The laminar to turbulent transition on a new cricket ball (of diameter 7.2 cm) occurs at a Re_D of about 1.4×10^5 if the flow does not encounter the seam. But it can be triggered by the seam e.g., at a Re_D as low as 9.5×10^4 (when it is at 30° to the airflow). Use the above information to advise a seam bowler about the speed in which he has to bowl to achieve swing of the ball. A very brief (two lines) reason must accompany your suggestion. The kinematic viscosity of air is 1.5×10^{-5} m²/s. 4

Cricket commentators often talk of late swings referring to balls that swings unpredictably late in flight. Explain this phenomenon based on the following facts. Consider a cricket ball of mass 0.156 kg and diameter 7.2 cm, being bowled at a speed of V_o (greater than the upper critical speed of the previous problem). If the drag coefficient in this situation is constant at 0.15, estimate the velocity at which the ball must be bowled so that it starts to late-swing at a distance of 15m from the bowling end. From your calculations, do you feel that a swing bowler can plan his delivery for a late swing or whether this delivery is just a matter of chance? Given $\rho_{air} = 1.22$ kg/m³. 6

(a) When the ball does not encounter the seam,

$Re_D = 1.4 \times 10^5$, transition Reynold's no.

$$\therefore V_{upper} = \frac{Re_D \times \nu}{D} = \frac{1.4 \times 10^5 \times 1.5 \times 10^{-5}}{7.2 \times 10^{-2}} \frac{m}{s} = 29.167 \text{ m/s}$$

$V_{upper} = 105$ km/hr.

When the ball encounters the seam,

$Re_D = 9.5 \times 10^4$, transition Re. no.

$$V_{lower} = \frac{9.5 \times 10^4 \times 1.5 \times 10^{-5}}{7.2 \times 10^{-2}} \frac{m}{s} = 19.79 \frac{m}{s} = 71.25 \frac{kg}{hr}.$$

When the speed is above 105 km/hr, turbulent B.L. exists on both sides of the ball, thus there will be no pressure difference on the two sides and hence no swing.

When the speed of the ball is below 71.25 km/hr, laminar B.L. exists on both sides, thus no swing.

However if the speed is in between these two values, laminar b.L. on one side, turbulent b.L. on the other. Hence pr. difference => swing of the ball.

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When velocity of the ball is greater than the up critical velocity (Km/h), the ball does not
But during its path, the ball encounters a drag that reduces its velocity. If the velocity redu $V_{upper\ critical}$, the ball will start swing. This phenomenon is late swing.

Thus

$$\text{Drag force} = -m\frac{dv}{dt}$$

$$\underbrace{C_D \cdot \frac{1}{2}\rho V^2 \cdot \frac{\pi D^2}{4}}_{\text{frontal area}} = -m\frac{dv}{dt}.$$

$$\int_0^t 0.15 \times \frac{1.22}{2} \times \frac{\pi \times (7.2\times10^{-2})^2}{4} \times \frac{1}{0.156}\, dt = -\int_{V_i}^{V_{cr}} \frac{dv}{v^2}$$

$$-\left(\frac{1}{V_i} - \frac{1}{V_{cr}}\right) = 2.39\times10^{-3}\, t. \quad \text{—(1)}$$

and

$$t \approx \frac{L}{v_i} = \frac{15}{V_i} \quad (\text{approx})$$

$$\frac{1}{V_{cr}} - \frac{1}{V_i} = \frac{0.0358}{V_i}$$

$$V_i = 1.036\, V_{cr(upper)}.$$

Therefore to expect late swing (at a distance of 15 m) the ball has to be bowled with a velocity (=108.8 Km/hr) equal to 1.036 times $V_{upper\ critical}$. Since this value is so close to the upper critical velocity, late swing appears to be a matter of chance.