Aerodynamics

Lesson Introduction

Lesson Overview

1. **Objective:** have a good understanding of the principles of flight and aerodynamics
2. **Key Elements:**
    a. Lift / Drag
    b. Load Factor / Maneuvering Speed
    c. Climbs, Turns, Stalls
3. **Student Actions:**
    a. Understand how aerodynamics affect flight
4. **Instructor Actions:**
    a. Clearly present all relevant information pertaining to aerodynamics
5. **Materials:**
    a. Electronic resources (IPAD, LAPTOP, FOREFLIGHT)
    b. Paper Resources (FAR/AIM, Sectional)

Drag

1. Anytime a object is moved through the air it generates drag
2. Drag always acts in the opposite direction of the motion of the object
3. In aviation there are four types of drag
    a. Form Drag: drag created by profile of airplane moving through air
    b. Skin Friction Drag: drag created by particles sticking to airplane skin
    c. Interference Drag: drag created by intersecting airflows (turbulence)
    d. Induced Drag: the drag created by the wings when they create lift
4. Induced drag decreases with velocity while all other drag increases with velocity (see PHAK Figure 5-6)

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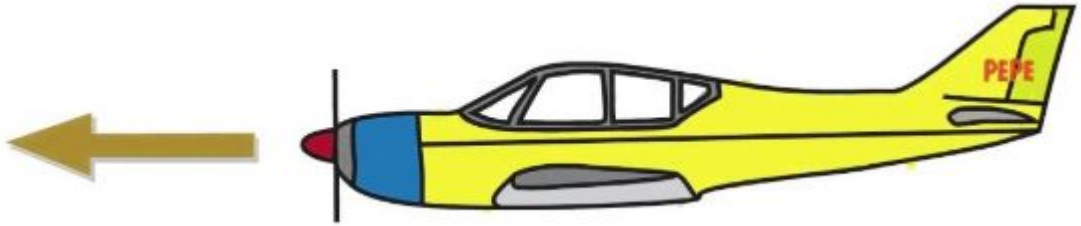
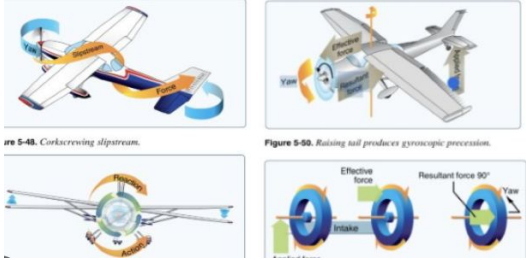
Thrust



1. Thrust is a forward force that pulls an object through the air, always provided by the engines
2. When thrust is greater than drag, the aircraft will accelerate
3. When thrust is equal to drag the aircraft will maintain a constant speed
4. When thrust is less than drag the aircraft will slow down
5. Thrust always applies a force in the direction the propeller / fan is pointed

Thrust: Left Turning Tendencies



1. When the propeller is spinning, and especially when spinning at high RPMs on the ground there are various forces which tend to turn the **plane to the left**
   a. **Gyroscopic Precession**: during rotation the force of the elevator acts 90° further in the rotation of the propeller than you'd expect. This adds a yawing force to the right
   b. **Spiral Slipstream**: downwash from the propeller tends to push the vertical stabilizer to the right causing the nose to yaw to the left
   c. **P-Factor**: when the airplane is at higher angles of attack, the relative wind the propeller "sees" makes the right side of propeller more effective, leading to a yaw to the left
   d. **Newton's 3rd Law**: the engine causes the propeller to spin, which makes the propeller want to spin the engine, but the engine is firmly attached to the airplane so the whole airplane wants to spin counterclockwise. This adds to the left turning tendency of the airplane

