

CFI Bootcamp

Flight Instructor Training

Aerodynamics

Va and the Left Turning Tendencies

The Whys

Va – Design Maneuvering Speed

- For a single axis and in one direction of the flight control – Rudder can be fully deflected once to each stop
- The speed at which the airplane can't develop more than the load limit – 3.8g to -1.52g
- The airplane will stall at the load limit

AT 110 knots indicated airspeed with an abrupt pull-back on the elevator or an encounter with a strong vertical wind gust.			
1G	2Gs	3Gs	4Gs
4.5° Angle of Attack	9.0° Angle of Attack	13.5° Angle of Attack	18.0° Angle of Attack
			
Original angle of attack in cruise flight at 110 knots	Sudden increase to twice the original angle of attack	Sudden increase to three times the original angle of attack	STALL Sudden increase to four times the original angle of attack

Va – Design Maneuvering Speed

- Va is determined by:
- $Va * \sqrt{DesignLimit} = Vs * \sqrt{3.8} = Vs * 1.95$
- It is approximately 2* the clean stalling speed
- GA planes have a stall speed of not to exceed 61 Kts CAS
- Maximum Va speed will then be $61 * \sqrt{3.8} = 118.0$

Va – Design Maneuvering Speed

- The load limit force is generated by Load Factor
- Load factor is a function of lift
- Lift increases at the square of the speed

Va – Design Maneuvering Speed

Stall lift (L at CLmax) increases with V²:

$$L_{stall} = \frac{1}{2} \rho V_{stall}^2 S C_{L_{max}}$$

At Va, we want:

$$L_{stall} = n_{limit} \cdot W$$

But $L \propto V^2$, so:

$$n_{limit} \propto \left(\frac{V_a}{V_s} \right)^2$$

Solve for Va:

$$V_a = V_s \sqrt{n_{limit}}$$

Va – Design Maneuvering Speed

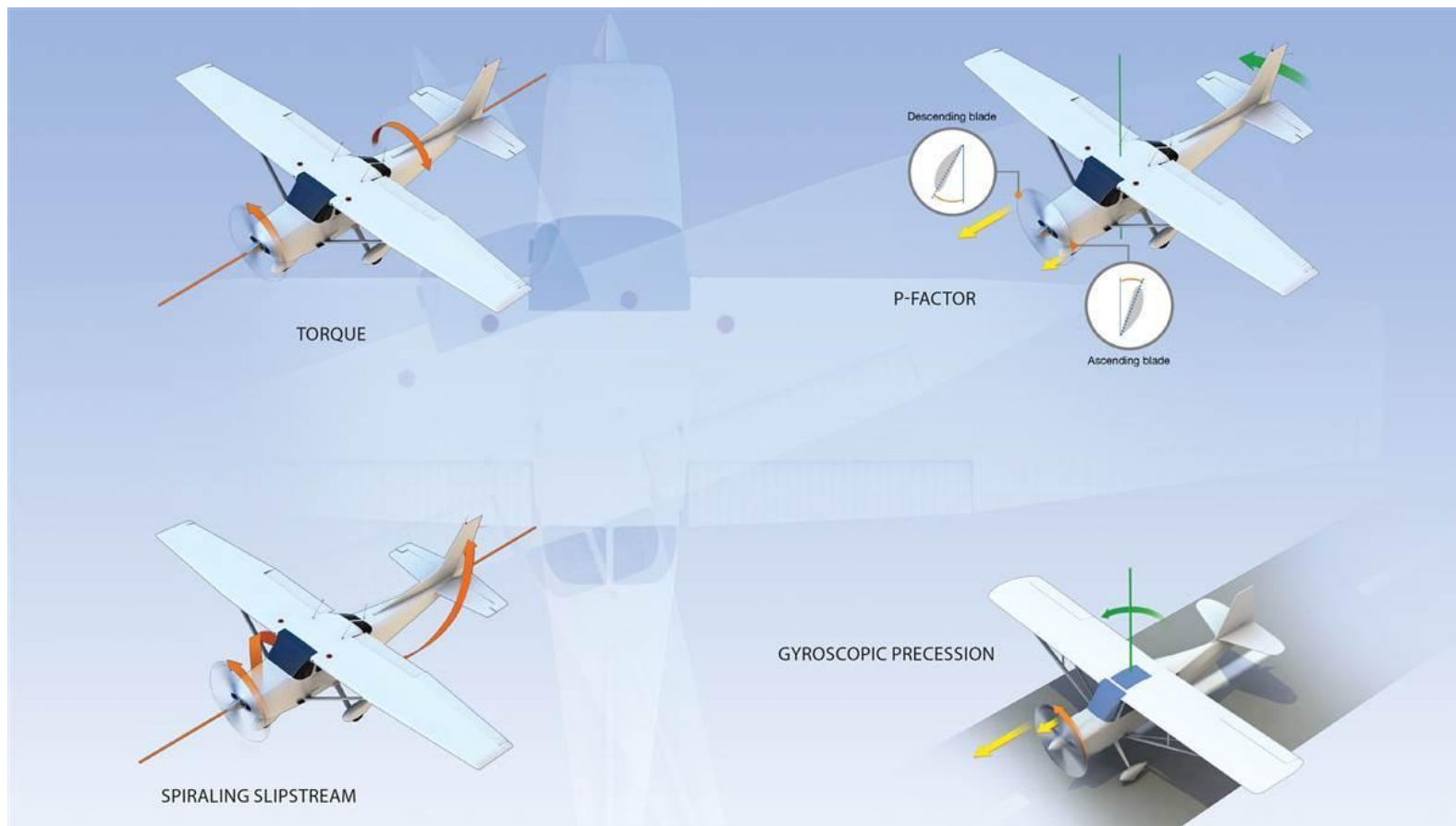
- The stall speed is a function of weight – Higher weight = Higher Stall Speed
- A control surface will generate an aerodynamic force that will cause a rotational acceleration
- Newtons second law $F=M*A$
- Rewritten $A=F/M$
- So a decrease in weight (mass) can cause a higher acceleration
- Va must then go down with a decrease in weight

