

॥ नमस्ते ॥



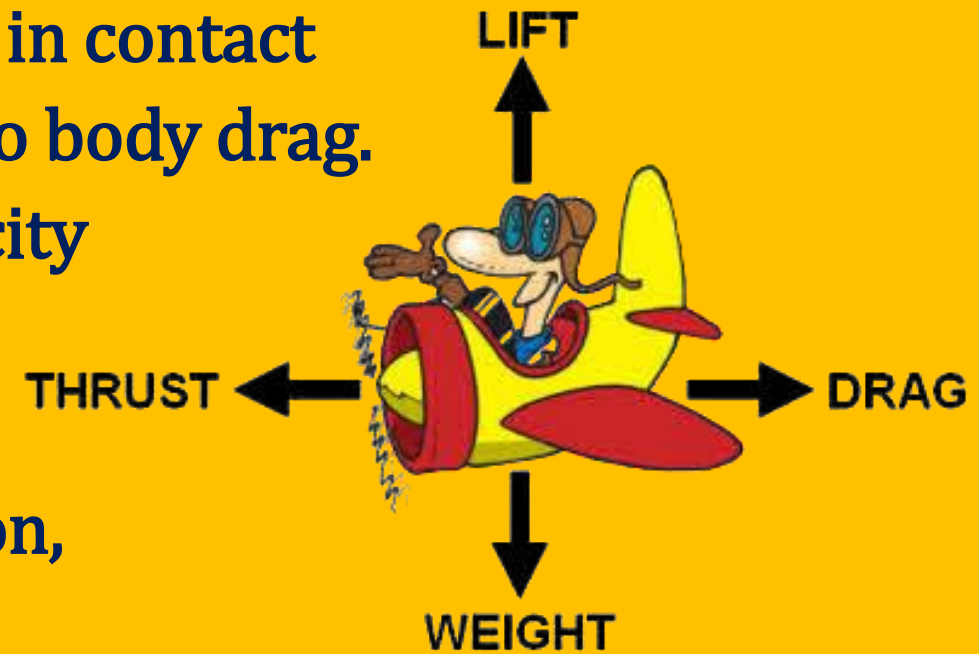
DRAG

WHAT IS A DRAG?

- Drag is the aerodynamic force that opposes an aircraft's forward motion through the air.
- Drag is generated by every part of the airplane (even the engines!).
- Drag is a force and is therefore a vector quantity having both a magnitude and a direction.
- Drag acts in a direction that is opposite to the motion of the aircraft. Lift acts perpendicular to the motion.
- Drag is pulling backward or pushing backward force.



- ✓ Drag is a mechanical force.
- ✓ it is generated by the interaction and contact of a solid body with a fluid (liquid or gas).
- ✓ For drag to be generated, the solid must be in contact with the fluid. If there is no fluid, there is no body drag.
- ✓ Drag is generated by the difference in velocity between the solid object and the fluid.
- ✓ There must be motion between the object and the fluid. If there is no motion, there is no drag.
- ✓ It makes no difference whether the object moves through a static fluid or whether the fluid moves past a static solid object.



TYPES OF THE DRAG

1. Parasite Drag
 - a) Form Drag /Pressure Drag
 - b) Skin friction Drag
 - c) Interference Drag
2. Induced Drag
3. Wave Drag

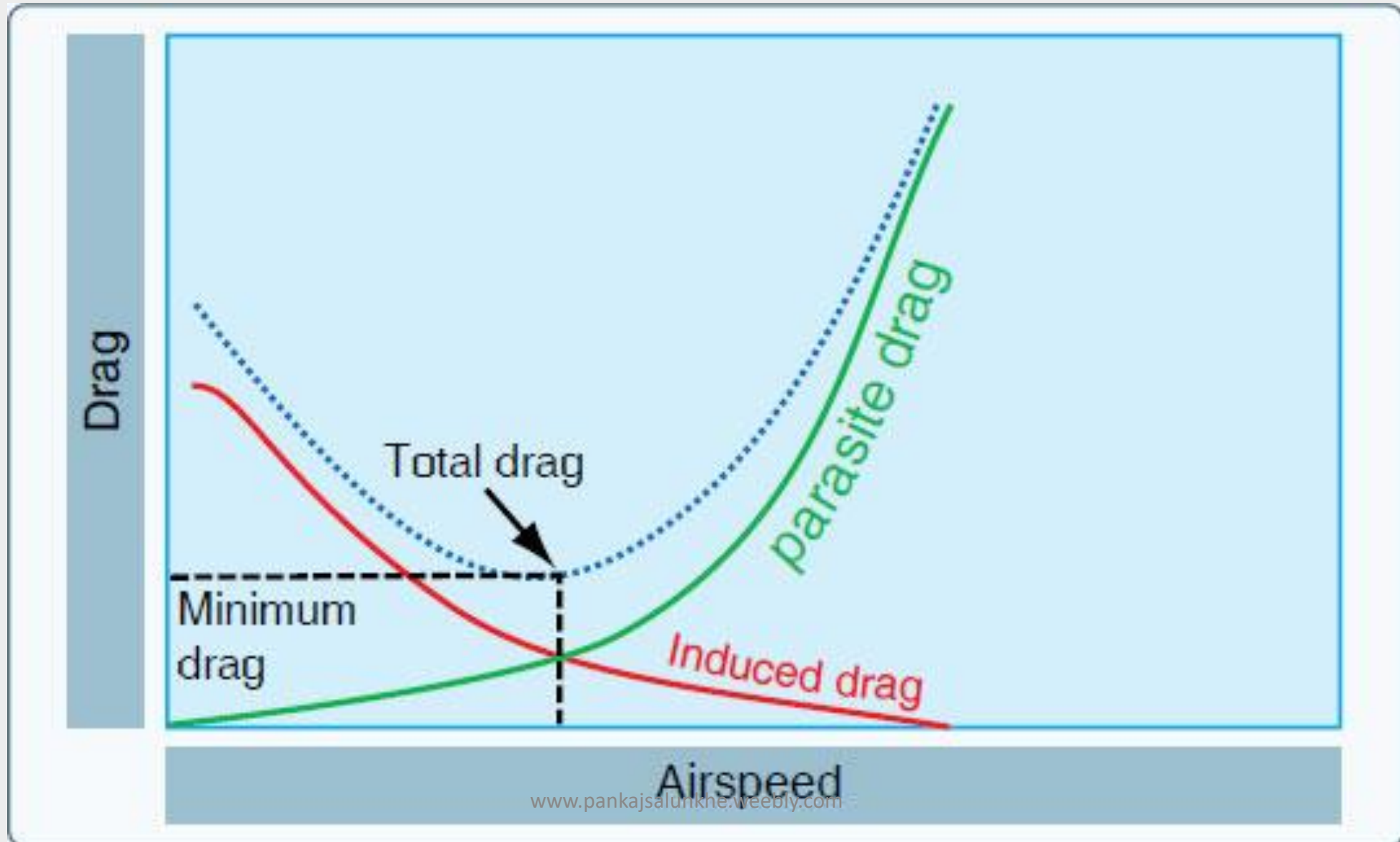
1. PARASITE DRAG

- The vortices or wakes are formed due to the aircraft's parts, shape, construction, fuselage attachments, and aircraft material that is called parasite drag.
- Parasite drag is further divided into three types
 - a) Form Drag /Pressure Drag
 - b) Skin friction Drag
 - c) Interference Drag

The sum of above drag is called parasite drag.

