AerE 344: Undergraduate Aerodynamics and Propulsion Laboratory

Lab Instructions

Lab #01: **Flow Visualization with Smoke Wind Tunnel**

Purpose: Use of Collins 690A-1 smoke tunnel to visualize the flow patterns as the airflow passes 2-D and 3-D models for studying the aerodynamic characteristics of bluff and streamline bodies.

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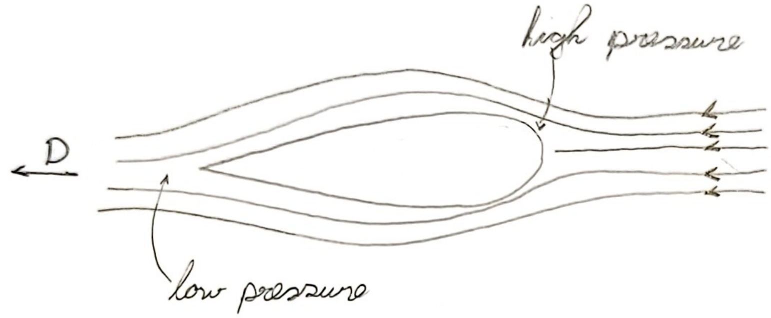
First Last

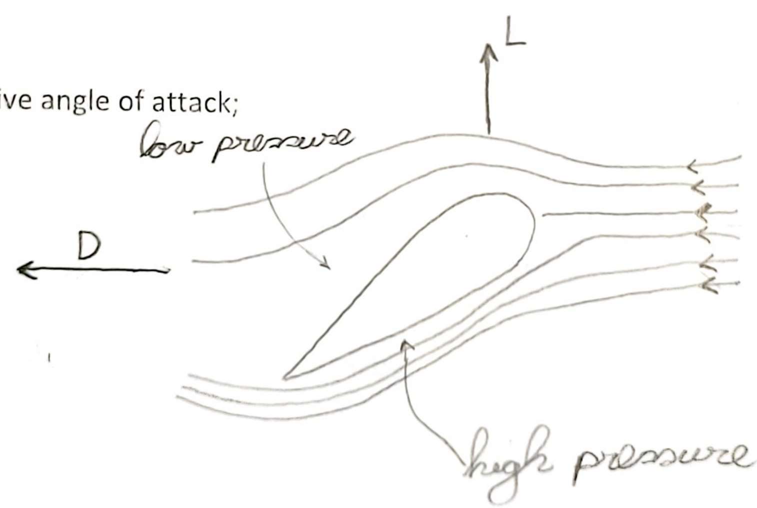
NOTE. On all sketches (for all questions), label areas of the highest and lowest pressure. If a lift force exists, draw a vector to represent it.

1. Sketch the flow pattern over a symmetrical airfoil for the following conditions:

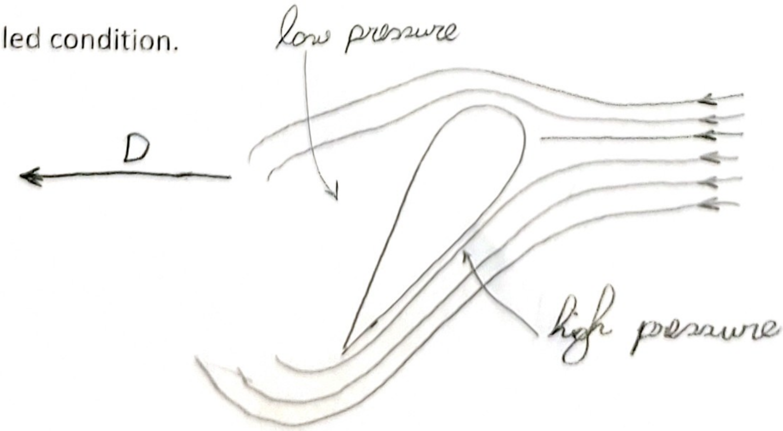
(a). "No Lift" condition, $\alpha=0$ °;



