1. Class 1: Aug 14

21 September 2020 13:22

What is flight?

Flight is the act of staying in air by generating an upward force (lift)

- ▶ If I throw a stone does it fly?
- ▶ If I drop a feather?
- ► I drop a parachute?
- ► I throw or launch a glider?

What do all of these objects have in common?

Why does an airplane fly?

An airplane flies by generating enough lift to balance its load It flies in a straight level flight for the given conditions

Important Fundas from Eng Mech.

$$\sum \vec{F} = 0$$

and

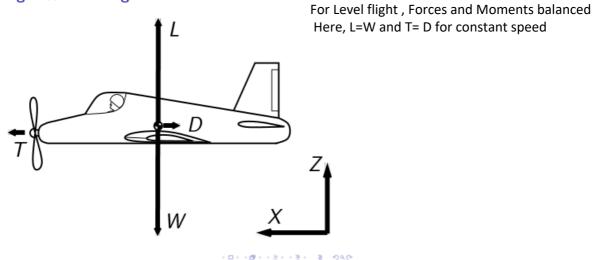
$$\sum \vec{M} = 0$$

(1) Thus, the enginer can produce Thrust<Weight as that thrust is able to generate enough lift to

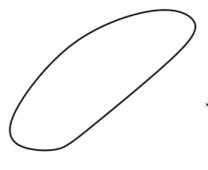
balance the weight of the loaded airplane

An Antonov An-225 has a maximum takeoff weight of 640,000 kg.

Straight & Level Flight



3D Airfoil



produces an aerodynamic force.

Generally, a well-designed airfoil generates more lift

And Airfoil is the cross-sectional shape of a wing, blade etc. An airfoil shaped body moving through a fluid

Generally, a well-designed airfoil generates more lift than drag it experiences.



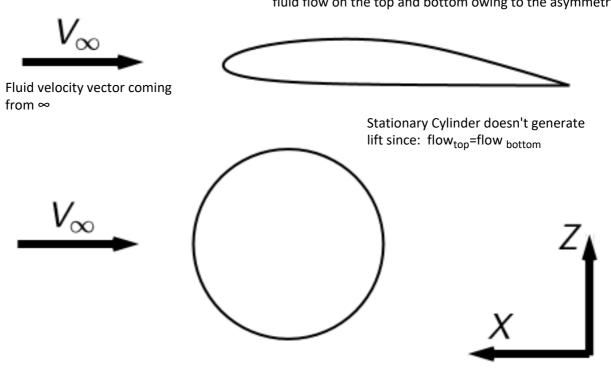
40 × 48 × 48 × 40 × 40 ×

Large lift L for small drag D

Airfoil cross-section / Circular Cylinder

Lift is created due to pressure difference due to unequal fluid flow on the top and bottom owing to the asymmetry

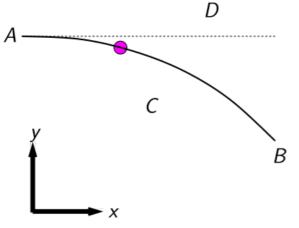
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The motion of a fluid is governed by the difference in pressure

Fluid Particle Dynamics

If fluid particle goes A --> B and not A --> D, we can conclude that $P_B < P_D$

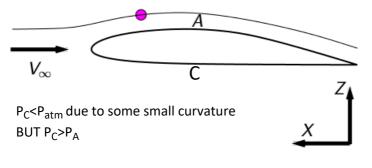


2D Airfoil - lift?

Hence $P_B > P_A$ and $P_B < P_{atm}$

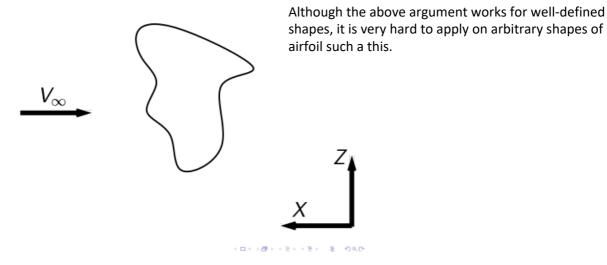
B If B is far away from the wing $P_B = P_{atm}$

900 S 151 151 101 101



Hence an upward force if generated due to the pressure difference

2D Arbitrary Shape



2D Airfoil - lift?

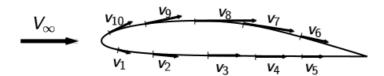


Thus $V_{upper} > V_{lower}$



Bernoulli's Equation $p+rac{1}{2}
ho V^2=$ Constant, So, $V\uparrow\Longrightarrow p\downarrow$



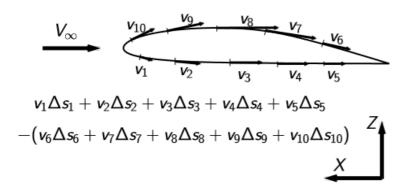


We quantify this by taking points on the wing and taking a small distance on the wing along the wing profile.



40 - 48 - 48 - 48 - 40 - 40 -

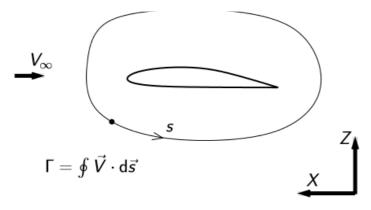
2D Airfoil - lift?



4 D > 4 B > 4 S > 4 S > 4 B + 9 9 4 C

2D Airfoil - lift?

We mathematically define it as Circulation



If we have circulation there is a possibility of lift



2D Airfoil - lift?

How do forces experienced generally depend on:

- Material of medium for example water versus air
- depends on density ρ
- Speed of movement traveling faster versus slower
- depends on speed V
- Circulation more circulation versus less circulation
- depends on circulation Γ



2D Airfoil - lift?

Kutta - Joukowski Force

$$L = \rho V_{\infty} \Gamma$$

In any formulae always check dimensions