- Parasite is proportional to aircraft velocity. That means parasite drag increases with square of aircraft velocity.

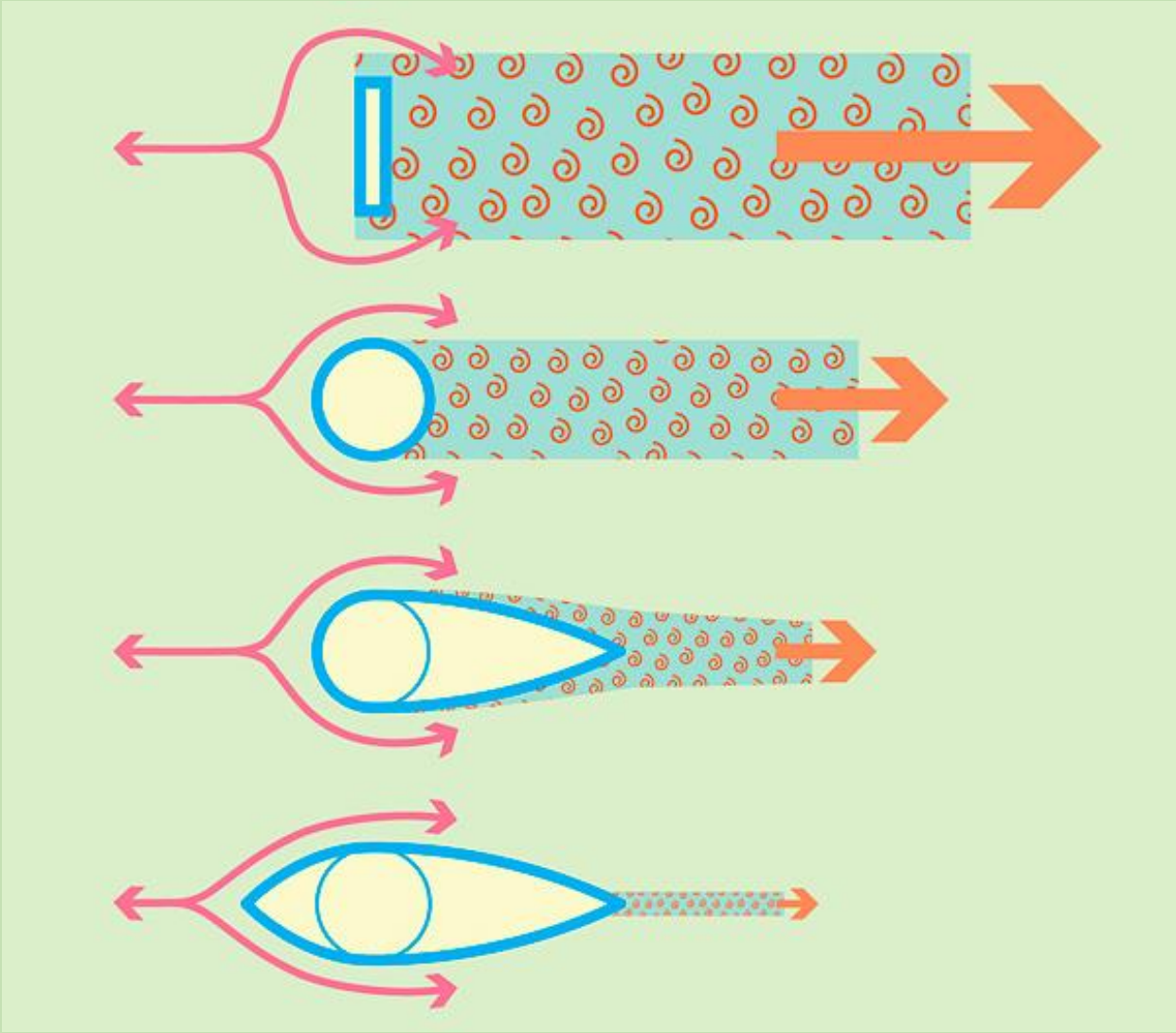
Parasite drag vs. velocity

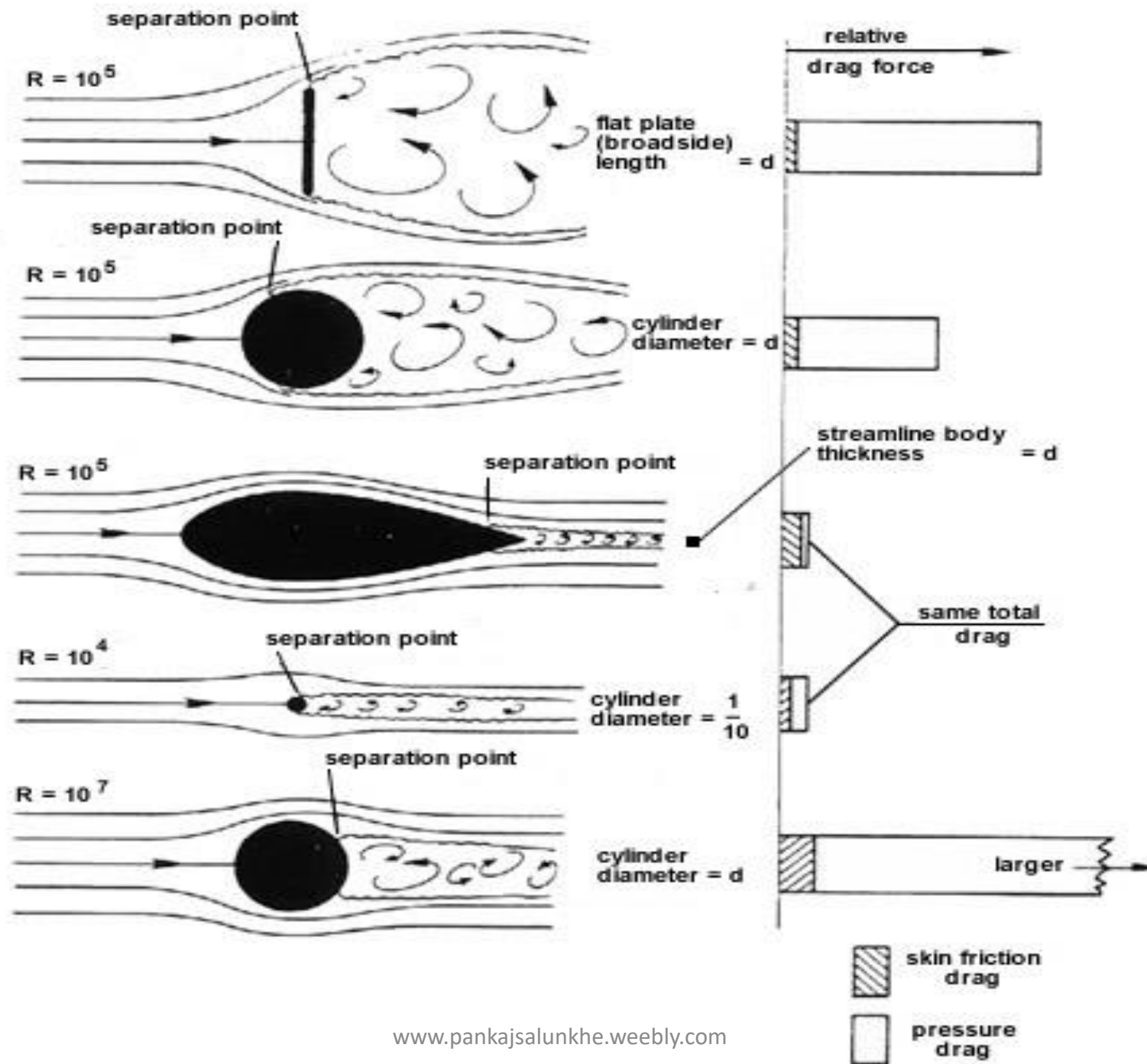


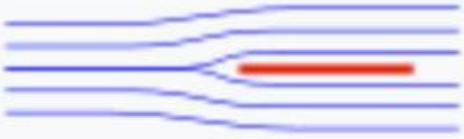
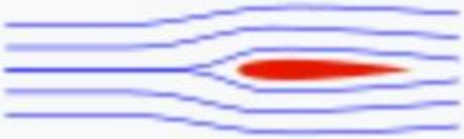

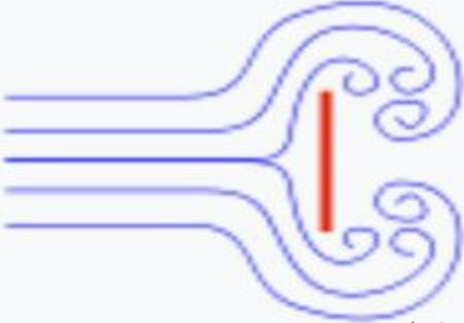
1.A) FORM DRAG / PRESSURE DRAG

- Form or pressure drag is subtype of parasite drag.
- The drag which is depend on the frontal area and air flowing over the aircraft.
- The separation of the air creates turbulence and results in pockets of low and high pressure that leaves a wake behind the aircraft.
- These wakes opposes the forward motion of the aircraft due to pressure difference.
- Since the drag is due to shape of the aircraft/ aerofoil and frontal shape of the aircraft / aerofoil so this drag is called form drag or pressure drag.