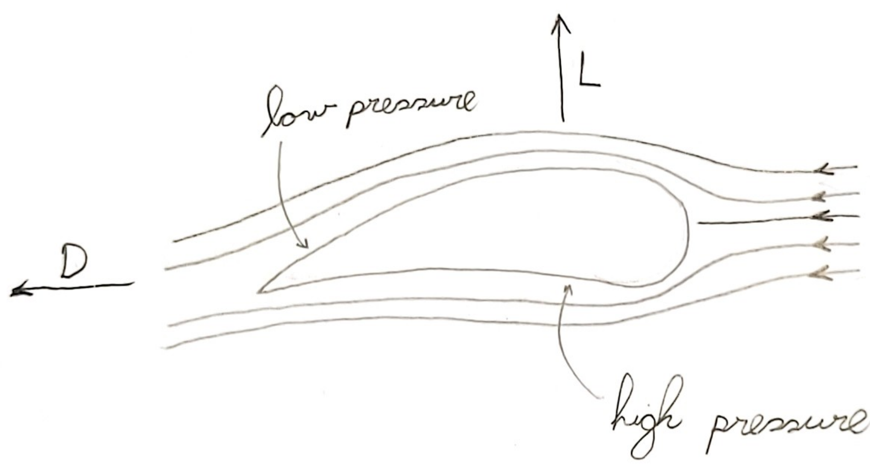
(b). A positive angle of attack;



(c). Stalled condition.



2 (a) Sketch the flow pattern around a cambered airfoil at zero angle of attack.

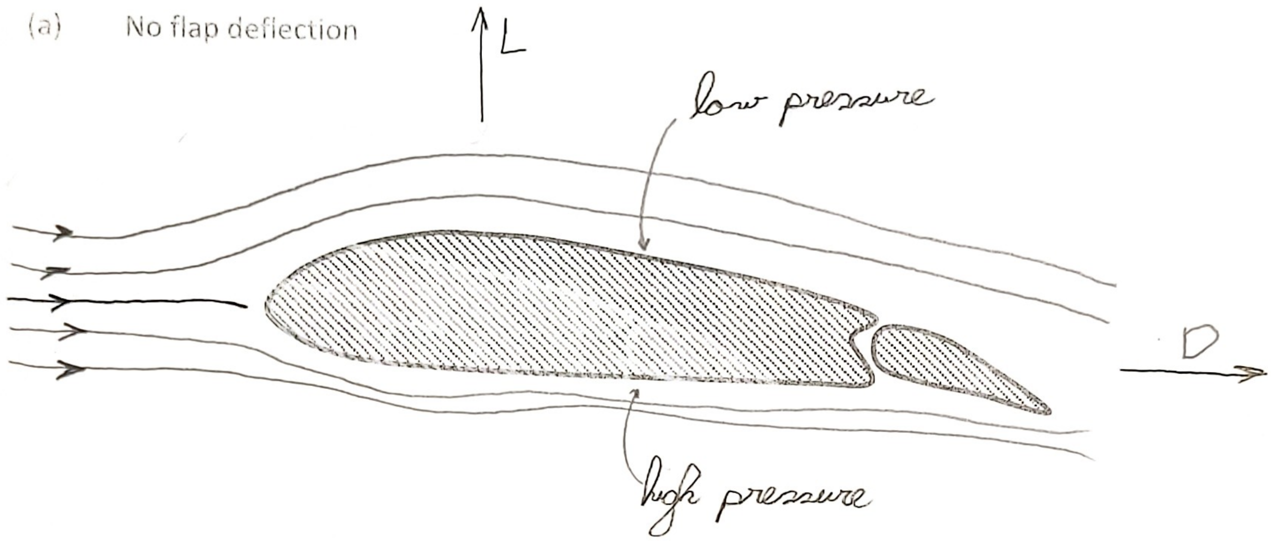


(b) Discuss the difference in the flow patterns around a symmetrical airfoil and a cambered airfoil at zero angles of attack.

