



Pitch Physics to Your Students: Using PITCHf/x Data from Major League Baseball

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How PITCHf/x Works

sportvision

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changing
the
game

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WINDOWS MEDIA PLAYER FORMAT
connection speed: [high](#) / [medium](#) / [low](#)

QUICKTIME FORMAT
connection speed : [high](#) / [medium](#) / [low](#)



Site Technical Requirements

How PITCHf/x Works

The logo for PITCHf/x, featuring a stylized white baseball bat and the word "baseball" in a green, lowercase, sans-serif font. The bat is positioned to the left of the word, and the letter 'i' in "baseball" has a small white dot above it, resembling a baseball.

baseball

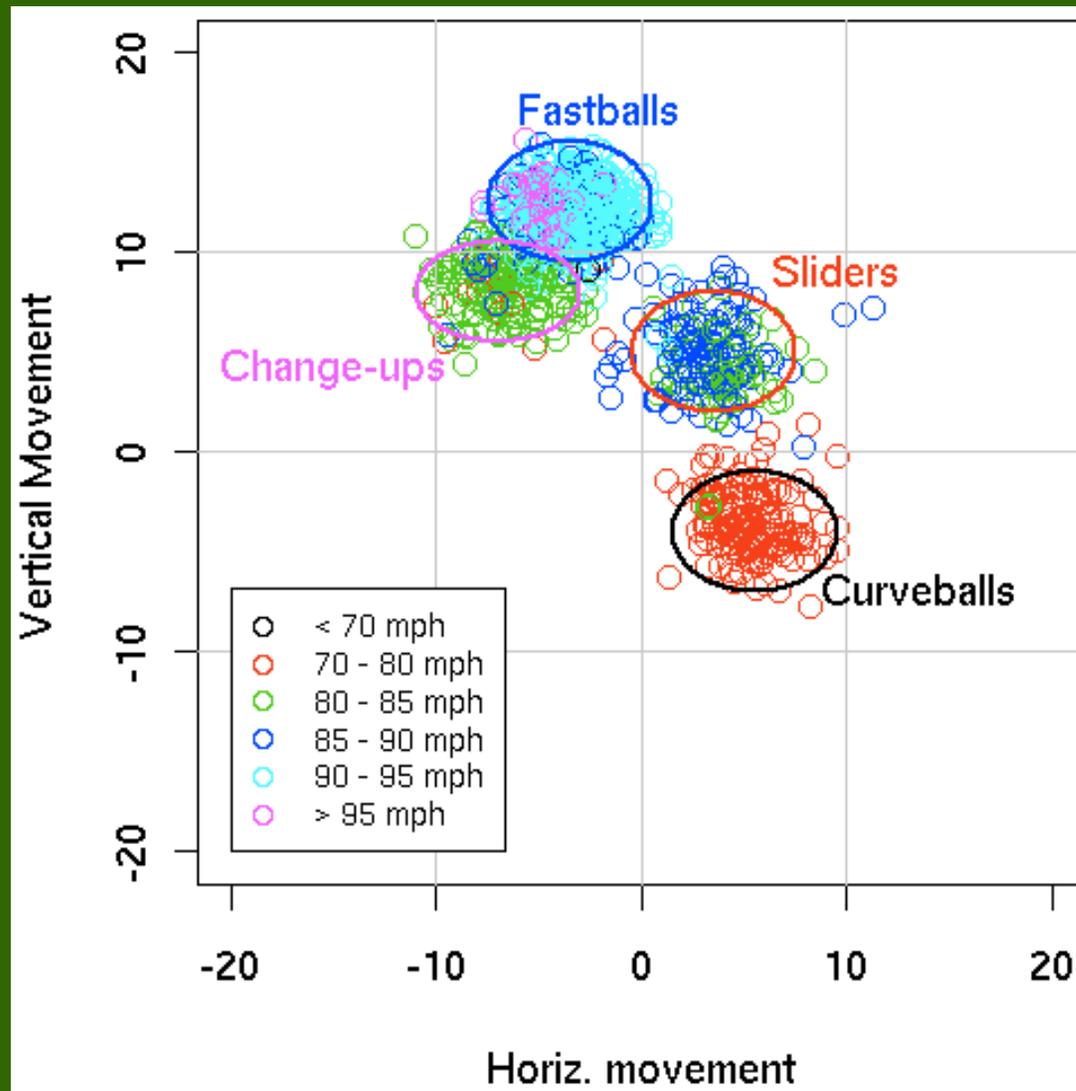
MLB Gameday

The screenshot shows the MLB.com website interface. At the top, there are navigation tabs: Scoreboard, Standings, Stats, Schedule, Players, and News. Below the navigation, the page is divided into two main sections. On the left is a scoreboard for Wednesday, listing several games with their scores and inning progress. On the right is a news article featuring a photo of Alex Rodriguez in a Yankees uniform. The headline of the article reads "Damon bedevils Sox as Yankee".

