MULTI-ENGINE

INSTRUCTOR LESSON PLANS

First Edition

CFI Bootcamp

Flight Instructor Training

Multi-Engine Instructor Lesson Plans

First Edition

Mike Shiflett

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Flight Instructor Training

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Multi-Engine Flight Instructor Lesson Plans
First Edition
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Mike Shiflett's Aviation credentials and experience are as follows:

FAA Certificates
Airline Transport Pilot Certificate – Airplane Multi-Engine Land. CE-525 Type rating
Commercial Pilot Privileges: Airplane Single Engine Land and Sea
Flight Instructor Certificate – Airplane Single and Multi-Engine Land, Instrument Airplane
Former FAA Designated Pilot Examiner – Recreational – ATP including Initial CFI, CFII, MEI

UK Certificates
Commercial Pilot – Airplane Single Engine Land
Former UK Flight Examiner for Private Pilot and IMC ratings
Mike has amassed over 16,000 hours of which most were in general aviation aircraft. He also administered around 3,000 practical tests (Checkrides) for the FAA.

Mike has authored numerous courses used by top flight schools and Universities in his previous company. At CFI Bootcamp he authored all the course content including 42 hours of video, 10 books used by students at CFI Bootcamp, and has been featured in many aviation media organizations. He has also presented at EAA Airventure – Oshkosh, WI, Sun-n-Fun, and Aviation conferences as a speaker. He also produced a Podcast "Flight Training the way I see it", and has a weekly webinar called "The Power Hour". The CFI Bootcamp website has links to the webinar and previous Podcasts. He continues to innovate in the aviation industry and is particularly focused on creating courses and training materials to produce better flight instructors.

Mike currently lives in both San Jose, CA, and more often in Miami Beach, FL. He flies from the Opa-Locka airport just north of Miami International.

Introduction

This is the first edition of Multi-Engine Land Lesson Plans. The work on these started in 2019, and it was started and stopped until the autumn of 2022. Inside, you'll find lesson plans for all Areas of Operations and Tasks from the Private and Commercial Pilot Multi-Engine Land Airman Certification Standards (ACS), both for flight maneuvers and aeronautical knowledge areas. In addition, there are also lesson plans for all Areas of Operations and Tasks for the Flight Instructor Airplane Multi-Engine Practical Test Standards (PTS.), except for the Fundamentals of Instructing.

The lesson plans were written using the Airplane Flying Handbook (FAA-H-8083-3C) and the Pilots Handbook of Aeronautical Knowledge (FAA-H-8083-25B), as the source materials. This book also includes some best practices from Hobie Tomlinson, who knows more about light twins than anyone I know. My assistant, Jonathan Ray, also helped author numerous lesson plans found in this book. His ability to write and attention to detail were vital in the successful completion of this project.

Following these lesson plans will guide you through each Area of Operation for your Private or Commercial students and Airplane Multi-Engine Flight Instructor (MEI) applicant. I hope you find them comprehensive and well-referenced. The order of the presentation for each lesson plan has been carefully chosen so the lesson "flows" logically.

If you are preparing for the MEI (Airplane Multi-Engine Flight Instructor) checkride, voice the lesson plans out loud. It's the only way to catch things you thought you knew but forgot. It also lets you modify the flow of the lesson by changing the order of the presentation if you feel that is necessary.

Thanks for purchasing your copy. They will serve you for years to come.

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Straight-and-Level Flight – Constant Airspeed Climbs – Constant Airspeed Descents – Turns to Headings	Basic Instrument Maneuvers
Flight Principles—Engine Inoperative	Maneuvering with One Engine Inoperative (PVT / COM ACS task / lesson plan: X-A.)
Postflight Procedures	After Landing, Parking and Securing (PVT / COM ACS task / lesson plan: XI-A.)

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Maneuvering with One Engine Inoperative

Objective:

To maintain airplane control and maneuver the airplane in a specific, deliberate manner after experiencing an engine failure.

Motivation:

An engine failure during flight is a very challenging situation. It requires the pilot to manage tasks appropriately and maneuver the airplane with decreased performance and handling characteristics. Practicing this will develop an automatic response in the event of an engine failure.

Presentation (20 minutes):

1. How this maneuver applies to other maneuvers (Single engine approach & landing, V_{mc} Demo, etc.) - See ACS tasks IX (G) - X (D.)
2. Critical engine concept and why the (usually left) engine is critical - P-Factor, Accelerated Slipstream, Spiraling Slipstream, Torque - See FAR 1.1, PHAK 5-30
3. Review the V_{mc} factors and how they affect rudder input and loss of directional control. (AFH 13-31.)
    a. Maximum power on the good engine at sea level - Causes the most yawing around the CG and will require more rudder to overcome.
    b. Propeller on the inoperative engine windmilling - Causes the most drag and will require more rudder to overcome.
    c. Banking up to 5 degrees toward the good engine - This causes a horizontal component of lift towards the good engine that helps with the amount of rudder needed.
    d. Least favorable weight and CG:
        i. Weight - Increased weight makes the airplane resist changes to heading - the horizontal component of lift is also more significant due to the need to create more total lift (more weight).
        ii. CG - The farthest aft CG results in a shorter arm between the CG and the rudder, causing reduced rudder effectiveness.
    e. Flaps in the takeoff position - Certification criteria.
    f. Gear up - Reduces the directional stability. If the gear is in the down position, it increases the "keel effect."

g. Trim in the takeoff position - Certification configuration.

h. Cowl flaps in the takeoff position - Certification configuration.

i. Out-of-ground effect - Induced drag is less in ground effect, so a lower V_{mc} speed is possible.

4. Recognition of approaching V_{mc} and avoiding it - Rudder is at full travel, and there is a loss of directional control (heading change) or an indication of a stall.
5. Single-engine service ceiling calculated with today's conditions - reference POH
6. Review single engine aerodynamics - when an engine fails, there will be a strong yawing/rolling moment towards the dead engine; therefore, rudder control input is required to maintain straight and level flight.
7. Raise the dead" concept - Banking into the good engine to about 3 degrees - ½ ball out-side of center on the inclinometer.
8. Discuss how to restart the inoperative engine for the model of aircraft flown - Explain how an unfeathering accumulator works and should be used (If installed.)