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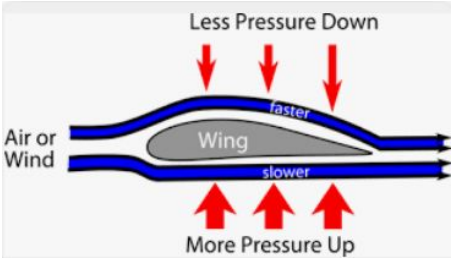
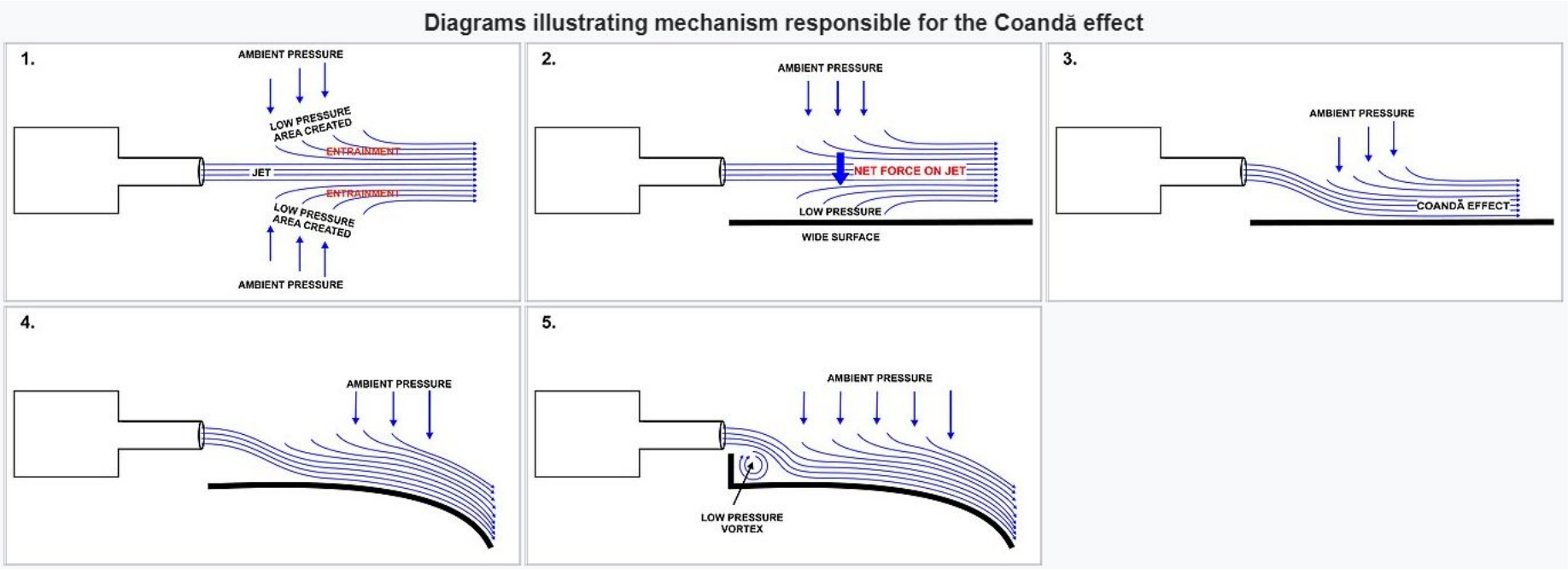
Lift



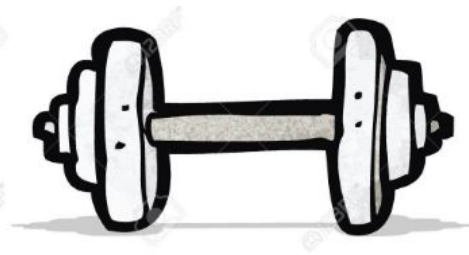
1. For an airplane, lift is generated in two ways
   a. Bernoulli's Principle: air is a fluid and that faster air has a lower pressure than slow air. The air moving over the wings is faster than air below the wings. The high pressure air pushes towards the lower pressure air, causing the airplane to rise into the air.
   b. Newton's 3rd Law: for every action there is an equal and opposite reaction. When an aircraft is taking off, the wings are angled upward (AOA is increased). The air hitting the bottom of the wings is partially deflected downwards, resulting in a opposite force pushing upwards.
2. If looking at an airplane from the front, lift always acts upwards at a 90° angle to the wings. Different components of this upward force of lift help the aircraft turn and help determine the total load factor on the wings (PHAK Figure 5-34)