FLOW OVER THE DIFFERENT SHAPES

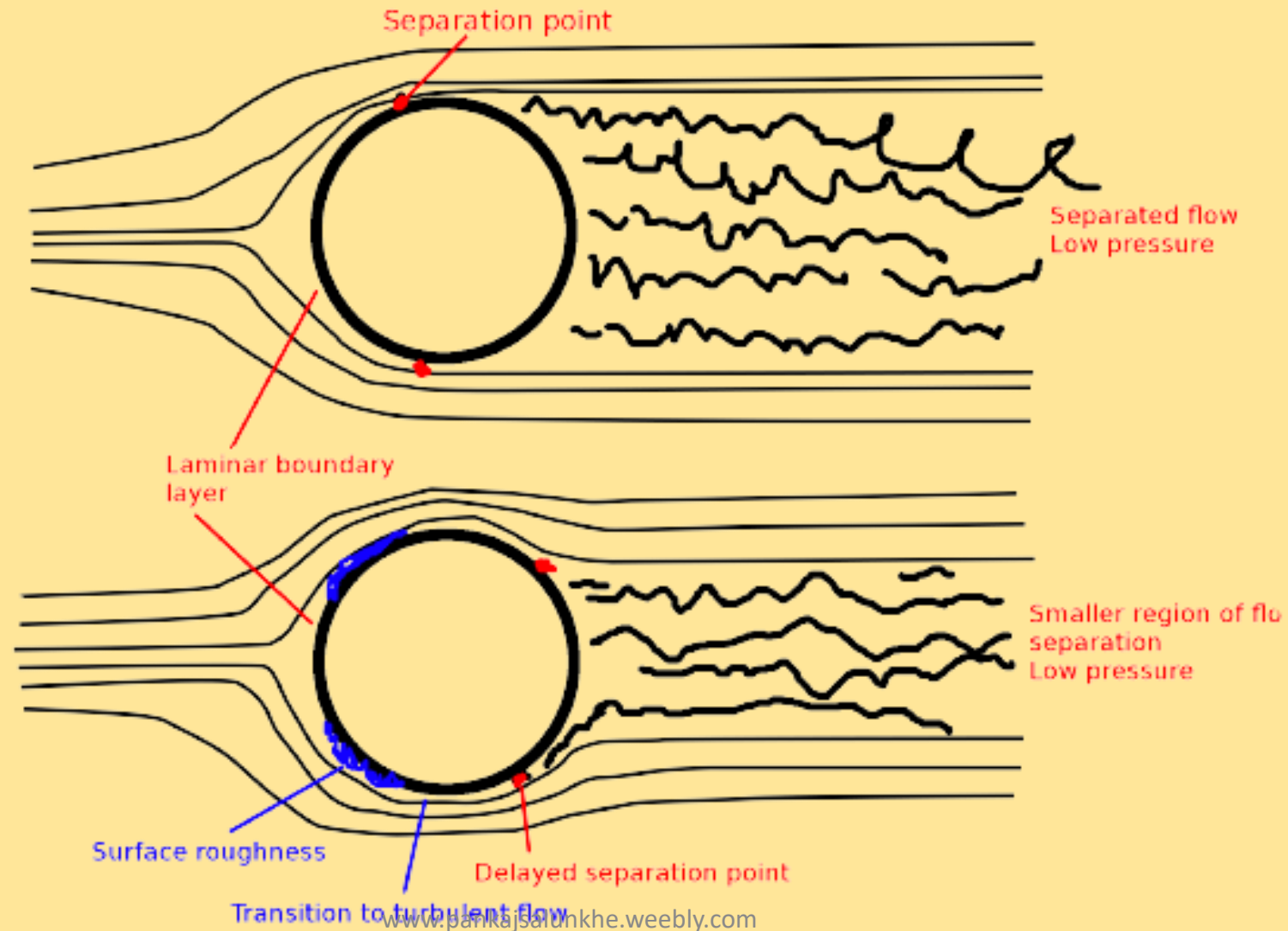




Shape and flow	Form Drag	Skin friction
	0%	100%
	~10%	~90%
	~90%	~10%
	100%	0%

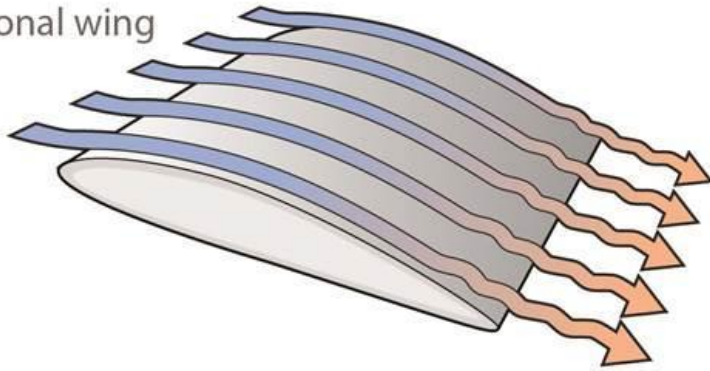
Methods to reduce pressure drag

- Pressure drag is less in turbulent flow.
- Pressure drag is more in laminar flow

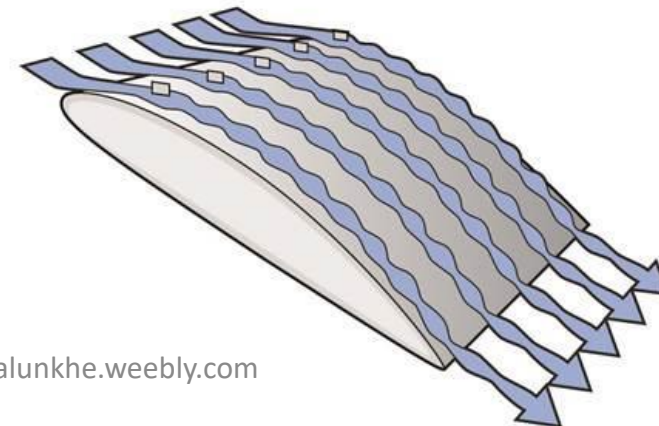
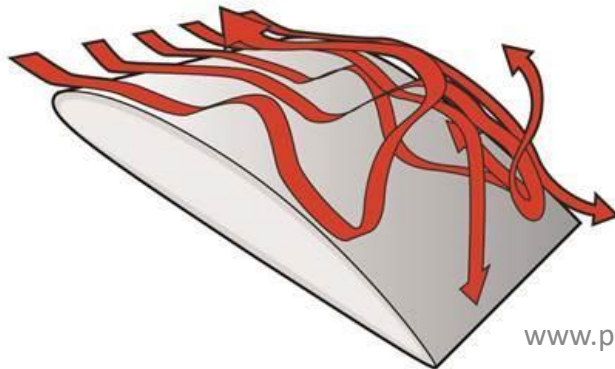
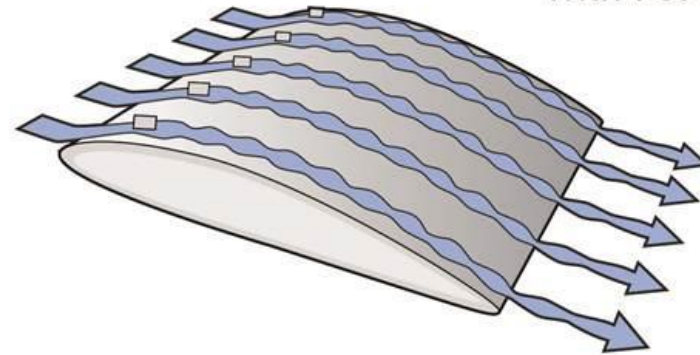


Using vortex generator on upper surface of the aerofoil just before the separation point /transition point.