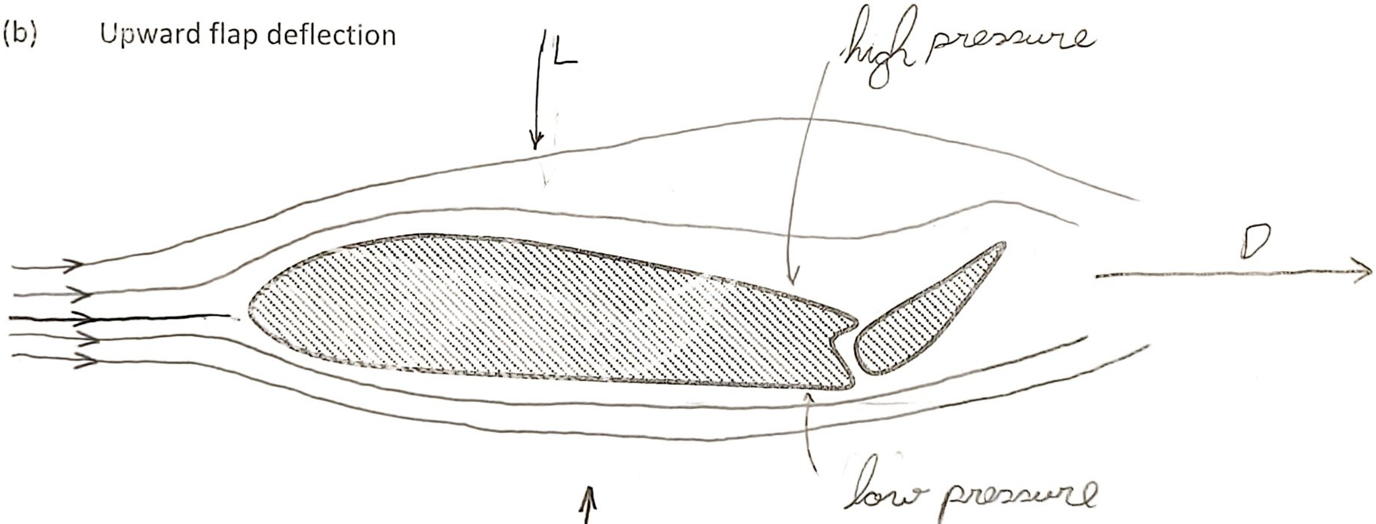
A symmetric airfoil, meaning possessing identical bottom and top surfaces, results in a symmetric flow distribution and the lack of a lift force at zero angle of attack. On the other hand, the cambered airfoil possesses a curvier top surface and a flatter bottom surface. Thus, there is a pressure difference between the top and bottom surfaces at zero angle of attack, generating a lift force.

