and yes, respectively. © 2011 American Association of Physics Teachers.

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“You can observe a lot by watching”

Collision time short (1 ms) ⇒ forces large (8000 lbs)
Collision is very inefficient
Bat slows down

Champaign News-Gazette
What Determines batted ball speed (BBS)?

- pitch speed
- bat speed
- “collision efficiency”
Baseball Quiz:

For longest fly ball, what matters more?

1. pitch speed
2. bat speed
Baseball Quiz:

For longest fly ball, what matters more?

2. bat speed

Each additional mph of bat/pitch speed is worth 6/1 ft.
What Determines BBS?

• pitch speed
• bat speed
• “collision efficiency”

• collision efficiency depends on…
  – “coefficient of restitution”
  – weight of bat

• bat speed depends on
  – weight of bat
Corking the Bat

- Corking the bat...
  - increases bat speed
  - decreases collision efficiency
- Which one “wins”?
Is There an Advantage to “Corking” a Bat?

Based on best experimental data available:

for home run distance: no

for “frequency of good contact”: possibly
What about steroids?

Steroids → added muscle → higher bat speed → higher batted ball speed → longer fly balls → more home runs

Some estimates:
10% increase in muscle mass → 50% more home runs!!!
Thanks to Roger Tobin

- Home Run Threshold
- Baseline
- Bat speed 3% higher
- 14.9%
- 10%

Probability (per ft)

Range (feet)
What Determines BBS?

• collision efficiency depends on…
  – “coefficient of restitution”
  – weight of bat
Coefficient of Restitution (COR)

“Bounciness” of ball

\(~1/2\) for baseball

- Bounces to \(1/4\) of initial height

- bat matters also
Ways to cheat involving COR

• Sneak in a superball or “sad” ball
  400 ft $\rightarrow$ 650 ft !  400 ft $\rightarrow$ 200 ft !

• Store at higher/lower temperature
  $70^\circ \rightarrow 35^\circ \Rightarrow 12$ ft reduction
  $70^\circ \rightarrow 105^\circ \Rightarrow 12$ ft increase

• Store at higher/lower relative humidity
  – more on this later

• mess around with the bat
  – ball-bat COR (BBCOR)
Contribucion of Bat to COR

“sweet spot”  outside
Vibrations, BBCOR, and the “Sweet Spot”

vibrations minimized
COR maximized
BBS maximized
best “feel”

demos
How does weight & strength of batter contribute to collision?

Suppose Albert Pujols and Albert Einstein both swing the bat at the same speed and make the same good contact. Who will hit the ball harder?

Or do they both hit the ball the same?
Hollow Bats and the “Trampoline” Effect:

demo
Quiz (Tennis)

To get higher speed on serve....

1. Tighten the strings
2. Loosen the strings
3. The strings don’t matter
Quiz (Tennis)

To get higher speed on serve….

2. Loosen the strings
Cheating and Hollow Bats

- **Shaving aluminum bats**
  - Thinner wall improves trampoline effect
- **Rolling composite bats**
  - Tiny cracks improve trampoline effect

These types of illegal modifications to bat can result in a large increase in fly ball distance (>35 ft!)
**Shaved / Juiced Bats** - Add 30-70 feet to your swing
www.outlawedbats.com

Rolling offered as well

**Ultimate Bat Rolling** - Bat Rolling Adds 20-40ft Instantly
www.batrolling4u.com

Industry Best - 7+ Yrs Experience

Is it Illegal to Roll a Softball Bat
www.softballbats.com/bat-questions/is-it-illegal-to-roll-a-softball-bat/

This article discusses the legalities of rolling a softball bat and goes over the official wording from the USSSA, NSA, and ASA softball associations.

Bat Rolling

According to ASA rules bat rolling or any other method to artificially break fibers of composite bat is bat altering and is ABSOLUTELY ILLEGAL in all ASA play.

BigDawg Bat Rolling and Bat Shaving, New Rolled or Shaved Bats...
www.bigdawgbatrolling.com/

We add 20-40 feet through Bat Rolling and 30-60 feet through Bat Shaving. We Roll or Shave Slow Pitch, ... Is Bat Rolling Illegal? What does ASA, USSSA, and ...

Bat Rolling - Does it Work? Is it Legal?
www.baseball-fever.com/showthread.php?...Bat-Rolling-Does...Legal

25 posts - 11 authors - Last post: Jul 15, 2009

The bat company did. That is what composite bats were designed for. If rolling the bat is legal, why not shaving the bat? Shaving completely ...