FAA-H-8083-25B, Page 5-3, Figure 5-2, Figure 5-34

Coanda Effect



Weight



1. Weight is the force created by gravity acting on all the mass of the airplane and all its contents
2. Weight always acts directly downward toward the earth, regardless of whether the airplane is climbing, descending, or turning (PHAC Figure 5-2 and 5-34)
3. To maintain a constant altitude (or maintain a steady rate of climb or descent), the upward component of lift must always equal weight

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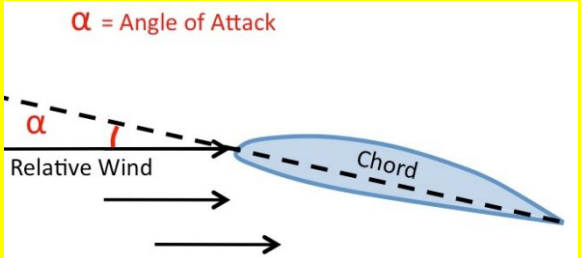
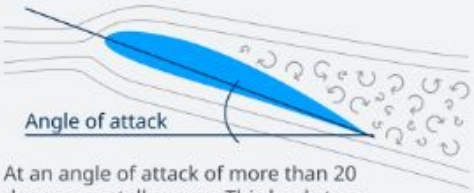
Angle of Attack (AOA)



1. The angle of attack is the angle between the relative wind and the chordline of the wing (PHAK Figure 5-3)
2. When the angle of attack is increased more lift is generated, primarily from more reactionary (Newton's 3rd law) lift
3. When the angle of attack is increased, drag also increases
4. If an aircraft moves slower, the angle of attack must be increased to maintain altitude. Same relationship if the airplane moves faster

FAA-H-8083-25B, Figure 5-5, Figure 5-3

Stalls



At an angle of attack of more than 20 degrees, a stall occurs. This leads to a loss of lift.

1. A stall occurs any time an airplane reaches its critical angle of attack
2. The critical angle of attack is always the same for a particular airplane, it never changes (except in severe icing conditions)
3. For our airplane the critical aoa is 20°
4. A stall can occur at any airspeed and any attitude, as long as the critical angle of attack is exceeded
5. When a stall occurs the airplane rapidly loses lift, and the airplane will begin to lose altitude (PHAK Figure 5-5)

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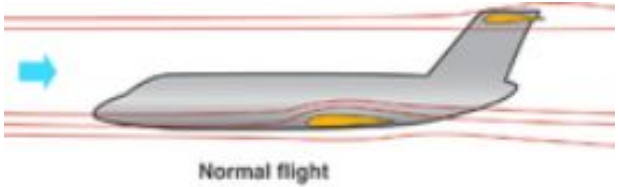
Straight and Level



1. When the aircraft is maintaining heading, altitude, and airspeed the aircraft is said to be “straight and level’
2. In straight and level flight, thrust is equal to drag, and lift is equal to weight (or all downward forces)
3. If any of the forces change, the aircraft will change altitude, airspeed, or heading
4. If an aircraft is disturbed from straight and level flight and returns to correct configuration the aircraft has *positive static stability*. If the disturbance is oscillatory in nature and it returns to straight and level then the aircraft has *Positive Dynamic Stability*

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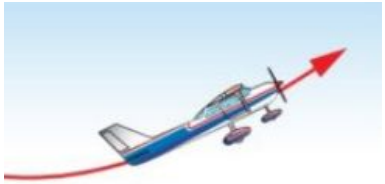
Climbs