3. Sketch the flow pattern around the airfoil and flap with the flap deflection specified.

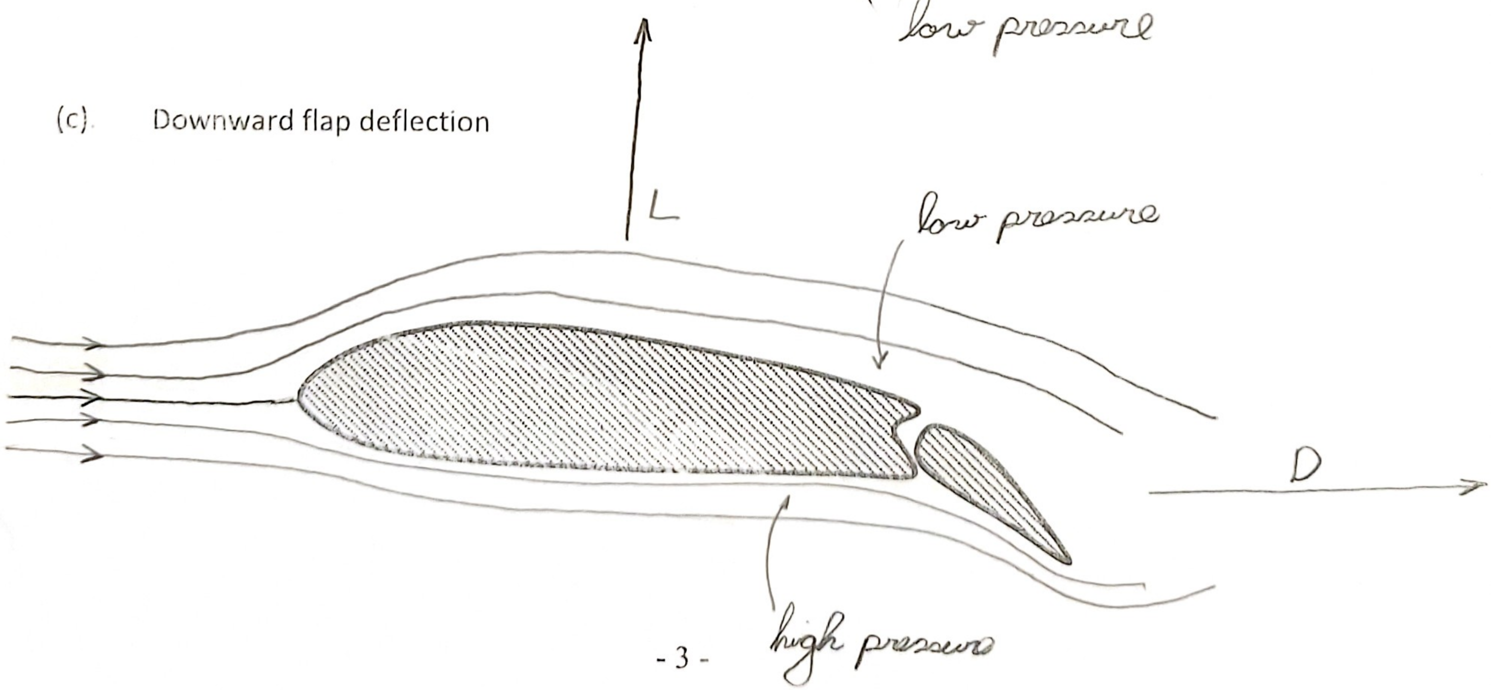
(a) No flap deflection



(b) Upward flap deflection



(c) Downward flap deflection



(d) Considering only the flow pattern around the airfoil state which of the above three conditions produces the greatest lift coefficient. Based on your observation of the flow pattern, state how you arrived at this solution.

Downward flap deflection. From observation, I could notice how the air flows even slower on the bottom surface compared to the top surface and the other configurations. With that we know the pressure will be higher, generating more lift.

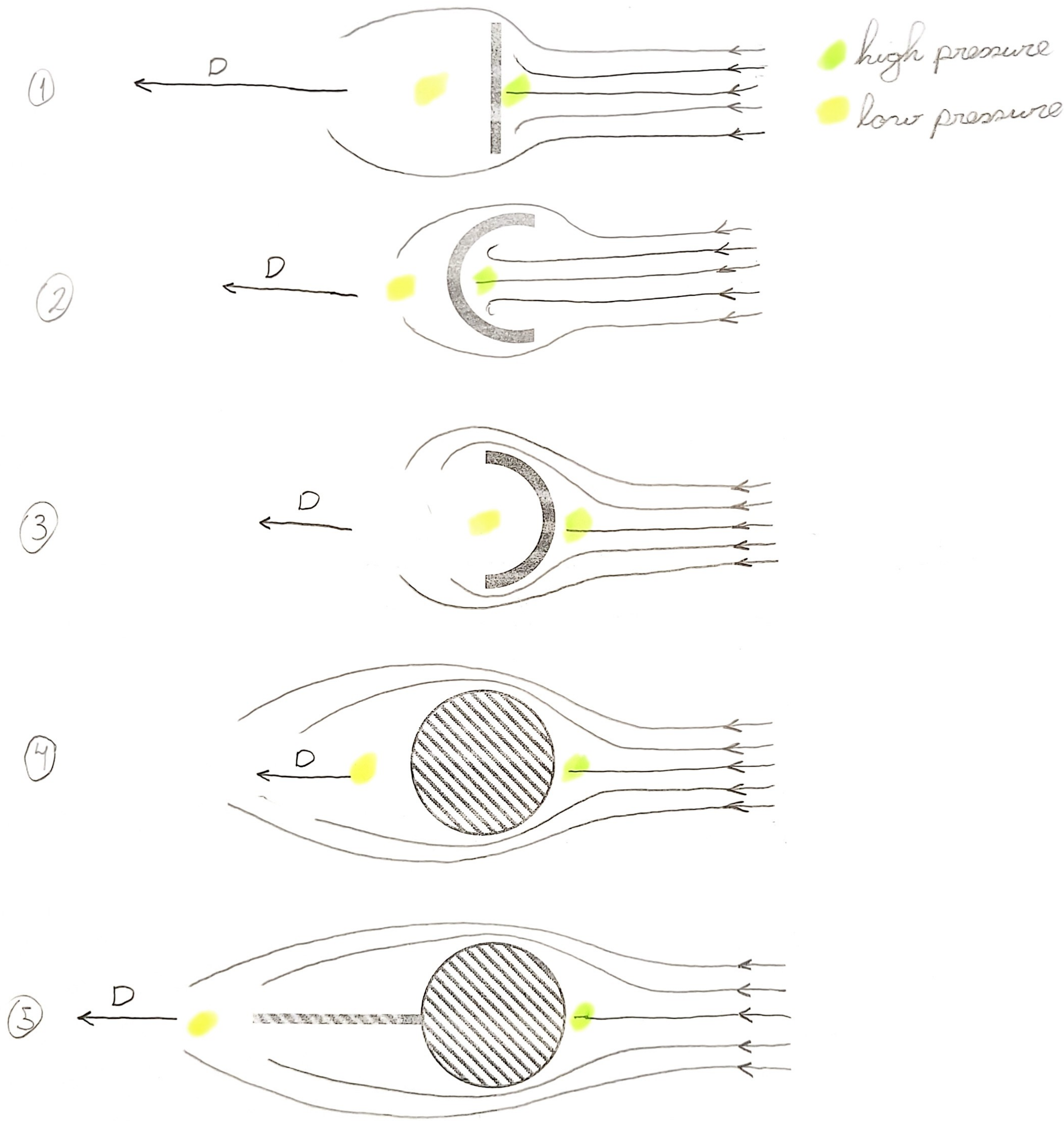
4. Describe the effects on a C_l vs. angle of attack plots of the symmetrical airfoil (Problem 1), cambered airfoil (Problem 2) and cambered airfoil with flap (Problem3).