Team	Score	Inning	Status
PIT	3	8	Final
BOS	0	0	Final
KC	6	8	Final
TEX	3	8	Final
SEA	5	3	In Progress
SD	2	4	In Progress
ORL	2	4	In Progress
LAD	2	3	In Progress
SF	0	3	In Progress

Damon bedevils Sox as Yankee

Stat-heads Have A Field Day



Stat-heads Have A Field Day



Stat-heads Have A Field Day

from small ball to the long ball

A baseball blog focused on the statistical side of the game. Topics include team defense, intentional walks, beanballs, the PITCHf/x system, and other things baseball related.

WEDNESDAY, AUGUST 6, 2008

➔ New player cards and web base tool available

Sadly, they are now a few days old from the weekend but they should be in sync at least. You can reach the player cards on the right side and the tool [here](#). Also, the righty/lefty problem should be now fixed (crosses fingers). Look for another update mid August.

posted by Josh Kalk @ [11:37 AM](#)

[1 comments](#)

FRIDAY, AUGUST 1, 2008

About Me

Name:
Josh Kalk

[View my complete profile](#)

➔ [My statistics](#)

➔ [Player Cards](#)

Getting the Data

- Go to <http://gd2.mlb.com/components/game/mlb/>.
- Click on any year 2007 or later, then on the month, then on the day, then on the specific game, and finally on pbp (play-by-play).
- Search for a pitch by the pitcher that threw it or the batter when it was thrown. Either way, you will see a collection of files labeled with a six-digit number (e.g. 123456.xml). There is a unique six-digit number for each player.
- You can get the names associated with the numbers by going back to the screen where you clicked on pbp and instead click on either batters or pitchers.

Getting the Data

- You will be in a data file that looks like this:

```
- <player id="434665">
- <atbat inning="6" num="53" b="0" s="0" o="1" batter="461235" stand="L" b_height="6-0" pitcher="434665" p_throws="R" des="Brandon Moss grounds out, second baseman Brandon Phillips to first baseman Javier Valentin. " event="Ground Out" brief_event="Groundout">
  <pitch des="In play, out(s)" type="X" id="414" x="110.73" y="153.69" sv_id="080814_210721" start_speed="93.0" end_speed="85.7" sz_top="3.380" sz_bot="1.500" pfx_x="-5.782" pfx_z="6.960" px="-0.397" pz="2.094" x0="-1.225" y0="50.000" z0="6.229" vx0="4.241" vy0="-136.094" vz0="-7.552" ax="-10.825" ay="30.341" az="-19.069" break_y="23.8" break_angle="25.6" break_length="5.0" pitch_type="FA" type_confidence="1.1313741483044553"/>
  </atbat>
- <atbat inning="6" num="54" b="3" s="2" o="2" batter="456665" stand="R" b_height="5-11" pitcher="434665" p_throws="R" des="Steve Pearce flies out to left fielder Chris Dickerson. " event="Fly Out" brief_event="Fly out">
```

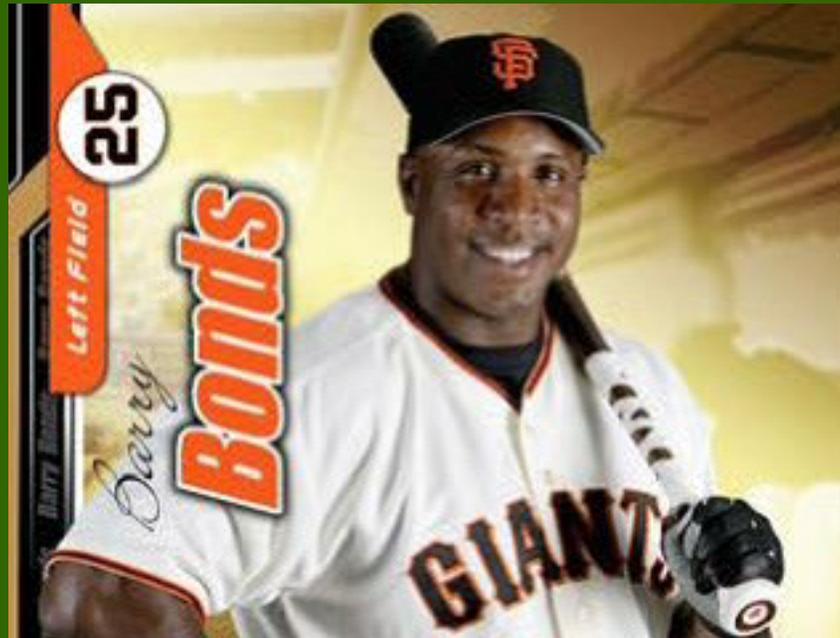
A Fun Pitch to Study



A Fun Pitch to Study



Not Just a Slugger...