Rolling bats to change Ball Exit Speed Ratio/BESR - 20 posts - Oct 4, 2008
More results from baseball-fever.com

Baseball Bats, Softball Bats, Bat Rolling and Shaving Services...
www.worldshottestbats.com/batShaving.php

A lot of people selling bat shaving services merely roll the bat and send it ... use the shaved bats in sanctioned league play, tournaments or anywhere it is illegal ...
What is the optimum launch angle for a home run?

1. $40^\circ$
2. $30^\circ$
3. $20^\circ$
4. $10^\circ$
Baseball Quiz:

What is the optimum launch angle for a home run?

2. $30^\circ$
Coors Field in Denver: What’s Up With That?!

• High altitude, reduced air density
  – 80% of sea level
  – Reduced air drag

• Fly balls carry farther
  • How much farther?
  • What does “carry” mean?
    distance/distance-in-vacuum
Analysis of 4354 HR from 2009

Denver: 6.5% or 26 ft

Cleveland

Yankee Stadium
Baseball Quiz:

What is the optimum launch angle for a base hit?

1. 40°
2. 30°
3. 20°
4. 10°
Baseball Quiz:

What is the optimum launch angle for a base hit?

4. 10°
Home Runs and Humidors

- Coors Field in Denver:
  - Pre-humidor (1995-2001): 3.20 HR/game
  - Post-humidor (2002-2020): 2.39 HR/game
  - 25% reduction

- Can we account for reduction?

- What if humidor were used in Phoenix?
So, where's the cheating?

DENVER -- Umpires are keeping a close eye on game balls at Coors Field after the San Francisco Giants expressed concern to the commissioner's office that the Colorado Rockies might be using "juiced" balls when they're batting.

Major League Baseball spokesman Pat Courtney confirmed umpires were instructed to monitor the game balls used Saturday night in the Giants-Rockies game.

Courtney said the Giants spoke to MLB about the Rockies possibly using balls that weren't properly stored in the humidor at Coors Field.

The story was first reported by the San Francisco Chronicle, which said the Giants filed a complaint with the commissioner's office.

"Complaint is too strong of a word," Courtney told The Associated Press. "There was concern raised."

For nine years, baseballs to be used in Rockies home games have been stored in a humidor, which helps keep them from becoming dried out and more hitter-friendly in Denver's thin air.

Before each game, balls are taken out of the humidor and rubbed up by the umpires' attendant. They are then placed in a ball bag and put back into the humidor. After the national anthem, the bag is taken to the Rockies' dugout and those balls are used during the game.
Home Runs and Humidors

• Measure ball COR at different RH
  – From 30% to 50%, COR decrease by 3.7%
  – Measurements @ WSU (Lloyd Smith)

• Physics + ball-bat collision model
  – Batted ball speed (BBS) reduced by 2.8 mph

• Hittracker+HITf/x
  – We know landing point, distance/height of nearest fence for every home run
  – Calculate new trajectory with reduced BBS
    • Mean HR distance reduced by 13 ft
  – Does ball make it over the fence?
Home Runs and Humidors

• The result:

27 ± 4 % calculated
25% actual (!)
What about Arizona D-Backs?

Arizona Diamondbacks back off idea of using humidor this year

by Nick Piecoro - Feb. 3, 2011 07:18 PM
The Arizona Republic

A couple of scientific minds, Alan Nathan from the University of Illinois and Greg Rybarczyk from hittrackeronline.com, estimated for The Republic in September that a humidor could have a drastic impact at Chase, perhaps resulting - and we're summarizing here - in a home-run reduction of about 38%
Trivia Timeout: Who is this guy?
Trivia Timeout: Who is this guy?

Urbana’s own Dr. Lou Skizas

Career HR/K
1. Joe Dimaggio 361/369
2. Lefty O’Doul
3. Yogi Berra
4. Lou Skizas 30/37
Game 1, 2011 WS
The George Brett Pine Tar Incident
The George Brett Pine Tar Incident

• So what’s the deal?
  – Pine tar increases friction between ball and bat
  – Friction is used to put backspin on batted ball
    • Increases distance
    • YouTube

• But careful investigation shows
  – Already enough friction
  – More doesn’t help

• Cooler heads prevailed
  – Umpire was overruled
And finally...the pitcher

- The break of a “normal” pitch
- Spitters and grease balls
- Scuff balls
- YouTube video
So in conclusion....

• Lots of examples of how physics enters the game of baseball
  I only covered a tiny fraction here
• I love talking about this stuff so feel free to contact me
  a-nathan@illinois.edu
• Or visit my web site
  go.illinois.edu/physicsofbaseball
• Thanks for your attention!
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