

The Physics of Sports



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DayCon 2016

Sports require feats of both strength and agility



Baria Tomblin/Go Pro/CC-BY:
Gifs courtesy Olympics USA:
https://commons.wikimedia.org/wiki/File:Julia_Katunina.jpg
olympicsusa.tumblr.com
g_BedarNageSpainBryan5.gif

Studying mathletics gives a competitive advantage

- Using the power of the force
 - Coaching tip #1: Be efficient!
 - Coaching tip #2: Slow down the slowing down process!
- Making things fly through the air
 - Ball speed crucial
 - Angling for good angles

Cheerleading: team work (and physics) make the dream work!



A force is a push or pull



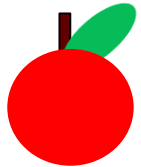
When forces are balanced, nobody moves!

A force is a push or pull

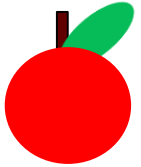


When forces are imbalanced, speeds or directions change!

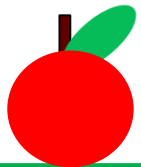
Gravity accelerates objects toward Earth



0 seconds – 0 m/s



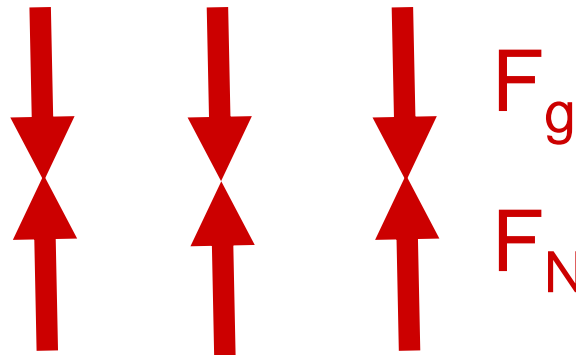
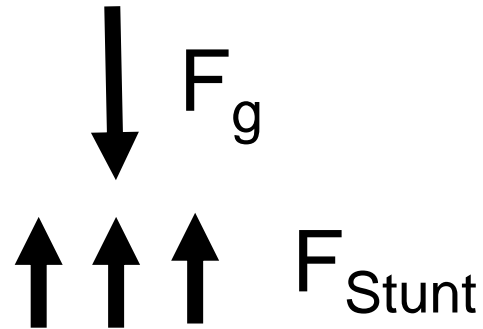
1 seconds – 9.8 m/s
(4.9 m)



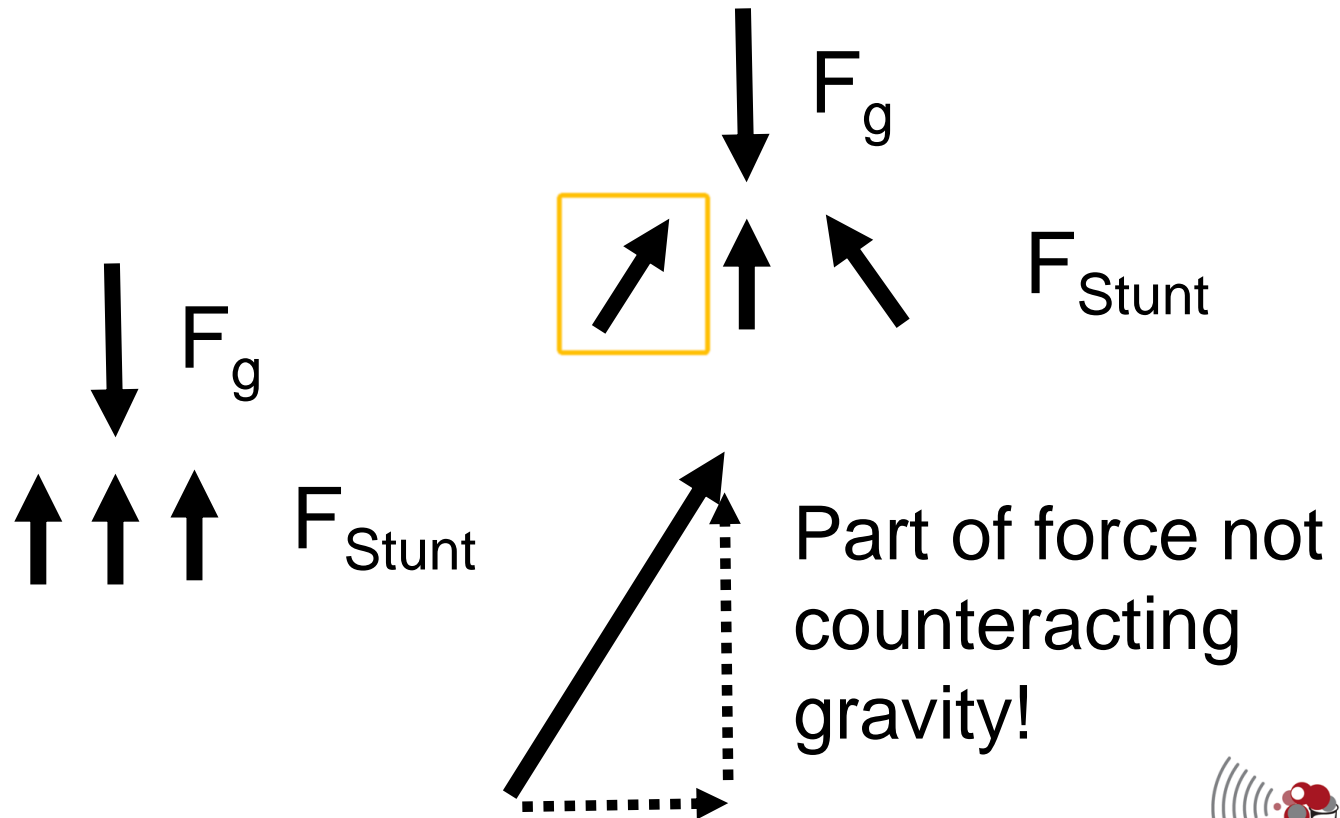
2 seconds – 19.6 m/s
(19.6m)