Presentation references:

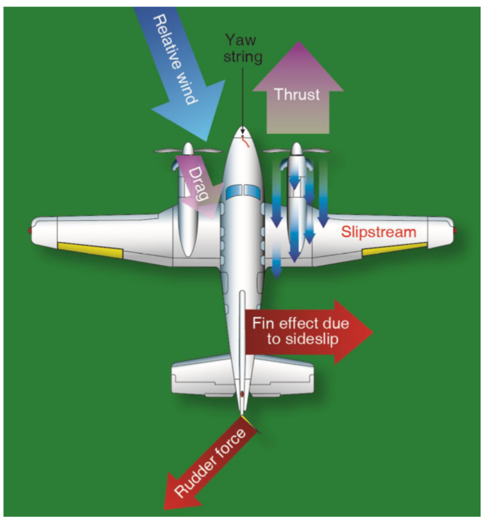
- Airplane Flying Handbook, pg. 13-31 - 34
- Commercial Pilot ACS, pg. 57
- FAR 1.1
- Pilot's Handbook of Aeronautical Knowledge pg. 5-30 - 33

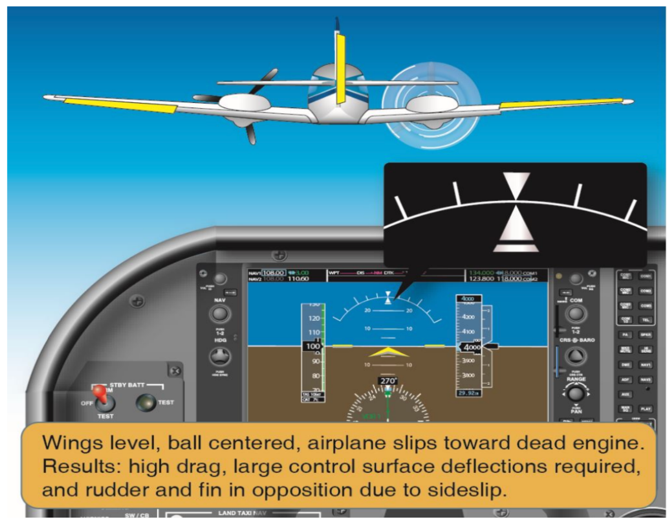
Key points:

- Requires increased control inputs. There will be a lack of control effectiveness with one engine inoperative.
- Maintaining a safe airspeed throughout maneuvering - Once energy/altitude is lost, it is difficult to regain it. (Keep the airspeed at or above blue line - V_{yse}.)
- Climbs (if possible) and Descents should be made at blue line or higher.

Risk Management:

1. Failure to maximize remaining available thrust once the engine fails (through clean-up andconfiguration).
2. Collision hazards, including aircraft and terrain.
3. Collision hazards, including obstacles and wires.
4. Risks associated with Low altitude maneuvering, including stall, spin, or CFIT.
5. Distractions, loss of situational awareness, or improper task management.





Questions for the student:

1. What is "zero sideslip," and why is it important?
2. What are the certification criteria for the determination of V_{mc}?
3. Why does additional thrust from our operating engine create more issues?

Common errors:

- Unintentional loss of airspeed/altitude with difficulty to reacquire.
- Failure to clean up / configure aircraft appropriately.
- Forgetting to attempt to solve the engine failure.
- Drifting off the desired course/altitude loss while troubleshooting the engine failure.
- Failure to restart the inoperative engine.

Completion Standards:

1. No minimum altitude is required; however, recommended entry altitude is at least 3500' AGL to allow for 500' altitude loss. (ACS pg. 43, CA.VII.A.S2)
2. Recognize an engine failure, maintain positive control, and reference memory item procedures.
3. Set the engine controls, identify and verify the inoperative engine, and feather the appropriate propeller.
4. Use flight controls in the proper combination as recommended by the manufacturer or as required to maintain the best performance, and trim as needed.
5. Attempt to determine and resolve the reason for the engine failure.
6. Secure the inoperative engine and monitor the operating engine and make necessary adjustments.
7. Restart the inoperative engine using the manufacturer's restart procedures.
8. Maintain altitude ±100 feet or a minimum sink rate if applicable, airspeed ±10 knots, and selected headings ±10°.
9. Complete the appropriate checklist.

V_{mc} Demonstration

Objective:

To be able to purposefully slow the aircraft to the loss of directional control speed (V_{mc}) and execute a prompt recovery before the aircraft enters an uncontrolled state.

Motivation:

Most accidents resulting from a multi-engine aircraft losing an engine are due to the pilot unintentionally slowing the aircraft below V_{mc}. Practicing this situation will develop the skill to avoid getting too slow with one engine and recognize and recover upon reaching V_{mc}.

Presentation (20 minutes):

1. Critical engine concept and why the (usually left) engine is critical - P-Factor, AcceleratedSlipstream, Spiraling Slipstream, Torque - See FAR 1.1, PHAK 5-30
2. Review the V_{mc} factors and how they affect rudder input and loss of directional control. (AFH 13-31.) Listed are the certification criteria for V_{mc}:
    a. Maximum power on the good engine at sea level - Causes the most yawing around the CG and will require more rudder to overcome.
    b. Propeller on the inoperative engine windmilling - Causes the most drag and will require more rudder to overcome.
    c. Banking up to 5° toward the good engine - This causes a horizontal component of lift towards the good engine that helps with the amount of rudder needed.
    d. Least favorable weight and CG -
        i. Weight - Increased weight makes the airplane resist changes to heading - the horizontal component of lift is also more significant due to the need to create more total lift (more weight).
        ii. CG - The farthest aft CG results in a shorter arm between the CG and the rudder, causing reduced rudder effectiveness.
    e. Flaps in the takeoff position - Certification criteria.
    f. Gear up - Reduces the directional stability. If the gear is in the down position, it increases the “keel effect.”
    g. Trim in the takeoff position - Certification configuration.
    h. Cowl flaps in the takeoff position - Certification configuration.

   i. Out-of-ground effect - Induced drag is less in ground effect, so a lower V_{mc} speed is possible.