Va – Design Maneuvering Speed

- $V_{new} = V_{amax} * \sqrt{\text{new weight} / \text{max weight}}$

Special Airworthiness Information Bulletin and Explanation

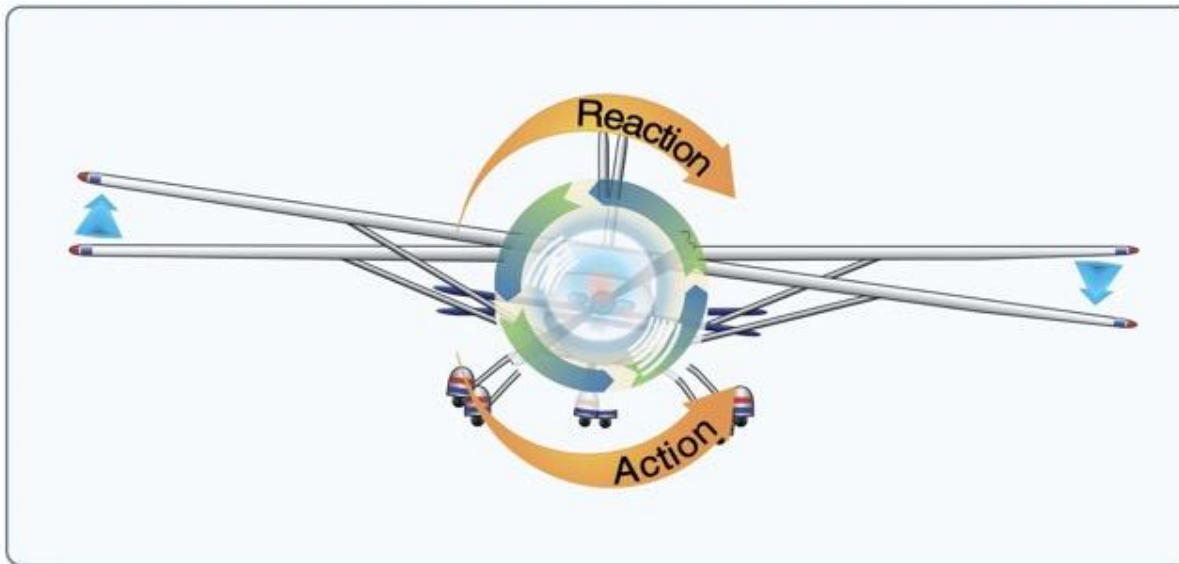
Left Turning Tendencies



Left Turning Tendencies

Torque

Newtons third law – For every action there is an opposite and equal reaction



Left Turning Tendencies

Torque

Newtons third law – For every action there is an opposite and equal reaction

The propeller rotates clockwise

The reaction is counter clockwise

This pushes on the left tire causing more drag/friction

Left Turning Tendencies

Torque

Newtons third law – For every action there is an opposite and equal reaction

In the air it is a left rolling tendency that turns into a left yawing tendency

Left Turning Tendencies

Torque

Designers try to minimize torque effect by:

Mounting the vertical stabilizer off of the longitudinal axis

Canting the engine

Providing more incidence on the left wing

Left Turning Tendencies

Slipstream Effect



Left Turning Tendencies

Slipstream Effect

The propeller causes air to blow backwards and in a corkscrew pattern

The air spirals around the fuselage and hits with vertical stabilizer on the left

The stronger the slipstream (engine power) the greater the effect

Left Turning Tendencies

Slipstream Effect

Also makes the elevator and rudder more effective with more power

The ailerons are not in the slipstream so they aren't affected

The effect is upon the takeoff roll and throughout the flight

Left Turning Tendencies

P-Factor

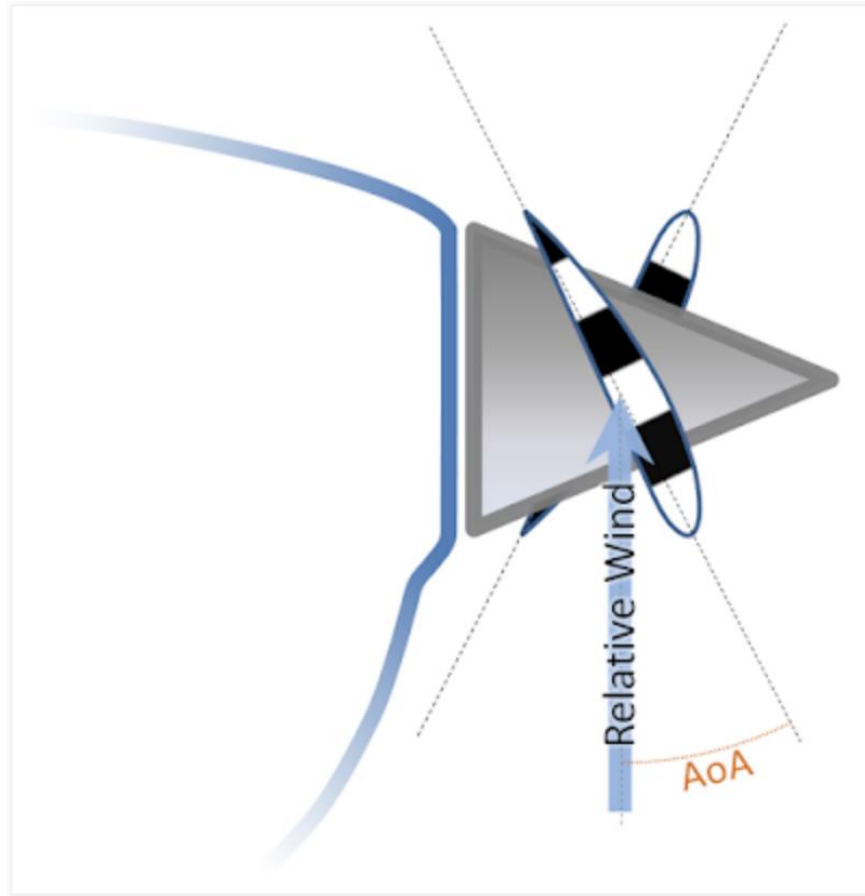
The propeller blades are mounted in opposite angles on each side of the hub and drive shaft

