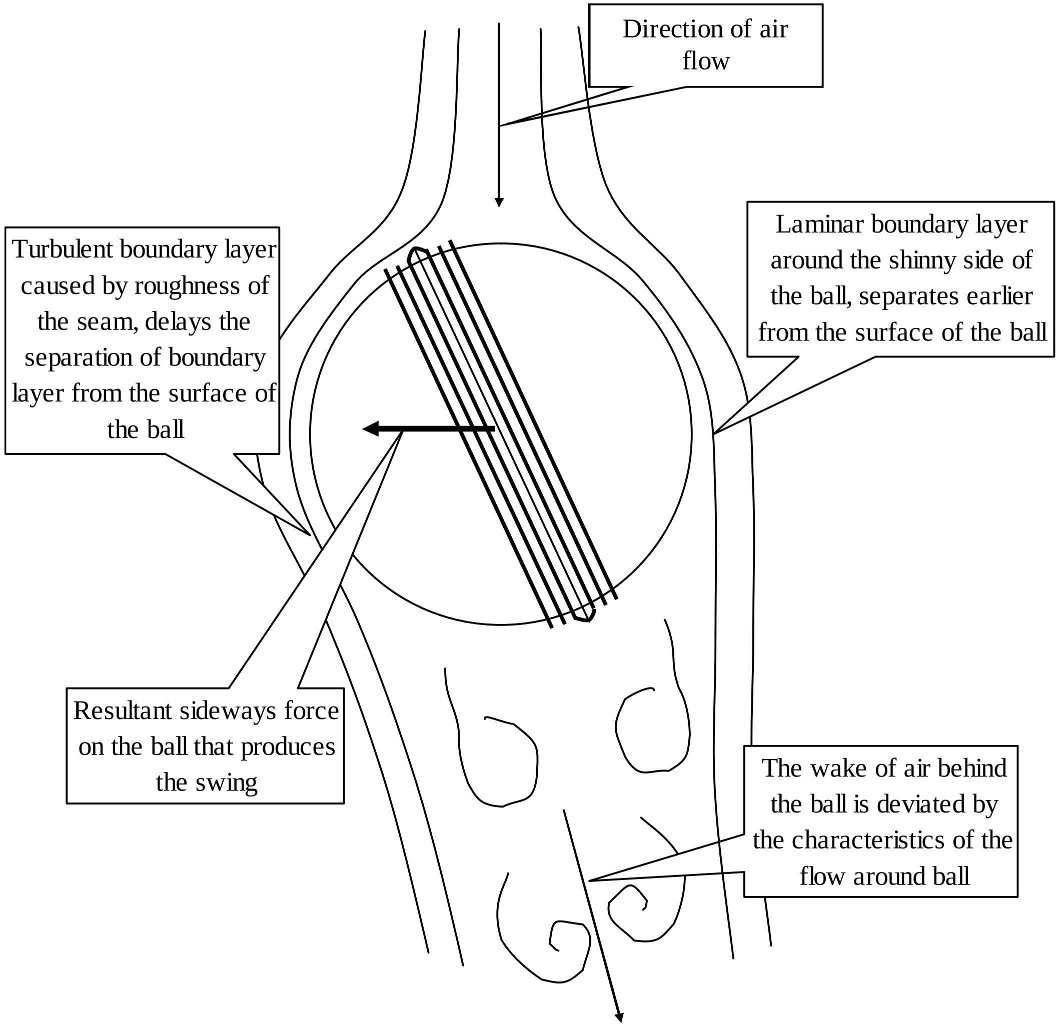
New ball swing

- New ball swing effect due to seam
- Experimental results for the amount of swing of a new ball at various angles of the seam and at different Reynolds numbers
- The new ball swings more at a seam angle of about 20^o, when the atmospheric pressure is higher and when bowled at a slower speed
- Atmospheric pressure has more impact on the amount of new ball swing than other atmospheric conditions such as humidity or temperature
- The temperature of the air has an inverse relationship on the amount of new ball swing: the lower the temperature, the greater the amount of swing
- The humidity of the air has very little impact on the amount of new ball swing
- Assumptions and other factors that are considered to influence new ball swing