3. Discuss simulating the critical engine (if applicable) failing, and the aircraft is configured forV$_{mc}$ per the manufacturer's recommendations.
4. Explain that the red radial line on the airspeed indicator can vary. It is a reference speed calculated with the airplane in the certificated configuration.
5. Explain how the actual V_{mc} speed decreases as altitude increases - The operating en-gineproduces less power, so there is less yaw.
6. Explain that V_{mc} can be at or below the stalling speed - If the airplane stalls in this way, it will cause the airplane to enter a spin.
7. Review the emergency spin recovery procedure detailed in the POH.
8. Discuss the procedure/standards for the maneuver itself:
   a. Before beginning, ensure recovery can be made by 3000' AGL.
   b. Establish a single-engine climb attitude with airspeed approximately 10 knots above VSSE.
   c. Operating engine: Full throttle / Inoperative engine: Idle and windmilling.
   d. Decelerate by pitching up slowly at approximately 1kt per second.
      i. Note: The increased power on the operating engine and decreasing airspeed will require additional aileron and rudder pressure.
      ii. Up to a 5° bank toward the operative engine is acceptable.
   e. Recognition of reaching V_{mc} - This will be recognizable by:
      i. The rudder is at full travel (up to 150lbs of force required possible.)
      ii. Loss of directional control (heading change.)
         1. Or an indication of a stall.
   f. Recovery:
      i. Reducing the pitch to below V_{mc} or,
      ii. Elimination of the stall warning indicator, and:
      iii. Simultaneously reducing both throttles to idle.
         1. Note: Maintaining altitude is not required for this maneuver.
      iv. Pitch for V_{yse}, and upon reaching that speed, apply full throttle on the operat-ing engine while maintaining heading.

Presentation references:

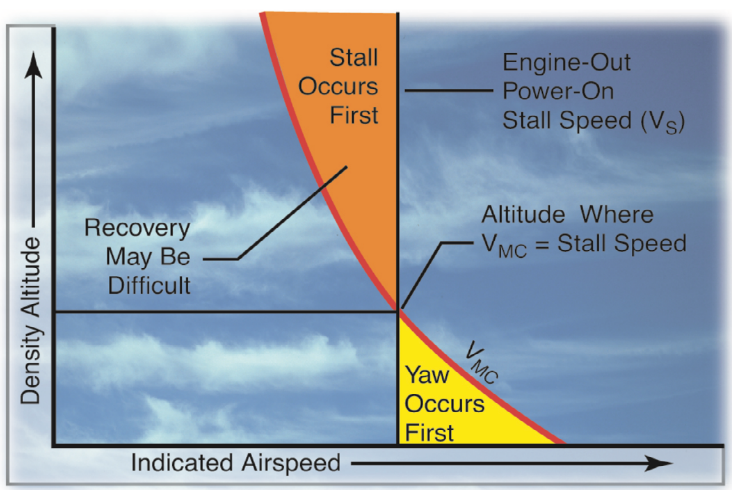
- Airplane Flying Handbook, pg. 13-23 - 27
- Commercial Pilot ACS, pg. 58
- 14 CFR part 23, section 23.149(c - e)

Key points:

- Requires Increased control inputs. There will be a lack of control effectiveness with one engine inoperative.
- Exercise extreme caution to not induce a stall - should a stall occur, immediate recovery is necessary - Close both throttles and lower the angle of attack.
- Always brief the maneuver for entry and safe recovery.
- Recognition of a stall before V_{mc} - No initial loss of heading - Stall warning indicator or buffeting.

Risk Management:

1. Proper airplane configuration. - As discussed previously.
2. Proper management of maneuvering the aircraft with one engine inoperative.
3. Risks associated with V_{mc} - Including inadvertent stall/spin entry.
4. Distractions, loss of situational awareness, or improper task management.



Questions for the student:

1. In what scenario are stall speed and V_{mc} close/the same?
2. Why is it important to practice the maneuver with the "worst case configuration/scenario?"
3. Why is deceleration at 1kt per second important

Common errors:

- Failure to have enough aileron/rudder input to maintain the desired heading.
- Decelerating faster than 1 kt per second.
- Improper altitude selection.
- Improper configuration.
- Entry airspeed less than Vsse +10 kts.
- Failure to recognize a loss of direction control.

Completion Standards:

1. No minimum altitude is required; however, recommended entry altitude is at least 3000'. (AFH 13-26)
2. Increase the pitch attitude slowly to reduce the airspeed at approximately 1 knot per second while applying rudder pressure to maintain directional control until full rudder is applied.
3. Recognize indications of loss of directional control, stall warning, or buffet.
4. Recover promptly by simultaneously reducing power sufficiently on the operating engine, decreasing the angle of attack as necessary to regain airspeed and directional control, and without adding power on the simulated failed engine.
5. Recover within 20° of the entry heading.
6. Advance power smoothly on the operating engine and accelerate to VSSE/V_{yse}, as appropriate, ±5 knots during recovery.

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One Engine Inoperative (Simulated) (solely by Reference to Instruments) During Straight-and-Level Flight and Turns

Objective:

To operate the aircraft solely by reference to instruments when an engine fails.

Motivation:

Practicing maneuvering the aircraft by sole reference to the flight instruments will develop the necessary skills for managing an engine failure in IMC.

Presentation (30 minutes):

1. Flying by sole reference to the flight instruments with one engine inoperative is different from maneuvering visually - Use the instruments as follows:
    a. Any heading change shows on the heading indicator - Note: If using a G5 or other EFIS primary flight display, take advantage of the magenta diamond showing the airplane's track.
    b. Set approximate zero sideslip by banking 3 degrees towards the good engine using the attitude indicator and ½ ball deflection on the turn coordinator.
    c. One engine inoperative causes a lack of thrust - Use the attitude indicator to maintain a specific pitch attitude that holds level flight. Note: It will be a higher pitch attitude than when both engines are operating.
    d. To climb, use the airspeed indicator and the V_{yse} or V_{xse} speed.
2. Review of the instrument flying methods:
    a. Control and Performance:
        i. Establish an attitude and power setting on the control instruments that result in the desired performance - This will be different from normal both-engines operating performance.
        ii. Trim until control pressures are neutralized - This will require a large amount of rudder trim.
        iii. Cross-check the performance instruments to determine if the established attitude or power setting provides the desired performance.

iv. Adjust the attitude and/or power setting as necessary.

b. Primary and Supporting:

i. Pitch control: Select which instrument to use for the primary vs. supporting instruments.

ii. Heading control: Same as pitch control; reference the table below.

