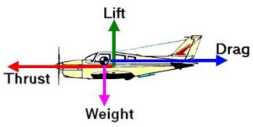
GROUND SCHOOL

PRINCIPLES OF FLIGHT 2

GROUND SCHOOL

LECTURE TWO: DRAG

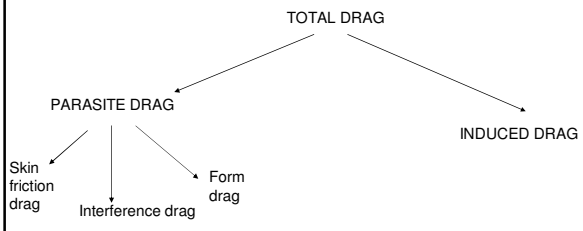
1. The Basics of Drag
2. Aircraft Design and Drag



GROUND SCHOOL

FOUR FORCES: DRAG

Drag is the resistance to movement and acts in the direction opposite to the direction of flight



FOUR FORCES: DRAG: PARASITE DRAG

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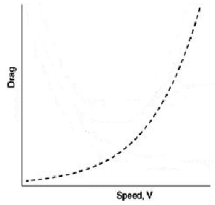
Parasite Drag is caused by the aircraft being in the airflow



Parasite Drag increases as speed increases

As speed increases more air molecules are hitting the surface and so more air molecules can be slowed down by drag

It is made up of 3 elements:

FOUR FORCES: DRAG: PARASITE DRAG

GROUND SCHOOL

1. SKIN FRICTION DRAG

Friction caused by the surface moving through the airflow

Surface roughness and thickness of aerofoil have an impact

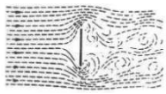
Skin friction is reduced by:

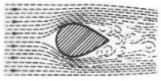
- Clean surfaces
- Fewer rivets on surface
- Thin aerofoil sections
- Flight at low angles of attack
- Smaller surface areas

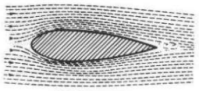
FOUR FORCES: DRAG: PARASITE DRAG

GROUND SCHOOL

2. INTERFERENCE DRAG

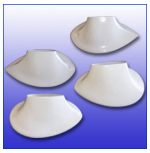






Drag due to junctions between surfaces giving off eddies which disrupts airflow over surfaces behind

Junctions are streamlined to reduce drag



FOUR FORCES: DRAG: PARASITE DRAG

GROUND SCHOOL

3. FORM DRAG

Small drag in streamlined position

Just like a swimmer – the way in which the airflow separates from the surface will cause drag

Large drag in unstreamlined position

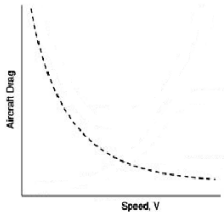
The more eddies that are caused, the more drag is produced

Streamlining of the aircraft will reduce form drag

FOUR FORCES: DRAG: INDUCED DRAG

GROUND SCHOOL

Induced drag is caused by the generation of lift

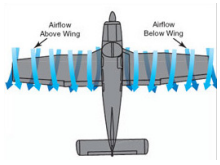


As speed increases, induced drag decreases

This is because the wing works harder at slower speeds to produce lift

FOUR FORCES: DRAG: INDUCED DRAG

GROUND SCHOOL



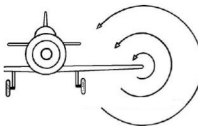
Lift is created by the pressure differential between the upper and lower surfaces of the wing

The higher pressure below the wing is trying to get to the lower pressure above the wing to equalise the pressure

At the wing tips, the easiest way for this to happen is for the airflow to be up and over the wing tips

FOUR FORCES: DRAG: INDUCED DRAG

GROUND SCHOOL

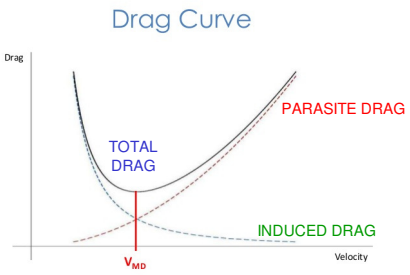


The downward pressure on the wing causes drag as does the vortices which are created behind the wing

The flow along the wing and up over the wing tips is called **spanwise** flow

FOUR FORCES: DRAG: TOTAL DRAG

GROUND SCHOOL



Minimum Drag Speed V_{MD}

FOUR FORCES: DRAG: GLIDING DISTANCE

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Aircraft have a **Lift : Drag** Ratio which defines how far they *should* be able to glide

A Lift : Drag ratio of 5:1 suggests that the aircraft will glide five times the height it is at

Example: An aircraft is at 2000 feet and has a lift : drag ratio of 5:1. How far will it glide in nautical miles? (1 nm = 6076 ft)

2000 feet x 5 = 10,000 feet gliding distance

10,000 ÷ 6076 = 1.65 nm

AIRCRAFT DESIGN AND DRAG

GROUND SCHOOL

Reduced by high aspect ratio wings (the spanwise flow has run out of energy by the time it gets to the wingtips)

Reduced by tapered wings (less for the downward force to push upon)

Reduced by washout (wing twist) so that most lift is created by the wing root

Reduced by tip tanks, winglets, wing fences, etc. to stop the spanwise flow leaving at the wingtip

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GROUND SCHOOL

PRACTICE QUESTION!

Does induced drag increase or decrease as the aircraft speeds up?

Decreases

GROUND SCHOOL

Lecture 2 complete

Any Questions?