An Example

Here's the data....

```
<atbat num="46" b="3" s="2" o="1" batter="111188" pitcher="407194" des="Barry Bonds homers (23) on a fly ball to
right center field." stand="L" event="Home Run" score="T">
  <pitch des="Ball" id="365" type="B" x="159.66" y="118.29" start_speed="84.1" end_speed="77.7" sz_top="3.836"
sz_bot="1.79" pfx_x="6.762" pfx_z="10.279" px="-1.798" pz="3.681" x0="1.306" y0="50.0" z0="6.852"
vx0="-9.683" vy0="-122.951" vz0="-4.355" ax="10.389" ay="23.528" az="-16.307" break_y="23.8"
break_angle="-26.7" break_length="5.1"/>
  <pitch des="Ball" id="366" type="B" x="153.65" y="178.73" start_speed="74.2" end_speed="70.0" sz_top="3.836"
sz_bot="1.79" pfx_x="3.301" pfx_z="-1.723" px="-1.613" pz="1.093" x0="1.619" y0="50.0" z0="6.637" vx0="-7.872"
vy0="-108.406" vz0="-3.976" ax="3.973" ay="16.921" az="-34.174" break_y="23.9" break_angle="-5.0"
break_length="11.7"/>
  <pitch des="Called Strike" id="367" type="S" x="122.75" y="155.42" start_speed="84.8" end_speed="79.3"
sz_top="3.836" sz_bot="1.79" pfx_x="8.742" pfx_z="8.711" px="-0.765" pz="2.094" x0="1.657" y0="50.0"
z0="6.628" vx0="-8.769" vy0="-123.907" vz0="-7.441" ax="13.81" ay="21.027" az="-18.339" break_y="23.9"
break_angle="-32.4" break_length="5.9"/>
  <pitch des="Foul" id="368" type="S" x="121.89" y="146.79" start_speed="84.1" end_speed="78.1" sz_top="3.836"
sz_bot="1.79" pfx_x="7.687" pfx_z="9.036" px="-0.673" pz="2.43" x0="1.677" y0="50.0" z0="6.566" vx0="-8.152"
vy0="-122.873" vz0="-6.332" ax="11.844" ay="22.547" az="-18.177" break_y="23.8" break_angle="-28.4"
break_length="5.8"/>
  <pitch des="Ball" id="369" type="B" x="155.36" y="163.19" start_speed="75.3" end_speed="71.0" sz_top="3.836"
sz_bot="1.79" pfx_x="3.443" pfx_z="-2.438" px="-1.659" pz="1.658" x0="1.536" y0="50.0" z0="6.647" vx0="-7.964"
vy0="-110.169" vz0="-2.869" ax="4.283" ay="17.337" az="-35.133" break_y="23.9" break_angle="-5.3"
break_length="11.6"/>
  <pitch des="Foul" id="370" type="S" x="131.33" y="159.74" start_speed="76.1" end_speed="71.8" sz_top="3.836"
sz_bot="1.79" pfx_x="2.481" pfx_z="-2.3" px="-0.925" pz="1.884" x0="1.622" y0="50.0" z0="6.705" vx0="-6.349"
vy0="-111.367" vz0="-2.747" ax="3.162" ay="17.2" az="-35.032" break_y="23.9" break_angle="-3.8"
break_length="11.2"/>
  <pitch des="In play, run(s)" id="371" type="X" x="0" y="0" start_speed="84.1" end_speed="77.2" sz_top="3.836"
sz_bot="1.79" pfx_x="8.68" pfx_z="9.55" px="-0.012" pz="2.743" x0="1.664" y0="50.0" z0="6.597" vx0="-6.791"
vy0="-123.055" vz0="-5.721" ax="13.233" ay="25.802" az="-17.54" break_y="25.2" break_angle="-32.1"
break_length="5.9"/>
  <runner id="111188" start="" end="" event="Home Run" score="T" rbi="T" earned="T"/>
</atbat>
```

