WYTHENSHAWE PARK

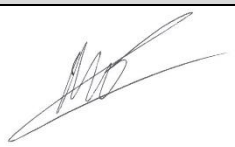
BALL STRIKE RISK ASSESSMENT

LABOSPORT

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BALL STRIKE ASSESSMENT – WYTHENSHAWE PARK

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INTRODUCTION	New baseball pitches are proposed to be installed at Wythenshawe Park, Manchester, which are in close proximity to residential properties, sports facilities (athletics track, football pitch) and site boundaries. There is a risk that balls may be hit into the adjacent areas causing potential for injury and/or property damage. Reasonable worst-case scenarios were identified for the site and a sophisticated trajectory model was used to predict the flight path of baseballs, based on representative hit scenarios. Analysis of the trajectories reveals the predicted height of the balls as they pass the proposed site boundaries. This information is used to provide recommendations for the height of any required ball stop mitigation in specific locations.

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Section 1 – Site Overview

Site Overview

New baseball pitches are proposed to be installed at Wythenshawe Park, Manchester, which are in close proximity to residential properties, sports facilities (athletics track, football pitch) and site boundaries, and this report will consider the ball trajectories towards the adjacent areas in all directions from the pitches. The illustration below provides an overview of the proposed site.



Figure 1. Overview of the proposed baseball pitches at Wythenshawe Park.

The locations of the proposed new baseball pitches are in close proximity to the site boundaries. There is a risk that baseballs may be hit beyond the site boundaries into the adjacent areas. This report will analyse reasonable worst case ball trajectories to measure shots into the road and propose a recommended ball containment solution.

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Section 2 – Baseball Trajectory Model

Baseball Trajectory Model Overview

A sophisticated three-dimensional trajectory model was developed to analyse the trajectory of a baseball. The model was built in the numerical programming software 'Matlab' and incorporated aerodynamic drag and lift forces, and the complexities arising from the ball's spin rate.

The model used published aerodynamic coefficients taken from wind tunnel studies on baseballs at different ball velocities (Nathan, A. The effect of spin on the flight of a baseball. American Journal of Physics 76, 199-224).

When a spinning baseball travels through the atmosphere, it experiences the force of gravity in addition to the drag and Magnus forces, F_D and F_M, as shown in Fig. 2. Conventionally the magnitudes of these forces are parametrized as:

$$F_D = \frac{1}{2} C_D \rho V^2 A$$
$$F_M = \frac{1}{2} C_L \rho V^2 A$$

where A is the cross-sectional area of the ball, v is its speed, ρ is the air density 1.23 kg/m^3, and C_D and C_L are the drag and lift coefficients, respectively. Data on other spherical sports balls suggest that C_L is mainly a function of the spin factor S=Rω/v, although it may also be a function of the Reynolds number Re=2ρRv/μ. Here R is the radius of the ball, ω is the angular velocity, and μ is the dynamic viscosity of the air. For a standard ball and air at normal temperature and pressure, μ=1.85 10−5 N-s/m^2, so that Re=2180v and S=8.53 10^{-3} ω/v with v in mph and ω in rpm.

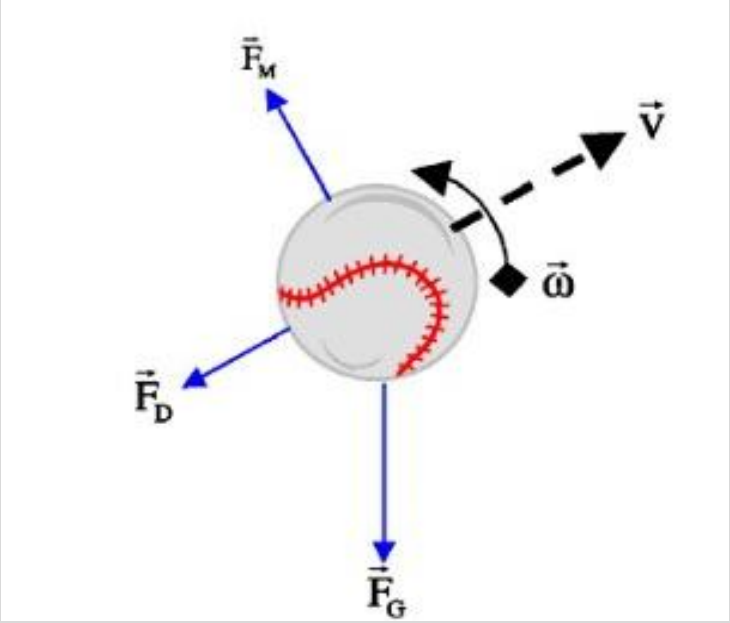


Figure 2. A free body diagram for the baseball trajectory model showing the aerodynamic drag and lift forces.

