

■ Trajectory

■ Constants

```
In[110]:= yH = 0;
ySZ = 1.417; (* Strike Zone *)
yRub = 60.5; (* Pitching Rubber *)
yInit = 50; (* Init measurement *)
yPFX = 40; (* Dragless path start *)
gGrav = -32.1740486; (* 32.1740486 feet per (second^2) *)
gFix[{p_, v_, a_}] := {p, v, {0, 0, gGrav}};
```

■ Geometry and Trajectory Functions

■ This Pitch, This Pitch

I used a few pitches but the ones I left in were

Manny Ramirez vs. LHP Horacio Ramirez (1st inning)

http://gd2.mlb.com/components/game/mlb/year_2007/month_08/day_03/gid_2007_08_03_bosmlb_seamlb_1/pbp/pitchers/400141.xml

and

Manny Ramirez vs. RHP Fausto Carmona (1st inning)

http://gd2.mlb.com/components/game/mlb/year_2007/month_10/day_20/gid_2007_10_20_clemlb_bosmlb_1/pbp/pitchers/433584.xml

```
In[141]:= (* initial positions pxyz , vxyz and axyz in rows *)
bp =  $\begin{pmatrix} 0.465 & 50.0 & 6.269 \\ -2.924 & -129.892 & -2.861 \\ -1.98 & 34.087 & -24.13 \end{pmatrix}$ ; bs = {-0.843, ySZ, 3.263};
(*Manny Ramirez vs.LHP Horacio Ramirez (1st inning)*)
pfxV = {-1.191, 0, 4.795} (* pfx_x, 0, pfx_z*)
(*bp=  $\begin{pmatrix} -1.653 & 50.0 & 5.525 \\ 4.963 & -141.772 & -4.01 \\ -8.836 & 40.683 & -20.375 \end{pmatrix}$ ; bs = {-0.436, ySZ, 2.745}; *)
(*Manny Ramirez vs.RHP Fausto Carmona (1st inning)*)
(*pfxV={-4.464,0,5.923}*) (* pfx_x, 0, pfx_z*)
gp = gFix[bp];
{
(* This should come out to px, 1.417, pz *)
varOfY[bp, p, ySZ],
bs,
(* This should come out to start_speed, end_speed *)
mph[mag[varOfY[bp, v, #]] & /@ {yInit, ySZ}]
}
(* The parameterized path starting at the PFX (dragless) path start point, 40ft. *)
bp40 = varOfY[bp, #, yPFX] & /@ {p, v, a};
gp40 = gFix[bp40];
```

```
Out[142]= {-1.191, 0, 4.795}
```

```
Out[144]= {{-0.842372, 1.417, 3.26339}, {-0.843, 1.417, 3.263}, {88.6066, 79.8828}}
```