|| The pitch! →

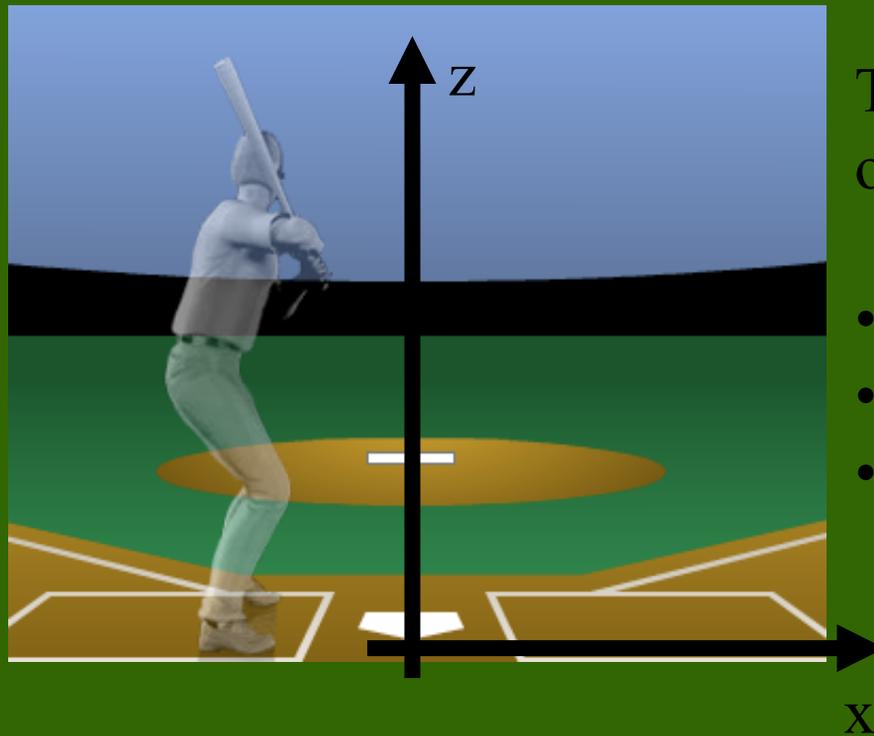
An Example

Here's the data
in a readable
table

No.	Quantity	Value	Units	Description
1	<u>des</u>	In play, run(s)		A comment on the action resulting from the pitch.
2	<u>type</u>	X		B=ball, S=strike, X=in play
3	<u>ld</u>	371		Code indicating pitch number
4	<u>x=</u>	112.45	<u>pixels</u>	<u>x</u> -pixel at home plate
5	<u>y=</u>	131.24	<u>pixels</u>	<u>z</u> -pixel at home plate (yes, it is z)
6	<u>start_speed</u>	84.1	<u>mph</u>	Speed at $y_0=50\text{ft}$
7	<u>end_speed</u>	77.2	<u>mph</u>	Speed at the front of home plate $y=1.417\text{ft}$
8	<u>sz_top</u>	3.836	<u>ft</u>	The z-value of the top of the strike zone as estimated by a technician
9	<u>sz_bot</u>	1.79	<u>ft</u>	The z-value of the bottom of the strike zone as estimated by a technician
10	<u>pfx_x</u>	8.68	<u>in</u>	A measure of the "break" of the pitch in the x-direction.
11	<u>pfx_z</u>	9.55	<u>in</u>	A measure of the "break" of the pitch in the z-direction.
12	<u>px</u>	-0.012	<u>ft</u>	Measured x-value of position at the front of home plate ($y=1.417\text{ft}$)
13	<u>pz</u>	2.743	<u>ft</u>	Measured z-value of position at the front of home plate ($y=1.417\text{ft}$)
14	<u>x0</u>	1.664	<u>ft</u>	<u>x</u> -position at $y=50\text{ft}$
15	<u>y0</u>	50.0	<u>ft</u>	Arbitrary fixed initial y-value
16	<u>z0</u>	6.597	<u>ft</u>	<u>z</u> -position at $y=50\text{ft}$
17	<u>vx0</u>	-6.791	<u>ft/s</u>	<u>x</u> -velocity at $y=50\text{ft}$
18	<u>vy0</u>	-123.055	<u>ft/s</u>	<u>y</u> -velocity at $y=50\text{ft}$
19	<u>vz0</u>	-5.721	<u>ft/s</u>	<u>z</u> -velocity at $y=50\text{ft}$
20	<u>ax</u>	13.233	<u>ft/s/s</u>	<u>x</u> -acceleration at $y=50\text{ft}$ assumed constant.
21	<u>ay</u>	25.802	<u>ft/s/s</u>	<u>y</u> -acceleration at $y=50\text{ft}$ assumed constant.
22	<u>az</u>	-17.540	<u>ft/s/s</u>	<u>z</u> -acceleration at $y=50\text{ft}$ assumed constant.
23	<u>break_y</u>	25.2	<u>ft</u>	Another measure of the "break."
24	<u>break_angle</u>	-32.1	<u>deg</u>	Another measure of the "break."
25	<u>break_length</u>	5.9	<u>in</u>	Another measure of the "break."

Kinematic data

An Example



The origin is at the back point of home plate.