3. Avoid these common instrument flying errors:

a. Fixation - Fixating on the trend indicator and making adjustments with references to that alone.

b. Omission - Omitting the stand-by instruments, turn coordinator, and magnetic compass from your scan.

c. Emphasis - Placing the importance of a single instrument above another and solely relying on that instrument for guidance.

4. Instrument scanning technique review - Crosscheck, Instrument interpretation, Aircraft control. This applies to single-engine flying, especially due to monitoring the failed engine and ensuring the working engine is being managed properly.

5. Aerodynamic forces creating difficulties - Maintaining coordinated flight and an assigned-heading will now be more difficult without an outside sight picture. The amount of various control inputs required increases due to one engine's inoperative aerodynamic forces.

6. Recognize that a standard rate turn towards the dead engine is measured differently - There will be a strong yawing/rolling moment toward the dead engine; therefore, more or less effort is required to execute a turn. For example, A left turn with your left engine failed will require less effort, and a turn to the right will require more effort.

Presentation references:

- Instrument Flying Handbook, pg. 6-2 - 6-14
- Airplane Flying Handbook, pg. 13-31 - 34
- Commercial Pilot ACS, pg. 59

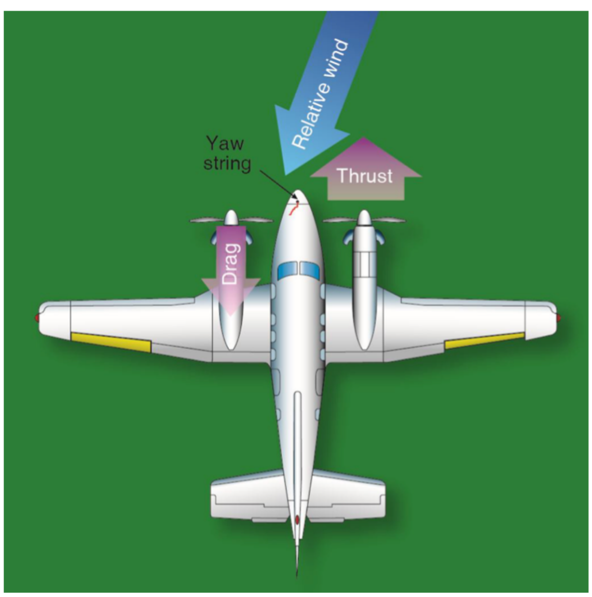
Key points:

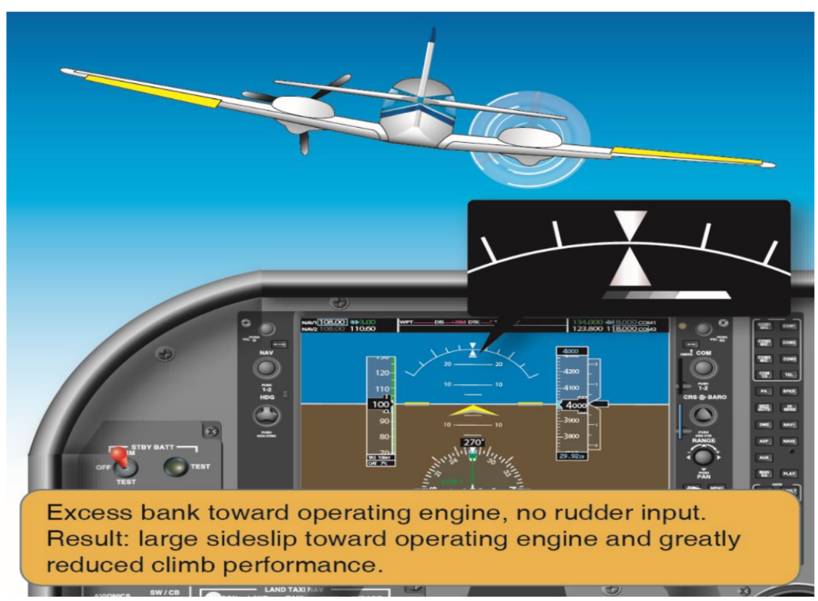
- Flying with one engine inoperative results in decreased performance.
- The control and performance method of instrument scanning is different in a multi-engine aircraft when one engine is inoperative, and the primary supporting method of instrument scanning remains the same.
- Ensure proper checklist usage and attempt to restart the engine per the manufacturer's recommendations.
- Avoiding common instrument flying errors in a multiengine airplane is vital.

Risk Management:

1. Failure to identify the inoperative engine.
2. Inability to climb or maintain altitude with an inoperative engine.
3. Low altitude maneuvering, including stall, spin, or CFIT.
4. Distractions, loss of situational awareness - or creating an unusual attitude situation. Improper task management - Not prioritizing the needs of the operating engine.
5. Fuel management during single-engine operation.

Achieving zero sideslip:





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Questions for the student:

1. Why is it important to acquire zero sideslip?
2. Which common instrument flying errors are most likely while in IMC? Why?
3. What speed should we aim to maintain altitude with today's conditions? What single-engine power setting might achieve this?

Common errors:

- Failure to promptly recognize engine failure and maintain positive airplane control.
- Failure to set the engine controls appropriately, reduce drag, identify and verify the inoperative engine, and simulate feathering of the propeller on the inoperative engine.
- Not establishing the appropriate speed for the maneuvering requested.
- Not following the prescribed checklist in a timely and accurate manner.
- Instrument fixation, omission, or emphasis.
- Not utilizing the appropriate combination of primary / supporting instruments for a given maneuver.

Completion Standards:

1. Verify the prescribed checklist procedures normally used for securing the inoperative engine.
2. Attempt to determine and resolve the reason for the engine failure.
3. Monitor engine functions and make necessary adjustments.
4. Maintain the specified altitude ±100 feet or minimum sink rate if applicable, airspeed ±10 knots, and the specified heading ±10°.
5. Assess the airplane's performance capability and decide an appropriate action to ensure a safe landing.
6. Avoid loss of airplane control or attempted flight contrary to the engine-inoperative operating limitations of the airplane.
7. Utilize SRM.

OEI Instrument Approach and Landing (IFR)

Objective:

To fly an instrument approach in simulated IMC conditions and complete a landing after an engine failure.