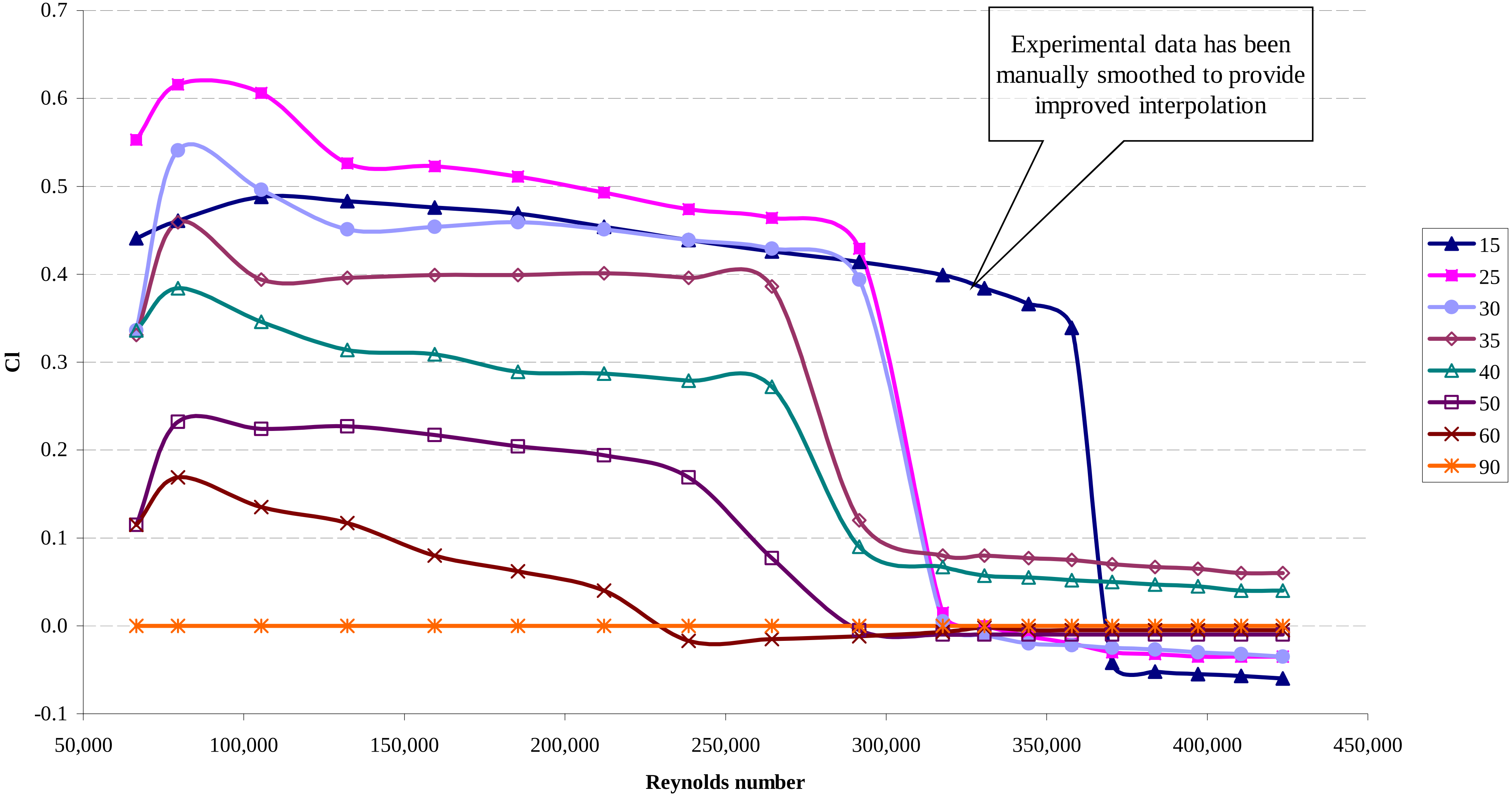
New ball swing effect due to seam



- The flow of air around a new ball, can be affected by the position of the seam
- The seam near the front of the ball acts to cause the flow in the boundary layer around one side of the ball to be tripped into turbulence, while the lack of seam allied with a shiny, non-rough surface on the other keeps the boundary layer flow laminar
- The turbulent boundary layer separates from the ball later than a laminar boundary layer
- This unsymmetrical air flow causes a sideways force to be exerted on the ball and the wake to be deviated to the opposite side (obeying Newton's 3rd law – the equal and opposite force)