1. When the aircraft enters a climb, lift is momentarily greater than weight. Once a steady state climb is achieved, lift and weight are same again
2. As the aircraft pitches up, weight continues to point directly downward. Because of the angle, a component of the weight is now pulling against thrust, so more thrust will be required in a climb if airspeed is to be kept consistent with straight and level

FAA-H-8083-25B, Page 5-23, Figure 5-36

Turns

1. If viewing the airplane from the front in a level attitude, the force of lift is always at a 90° angle to the wings and pointed upward
2. As the airplane banks, that upward force is now pointed somewhat to the left or right depending on the direction of bank. That same upward force of lift will now pull the airplane either to the left or the right, initiating a turn
3. Because the direction of weight is always acting towards the earth regardless of the airplane's attitude, and because the lift force is tilted during a turn, less of the original lifting force is available to help fight against weight. As a result, if altitude is be kept constant during a turn then more lift will be needed. This is primarily why we increase back pressure during a turn, because it increases the angle of attack of the wings and therefore increases lift (PHAK Figure 5-5)

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Load Factor

1. Load factor is the force the wings and structure of the airplane are feeling
   a. If the plane is rapidly pitched up or down, the wings will experience a huge force that is greater than weight
   b. Because total lift created by the wings must increase during a turn, the load the wings feel is greater
   c. Because the wings don't shrink when the airplane gets faster, and the wings don't shrink when the airplane gets lighter, the faster and lighter the airplane is, the greater the accelerations it can potentially experience
2. When it comes to the load factor that an airplane can withstand, there are three categories; normal, utility and acrobatic

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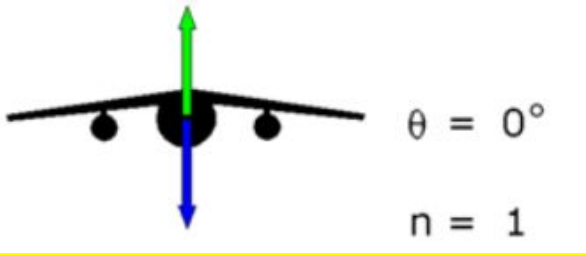
Load Factor Continued



1. Maneuvering Speed: the speed at which an airplane will always stall before the load factor limit is exceeded. While flying at maneuvering speed it is possible to fully deflect one of the flight controls without exceeding the load limit. Maneuvering speed is specific to an airplane and is usually calculated assuming maximum gross weight
2. A V_g diagram shows the relationship between indicated airspeed and the load factor an airplane will experience. It also shows the relationship between the normal stall speed and the maneuvering speed. Note that because normal stall speed decreases with weight, so will the maneuvering speed.

FAA-H-8083-25B, Pages 5-35 and 5-38, Figure 5-55

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sky news
GENDER REVEAL PARTY PLANE CRASH


MAVERICK
CLIP

WingTip Vortices

1. The slower moving air underneath a wing has a higher total pressure than faster moving air above the wings. Air always flows from higher pressure to lower pressure. High pressure air leaks around the wing tip edge and moves to the top of the wing creating vortices
2. Wingtip vortices created by larger aircraft can be strong enough to overturn small general aviation aircraft. Because wing tip vortices have a tendency to sink, are only created when lift is being generated, and are typically created when an aircraft is heavy, clean, and slow, general aviation aircraft should always maintain a flight path above a large aircraft or wait 2 minutes

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AIM 7-4-3 (page 877, 2023 FAR/AIM)

Ground Effect

1. When an aircraft is within one wing length of the ground, the induced drag required to create lift decreases, resulting in an overall increase in lifting performance
2. This decrease in reduced drag is primarily due to the ground stopping the formation of wingtip vortices
3. The increase in lifting performance can lead to aircraft to leave the ground when it hasn’t achieved a proper airspeed or to significant floating during the flare
4. Because there is less induced drag, the aircraft can maintain altitude in ground effect with a smaller angle of attack

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Story

Flying with Rob in SLING TSI doing 140 kts in rough air. I made the decision to slow down