**Gravity pulls on
objects with mass
(and therefore exerts
a force!)**

Understanding forces can help us understand stunting



Coaching tip #1: Don't exert more force than necessary!



Force distribution important in ice skating too!



We can build even higher structures



Questions?

Athletes in motion – moving from statics to dynamics



Safety is the most important aspect



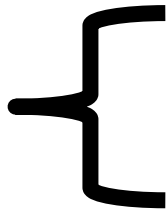
Time to decelerate determines the force you experience

Small force
on bear



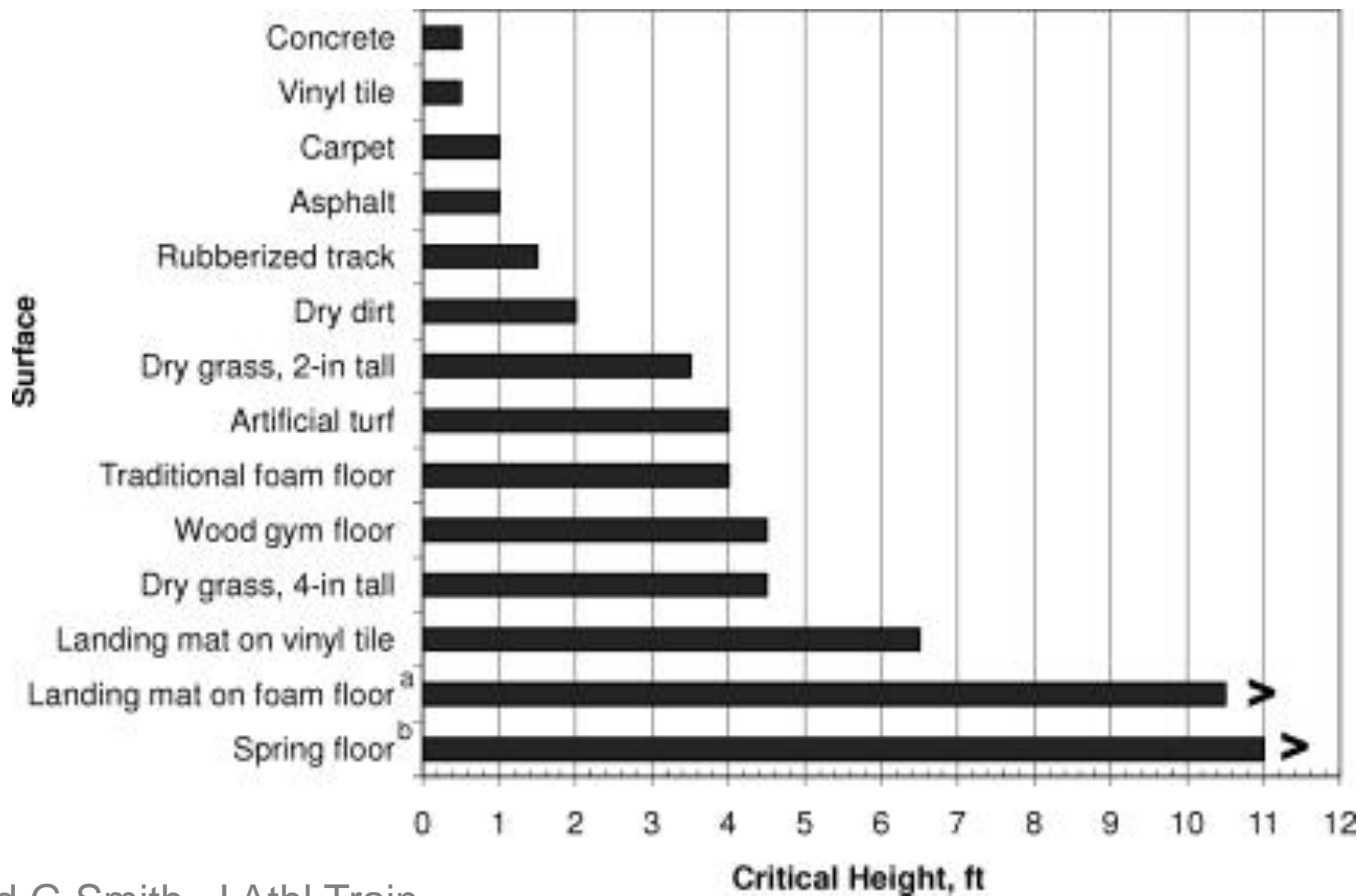
**LARGE
force
on
bear!!!**

Time to
stop



https://www.reddit.com/r/photoshopbattles/comments/24gnx1/a_bear_falling_from_a_tree_onto_a_police_mat/

Current regulations governed by deceleration concerns



Coaching tip #2: CATCH HIGH



Another application: Rugby!



PierreSelim/CC-BY: [https://en.wikipedia.org/wiki/Line-out_\(rugby_union\)#/media/File:ST_vs_LOU_-_21.jpg](https://en.wikipedia.org/wiki/Line-out_(rugby_union)#/media/File:ST_vs_LOU_-_21.jpg)

Human pyramids galore!



Castellersvilafrance/GFDL:
https://en.wikipedia.org/wiki/Castell#/media/File:4de9agulla_1.JPG

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What happens when things move both vertically and horizontally?