Due to the complexity of the flight dynamics, the trajectory can only be resolved by using a numerical time step approach whereby the ball conditions are calculated at small timesteps throughout the trajectory. The conditions at time step 1 are used to calculate the conditions at time step 2; the conditions are timestep 2 are used to calculate the conditions at time step 3 and henceforth. A timestep of 0.001 seconds was used to generate high-resolution trajectory data.

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Baseball Scenarios

In the game of baseball, the ball can be hit in a range of directions with a wide range of launch velocities. Nonetheless, some trajectories are far more common than others. This risk assessment uses a proportionate approach by focusing on the common trajectories to determine the most likely scenarios where a ball may surpass the site boundary.

Labosport has significant experience and expertise in ball sports and provides technical support to several international and national governing bodies (e.g. the FIFA, ECB and World Rugby). Labosport have drawn on their expertise to define different in game scenarios where the ball may be hit on a trajectory that surpasses the site boundary.

For each ball launch scenario, a reasonable initial speed is determined, and the trajectory is simulated for a range of representative launch angles (15 degrees to 30 degrees). Figures 2a & 2b show the typical spread of ball launch directions and locations of where batted balls land for four ranges of launch angle taken from Kato & Yanai (2022).

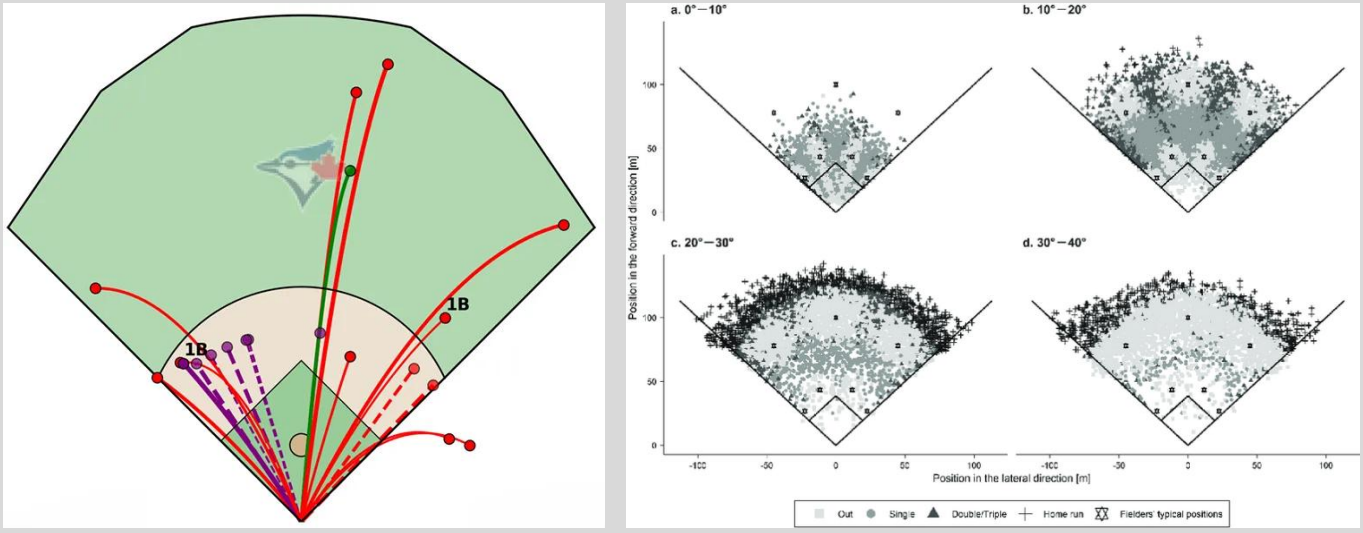


Figure 3a & 3b. Typical spread of trajectories and locations where batted balls typically land for four launch angle ranges.