When the airplane isn't moving, both blades have an equal angle of attack

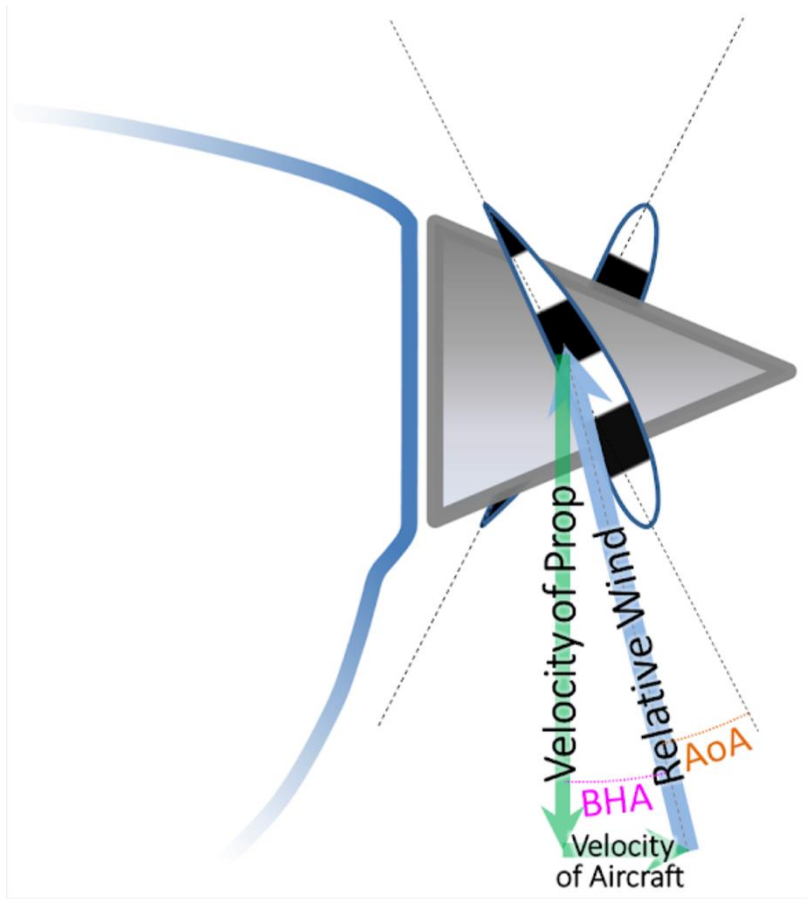
The relative wind to the descending blade is straight up from the ground