Motivation:

This procedure combines the skills gained from two previous engine failure tasks. First, there is the need to maneuver an aircraft in simulated or IMC on a single-engine, and second a single-engine approach and landing. Again, practice is required, so the response is automatic.

Presentation (35 minutes):

1. Maneuvering the aircraft with one engine inoperative:
    a. Identifying which engine failed:
        i. Dead foot: Dead engine - The foot that does not apply rudder pressure is on the same side as the failed engine.
        ii. Confirm with engine instruments - Look for a drop in RPM/Manifold pressure, oil pressure, and/or low oil pressure annunciation. NOTE: Instruments may still show MAP, RPM, and Oil Pressure as the engine may be windmilling.
    b. Concept of memory items vs. checklist items done later and cockpit flow - Engine failures always have memory items to perform before referring to the checklist.
    c. How to identify, verify, feather, and secure the inoperative engine:
        i. Mixtures, Props, Throttles, Flaps Up, Gear Up,
        ii. Identify - Dead Foot, Dead Engine,
        iii. Verify - Reduce throttle on the failed engine - There should be no change in performance/sound if this is the failed engine.
        iv. Feather - If there is no change - Feather the inoperative engine.

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2. Maneuvering with one engine inoperative in IMC:
   a. Flying by sole reference to the flight instruments with one engine inoperative is different from maneuvering visually - Use the instruments as follows:
      i. Heading changes are shown on the heading indicator.
      ii. Set zero sideslip by banking 3° towards the operating engine and ½ ball deflection on the inclinometer.
      iii. Use the attitude indicator to maintain a specific altitude.
   b. Review of the instrument flying methods:
      i. Control and Performance (Instrument Flying Handbook pg. 6-2 - 6-4.)
      ii. Primary and Supporting (Instrument Flying Handbook pg. 6-3 - 6-10.)
   c. Review of instrument fundamental skills/Cross-check errors:
      i. Skills: Cross-check, instrument interpretation.
      ii. Errors: Fixation, omission, emphasis.
   d. Fundamental scanning skills:
      i. Cross-check - Not ignoring the operating engine and how it affects the flight characteristics.
      ii. Instrument Interpretation - Interpreting the various instruments, both engine and otherwise, to confirm your desired input for a given configuration.
      iii. Aircraft Control - Manipulation of the engine controls and primary/secondary flight controls for the desired outcome.

3. Flying an approach to landing - One engine inoperative:
   a. Flying/landing from the instrument approach:
      i. Reminder: Once altitude is lost, it may be impossible to regain; consider this when making power adjustments.
      ii. The approach is determined based on current conditions and landing runway(s). - Note: If possible, a crosswind approach and landing should be avoided.
      iii. Receiving arrival/approach clearance - in an actual situation, you will declare an emergency to ATC.
      iv. Briefing the approach plate (and missed approach procedure) and configuring the aircraft accordingly - delaying the input of flaps/gear until a landing is assured and remaining at or above V_{yse} - (blue line.)

v. Determining the descent rate required for the approach - ensuring a stabilized approach with one engine.

vi. Completing the before-landing checklist.

vii. Transition at the DA/DH, MDA, or visual descent point (VDP) to a visual, normal landing - When the landing is assured, and the glidepath can be maintained, slow to the approach speed.

Note: The airplane will yaw towards the operating engine when a propeller is feathered during the roundout and flare - Due to the operating engine windmilling at idle.

Presentation references:

- Instrument Flying Handbook pgs. (6-2 - 6-10, 10-15)
- Commercial Pilot ACS pgs. 59, 60
- Instrument Pilot ACS, pg. 20
- Airplane Flying Handbook pgs. 13-34,35

Key points:

Tasks should be managed in the following manner:

a. Dealing with an engine failure - Priority of tasks - Control, Identification, Engine Shutdown or not, Risk analysis, and decision of what to do next.

b. Maneuvering the airplane - It will be easier to turn in the direction of the inoperative engine and harder in the direction of the operating engine.

c. Communicating with ATC.

d. Flying an instrument approach.

The concept of energy conservation is that when an engine has failed, once lost, airspeed and altitude are nearly impossible to regain.
One of the most challenging pieces is configuring the airplane and establishing and maintaining a stable descent rate on a single engine. In addition, flying a non-precision approach is more difficult due to the step-downs and level-offs.

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Risk Management:

1. Failure to plan for an engine failure during approach and landing.
2. Collision hazards to include aircraft, terrain, obstacles, wires, vehicles, vessels, persons, and wildlife.
3. Improper airplane configuration.
4. Low altitude maneuvering, including stall, spin, or CFIT
5. Distractions, loss of situational awareness, or improper task management.
6. Attempting to land from an unstable approach.
7. Flying below the glidepath.
8. Transitioning from instrument to visual references for landing.
9. Performing a go-around/rejected landing with a powerplant failure.

Questions for the student:

1. Given today's conditions, what would you expect the single-engine climb/descen performance to be if vectored onto (x) approach for (y) runway?
2. If given the option, which approach would you choose to fly on a single-engine, and why?
3. What gear/flap/power configuration would achieve your desired descent profile?
4. When do you anticipate extending the landing gear? Why?

Common errors:

a. Failure to promptly recognize an engine failure and maintain positive airplane control.

b. Instrument fixation, omission, or emphasis.

c. Not utilizing the appropriate combination of primary/supporting instruments for a given maneuver.

d. Not monitoring the operating engine and making adjustments as necessary.

e. Failure to receive an actual (or simulated) approach clearance from ATC/the examiner.

f. Failure to adhere to an instrument approach clearance - altitude deviations/not maintaining localizer/glideslope.

g. Descending below minimum altitudes by not recognizing the lack of performance due to the engine failure.

Completion Standards:

1. Follow the manufacturer's recommended emergency procedures.
2. Monitor the operating engine and make adjustments as necessary.
3. Request and follow an actual or a simulated ATC clearance for an instrument approach.
4. Maintain altitude ±100 feet or minimum sink rate if applicable, airspeed ±10 knots, and selected heading ±10°.
5. Establish a rate of descent that will ensure arrival at the MDA or DA/DH, with the airplane in a position from which a descent to a landing on the intended runway can be made, either straight in or circling as appropriate.
6. On final approach segment, maintain vertical (as applicable) and lateral guidance within 3/4-scale deflection.
7. Avoid loss of airplane control or attempted flight contrary to the operating limitations of the airplane.
8. Comply with the published criteria for the aircraft approach category if circling.
9. Execute a normal landing.
10. Complete the appropriate checklist.