Foul Balls

In addition to baseball trajectories that land within the diamond, there are those mishit ball trajectories which will land outside of the field of play, known as "foul balls". These foul balls can land directly behind the home plate/batter location or along the angled side lines of the playing diamond, as the analysis of an MLB baseball player below shows. Right-handed batters predominantly pull foul balls toward the first base (left) side, while left-handed batters push or pull fouls toward the third base (right) side.

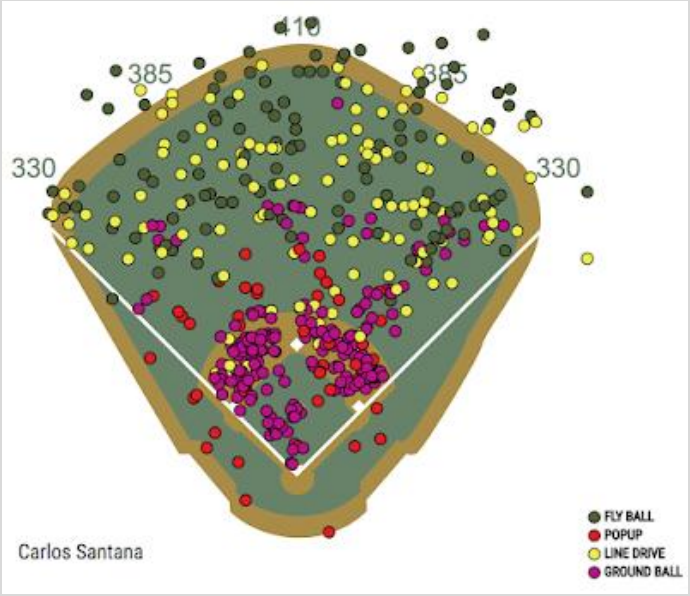


Figure 4. Simulated baseball landing locations for MLB player Carlos Santana

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To prevent these foul balls leaving the playing field on either side, the standard approach is to erect backstop fencing. In the UK, there are no standard dimensions for this backstop fencing for use in amateur baseball, however the accepted performance requirement for backstop fencing / netting behind home plate is generally as follows:

Height

- Minimum functional height 6 m
- Recommended community / club standard 7–9 m
- High containment / constrained sites 10–12 m

For most UK community baseball facilities, an 8 m high backstop would generally be considered appropriate mitigation.

Width & Wing Returns

- Central backstop width - Typically 9–12 m
- Wing returns:
  - Extend 6–12 m either side of central backstop.
  - Angled approximately 30–45° along foul lines of playing diamond.



Figure 5. Example of baseball backstop fencing structure

Baseball Launch Velocities

In the game of baseball, the ball can be hit with a wide range of velocities (speeds and angles). Nonetheless, previous researchers have made accurate measurements of ball speeds and spin rates using high speed video and similar technologies. The table below summarises maximal baseball hit velocities taken from published literature and baseball statistics websites (e.g. MLB Statcast). The table below shows typical maximum exit velocity ranges observed for different age groups:

Age	Average Player Max	Elite Player Max
Under-8 – Under-10	45–55 mph	55–65 mph
Under-11 – Under-12	55–60 mph	60–70 mph
Under 13 – Under-14	60–65 mph	65–75 mph
Under-15 – Under-16	70–80 mph	75–85 mph
College level	80–100 mph	90–110 mph
Pro level	105–110 mph	115–120 mph

Table 1. Maximum resultant ball velocities for different age groups.

The pitch usage at Wythenshawe Park will be as follows:

- The two adult baseball diamonds will be used by the Manchester 'A's' Division 1 adult team. Therefore, a maximal ball launch velocity of 100 mph for senior level play with spin rates ranging between 0-2000 rpm will be used for the assessment of the adult baseball pitches in this ball strike assessment.
- The junior baseball diamond will be used by players up to under-16 level. Therefore, a maximal ball launch velocity of 80 mph for junior level play with spin rates ranging between 0-2000 rpm will be used for the assessment of the junior baseball pitch in this ball strike assessment.

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Section 3 – Trajectory Model Simulations

Trajectory simulation

Northern baseball pitch

The diagram below shows a global view of the worst-case trajectory scenarios that will be considered for the northern baseball pitch.



Figure 6. A global overview of the site with the three different trajectory scenarios identified for the northern baseball pitches.