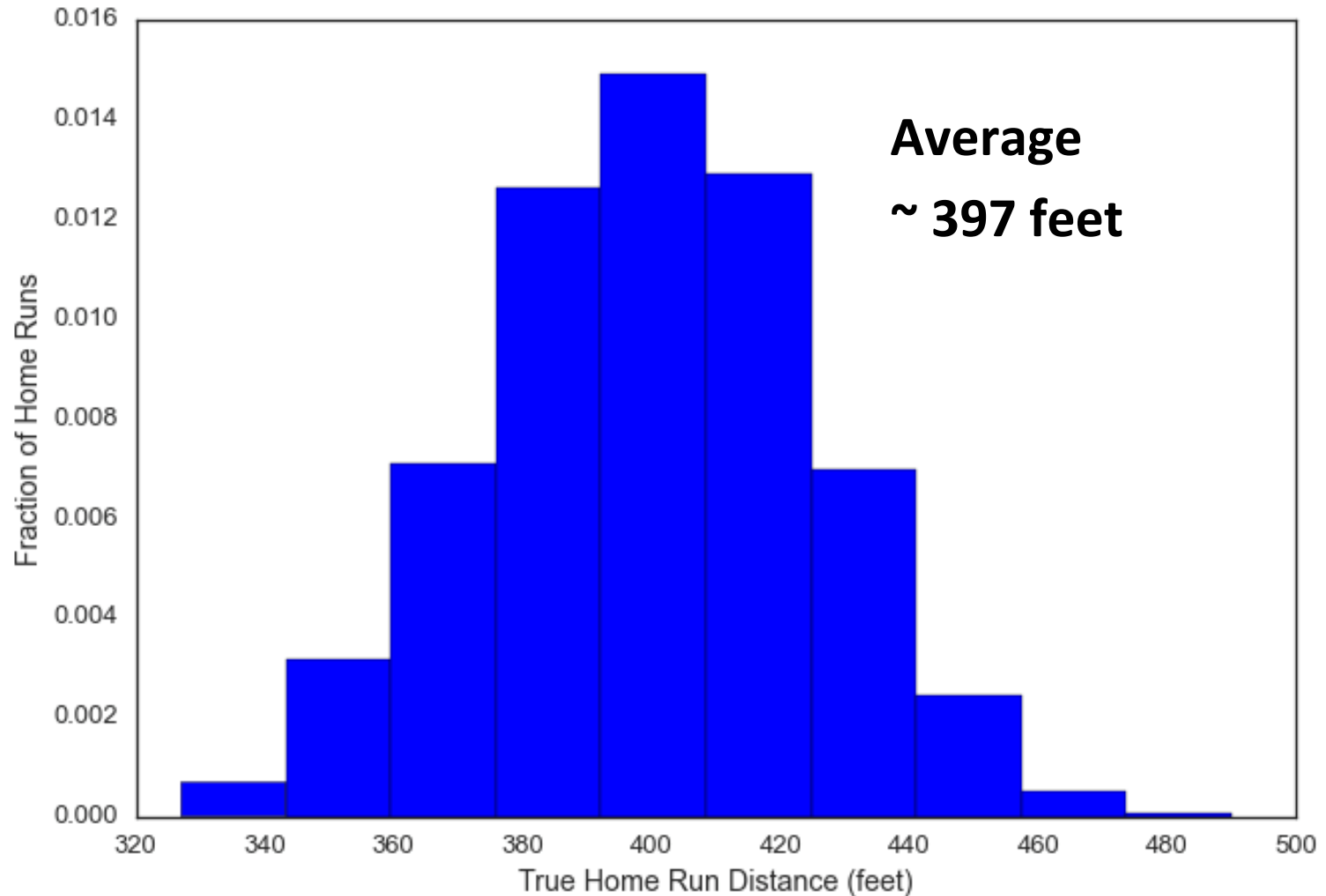
<https://summitinternational.files.wordpress.com/2012/01/free-golf-games2.jpg>

Home runs require a lot of talent...and physics!



UCInternational/CC-BY:
https://en.wikipedia.org/wiki/David_Ortiz#/media/File:DavidOrtiz.JPG

How far does a home run go?