- For the symmetrical airfoil, the zero lift angle of attack is 0, the C_L increases linearly as the angle of attack increases.

- For the cambered airfoil, the zero lift angle of attack is negative, the line of best fit is similar to the symmetrical airfoil one, but includes a broader range of C_Ls and respectives angle of attack, the stall behavior is often more gradual.

- The cambered airfoil with flap, compared to the cambered airfoil possess greater lift coefficients within respective angle of attack, specially for lower angles of attack. It also presents an extended C_L range, and delays the stall.

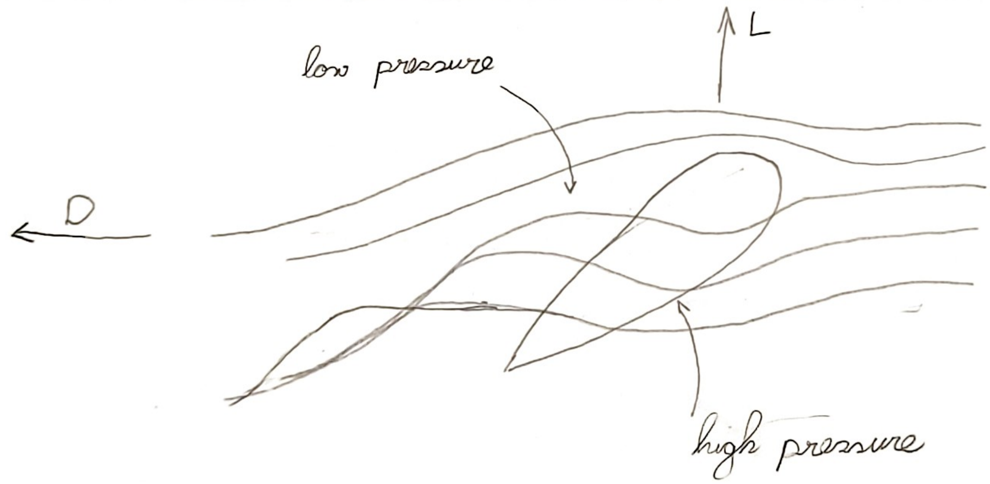
5. (a) Using the smoke tunnel, sketch the flow pattern around the five shapes tested.



(b). Discuss the relative magnitude of the drag of the different configurations in consideration of the streamlines and the wake width.

The vertical bar in 1 clearly creates more drag among the different configurations. The C-shape in 2 create some considerable drag, and the rounded shape behind induce the streamlines to circulate. In 3, the rounded front shape helps reducing drag, but circulation is still induced by the lack of volume in the back. In 4, the full circle shape already helps reduce circulation. Shape 5 acts almost like a symmetric airfoil

6. (a) Sketch the flow pattern around the tip of a finite wing.



(b) Explain how this difference (compared to the 2-D cases) gives rise to another form of drag known as 'induced drag'.

A 3D wing has a finite span, we need to consider that the air flows in 3 directions, in contrast to a 2D airfoil where we are just considering 2 directions. At the wingtip, vortices are created due to the pressure differences along the wingspan while it generates lift. Those vortices cause downward movement of air. They are known as induced downwash and can be observed on the sketch above.