- x-axis - to the catcher's right
- y-axis - toward the pitcher
- z-axis - vertically upward

$$x_o = 1.664\text{ft}$$

$$v_{x_o} = -6.791\text{ft/s}$$

$$a_x = 13.233\text{ft/s}^2$$

$$y_o = 50.00\text{ft}$$

$$v_{y_o} = -123.055\text{ft/s}$$

$$a_y = 25.802\text{ft/s}^2$$

$$z_o = 6.597\text{ft}$$

$$v_{z_o} = -5.721\text{ft/s}$$

$$a_z = -17.540\text{ft/s}^2$$

An Example

Problem 1: Find the initial speed of the ball (at $y=50.0\text{ft}$) in mph.

In 3-dimensions the initial speed is the magnitude of the initial velocity vector. Since the components are listed below we take the square root of the sum of their squares,

$$v_o = \sqrt{v_{ox}^2 + v_{oy}^2 + v_{oz}^2}$$

$$v_o = \sqrt{(-6.791)^2 + (-123.055)^2 + (-5.721)^2}$$

$$v_o = 123.375 \text{ ft/s} = 84.1 \text{ mph}$$

5	v_x	131.24	pixels	z-pixel at home plate (yes, it is z)
6	start_speed	84.1	mph	Speed at $y_0=50\text{ft}$
7	end_speed	77.2	mph	Speed at the front of home plate $y=1.417\text{ft}$
8	sz_top	3.836	ft	The z-value of the top of the strike zone as

$$x_o = 1.664\text{ft} \quad v_{x_o} = -6.791\text{ft/s} \quad a_x = 13.233\text{ft/s}^2$$

$$y_o = 50.00\text{ft} \quad v_{y_o} = -123.055\text{ft/s} \quad a_y = 25.802\text{ft/s}^2$$

$$z_o = 6.597\text{ft} \quad v_{z_o} = -5.721\text{ft/s} \quad a_z = -17.540\text{ft/s}^2$$

An Example

Problem 2: Find the components of the final velocity of the pitch when it reaches the front of home plate ($y=1.417\text{ft}$).

Since we know the initial and final y -values we can get the y -component of the velocity using the kinematic equation,

$$v_y^2 = v_{oy}^2 + 2a_y(y - y_o)$$

$$v_y = -\sqrt{v_{oy}^2 + 2a_y(y - y_o)}$$

$$v_y = -\sqrt{(-123.055)^2 + 2(25.802)(1.417 - 50.00)}$$

$$v_y = -112.408 \text{ ft/s}$$

$$x_o = 1.664\text{ft}$$

$$v_{x_o} = -6.791\text{ft/s}$$

$$a_x = 13.233\text{ft/s}^2$$

$$v_x = ?$$

$$y_o = 50.00\text{ft}$$

$$v_{y_o} = -123.055\text{ft/s}$$

$$a_y = 25.802\text{ft/s}^2$$

$$v_y = -112.408\text{ft/s}$$

$$z_o = 6.597\text{ft}$$

$$v_{z_o} = -5.721\text{ft/s}$$

$$a_z = -17.540\text{ft/s}^2$$

$$v_z = ?$$

An Example

Problem 2: Find the components of the final velocity of the pitch when it reaches the front of home plate ($y=1.417\text{ft}$).

The time of flight must be found to get the other velocity components. Using another kinematic equation,

$$v_y = v_{oy} + a_y t$$

$$t = \frac{v_y - v_{oy}}{a_y}$$

$$t = \frac{-112.408 - (-123.055)}{25.802}$$

$$t = 0.4127\text{s}$$

$$x_o = 1.664\text{ft}$$

$$v_{x_o} = -6.791\text{ft/s}$$

$$a_x = 13.233\text{ft/s}^2$$

$$v_x = ?$$

$$y_o = 50.00\text{ft}$$

$$v_{y_o} = -123.055\text{ft/s}$$

$$a_y = 25.802\text{ft/s}^2$$

$$v_y = -112.408\text{ft/s}$$

$$z_o = 6.597\text{ft}$$

$$v_{z_o} = -5.721\text{ft/s}$$

$$a_z = -17.540\text{ft/s}^2$$

$$v_z = ?$$

An Example

Problem 2: Find the components of the final velocity of the pitch when it reaches the front of home plate ($y=1.417\text{ft}$).

Having the time of flight and using kinematic equations for the other two axes,

$$v_x = v_{ox} + a_x t = -6.791 + (13.233)(0.4127) = -1.330 \text{ ft/s}$$

$$v_z = v_{oz} + a_z t = -5.721 + (-17.540)(0.4127) = -12.960 \text{ ft/s}$$

$$t = 0.4127 \text{ s}$$

$$x_o = 1.664 \text{ ft}$$

$$v_{x_o} = -6.791 \text{ ft/s}$$

$$a_x = 13.233 \text{ ft/s}^2$$

$$y_o = 50.00 \text{ ft}$$

$$v_{y_o} = -123.055 \text{ ft/s}$$

$$a_y = 25.802 \text{ ft/s}^2$$

$$z_o = 6.597 \text{ ft}$$

$$v_{z_o} = -5.721 \text{ ft/s}$$

$$a_z = -17.540 \text{ ft/s}^2$$

$$v_x = -1.330 \text{ ft/s}$$

$$v_y = -112.408 \text{ ft/s}$$

$$v_z = -12.960 \text{ ft/s}$$

An Example

Problem 2: Find the components of the final velocity of the pitch when it reaches the front of home plate ($y=1.417\text{ft}$).