■ Plot Functions

```

In[147]:= myListPlot[color_, tab_] := ListPlot[tab, PlotStyle -> {color, PointSize[0.01]};
pitchPlot[bp_, bs_, gp_, dim_] := Show[
  myListPlot[Hue[.66, 0.6, 0.8], pvTab[bp, dim, bp]],
  myListPlot[Hue[.33, 0.6, 0.8], pvTab[gp, dim, bp]],
  (*myListPlot[Hue[.30, 0.4, 0.9], pvTab[gp, dim, gp]], *)
  myListPlot[Hue[.00, 0.4, 0.9], {
    bp // p // {y[#], dim[#]} &,
    bs // {y[#], dim[#]} &},
  Graphics[{Hue[0, 0.1, 1], Rectangle[{-17 / 12, -17 / 12}, {0, 17 / 12}], Hue[0, 0, 0]}],
  ParametricPlot[{
    {pOfT[y[bp], t], pOfT[dim[bp], t]},
    {pOfT[y[gp], t], pOfT[dim[gp], t]},
  }, {t, tOfY[bp, yRub], tOfY[bp, yH]}],
  (*Plot[dim[pLineOfY[bp, yy]], {yy, yRub, yH}], *)
  ImageSize -> 640, AspectRatio -> .7, PlotRange -> {{-ySZ, yRub}, Automatic}, AxesOrigin -> {0, 0}
]

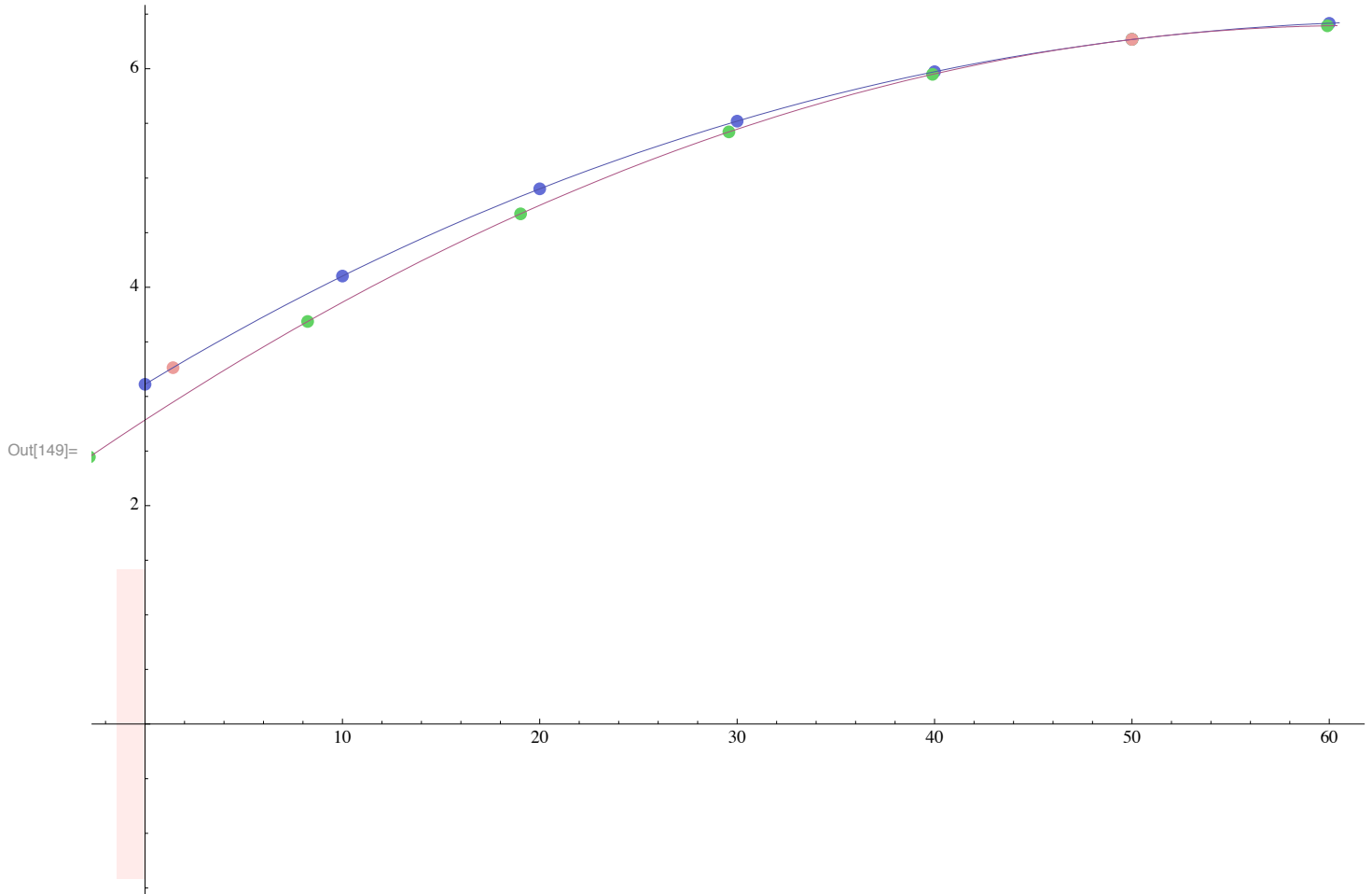
```