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After Landing, Parking and Securing

Objective:

To be able to have situational awareness and take the proper steps after landing and taxiing to park and secure the airplane in a safe and efficient manner.

Motivation:

This is another task that must be completed after each flight, regardless of the mission of the flight. Properly parking and securing the airplane is an important task because, if done incorrectly, the airplane can incur damage from the environment, or even from other airplanes if it rolls out of its parking spot.

Presentation (15 minutes):

1. After landing, slow the airplane down to a reasonable speed using the brakes.
2. Give full attention to controlling the airplane during the landing roll, and only complete the after-landing checklist after the airplane is stopped.
3. See the POH/AFM for the manufacturer's recommended after-landing procedure - See addendum 1 at the end of this lesson for some general procedures.
4. After exiting the runway and any movement areas, have an understanding of parking procedures both at your airport and away from your airport. This includes some of the following:
    a. Knowing where the FBO / General Aviation / Transient parking is - Use foreflight / chart supplement (or ask ATC for assistance).
    b. Getting marshalled in or finding your own parking spot - Reference tie-downs, paint lines, etc.
    c. If no obvious pre-determined spot is available, select a location based on the following:
        i. Prevents propeller or jet blast from other planes possibly harming your airplane.
        ii. Can be positioned into the existing or forecast wind

Note: When parking, allow the airplane to roll straight ahead a bit to help straighten the nosewheel.

5. See the POH/AFM for the manufacturer's recommended shutdown procedure - See addendum 2 at the end of this lesson for some general procedures.
6. Once the airplane is fully shut down, exit the airplane and apply chocks / tie-downs, then release the parking brake in accordance with the POH.
7. Secure the airplane by locking the doors, applying an aircraft cover (if applicable), etc.
8. Complete a thorough post-flight visual inspection, and notate any maintenance discrepancies, or, if necessary, down the aircraft for any safety concerns.

Presentation references:

- Airplane Flying Handbook: pgs. 2-22, 23
- Pilot's Handbook of Aeronautical Knowledge: chapter 14.
- Commercial Pilot ACS: pg. 61
- AFM/POH: Piper Seminole - pg. 4-25.

Key points:

- Planning each flight "all the way to the tiedowns"
- Following manufacturer's recommended procedures at all points.
- Asking ATC for assistance if required.
- Using a checklist properly to ensure task completion.
- Not hesitating to contact a mechanic or request outside help if things go wrong.

Risk Management:

- Inappropriate activities and distractions.
- Confirmation or expectation bias as related to taxi instructions.
- Airport specific security procedures.
- Disembarking passengers.

Questions for the student:

1. What would you do if upon landing you lost steering control of the airplane?
2. What is an important task to complete when tying down the airplane with chains?
3. What are some common marshalling signals?

Common errors:

- Lack of preflight preparation resulting in being unsure where to park.
- Lack of knowledge regarding various tiedown procedures.
- Failure to park the airplane relative to current or forecasted strong winds.
- Failure to complete the appropriate checklist.
- Failure to be aware of surroundings, endangering others.
- Mistakenly operating the wrong controls after landing (gear up while taxiing)

Completion Standards:

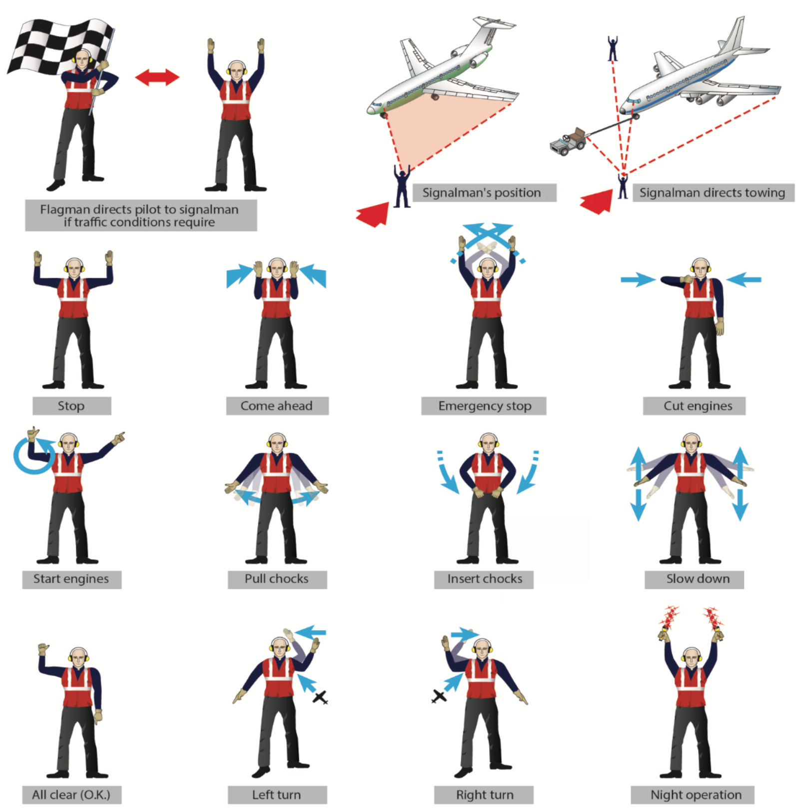
1. Utilize runway incursion avoidance procedures.
2. Park in an appropriate area, considering the safety of nearby persons and property.
3. Complete the appropriate checklist.
4. Conduct a postflight inspection and document discrepancies and servicing requirements, if any.
5. Secure the airplane.

Addendums:

1. General after-landing procedures:
    a. Throttle: IDLE / 1,000RPM.
    b. Fuel: Fuel pump(s) OFF
    c. Flaps: Clean up / retract.
    d. Cowl flaps: Open or close - temperature dependent.
    e. Trim: Neutral.
    f. Some lights: OFF - usually landing light / anti-collision lights.

g. Avionics: Transponder set to standby, comms set to ground / CTAF.