The final speed is the magnitude of the final velocity vector.

Taking the square root of the sum of the squares,

$$v = \sqrt{v_x^2 + v_y^2 + v_z^2}$$

$$v = \sqrt{(-1.330)^2 + (-112.408)^2 + (-12.960)^2}$$

$$v = 113.160 \text{ ft/s} = 77.2 \text{ mph}$$

5	y=	131.24	pixels	z-pixel at home plate (yes, it is z)
6	start_speed	84.1	mph	Speed at $y_0=50\text{ft}$
7	end_speed	77.2	mph	Speed at the front of home plate $y=1.417\text{ft}$
8	sz_top	3.836	ft	The z-value of the top of the strike zone as

$$t = 0.4127\text{s}$$

$$x_0 = 1.664\text{ft}$$

$$v_{x0} = -6.791\text{ft/s}$$

$$a_x = 13.233\text{ft/s}^2$$

$$v_x = -1.330\text{ft/s}$$

$$y_0 = 50.00\text{ft}$$

$$v_{y0} = -123.055\text{ft/s}$$

$$a_y = 25.802\text{ft/s}^2$$

$$v_y = -112.408\text{ft/s}$$

$$z_0 = 6.597\text{ft}$$

$$v_{z0} = -5.721\text{ft/s}$$

$$a_z = -17.540\text{ft/s}^2$$

$$v_z = -12.960\text{ft/s}$$

An Example

Problem 3: Since a typical batter doesn't get a sense of the motion of the pitch until the ball is about 40ft away from home plate, find the time to get there and the x and z components of the position and velocity when it arrives.

The time can be found using the kinematic equation,

$$y = y_o + v_{oy}t_{40} + \frac{1}{2}a_y t_{40}^2$$

$$t_{40} = \frac{-v_{oy} \pm \sqrt{v_{oy}^2 - 2a_y(y_o - y)}}{a_y}$$

$$t_{40} = \frac{-(-123.055) - \sqrt{(-123.055)^2 - 2(25.802)(50 - 40)}}{(25.802)} = 0.08197s$$

$$t_{40} = 0.08197s$$

$$t = 0.4127s$$

$x_o = 1.664ft$	$v_{x_o} = -6.791ft/s$	$a_x = 13.233ft/s^2$
$y_o = 50.00ft$	$v_{y_o} = -123.055ft/s$	$a_y = 25.802ft/s^2$
$z_o = 6.597ft$	$v_{z_o} = -5.721ft/s$	$a_z = -17.540ft/s^2$

$$t_{40} = 0.08197s$$

$$x_{40} = ?$$

$$v_{x_{40}} = ?$$

$$z_{40} = ?$$

$$v_{z_{40}} = ?$$

An Example

Problem 3: Since a typical batter doesn't get a sense of the motion of the pitch until the ball is about 40ft away from home plate, find the time to get there and the x and z components of the position and velocity when it arrives.

The x-position and velocity can now be found,

$$x_{40} = x_o + v_{ox}t_{40} + \frac{1}{2}a_x t_{40}^2 = 1.664 + (-6.791)(0.08197) + \frac{1}{2}(13.233)(0.08197)^2 = 1.152 \text{ ft}$$

$$v_{x40} = v_{ox} + a_x t_{40} = -6.791 + (13.233)(0.08197) = -5.706 \text{ ft/s}$$

as can the z-position and velocity,

$$z_{40} = z_o + v_{oz}t_{40} + \frac{1}{2}a_z t_{40}^2 = 6.597 + (-5.721)(0.08197) + \frac{1}{2}(-17.540)(0.08197)^2 = 6.069 \text{ ft}$$

$$v_{z40} = v_{oz} + a_z t_{40} = -5.721 + (-17.540)(0.08197) = -7.159 \text{ ft/s}$$

$$t = 0.4127\text{s}$$

$$x_o = 1.664\text{ft}$$

$$v_{xo} = -6.791\text{ft/s}$$

$$a_x = 13.233\text{ft/s}^2$$

$$y_o = 50.00\text{ft}$$

$$v_{yo} = -123.055\text{ft/s}$$

$$a_y = 25.802\text{ft/s}^2$$

$$z_o = 6.597\text{ft}$$

$$v_{zo} = -5.721\text{ft/s}$$

$$a_z = -17.540\text{ft/s}^2$$

$$t_{40} = 0.08197\text{s}$$

$$x_{40} = 1.152\text{ft}$$

$$v_{x40} = -5.706\text{ft/s}$$

$$z_{40} = 6.069\text{ft}$$

$$v_{z40} = -7.159\text{ft/s}$$

An Example

Problem 4: Now that the batter has a sense of the position and velocity of the ball, he can begin to plan his swing. If the ball only felt gravity in the z-direction and no force in the x-direction from this point on, where would it cross home plate.