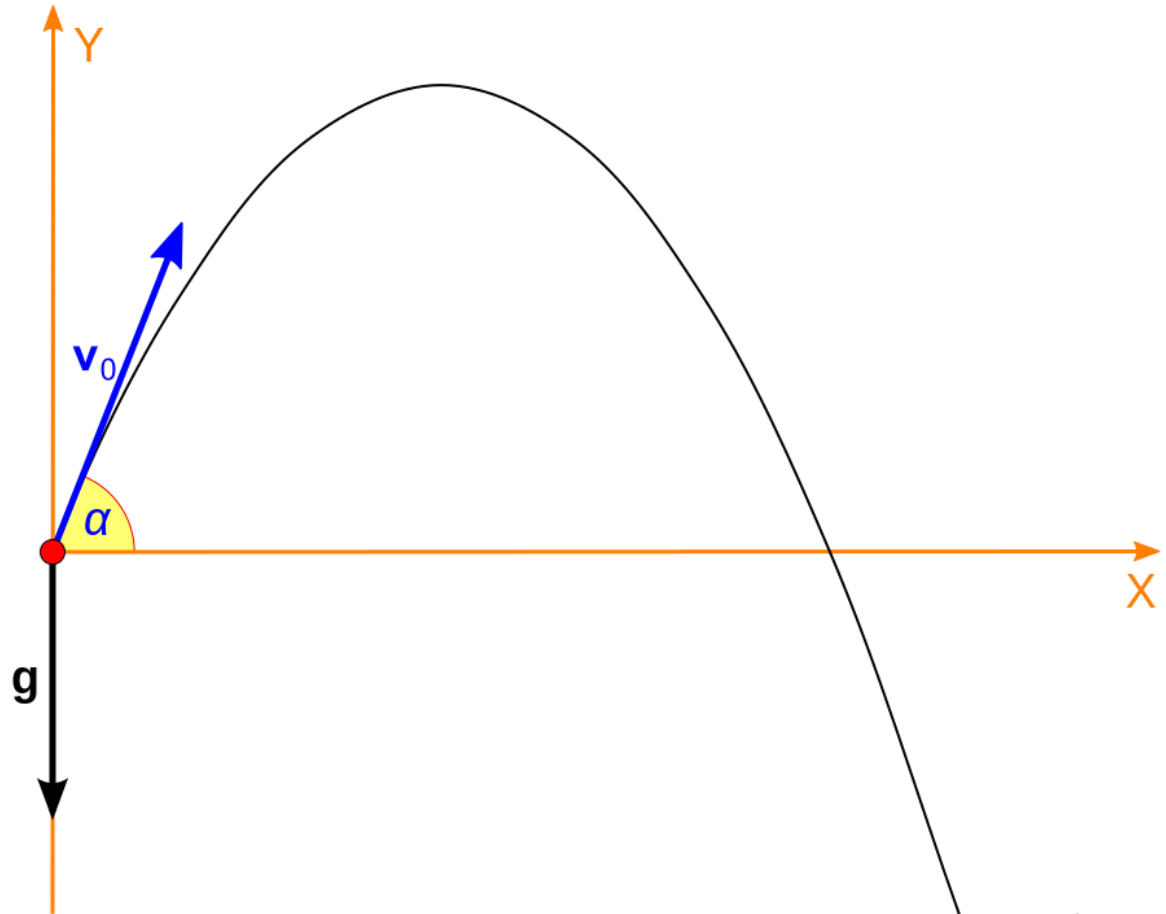


Data courtesy of ESPN Home Run Tracker:
<http://www.hittrackeronline.com/>

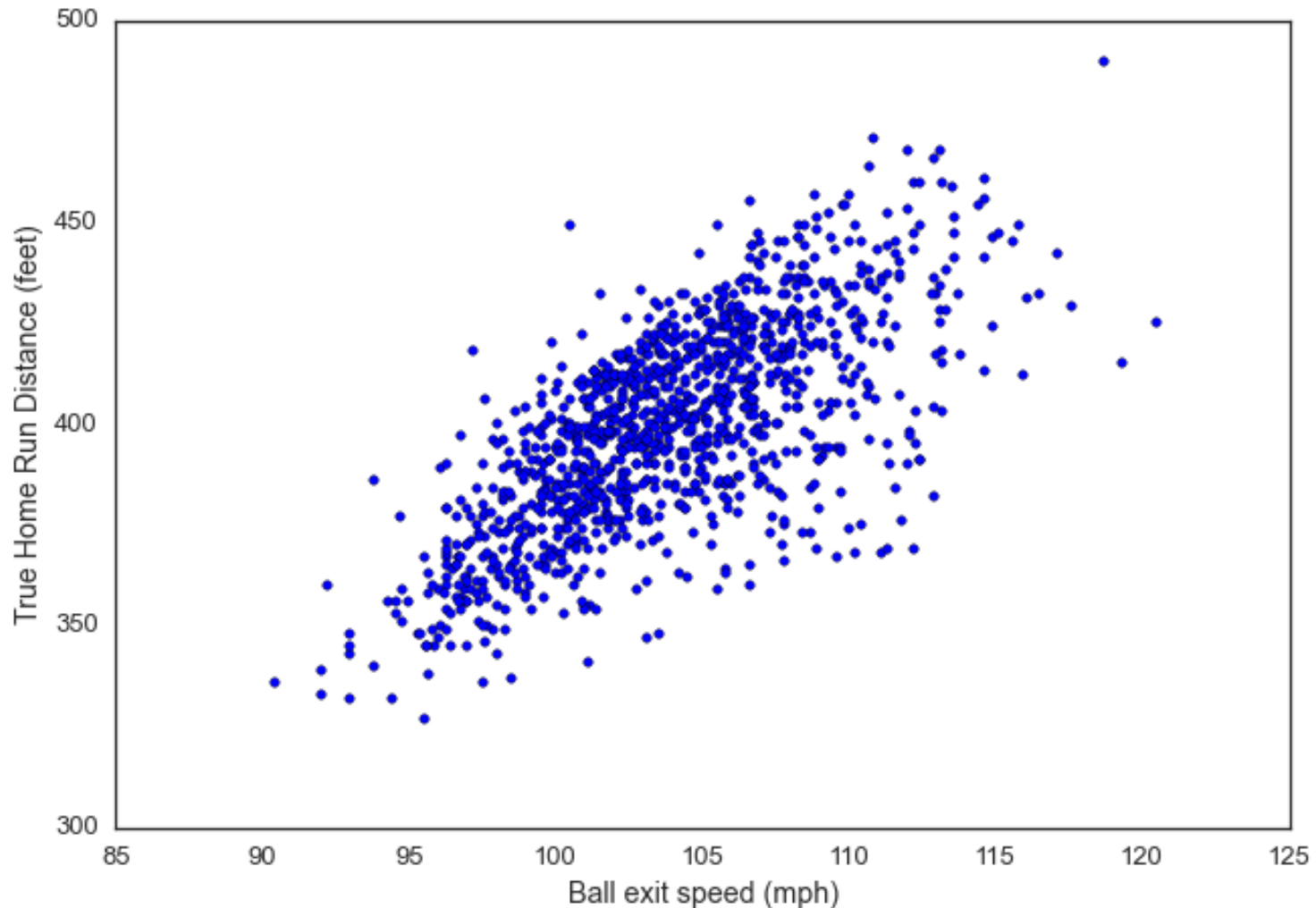
What determines how far a ball will travel?