The relative wind of the ascending blade is directly from above

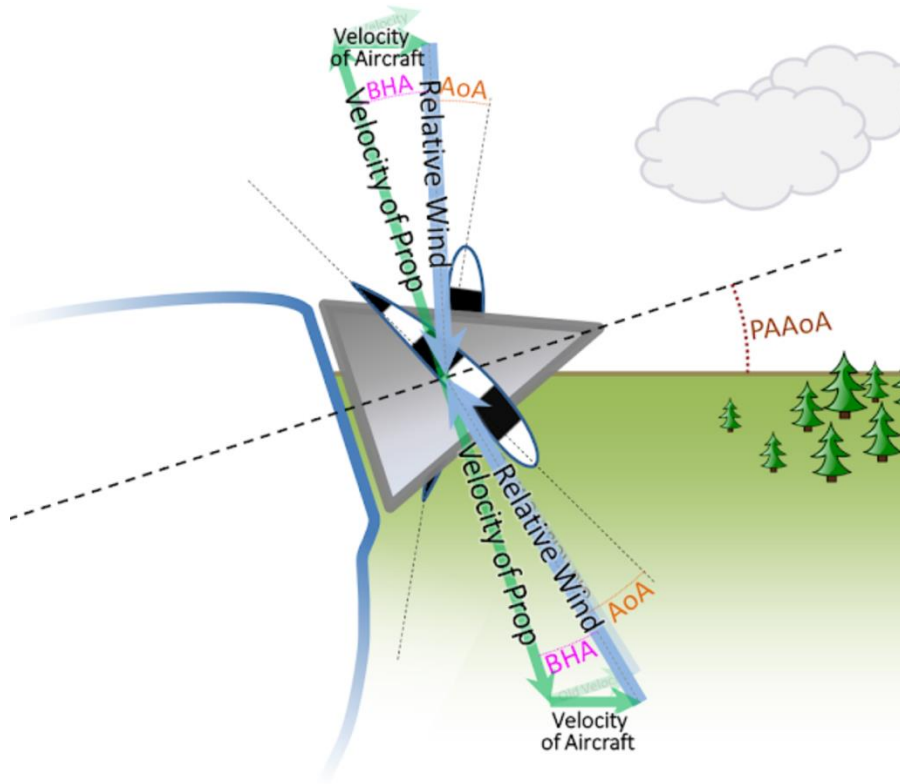
Left Turning Tendencies



Left Turning Tendencies



Left Turning Tendencies



Left Turning Tendencies

P-Factor

When the airplane has an angle of attack of more than 0° , the descending blade will have a higher angle of attack than the ascending blade

This means the right blade will develop more lift - Thrust

This causes a left yawing tendency

This is felt upon rotation and climbing and when the speed is low in level flight (High Angle of Attack)

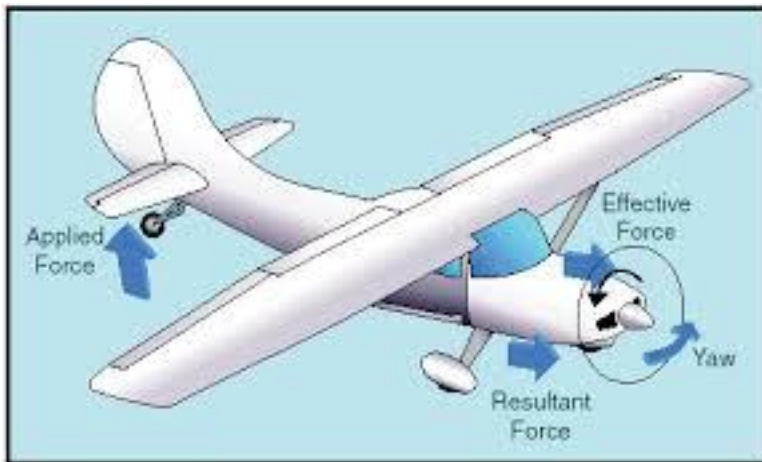
Left Turning Tendencies

Gyroscopic Precession - Sometimes

The propeller is rotating

It can be considered a disc for practical purposes

If a force is applied to a rotating disc the effect of that force will be 90° from the applied point in the direction of the rotation



Left Turning Tendencies

Gyroscopic Precession - Sometimes

On rotation in a nosewheel airplane the force is applied to the bottom of the disc

The force is applied 90° later – on the left side of the disc

This causes a RIGHT turning tendency

Left Turning Tendencies

Gyroscopic Precession - Sometimes

On a tailwheel airplane the force is applied to the top of the disc on the takeoff roll to lift the tail

The force is applied to the top of the disc

The force is applied 90° later – on the right side of the disc

This causes a LEFT turning tendency

Left Turning Tendencies

Gyroscopic Precession - Sometimes

Upon rotation the precession will be a right turning tendency

In nosewheel/tailwheel airplane pushing the control wheel or stick forward applies a force to the top of the disc

This causes a LEFT turning tendency

Left Turning Tendencies

[Left turning tendencies video](#)

[P-Factor Video](#)

[Gyroscopic Precession – Intuitive Explanation](#)

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From Us to You!