2. General shutdown procedures:
    a. Parking brake: ON.
    b. Throttle(s): Idle / 1,000RPM.
    c. Magnetos: Checked.
    d. Prop: Full forward.
    e. Avionics: OFF.
    f. Alternator(s): OFF.
    g. Mixture: Idle/cutoff - kills the engine.
    h. Magneto(s): OFF - after engine quits.
    i. Master switch: OFF.
    j. Secure: Exit, then tie-down the airplane, lock the doors, etc.



Airman Certification Standards Differences - Pvt. vs. Com.

All of the maneuvers listed in these lesson plans are to Commercial Pilot ACS Standards. The following table shows the completion standards for the Private Pilot ACS.
Refer to the latest ACS for the details.

Steep Turns	45° of bank
Slow Flight	±100 feet altitude, +10/-0 kts airspeed, ±10° specified heading
Power-Off Stalls	Recover after a full stall occurs.
Power-On Stalls	Recover after a full stall occurs.
Normal Landing	+400/-0 feet
Short Field Landing	+200/-0 feet

Runway Incursion Avoidance

Objective:

The student will be able to understand and apply knowledge of the airport environment so that they avoid either a runway incursion or unauthorized operation in a movement area.

Motivation:

Runway incursions in General Aviation are higher than airline and charter operations due to unfamiliar airport structures and a typical one crew environment. Understanding and applying avoidance principles will help avoid runway and movement are incursions.

Presentation (30 minutes):

1. Distinct challenges and requirements during taxi operations not found in other phases of flight operations - (FAA-S-8081-6D 34).
2. Procedures for appropriate cockpit activities during taxiing including taxi route planning, briefing the location of hot spots, communicating, and coordinating with ATC.
3. Procedures for steering, maneuvering, maintaining taxiway, runway position, and situational awareness.
4. The relevance/importance of hold lines.
5. Procedures for ensuring the pilot maintains strict focus on the movement of the aircraft and ATC communications, including the elimination of all distractive activities (i.e., cell phone, texting, conversations with passengers) during aircraft taxi, takeoff and climb out to cruise altitude.
6. Procedures for holding the pilot's workload to a minimum during taxi operations which should increase the pilot's awareness while taxiing.
7. Taxi operation planning procedures, such as recording taxi instructions, reading back taxi clearances, and reviewing taxi routes on the airport diagram.
8. Procedures for ensuring that clearance or instructions that are actually received are adhered to rather than the ones expected to be received.
9. Procedures for briefing if a landing rollout to a taxiway exit will place the pilot in close proximity to another runway which can result in a runway incursion.
10. Appropriate after landing/taxi procedures in the event the aircraft is on a taxiway that is between parallel runways.

11. Specific procedures for operations at an airport with an operating air traffic control tower, with emphasis on ATC communications and runway entry/crossing authorizations.
12. ATC communications and pilot actions before takeoff, before landing, and after landing at towered and non-towered airports.
13. Procedures unique to night operations.
14. Operations at non-towered airports.
15. Use of aircraft exterior lighting.
16. Low visibility operations.

Apparent Horizon:

Runway incursions – Any occurrence at an airport involving the incorrect presence of an aircraft on the surface at an airport designated for the take-off and landing of aircraft.

Why it happens – Unfamiliar airport, complicated taxi structure, complicated taxi instructions, in attention, distractions, low visibility, incomplete information.

Tools and information available to the pilot:

Airport diagrams – How to plan a taxi route.

Hot Spots – How to identify them and what are the details of why they are hot spots. Airport.

Signs – Use AOPA's fashcards to step through the signs and meanings.

Signage – Runway signs, runway boundary markings (Hold short lines) Taxiway signs – On a specific taxiway sign, approaching a taxiway sign
Movement areas vs. Non-movement areas – Pavement markings – When an ATC clearance is required.

Information signs – FBO, Ramp, Military area.

Taxi procedures and techniques to avoid incursions:

Pre-planning taxi and departure procedures to reduce pilot's workload – Plan taxi routes, identify hot spots, copy clearances from ATC.

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Usually taxiing and take-off operations involve the movement of airplanes close to other air

planes, vehicles, pedestrians, runways, and taxiways where it is easy to lose situational awareness and become a potential hazard.

Maintaining situational awareness – Appropriate times for checklist usage, using airport diagrams, Foreflight runway proximity advisor, understanding the clearance, or asking for clarification before moving. STOP the airplane if you are unsure.

Importance of full attention to taxi operations – Apply sterile cockpit rule, turn off Mobile phone/ texts, avoid conversations with passengers, full attention to ATC communications until at a safe altitude and distance from the airport.
ATC communications and clearances – Anticipation of clearances and read-backs – Problems with pilots thinking they heard the clearance as they anticipated it, but another clearance was given – Read back solves this problem.

Progressive taxi procedure from ATC.

Requirements for ATC to issue runway crossing instructions and pilot read-back. Creating a mental picture of aircraft movements and intentions that are on frequency so that the pilot gains better insight and awareness of the entire airport or section of the airport that the pilot is operating in.

Hazards of maneuvering in low visibility – Difficulty in seeing, requires extra diligence, slower taxi speeds, importance of signage, tower not able to see aircraft.

Clearance Requirements and Examples:

Requirements for obtaining a takeoff clearance - Example clearances Requirements for a landing clearance - Examples of these clearances.

After landing instructions from ATC to pilots and hold between runway or runway crossing clearance – Examples.

During the landing phase, the pilot should brief an exit strategy so that the pilot is aware of potential parallel runways with the need to hold in between, or other taxiway/runway issues that could cause the pilot to lose situational awareness.

Non-Towered Airport Operations

ATC clearances not required. Pilots self-separate via radio.
Not all airplanes have radios – Use extra diligence in key places: take-off, turns, 45, and base to final.

There are no movement and non-movement areas.
Pilots should visually clear the downwind, base, and final leg in both left and right traffic before taxiing onto the runway.

Night Operations:

Requires more attention due to reduced visual cues.

Position lights and what they mean – Green right, Red left, White rear.

Runway environment lighting – Runway edge (white), taxiway (blue), threshold (green), end of runway (red), obstructions (red)

Runway signs are usually lighted at towered airports – not necessarily at non-towered airports.

Easier to make a mistake with regards to a taxiway, runway, or movement area marking. Use of exterior lighting to indicate intent.