Two main factors:

- Ball speed after hit
- Ball angle

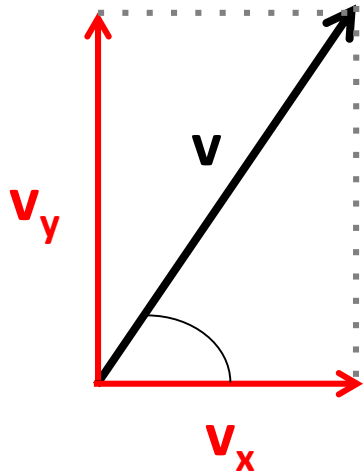


Higher ball speed \rightarrow longer distance

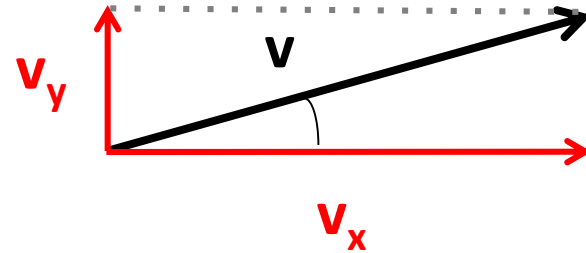


Data courtesy of ESPN Home Run Tracker:
<http://www.hittrackeronline.com/>

Why is angle important?