Traditional wing



With VGs

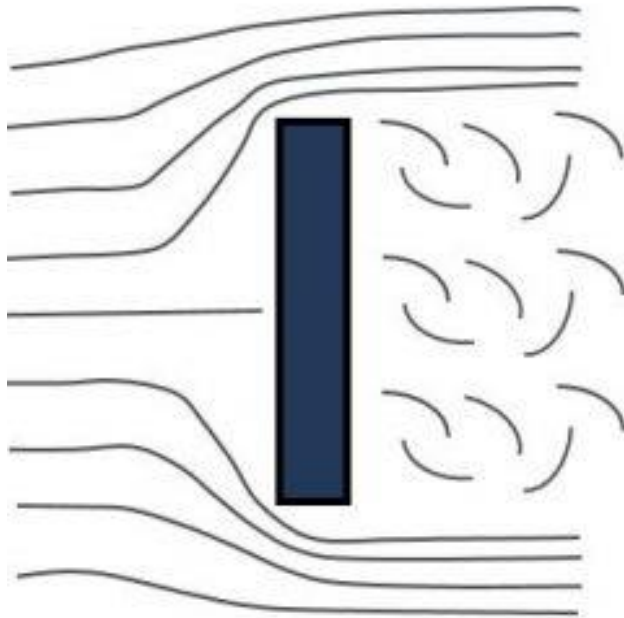


VORTEX GENERATOR ON AIRCRAFT



Reduce the frontal area

Flat Plate - High Pressure Drag

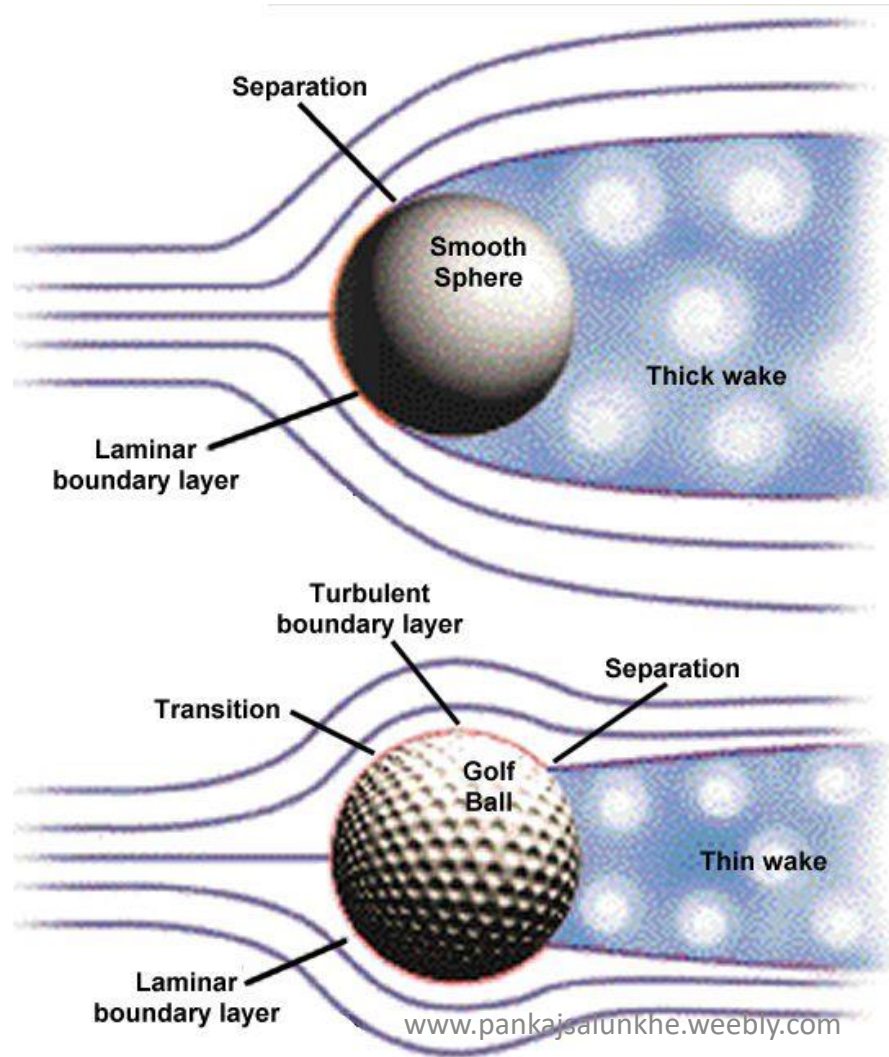


Airfoil - Low Pressure Drag



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Using the turbulent flow over the aerofoil



Using advanced shark skin Technology.





Today's Amazing Fact



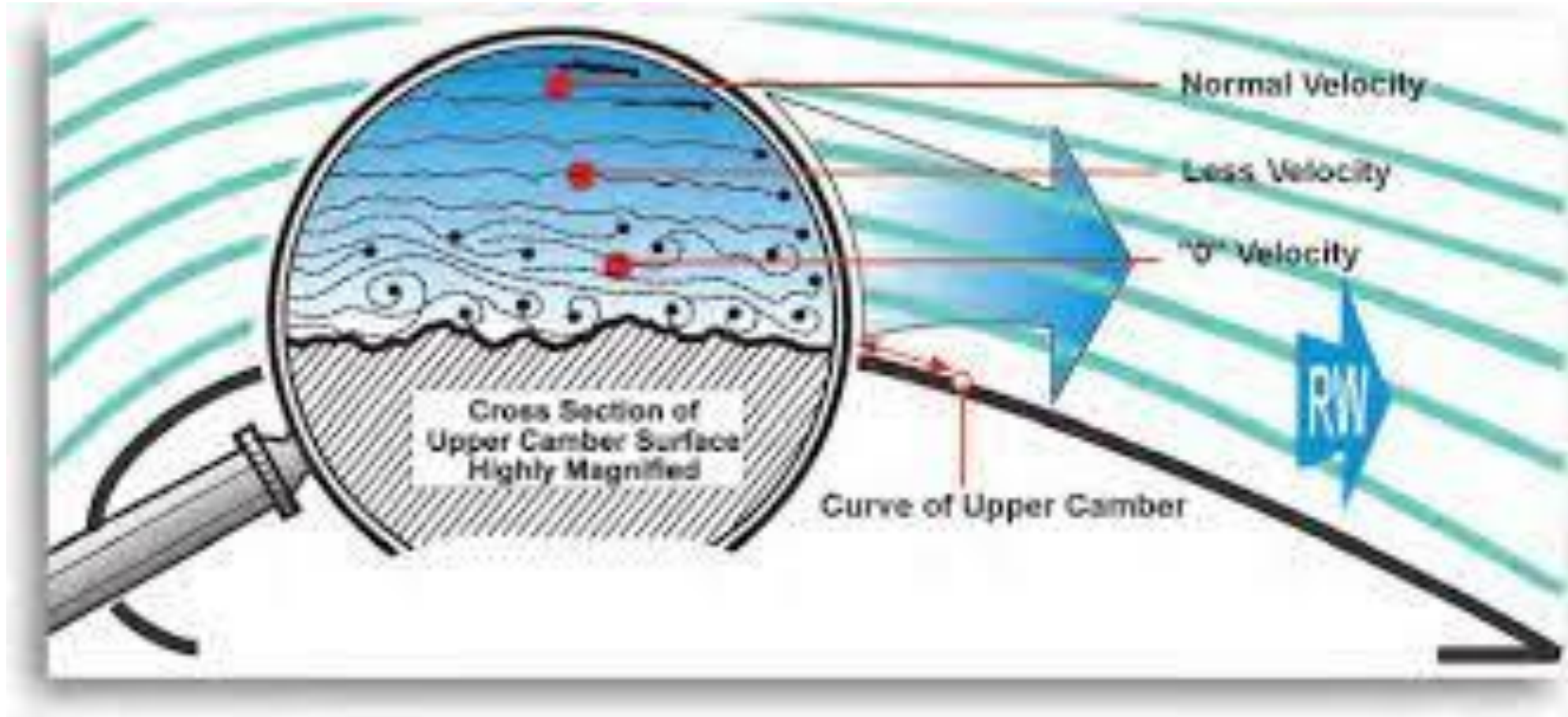
While you sleep you cant smell anything ...Even really really Bad or potent smells

1.B) Skin Friction Drag

- It is caused by the friction between air molecules and surface of the aircraft / aerofoil.
- Friction tends to heat generation between air stream lines.
- Increased heat in between air stream lines leads increase the distance between two adjacent air stream line hence boundary layer get separated.
- Due to separation boundary layers get detached from aerofoil surface.

- **Air flow detachment leads to increase adverse pressure gradient.(adverse pressure gradient means when pressure increases and flow velocity negative that means air flow starting to move backward in curly motion)**
- **Flow is detached due to separation. And separation is due to increase in pressure between air stream line.**
- **Detached flow leads to form vortices.**
- **So this vortices formed due skin friction hence this drag is known as skin friction drag.**