The time of flight from $y=40\text{ft}$ can be found from by subtracting the total time from the time to get to $y=40\text{ft}$,

$$t_h = t - t_{40} = 0.4127 - 0.08197 = 0.3307s$$

$$t = 0.4127s \quad t_h = 0.3307s$$

$x_o = 1.664\text{ft}$	$v_{x_o} = -6.791\text{ft/s}$	$a_x = 13.233\text{ft/s}^2$
$y_o = 50.00\text{ft}$	$v_{y_o} = -123.055\text{ft/s}$	$a_y = 25.802\text{ft/s}^2$
$z_o = 6.597\text{ft}$	$v_{z_o} = -5.721\text{ft/s}$	$a_z = -17.540\text{ft/s}^2$

$$t_{40} = 0.08197s$$

$$x_{40} = 1.152\text{ft}$$

$$v_{x_{40}} = -5.706\text{ft/s}$$

$$z_{40} = 6.069\text{ft}$$

$$v_{z_{40}} = -7.159\text{ft/s}$$

An Example

Problem 4: Now that the batter has a sense of the position and velocity of the ball, he can begin to plan his swing. If the ball only felt gravity in the z-direction and no force in the x-direction from this point on, where would it cross home plate.

Along the x-direction there would be no acceleration,

$$x_{noair} = x_{40} + v_{x40}t_h + \frac{1}{2}a_x t_h^2 \Rightarrow x_{noair} = 1.152 + (-5.706)(0.3307) = -0.735 \text{ ft}$$

Along the z-axis there would only be gravitational acceleration,

$$z_{noair} = z_{40} + v_{z40}t_h + \frac{1}{2}a_z t_h^2$$

$$z_{noair} = 6.069 + (-7.159)(0.3307) + \frac{1}{2}(-32.174)(0.3307)^2 = 1.942 \text{ ft}$$

$$t = 0.4127\text{s} \quad t_h = 0.3307\text{s} \quad x_{noair} = -0.735\text{ft} \quad z_{noair} = 1.942\text{ft}$$

$$x_o = 1.664\text{ft} \quad v_{x_o} = -6.791\text{ft/s} \quad a_x = 13.233\text{ft/s}^2$$

$$y_o = 50.00\text{ft} \quad v_{y_o} = -123.055\text{ft/s} \quad a_y = 25.802\text{ft/s}^2$$

$$z_o = 6.597\text{ft} \quad v_{z_o} = -5.721\text{ft/s} \quad a_z = -17.540\text{ft/s}^2$$

$$t_{40} = 0.08197\text{s}$$

$$x_{40} = 1.152\text{ft}$$

$$v_{x40} = -5.706\text{ft/s}$$

$$z_{40} = 6.069\text{ft}$$

$$v_{z40} = -7.159\text{ft/s}$$

An Example

Problem 5: Batters describe the effect of spin on the ball as the “break.” One way to analytically define the break is the difference between where the ball actually arrives and where it would have arrived only feeling gravity. Find the break along the x and z directions.

The actual x and z positions are in the data table.

12	<u>px</u>	-0.012	<u>ft</u>	Measured x-value of position at the front of home plate (y=1.417ft)
13	<u>pz</u>	2.743	<u>ft</u>	Measured z-value of position at the front of home plate (y=1.417ft)

$$\begin{array}{l}
 t = 0.4127\text{s} \quad t_h = 0.3307\text{s} \quad x_{\text{noair}} = -0.735\text{ft} \quad z_{\text{noair}} = 1.942\text{ft} \\
 px = -0.012\text{ft} \quad pz = 2.743\text{ft} \\
 t_{40} = 0.08197\text{s} \\
 x_{40} = 1.152\text{ft} \\
 v_{x40} = -5.706\text{ft/s} \\
 z_{40} = 6.069\text{ft} \\
 v_{z40} = -7.159\text{ft/s} \\
 \begin{array}{l}
 x_o = 1.664\text{ft} \quad v_{x_o} = -6.791\text{ft/s} \quad a_x = 13.233\text{ft/s}^2 \\
 y_o = 50.00\text{ft} \quad v_{y_o} = -123.055\text{ft/s} \quad a_y = 25.802\text{ft/s}^2 \\
 z_o = 6.597\text{ft} \quad v_{z_o} = -5.721\text{ft/s} \quad a_z = -17.540\text{ft/s}^2
 \end{array}
 \end{array}$$

An Example

Problem 5: Batters describe the effect of spin on the ball as the “break.” One way to analytically define the break is the difference between where the ball actually arrives and where it would have arrived only feeling gravity. Find the break along the x and z directions.