Trajectory 1 – Towards athletics track – 191.6 metres (100 mph ball speed)

Estimated Ball Height @ 191 m		Ball launch angle (degrees)			
		15	20	25	30
Spin rate (rpm)	0	0	0	0	0
	1000	0	0	0	0
	2000	0	0	0	0

Trajectory 2 – Towards football pitch – 117.5 metres (100 mph ball speed)

Estimated Ball Height @ 118 m		Ball launch angle (degrees)			
		15	20	25	30
Spin rate (rpm)	0	0	0	0	0
	1000	0	0	0	0
	2000	3.5	3.0	2.8	2.9

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Trajectory 3 – Towards site boundary – 182.9 metres (100 mph ball speed)

Estimated Ball Height @ 183 m		Ball launch angle (degrees)			
		15	20	25	30
Spin rate (rpm)	0	0	0	0	0
	1000	0	0	0	0
	2000	0	0	0	0

Southern baseball pitches

The diagram below shows the worst-case trajectory scenarios that will be considered for the southern baseball pitches.

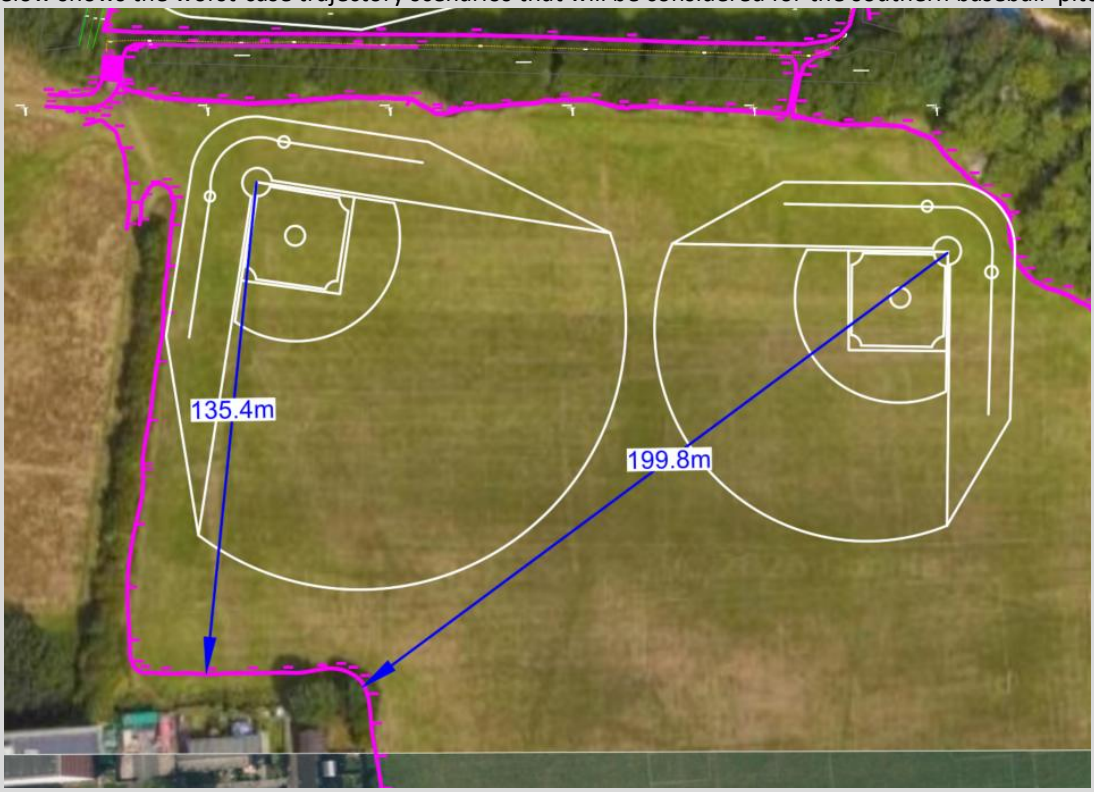


Figure 7. A global overview of the site with the two different trajectory scenarios identified for the southern baseball pitches.

Trajectory 1 – Towards site boundary from adult pitch – 135.4 metres (100 mph ball speed)

Estimated Ball Height @ 135 m		Ball launch angle (degrees)			
		15	20	25	30
Spin rate (rpm)	0	0	0	0	0
	1000	0	0	0	0
	2000	0	0	0	0

Trajectory 2 – Towards site boundary from junior pitch – 199.8 metres (80 mph ball speed)

Estimated Ball Height @ 200 m		Ball launch angle (degrees)			
		15	20	25	30
Spin rate (rpm)	0	0	0	0	0
	1000	0	0	0	0
	2000	0	0	0	0

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Section 4 – Discussions and Conclusions

Discussions and Conclusions

This report has been prepared to assess the potential risk of baseballs surpassing the site boundaries and impacting on adjacent sports facilities at Wythenshawe Park and to advise on the mitigation recommended to provide a suitable level of protection.