SKIN FRICTION DRAG DIAGRAMS

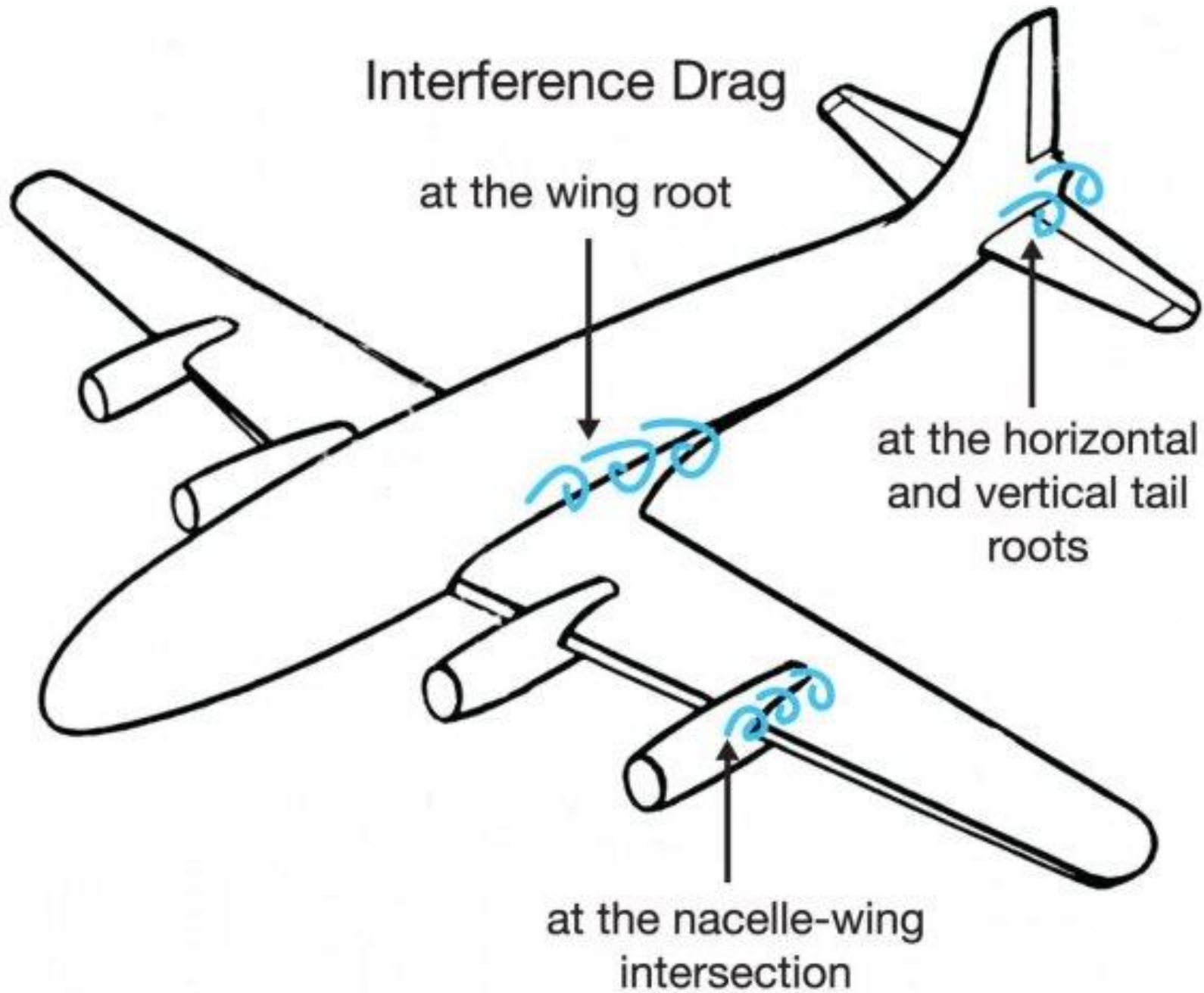


Methods to Reduce Skin Friction Drag

1. By keeping aircraft surface clean and polished
2. By using high quality paints
3. Removing unwanted area so that total area get reduces
4. Use the material of aircraft skin which has low coefficient of friction.

1.C) INTERFERENCE DRAG

- Every part of the aircraft has own boundary layer. Eg. Fuselage has its own boundary layer and wings have their own boundary layer.
- Separate boundary layer means air has different velocity on different parts of aircraft.
- When two different boundary layers intersect with other then third boundary layer is created that is called eddy current. Eddy current means small diameter vortices.
- Now those eddy current vortices formed due to intersection of two different boundary layers so this drag is called interference drag.
- Eddy current will create turbulence , swirling flow, and reduce the flow velocity which restrict the smooth flow.



Interference Drag

at the wing root

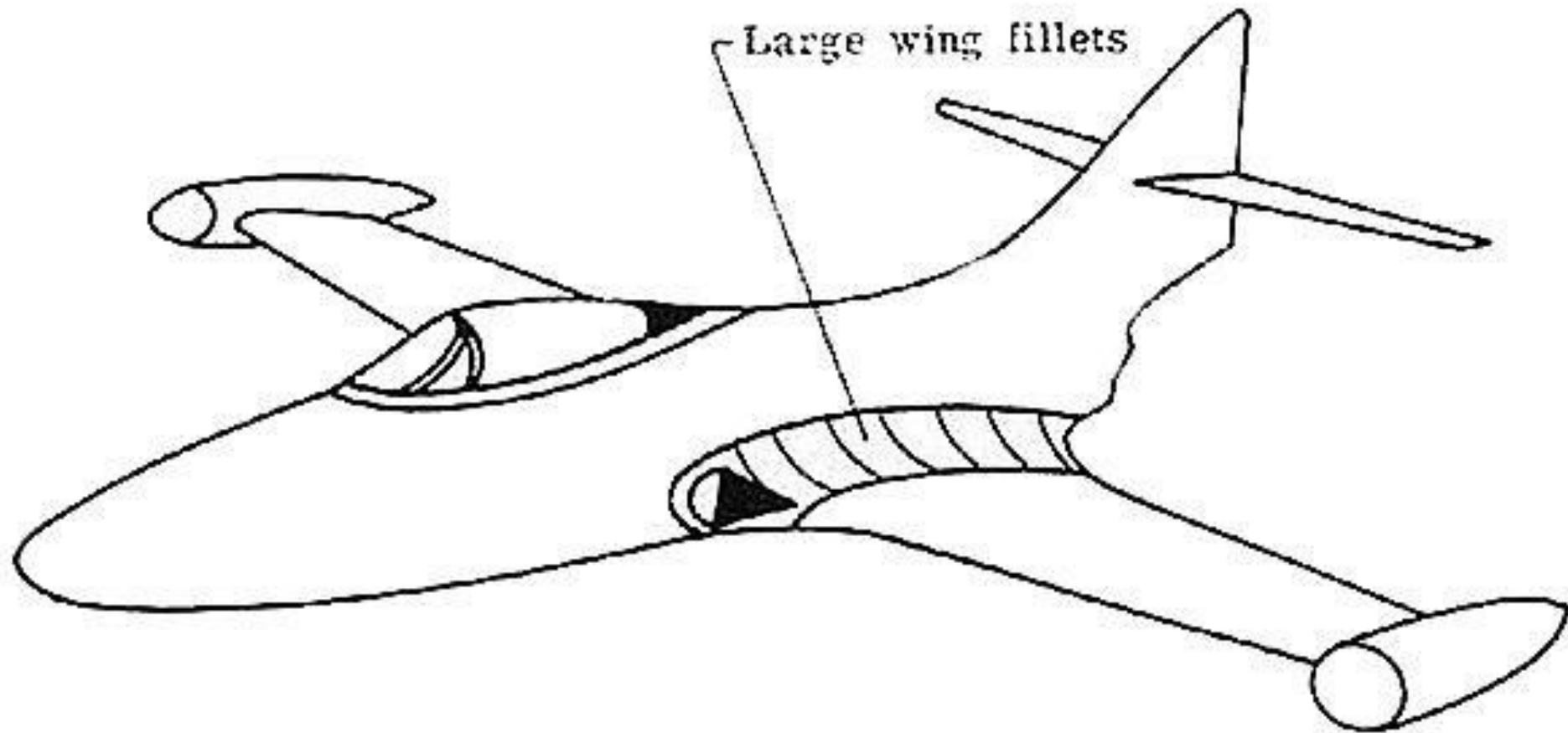
at the horizontal
and vertical tail
roots