Steep Turns

1. Clear the airspace and identify emergency landing areas.
2. Adjust the throttle to 2100 RPM - 90 KIAS.
3. Altitude no lower than 1500 feet AGL.
4. Identify a reference point in front of the aircraft and note the heading.
5. Roll into a 45 - 50 degree bank turn - Stop adverse yaw with rudder.
6. Maintain bank, altitude, and airspeed.
7. Elevator maintains altitude, throttle maintains airspeed, aileron - angle of bank.
8. Remain coordinated.
9. Begin the roll out 25 degrees before the 360 degree point - Stop adverse yaw.
10. Level the wings on the entry heading.
11. Reduce elevator to maintain altitude and decrease throttle for air-speed.
12. Roll into a 45 - 50 - degree bank turn in the opposite direction.
13. Repeat maneuver in the opposite direction.

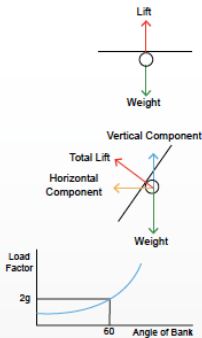


Diagram illustrating the forces in a steep turn. The aircraft is shown in a banked position. The forces acting on it are Lift (up), Weight (down), Total Lift (up and to the left), Horizontal Component (left), and Vertical Component (up). A graph shows Load Factor (Y-axis) versus Angle of Bank (X-axis). The curve starts at 2g for 60 degrees.

Teach Brief-Fly!

Slow Flight

1. Clear the area.
2. Reduce the throttle to 1500 RPM.
3. Maintain altitude with elevator back-pressure as the airspeed slows.
4. Lower the flaps to full in stages. 10 degrees below 110, the rest below V_{FE} .
5. Anticipate elevator pressure changes.
6. Slow to 50 KIAS, and apply throttle as necessary to maintain altitude.
7. Use elevator to maintain airspeed.
8. Apply rudder to keep the to maintain heading. Keep the wings level with ailerons.
9. Perform a level 90 degree turn to the left. Additional throttle will be required to maintain altitude.
10. Perform a level 90 degree turn to the right.
11. Return to straight and level flight at cruise speed by applying full power first.
12. As the airspeed increases, retract the flaps in stages while maintaining altitude.
13. When the airspeed is 90 KIAS reduce throttle to 2100 RPM and trim.

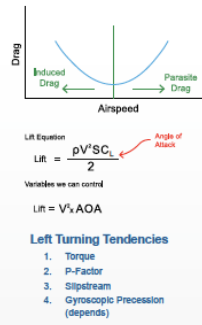
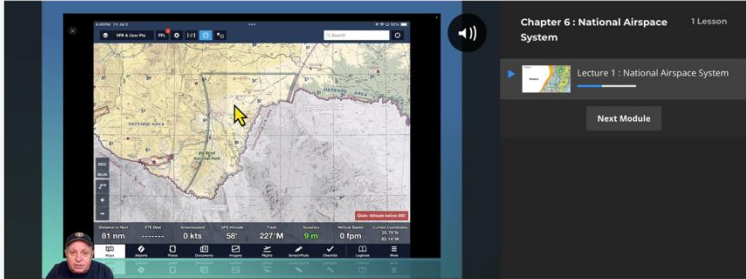


Diagram illustrating the forces in slow flight. The aircraft is shown in a steep climb. The forces acting on it are Drag (up), Induced Drag (down), Parasite Drag (down), and Airspeed (up). A graph shows Drag (Y-axis) versus Airspeed (X-axis). The LR Equation is shown: $L/R = \frac{\rho V^2 S C_L}{2}$. Variables we can control are listed: $L/R = V^2 AOA$. Left Turning Tendencies are listed: 1. Torque, 2. P-Factor, 3. Slipstream, 4. Gyroscopic Precession (depends).

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The screenshot shows a video player with a map of the United States, a small video feed of the instructor, and a sidebar with course navigation. The sidebar includes a 'Mark As Complete' button, the chapter title 'Chapter 6 : National Airspace System', and a 'Downloads' section with links to 'National Airspace System' and 'Chapter 12: Workbook Questions'.

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