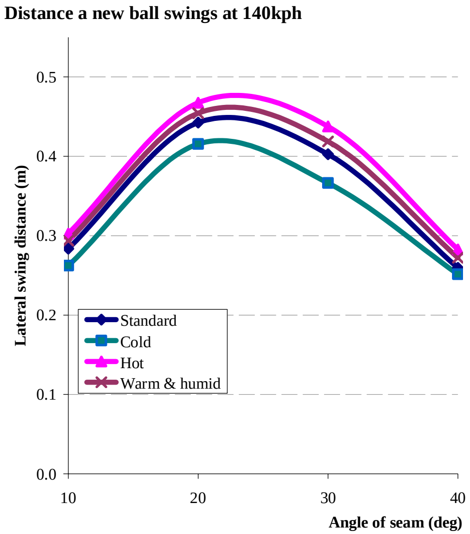
Experimental results for the amount of swing of a new ball at various angles of the seam and at different Reynolds numbers

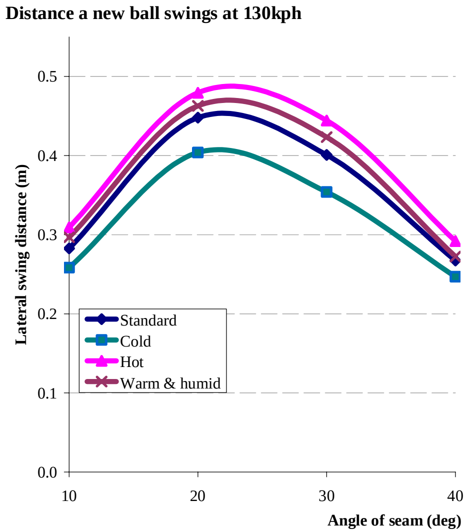
New ball swing - coefficient of lift

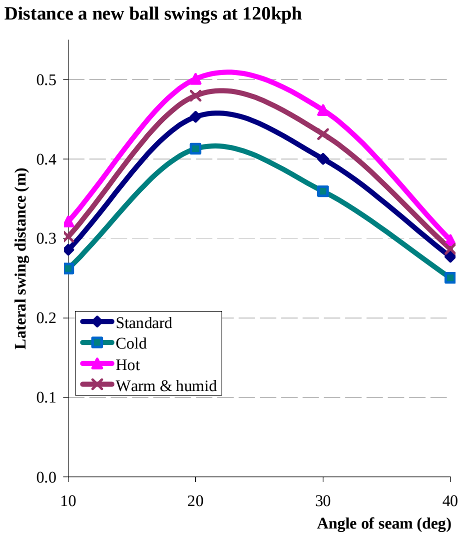


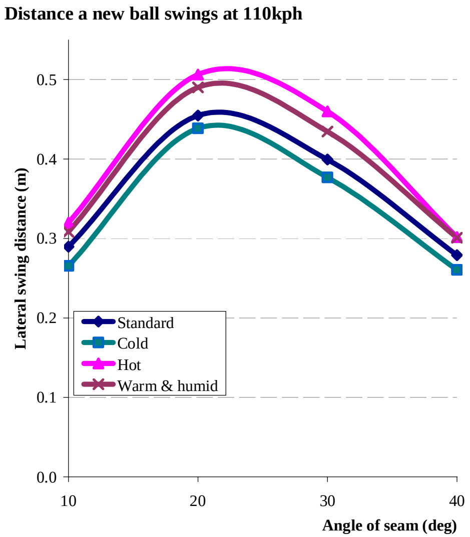
Source: Sayers, AT, (2000), 'On the reverse swing of a cricket ball – modelling and measurements', Proceedings of the Institution Mechanical Engineers, Vol 215, Part C

The new ball swings more at a seam angle of about 20º, when the atmospheric pressure is higher and when bowled at a slower speed