at the nacelle-wing
intersection

Methods to Reduce Interference Drag

- **Avoid the attachment of two parts in perpendicular instead provide round fillet to attachment**
- **Use the aerofoil shape antenna instead of long telescopic circular shape antenna.**
- **Avoid the mounting or attaching the unwanted objects or instruments on fuselage.**

Avoid the attachment of two parts in perpendicular instead provide round fillet to attachment



USE THE AEROFOIL SHAPE ANTENNA INSTEAD OF LONG TELESCOPIC CIRCULAR SHAPE ANTENNA.





**The smell of an orange
relieves stress.
Smelling and eating an
orange can reduce the
stress up to 70%.**



2. Induced Drag

- According to Bernoulli's theorem, Upper surface of the aerofoil has more velocity due to more curvature and lower surface has low velocity due to less curvature.
- So that upper surface create low pressure and lower surface create high pressure. And this pressure difference responsible for lift generation.
- As per the nature law, Fluid always travel from high pressure to low pressure.
- So that air at tip try to flow from lower to upper surface and this motion will create wing tip vortices.
- The drag is caused by this wings tip vortices is called induced drag.
- Induced drag is inversely proportional to the square of the speed whereas all other drag is directly proportional to the square of the speed.

Wingtip Vortex



Low Pressure

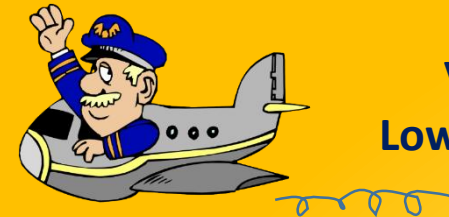
High Pressure



- **As we know that higher the pressure difference between upper and lower surface more the lift produces and same time larger the diameter of wingtip.**
- **So we can conclude that vortices diameter is proportional to the lift.**
- **Induced drag is also called DRAG DUE TO LIFT because induced drag is proportional to the lift.**

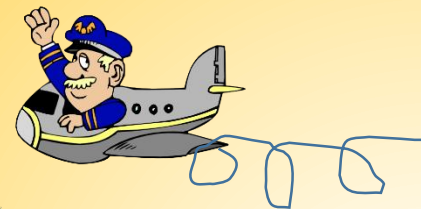
Why induced drag is less at higher speed?

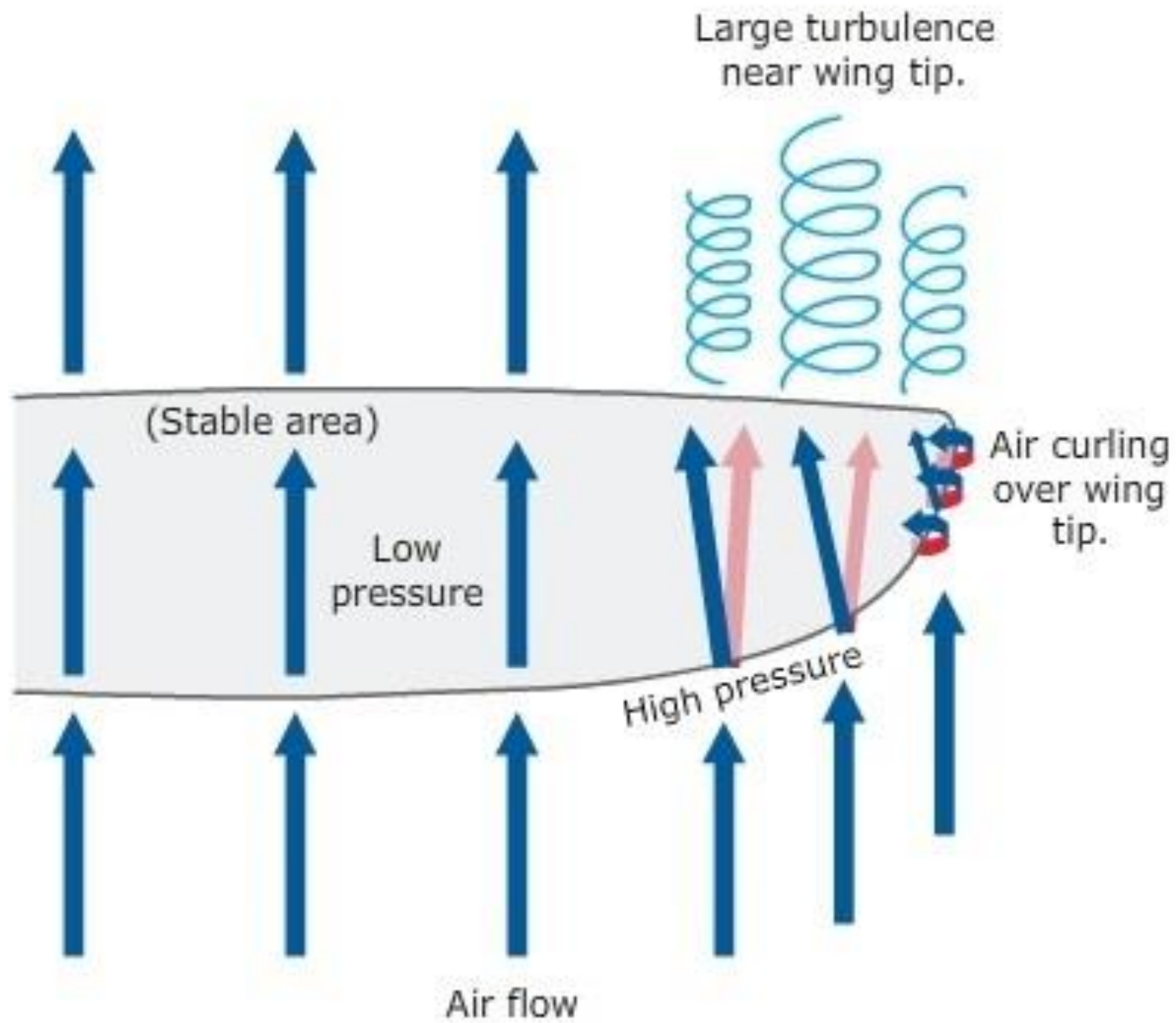
- As we know that induced drag is nothing but wingtip vortices.
- If aircraft is producing more lift then large vortices are formed(High induced Drag) and If aircraft is producing less lift then small vortices are formed(Low induced Drag).
- At the time of take off or landing aircraft has more angle of attack so wings create more lift so aircraft will create more induced drag.
- But at the higher altitude where aircraft has high velocity then aircraft has low angle of attack so aircraft wings generate less lift compared to landing and take off so at the high speed low induced drag.



