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Basic aerodynamic forces in cricket

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Newton's first law of motion – inertia

- *'Corpus omne perseverare in statu suo quiescendi vel movendi uniformiter in directum, nisi quatenus a viribus impressis cogitur statum illum mutare.[1]'*
- or, 'A body at rest or in uniform motion in a straight line, will remain at rest or in uniform motion in a straight line, unless acted upon by an outside force.'
- Once the ball has left your hand, there is nothing you can do that will impact on the flight of the ball – from there on it is under the influence of aerodynamic and contact forces only.
- The bowler's job is to impart forces on the ball to get the ball into the dynamic state that will result in the trajectory they desire through its interaction with these aerodynamic and contact forces.
- *Caveats*
  - *The results presented here are reliant on experimental wind tunnel results obtained by other researchers and made available from published resources. They have not been independently verified by the author.*
  - *Importantly the measurement of forces on the ball during these experiments will have been obtained in steady state air flow conditions, whereas it is unlikely that steady state flow conditions will have been achieved around a bowled cricket ball during the time taken to reach the batsman when it is delivered at 140kph. The impact of this on the reported results is a matter for further experimentation.*

1. Newton, Isaac (1697), "Principia Mathematica"

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Types of aerodynamic forces that can act on the ball

- Drag
  - A full toss delivered from the bowler's hand at 140kph, will lose about 2–12% of its velocity by the time it reaches the batsman through drag alone.
  - The actual velocity loss depends on the atmospheric conditions, and the surface roughness and shape of the ball.
- New ball swing effect due to seam
  - The seam of a new ball can act to create an unbalanced air flow around the ball, which results in a sideways force on the ball.
  - The amount of swing depends on the 'angle of seam', the velocity of the apparent wind, the atmospheric conditions and the shape of the ball
- Old ball reverse swing effect due to roughness
  - A difference in roughness between the two sides of an old ball can also create an unbalanced air flow around the ball again resulting in a sideways force on the ball
  - The amount of swing depends on the difference in roughness between the two sides and the usual atmospheric conditions
- Magnus effect
  - Spin or rotation of the ball creates an unbalanced air flow around the ball, creating a 'lift' force on the ball mutually perpendicular to the axis of rotation and the apparent wind direction
  - This can be used to create the 'loop' and 'drift' that a spinner will utilise
  - The amount of 'loop' and/or 'drift' depends mainly on the amount of rotation imparted on the ball, the axis about which the ball is rotating, the atmospheric conditions and the velocity and direction of the apparent wind.
- NB – all of these aerodynamic forces depend on the atmospheric conditions and the instantaneous velocity of the ball relative to the apparent wind, which changes from the time it leaves the bowler's hand to when it reaches the batsman

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Four atmospheric condition scenarios were used to investigate the changes in aerodynamic forces on the ball

Note the air density becomes higher as the pressure increases – aerodynamic forces on the ball are typically proportional to air density: so the higher the air pressure, the larger the forces on the ball.

	Pressure (kPa)	Temp (ºC)	Humidity (%)	Air density (kg/m^3)	Comments
Standard atmosphere	102	24	58	1.19	
Cold day	90	10	75	1.10	A very cold, cloudy day (e.g. North England)
Hot day	120	38	20	1.34	A hot, dry day (e.g. Perth, Adelaide, Melbourne)
Warm, humid day	110	30	75	1.25	A warm humid day (e.g. Brisbane)

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