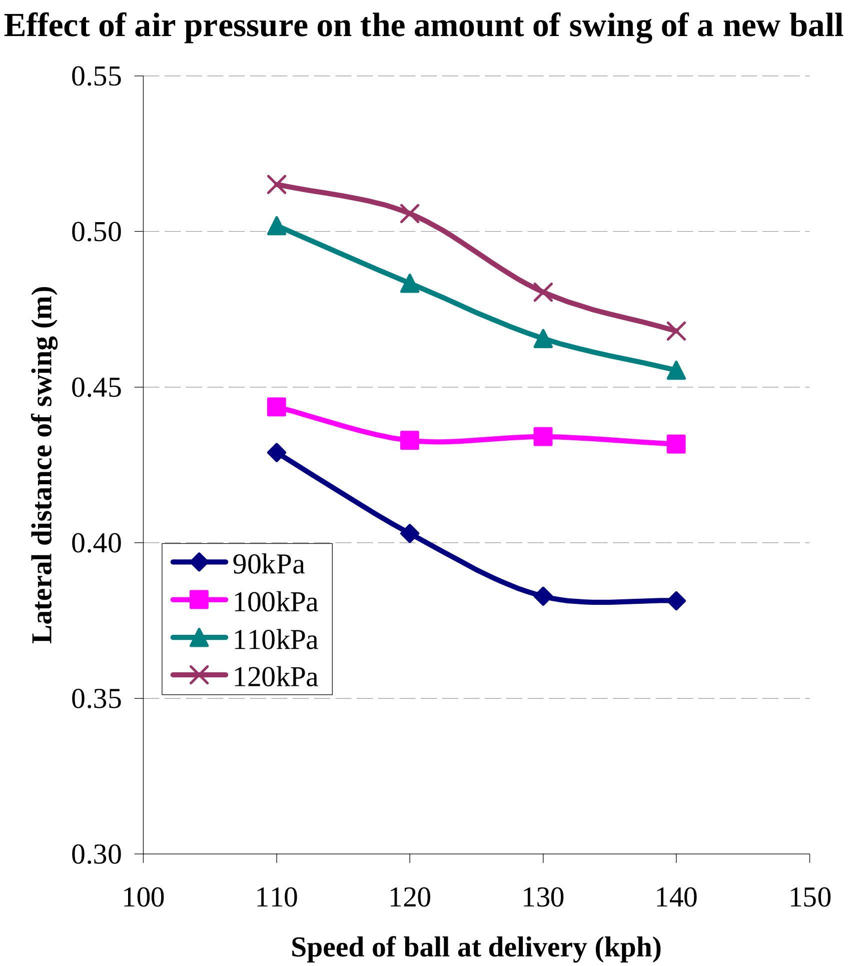




Source: Vaughan Roberts' bowling trajectory model

- It appears the ball swings more in hotter temperatures than colder ones, but this is related to the air pressure, not the temperature
  - the lateral swing forces are higher because of the greater air density associated with the higher air pressures used in the hot and warm scenarios
  - the density of air decreases as the temperature rises under constant pressure
- Greatest amount of swing is achieved with an angle of seam of about 20º
  - this result is dependent on the angles actually measured in the wind tunnel as the plotted data points are obtained by using a polynomial fitting algorithm to the measured data
- Generally, the slower the delivery speed, the greater the amount of swing, due to the extra time the ball is subject to the aerodynamic force before it bounces
- *Assumptions*: balls landing 3m in front of batsman's crease, no air flow time delay, bi-cubic spline interpolation used to obtain coefficient of lift from smoothed experimental data

Atmospheric pressure has more impact on the amount of new ball swing than other atmospheric conditions such as humidity or temperature