The exact frequency of events resulting in a ball being hit into the adjacent areas is unknown and impossible to predict with certainty (player skills, type of game and many other factors can influence this) hence a proportionate approach needs to be taken to provide safety to these users. In reality, there may be a "freak" trajectory that will result in a further than expected trajectory, but a balanced risk mitigation strategy needs to be implemented that is proportionate. Indeed, there are risks associated with many everyday activities, but plans need to be developed to reduce risk following good practical health and safety principles including a combination of likelihood and severity.

In consideration of the risks posed by the simulated baseball trajectories in relation to the context of the location, this report recommends the below mitigation solution to provide protection against potential ball strike risks to the adjacent football pitch. The fencing proposed in the location of the recommended mitigation is proposed to be 4.5m high, as per the submitted 'boundaries' drawing (attached /appended), and therefore meets and exceeds the recommendation. Management and maintenance of this fencing will be the responsibility of Leisure United who will maintain the fencing as part of their wider management of the site.

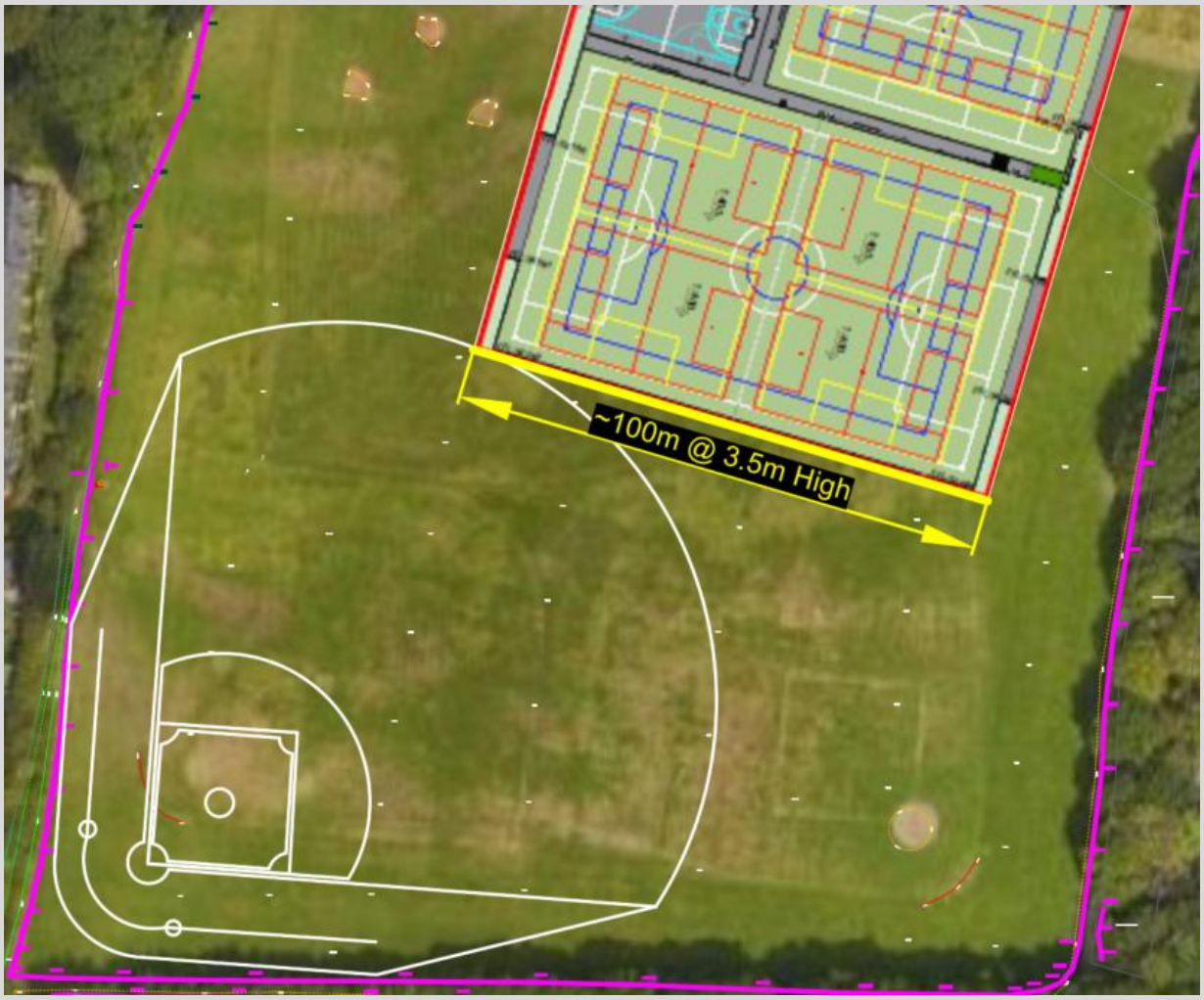


Figure 8. Ball containment recommendations based on simulated trajectories

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In addition, to provide protection against the risk of foul balls leaving the playing area on either side of the baseball diamond, it is recommended that backstop fencing is erected behind the batting location of the proposed baseball diamonds. It is recommended that 8 m high backstop fencing is erected behind the batting locations of the proposed baseball diamonds, as suggested or UK community baseball facilities.

Width & Wing Returns

- Central backstop width - Typically 9–12 m
- Wing returns:
  - Extend 6–12 m either side of central backstop.
  - Angled approximately 30–45° along foul lines of playing diamond.



It is important to note that these recommendations may not stop all balls from landing beyond the proposed mitigation location, but it is predicted from the assessment of ball trajectory it will significantly reduce their frequency.