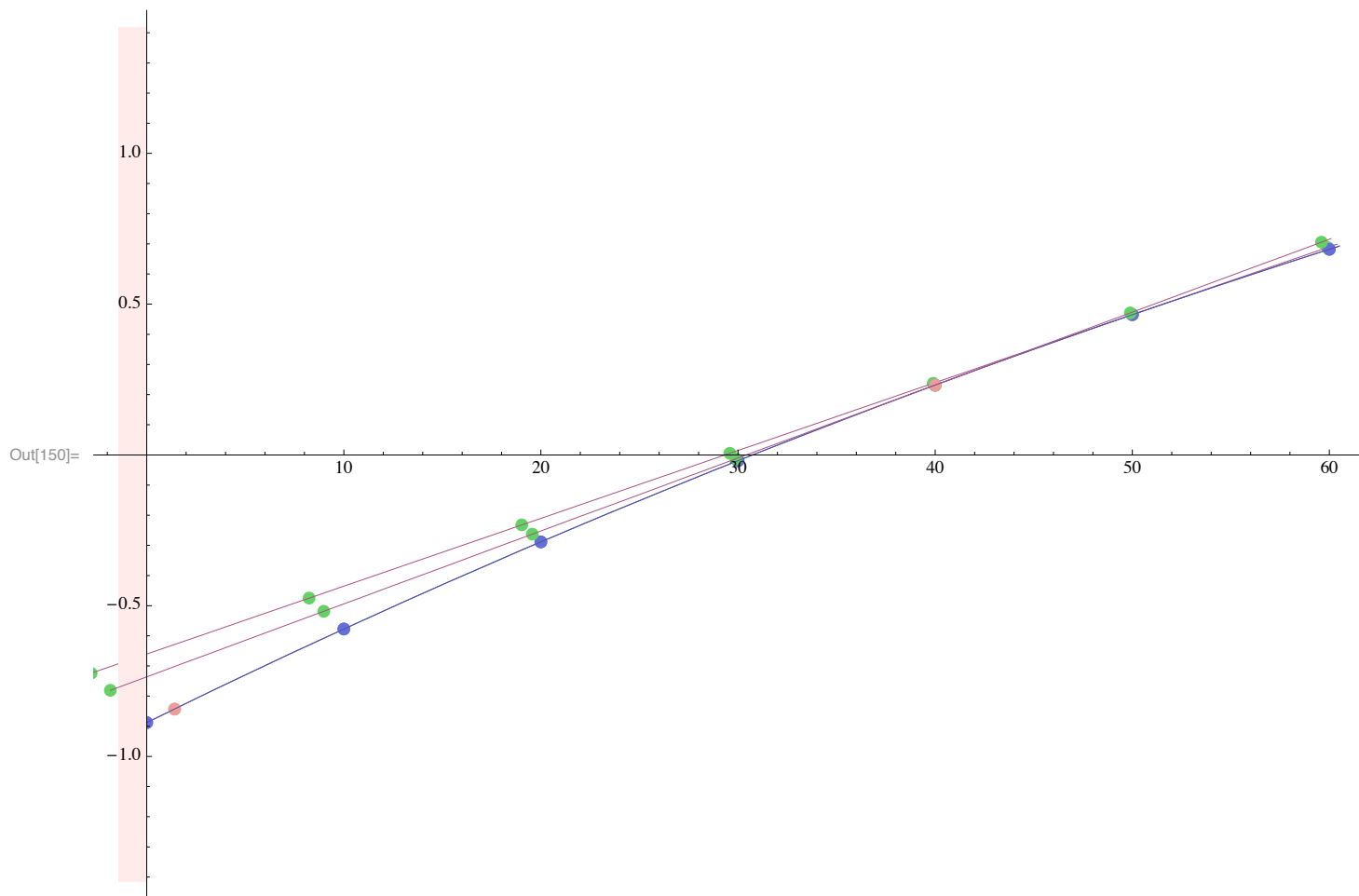
■ Plot Trajectory

```

In[149]:= pitchPlot[bp, bs, gp, z]
Show[
  pitchPlot[bp, bs, gp, x],
  pitchPlot[bp40, bs, gp40, x]
]