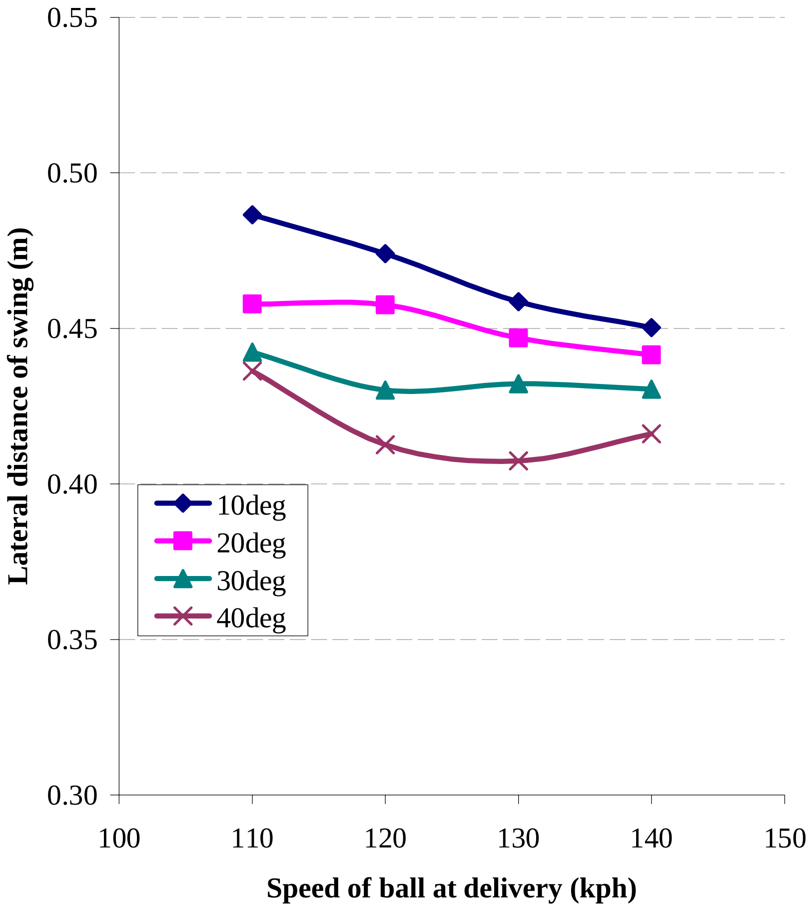


Source: Vaughan Roberts' bowling trajectory model

- Results from the model with standard temperature (24°C) and humidity (58%), indicate that the biggest effect (after seam angle) on the amount of swing is atmospheric pressure
- Air pressure was varied between 90kPa and 120kPa for a 20° seam angle and demonstrated that there was about 20-25% more swing when the air pressure was 120kPa than at 90kPa
- The density of the air increases as the pressure increases, this increase in density means that there is an increase in the force exerted on the ball and hence more swing
- *Assumptions*: balls landing 3m in front of batsman's crease, no air flow time delay, bi-cubic spline interpolation used to obtain coefficient of lift from smoothed experimental data

The temperature of the air has an inverse relationship on the amount of new ball swing: the lower the temperature, the greater the amount of swing

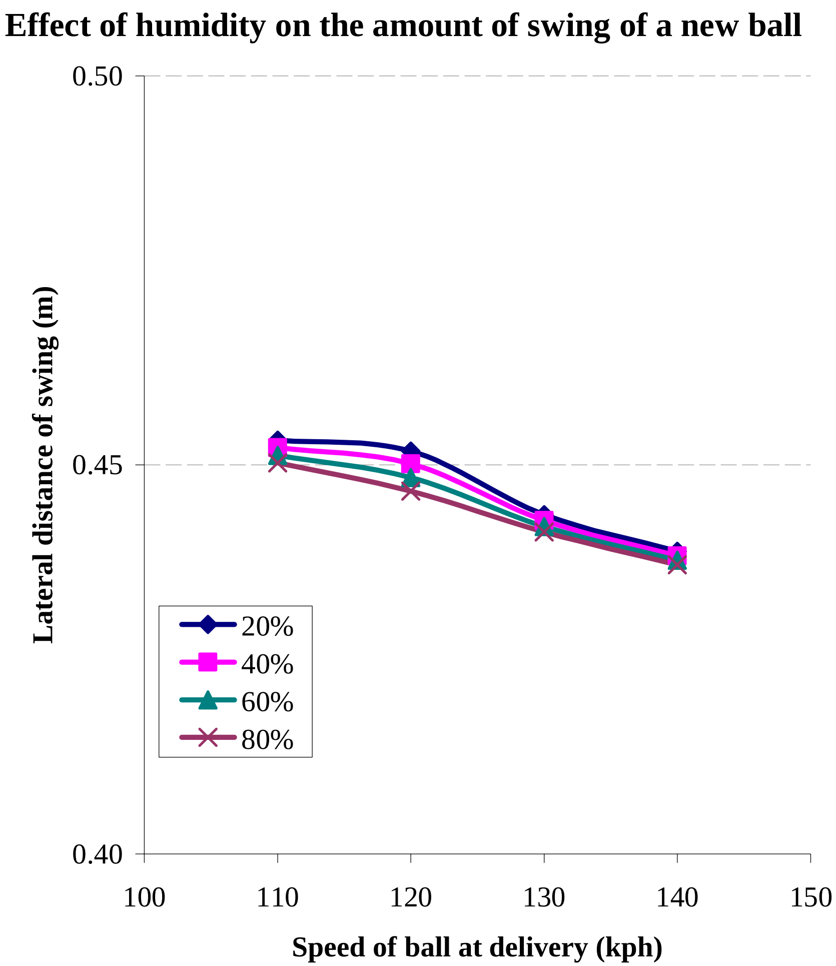
Effect of air temperature on the amount of swing of a new ball