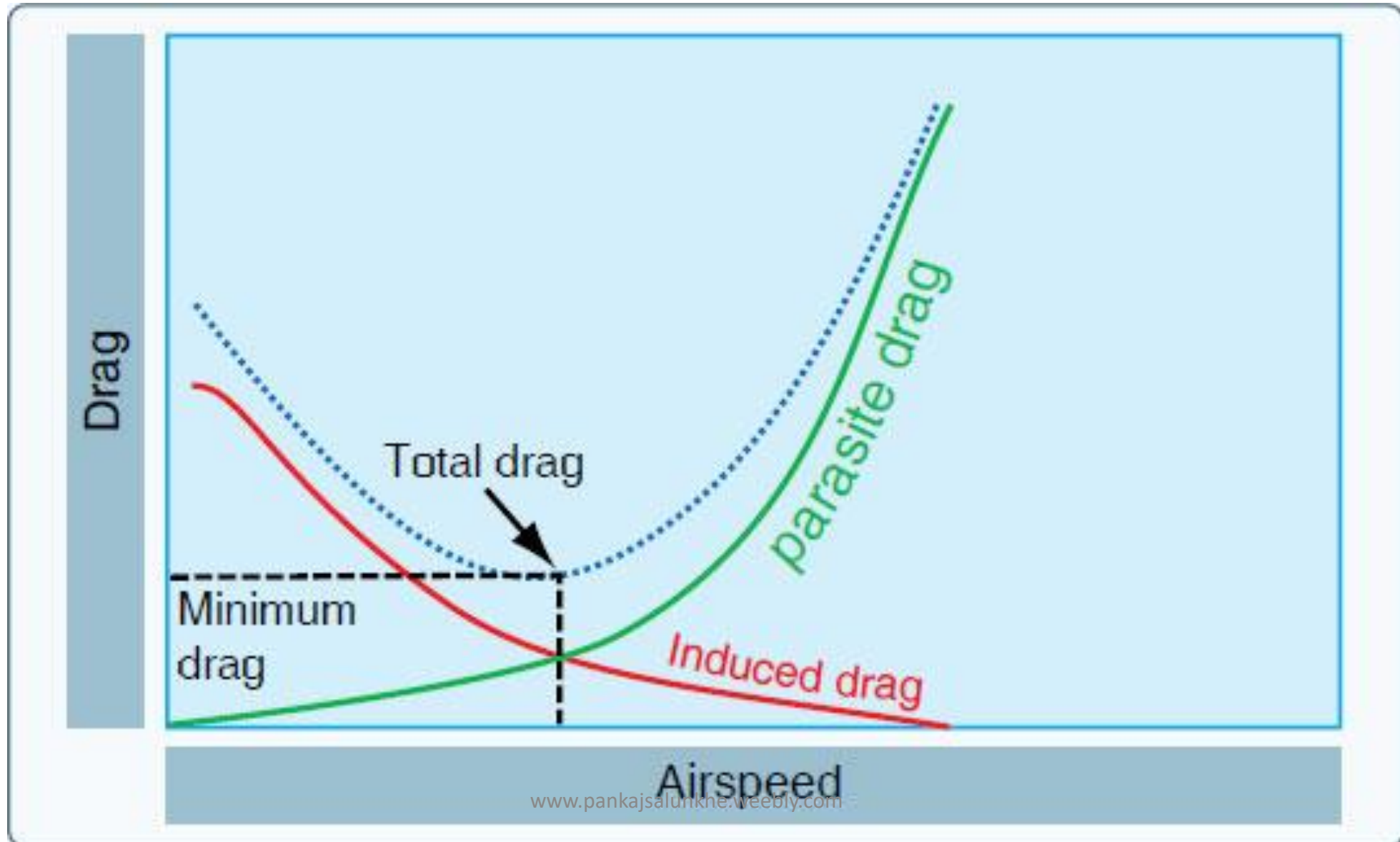
V=200 m/s
Low induced Drag

V=20 m/s
High induced Drag





Induced drag vs. velocity





METHODS TO REDUCE INDUCED DRAG



• **BY USING WINGLETS AND SHARK LETS**

BY USING HIGH ASPECT RATIO WINGS



The forward motion of aircraft is restricted in transonic or sonic and hypersonic speed is called wave drag.



3. WAVE DRAG





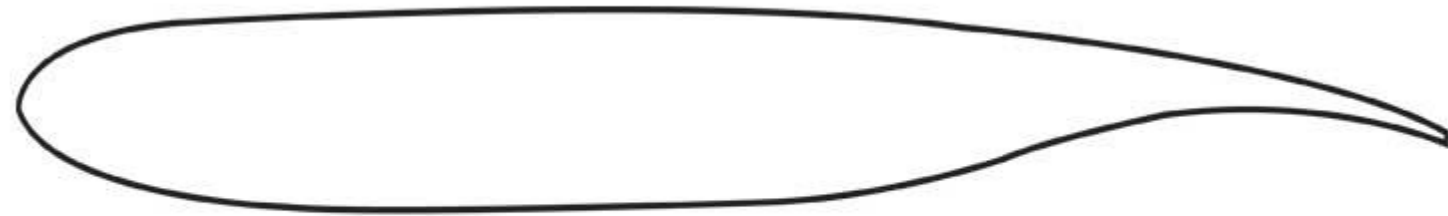
Methods to Reduce Wave Drag

- By using Sweep back wings
- Use supercritical aerofoil
- Using Coke Bottle shape Wings and fuselage configuration.
- Use high fineness ratio wings

BY USING SWEEP BACK WINGS



Use supercritical aerofoil. It delays shock waves



Supercritical wing diagram

**Using Coke Bottle shape Wings and fuselage configuration.
That means reducing fuselage area and increasing wing area**





Use high fineness ratio wings

ANY
QUESTIONS?



**HE NEEDED HIS
MOTHER'S MILK.**

WE DIDN'T.

**Male calves are discarded like trash
because they can't produce milk.**

Go vegan.

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PETA INDIA

धन्यवाद

Prepared By
Mr.Pankaj Salunkhe
(M.Tech Design , B-Tech Aerospace, DME)