```

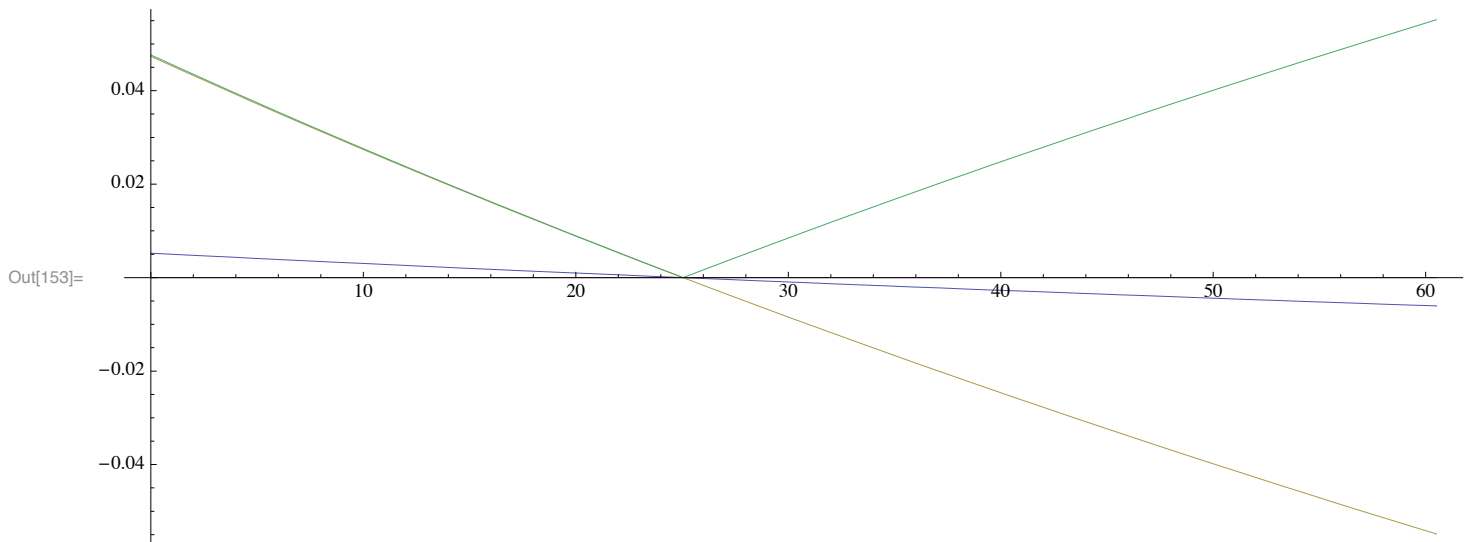




■ Maximum Break

```
In[151]:= pLineOfT[bp_, t_] := Module[{tf, pi, pf}, tf = tOfY[bp, ySZ]; pi = pOfT[bp, 0]; pf = pOfT[bp, tf];
  pi + ((t - 0) / (tf - 0)) (pf - pi)]
pLineOfY[bp_, yy_] := Module[{pi, pf}, pi = pAllofY[bp, yInit]; pf = pAllofY[bp, ySZ];
  pi + ((yy - yInit) / (ySZ - yInit)) (pf - pi)]
```

```
In[153]:= (* Graph the derivative of the pitch-flatline displacement: the zero crossing is the maximum*)
Show[
Plot[Evaluate[{{
  x[ $\partial_{yy}$  (pAllOfY [bp, yy] - pLineOfY[bp, yy])],
  y[ $\partial_{yy}$  (pAllOfY [bp, yy] - pLineOfY[bp, yy])],
  z[ $\partial_{yy}$  (pAllOfY [bp, yy] - pLineOfY[bp, yy])],
  mag[ $\partial_{yy}$  (pAllOfY [bp, yy] - pLineOfY[bp, yy])],
}], {yy, yRub, yH}],
ImageSize → 640, AspectRatio → .4, PlotRange → Automatic,
AxesOrigin → {0, 0}
]
```



```
In[154]:= {
(* Solve for the maximum displacement*)
bpbreakY = ((yy /. Solve[(mag[ $\partial_{yy}$  (pAllOfY [bp, yy] - pLineOfY[bp, yy])] // Simplify) == 0, yy]) // First),
(* MLB actually reports the strikeplane-maxbreak distance, not the distance to the origin*)
bpbreakY - ySZ,
(* position at that break_y *)
bpfx = pAllOfY [bp, bpbreakY] - pLineOfY[bp, bpbreakY],
(* Angle, from 0=down *)
ArcTan[x[bpfx] / z[bpfx]] * 180 /  $\pi$ ,
(* Magnitude of displacement in the y=break_y plane *)
mag[{x[bpfx], z[bpfx]}]
}
```

```
Out[154]:= {25.0456, 23.6286, {0.0563462, 3.90799  $\times 10^{-14}$ , 0.51029}, 6.30106, 0.513392}
```

■ Table of Positions

■ Plot PFX values

```
In[159]:= (* pfx_x, pfx_z -- the distance from where the pitch crosses the strikeplane
to the point a dragless (But gravity-bound) ball would have reached: *)
{{bp40 = varOfY[bp, #, 40] & /@ {p, v, a}, gp40 = gFix[bp40]}};
Plot[12 * {(pOfY[bp40, x, yy] - pOfY[gp40, x, yy, bp40]), x[pfxV] / 12}, {yy, 40, 0},
AxesOrigin → {ySZ, 0}, PlotRange → Automatic, ImageSize → 640]
Plot[{pOfY[bp40, z, yy] - pOfY[gp40, z, yy, bp40]}, z[pfxV] / 12}, {yy, 40, 0},
AxesOrigin → {ySZ, 0}, PlotRange → Automatic, ImageSize → 640]
(* note that such a ball will be behind the strikeplane -- however its y displacement is ignored. *)
```