Source: Vaughan Roberts' bowling trajectory model

- Results from the model with standard humidity (58%) and pressure (102kPa), indicate that the temperature of the air has an inverse relationship on the amount of swing
- Air temperature was varied between 10^{o}C and 40^{o}C for a 20^o seam angle and demonstrated that there was about 8-15% more swing when the air temperature was 10^{o}C than at 40^{o}C
- The density of the air decreases as the temperature increases, this decrease in density means that there is a decrease in the force exerted on the ball and hence less swing
- *Assumptions*: balls landing 3m in front of batsman's crease, no air flow time delay, bi-cubic spline interpolation used to obtain coefficient of lift from smoothed experimental data

The humidity of the air has very little impact on the amount of new ball swing



Source: Vaughan Roberts' bowling trajectory model

- The amount of humidity of the air has long been associated with the amount of swing of a new ball
- Results from the model with standard temperature (24^{o}C) and pressure (102kPa), indicate that this is probably not valid and that there is a slight negative impact from increased humidity of the air on the amount of swing
- The density of the air decreases as the humidity increases as water vapour is lighter than nitrogen or oxygen, this decrease in density means that there is a slight decrease in the force exerted on the ball and hence slightly less swing
- *Assumptions*: balls landing 3m in front of batsman's crease, no air flow time delay, bi-cubic spline interpolation used to obtain coefficient of lift from smoothed experimental data

Assumptions and other factors that are considered to influence new ball swing

- An important assumption made in these results is that the air flow around the ball is in steady-state conditions.
  - Wind-tunnel experiments usually ensure that they reach steady-state flow conditions before making any measurements.
- In practice the ball will go through a transition period immediately after leaving the bowler's hand before reaching steady-state flow conditions, if, in fact, it ever does.
  - I have not seen any investigation on the length of time for this transition period.
  - It should be noted that the impact of this transition period is likely to reduce the amount of swing and to delay its onset: possibly producing the so-called 'late swing' effect.
  - The model uses a first order exponential function which assumes that the forces on the ball will increase in a smooth fashion during the transition. The value for the rise time constant is still a matter of speculation (Wilkins[1] suggests a delay of 0.1–0.2 seconds before the air flow becomes established). I have used a zero rise time (i.e. no delay) here as it will only affect the magnitude of the movement not the relativities between the different scenarios tested.
- The impact of different atmospheric conditions on the time taken for steady-state conditions to be achieved also needs to be investigated.
  - The affect of humidity of the air on the time taken to establish the flow around the ball will be important in order to understand whether the ball swings more in humid rather than dry air.
- Wilkins[1] has proposed that micro-turbulence in the air can cause interference with the flow of air around the ball and prevent the formation of different points of separation of the boundary layer on either side of the ball. This, in turn, is postulated to prevent the ball from swinging.
  - At this point in time, I have not seen any compelling research of the influence of this effect on a cricket ball and so I am going to remain sceptical about this until the research demonstrates otherwise.
- A number of commentators[1] have expressed the assumption that the flow in the boundary layer on one side of the ball is laminar whilst the flow in the other is turbulent
  - I am sceptical about the assumption that the flow is laminar and it would require careful experimental investigation in order to demonstrate this in a convincing fashion.

[1] Wilkins, Brian, (1997), 'Cricket: the bowler's art', 2nd ed, Kangaroo Press