References

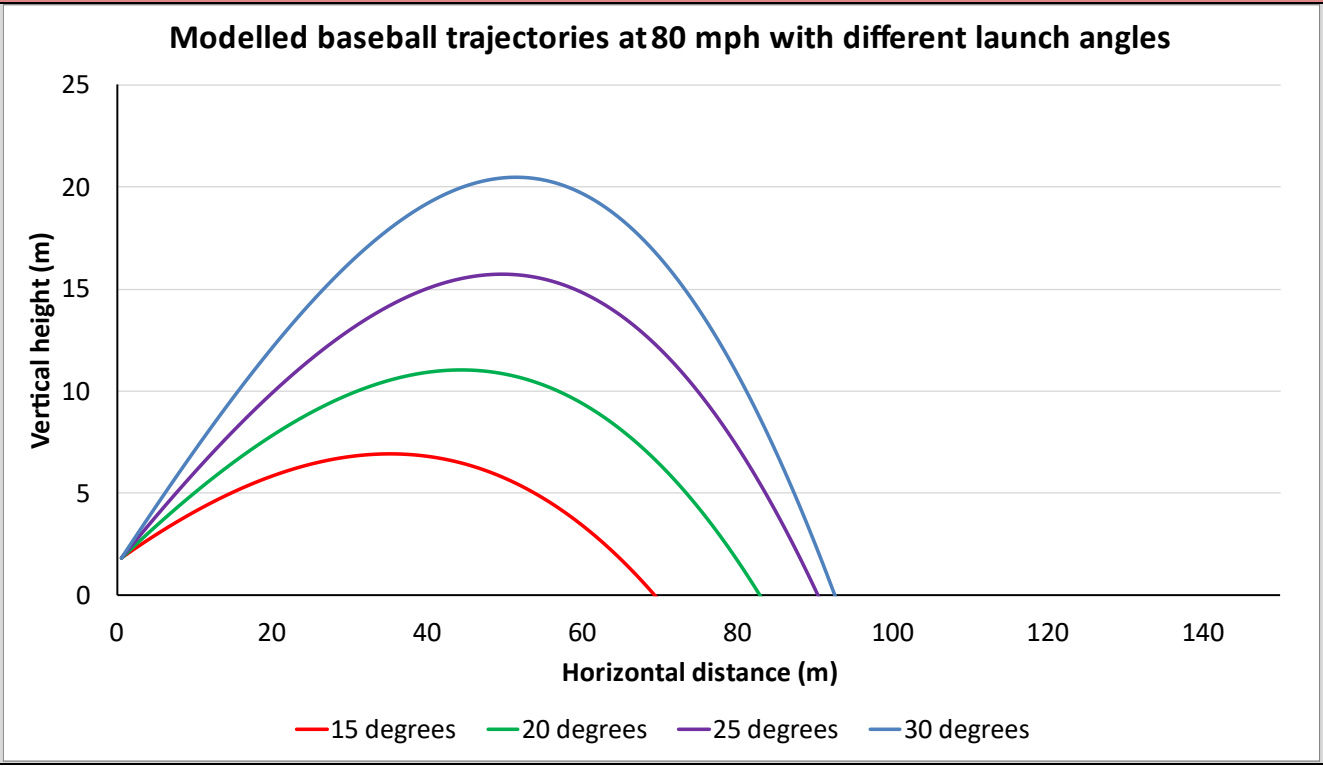
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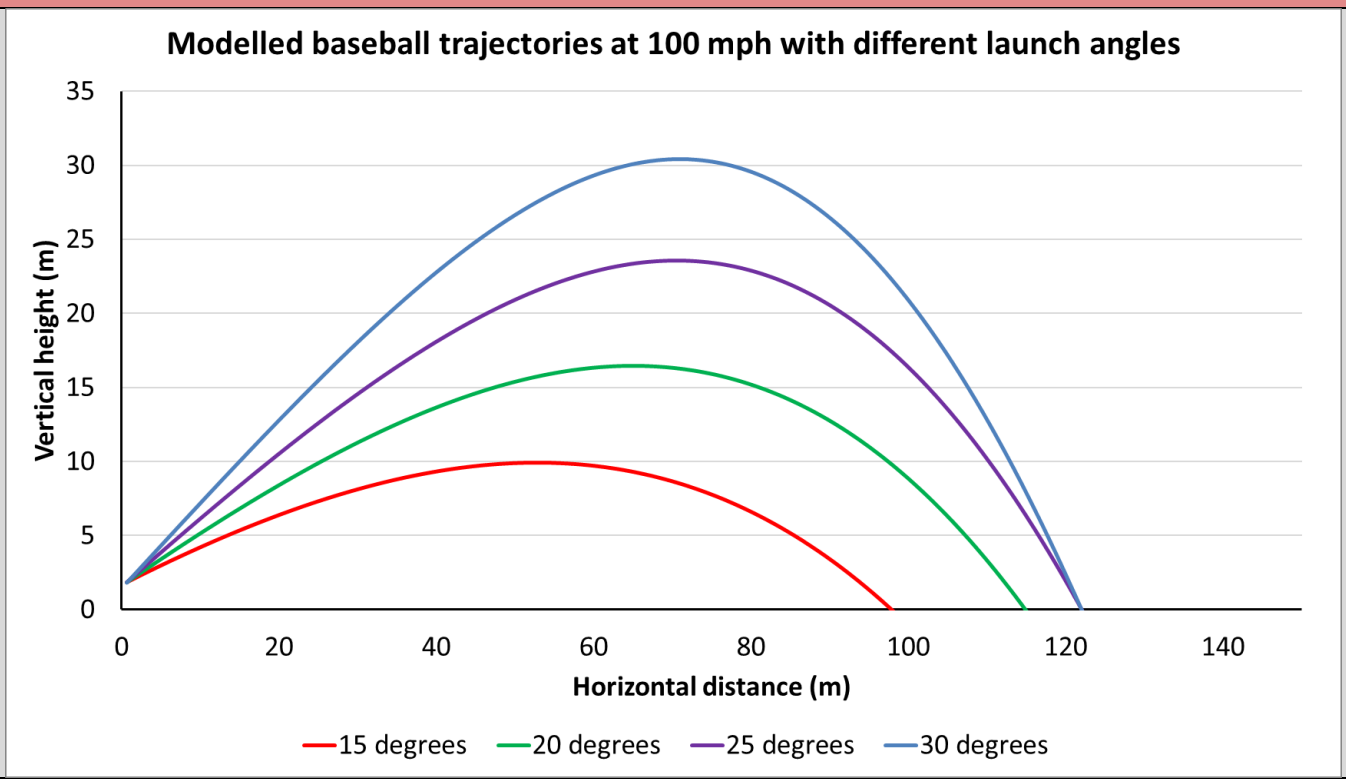
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Appendix – Example Baseball Trajectories

Modelled baseball trajectories at 80 mph



Modelled baseball trajectories at 80 mph



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