This definition of break can now be calculated for the x and z directions.

$$x_{break} = px - x_{noair} = -0.012 - (-0.735) = 0.723 \text{ ft} = 8.68 \text{ in}$$

$$z_{break} = pz - z_{noair} = 2.743 - 1.942 = 0.801 \text{ ft} = 9.61 \text{ in}$$

10	<u>px_x</u>	8.68	<u>in</u>	A measure of the “break” of the pitch in the x-direction.
11	<u>px_z</u>	9.55	<u>in</u>	A measure of the “break” of the pitch in the y-direction.

$$px = -0.012 \text{ ft} \quad pz = 2.743 \text{ ft}$$

$$t = 0.4127 \text{ s} \quad t_h = 0.3307 \text{ s} \quad x_{noair} = -0.735 \text{ ft} \quad z_{noair} = 1.942 \text{ ft}$$

$$x_o = 1.664 \text{ ft} \quad v_{x_o} = -6.791 \text{ ft/s} \quad a_x = 13.233 \text{ ft/s}^2$$

$$y_o = 50.00 \text{ ft} \quad v_{y_o} = -123.055 \text{ ft/s} \quad a_y = 25.802 \text{ ft/s}^2$$

$$z_o = 6.597 \text{ ft} \quad v_{z_o} = -5.721 \text{ ft/s} \quad a_z = -17.540 \text{ ft/s}^2$$

$$t_{40} = 0.08197 \text{ s}$$

$$x_{40} = 1.152 \text{ ft}$$

$$v_{x_{40}} = -5.706 \text{ ft/s}$$

$$z_{40} = 6.069 \text{ ft}$$

$$v_{z_{40}} = -7.159 \text{ ft/s}$$

A Word About Forces

Problem 6: Given the weight of a baseball is 0.320lbs, find the x, y, and z components of the force exerted on the ball by the air during its flight.

Use Newton's Second Law along each direction. Along x and y the only force is due to the air,

$$F_x = ma_x = mg \left(\frac{a_x}{g} \right) = (0.320) \left(\frac{13.233}{32.174} \right) = 0.132 \text{ lbs}$$

$$F_y = ma_y = mg \left(\frac{a_y}{g} \right) = (0.320) \left(\frac{25.802}{32.174} \right) = 0.257 \text{ lbs}$$

$$x_o = 1.664 \text{ ft}$$

$$v_{x_o} = -6.791 \text{ ft/s}$$

$$a_x = 13.233 \text{ ft/s}^2$$

$$F_x = 0.132 \text{ lbs}$$

$$y_o = 50.00 \text{ ft}$$

$$v_{y_o} = -123.055 \text{ ft/s}$$

$$a_y = 25.802 \text{ ft/s}^2$$

$$F_y = 0.257 \text{ lbs}$$

$$z_o = 6.597 \text{ ft}$$

$$v_{z_o} = -5.721 \text{ ft/s}$$

$$a_z = -17.540 \text{ ft/s}^2$$

$$F_z = ?$$

A Word About Forces

Problem 6: Given the weight of a baseball is 0.320lbs, find the x, y, and z components of the force exerted on the ball by the air during its flight.

Along z gravity is also in play,

$$F_z - mg = ma_z \Rightarrow F_z = mg + mg\left(\frac{a_z}{g}\right) = mg\left(1 + \frac{a_z}{g}\right) = (0.320)\left(1 + \frac{-22.232}{32.174}\right) = 0.146\text{lbs}$$

The magnitude of the force caused by the air is,

$$F_{air} = \sqrt{F_x^2 + F_y^2 + F_z^2} = \sqrt{(0.132)^2 + (0.257)^2 + (0.146)^2} = 0.324\text{lbs}$$

The force exerted by the air is about equal to the weight!

$x_o = 1.664\text{ft}$	$v_{x_o} = -6.791\text{ft/s}$	$a_x = 13.233\text{ft/s}^2$	$F_x = 0.132\text{lbs}$
$y_o = 50.00\text{ft}$	$v_{y_o} = -123.055\text{ft/s}$	$a_y = 25.802\text{ft/s}^2$	$F_y = 0.257\text{lbs}$
$z_o = 6.597\text{ft}$	$v_{z_o} = -5.721\text{ft/s}$	$a_z = -17.540\text{ft/s}^2$	$F_z = 0.146\text{lbs}$

Summary

- PITCHfx data can provide a wealth of interesting real world problems (and answers) for your students.



Resources

For more ideas of how to use baseball to teach physics, check out....

phys.csuchico.edu/baseball