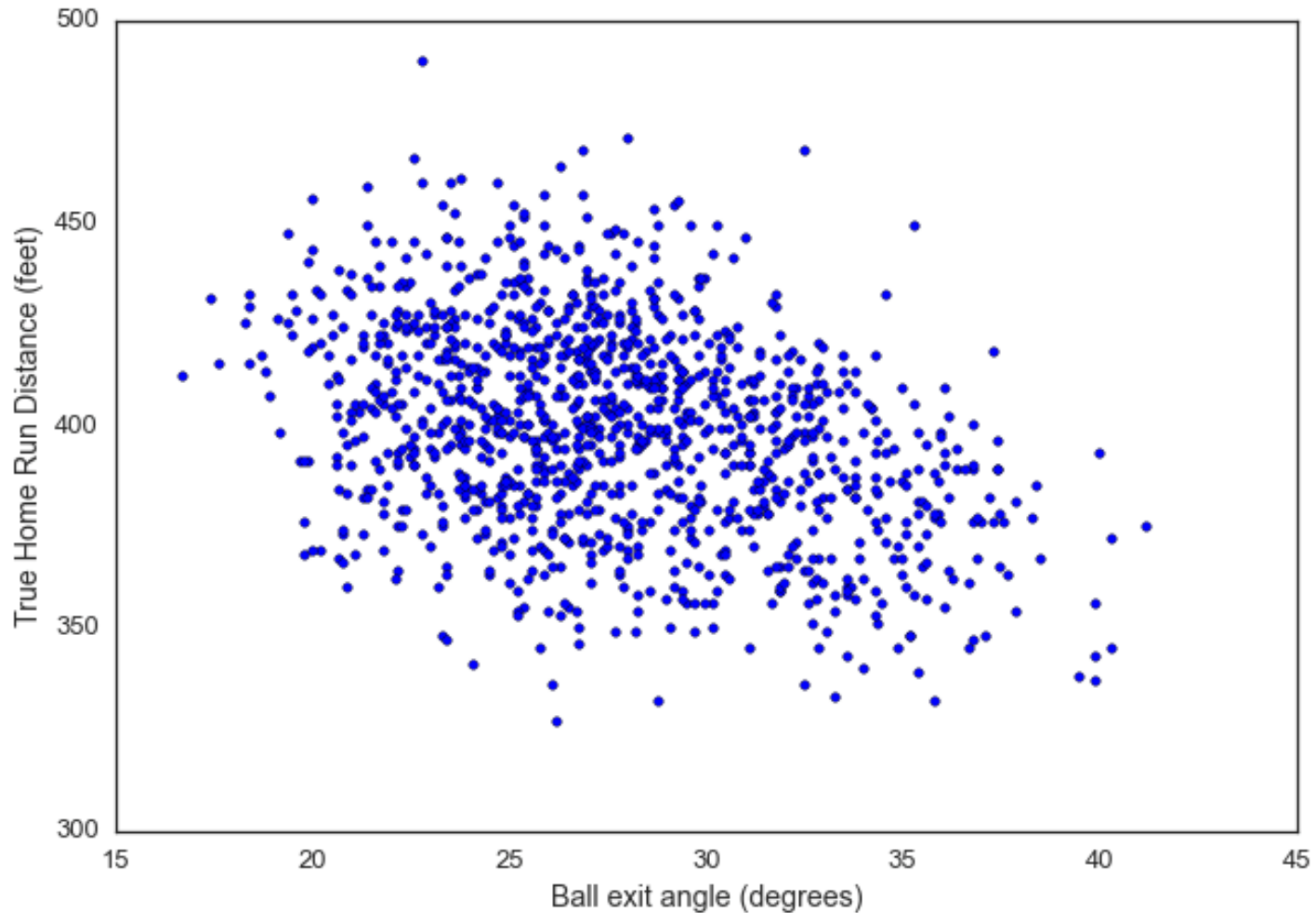
Steep angle



Shallow angle

- Angle determines how much of the ball's speed goes into the vertical and horizontal directions
- **Vertical component:** how long ball stays in the air
- **Horizontal component:** how far the ball goes during that time interval

Angle helps determine distance



Data courtesy of ESPN Home Run Tracker:
<http://www.hittrackeronline.com/>

Angle helps determine distance



Googie Man/CC-BY:
https://en.wikipedia.org/wiki/Hitting_mechanics#/media/File:Chase_Utley_Home_Run.jpg

Philpottm/CC-BY:
[https://en.wikipedia.org/wiki/Batting_\(baseball\)#/media/File:Marcus_Thames_Tigers_2007.jpg](https://en.wikipedia.org/wiki/Batting_(baseball)#/media/File:Marcus_Thames_Tigers_2007.jpg)

Questions?

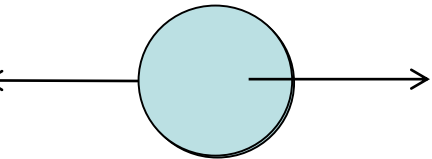
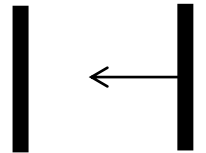
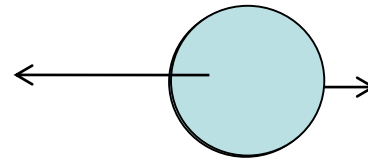
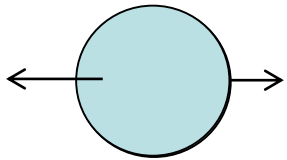
Momentum

$$\text{Momentum} = \text{Mass} \times \text{Velocity}$$



Ball exit speed

- How fast does ball go after being hit?
- Determined by **pitch speed** and **bat speed**



Both swing speed and bat weight are important

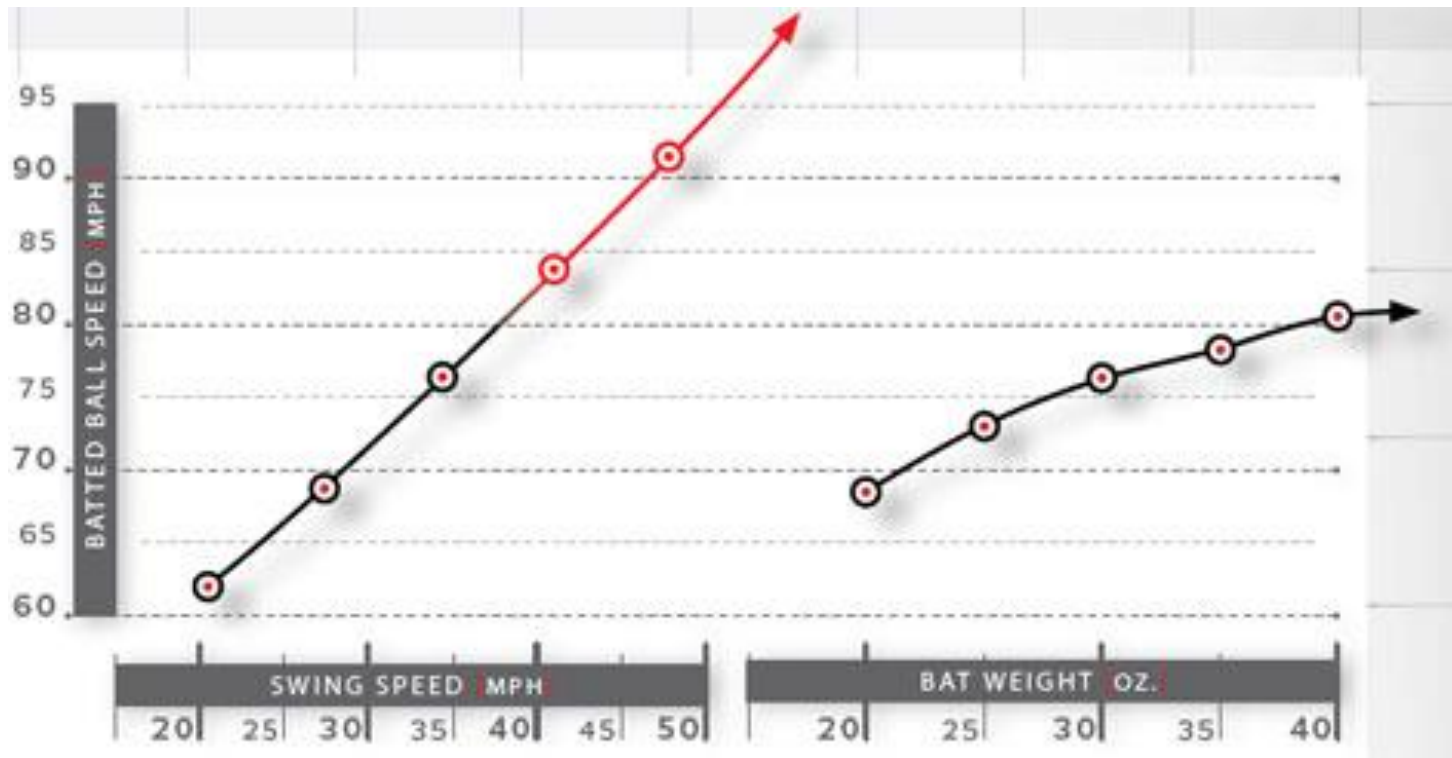


Illustration by Intaroute/Popular Mechanics: <http://www.popularmechanics.com/adventure/sports/a4569/4216783/>

Based on research by Prof. Daniel Russell: <http://www.acs.psu.edu/drussell/bats/batw8.html>

Important for other sports also!



Larry A. Simmons/CC:
https://en.wikipedia.org/wiki/2006_New_England_Patriots_season#/media/File:J.P._Losman_tackled_in_the_end_zone_by_Ty_Warren_2006-09-10.jpg

Important for other sports also!



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Norman Bailey/CC:
https://commons.wikimedia.org/wiki/File:Donna_Smith_throwin_g_javelin,_1992_Paralympics.jpg

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Thank you!

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