Standardized Aircraft Lighting

💡 = Turn on	Rotating beacon	Navigation/Position lights	Strobe light*	Taxi lights	Logo lights	Landing lights
Engine(s) running	💡					
Taxiing	💡	💡	💡	💡	💡	
Crossing a runway	💡	💡	💡	💡	💡	💡
Entering departure runway for line up and wait	💡	💡	💡	💡	💡	
Takeoff	💡	💡	💡	💡	💡	💡

Presentation references

- Pilots Handbook of Aeronautical Knowledge
- The FAA “Taxi Test”

Completion Standards

The lesson is complete when the student can identify all airport signs and show on an airport diagram where they would be located. The student will be able to understand ATC clearances and how to minimize distractions. The student will also describe how to operate at night and at a non-towered airport.

Visual Scanning and Collision Avoidance

Objective:

To develop a methodical approach to visual scanning & collision avoidance.

Motivation:

Avoiding a collision with another airplane when VFR is always the responsibility of the pilot even if radar services are used. The See and avoid concept applies to all pilots.

Presentation (45 minutes):

1. Relationship between a pilot's physical condition and vision.
2. Environmental conditions that degrade vision.
3. Vestibular and visual illusions.
4. "See and avoid" concept.
5. Proper visual scanning procedure.
6. Relationship between poor visual scanning habits and increased collision risk.
7. Proper clearing procedures.
8. Importance of knowing aircraft blind spots.
9. Relationship between aircraft speed differential and collision risk.
10. Situations that involve the greatest collision risk.
11. Using TIS and ADS-B.

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Relationship between a pilot's physical condition and vision

i. Vision is the most important sense in light.

ii. Good eyesight depends on good physical health.

1. Fatigue, illness, smoking, drugs, alcohol, oxygen deprivation, lack of vitamins.

a. Environmental conditions that degrade vision (AIM 8-1-6)

i. Dark adaptation: Requires 30min.

1. Impaired by cabin Pressure Alt >5,000'MSL, CO (exhaust or smoking), Vitamin A deficiency.

b. Vestibular and visual illusions. (AIM 8-1-5)

i. False perception of one's position and motion with respect to the earth.

ii. Sensory illusions can lead to differences between instrument indications and what the pilot "feels".

iii. Disoriented pilots are not aware of their orientation.

iv. When an attitude is maintained for an extended period, the vestibular system will cause the pilot to incorrectly determine attitude.

v. An abrupt change in attitude or head position can create spatial disorientation.

vi. Correct orientation only by visual reference to a reliable fixed position on the ground or by using the light instruments.

vii. Examples of Illusions leading to Spatial Disorientation and Landing Errors.

1. See AIM 8-1-5.

"See and Avoid" Concept (AIM 5-5-8, FAR 91.113b)

- Regardless of the type of light plan or whether or not under the control of a radar facility, the pilot is responsible to see and avoid other traffic, terrain, and obstacles.

Proper visual scanning procedure. (AIM 8-1-6c , AC 90-48)

- Scanning the sky for other aircraft is a key factor in collision avoidance.
- It should be used continuously by the pilot and copilot to cover all areas of the sky visible from the cockpit.
- Effective scanning is accomplished with a series of short, regularly spaced eye movements that bring successive areas of the sky into the central visual field.

- Each movement should not exceed 10 degrees, and each should be observed for at least 1 second to enable detection.
- Eyes should be outside about 3/4 of the time. 4 to 5 secs on the instrument panel for every 19 seconds outside.
- Avoid “Empty-Field Myopia” - Condition such as above the clouds or haze layer with nothing specific to focus on outside the aircraft. This causes the eyes to relax and seek a comfortable focal distance which may range from 10 to 30 feet. This means looking without seeking, which is dangerous.

Relationship between poor visual scanning habits and increased collision risk

- Poor scanning habits will elevate the risk of collision.

Proper clearing procedures. (AC 90-48)

- Taxi onto Runway: scan for approaching traffic. (Maneuver the aircraft to get a clear view)
- Climb/Descend: Gentle banks left/right.
- Clearing turns before maneuvers.

Importance of knowing aircraft blind spots. (AC 90-48)

- Look around physical obstructions. (Doors / Window post)

Relationship between aircraft speed differential and collision risk Situation that involve the greatest collision risk. (AIM 8-1-8, AC 90-48)

- Places where aircraft tend to cluster:
- Airways, especially near VORs and IFR waypoints.
- Near airports, especially on clear sky and good visibility days.

Presentation references:

- FAA-H-8083-25b
- AC 91-73B
- Runway Safety FAA Taxi Test
- Faa.gov/go/runwaysafety

Principles of Flight - Aerodynamics (Lift, Drag, and Wing Planform)

Objective:

To understand the aerodynamic concepts of how an airplane can overcome its own weight and understand how resistance to its movement is generated and managed.

Motivation:

An airplane must overcome its weight to fly and must be able to move through the air in order to do it. An understanding of these aerodynamic concepts/forces allows the pilot to understand how to anticipate and manage these forces.

Presentation (45 minutes):

Airplane Components to Introduce:

1. Fuselage – Airplane minus the wings and stabilizers – contains the cabin, engine, etc.
2. Airfoil – Generates force to overcome weight.
3. Horizontal Stabilizer – Allows the airplane to be controlled to balance the effect of the airfoil.

The Four Forces:

1. Weight
2. Lift
3. Thrust
4. Drag

Lift and Weight

1. For an airplane to fly it must overcome its weight. Weight is always directed downward.
2. The force created to overcome weight is called lift.
3. Newtons Third Law – Reaction.
4. Bernoulli's Principle – Relationship of Pressure and Velocity.
5. Airfoil components.
6. Show restricted pipe and relate it to an airfoil.
7. Relative wind – Parallel and opposite the flight path.
8. Angle of attack of the airfoil – Larger AOA increases the path on the top of the airfoil = more velocity = increase in lift.

9. Lift equation – Lift = $PV^2SC_L/2$ – Lift increases at the square of the velocity.
10. Critical angle of attack – Air can no longer stay attached to the airfoil – Aerodynamic stall occurs – Lift decreases.
11. Lift equation – variables controlled by the pilot are velocity and C_L. (Angle of attack)
12. The slower the airplanes speed the more Angle of Attack is needed (C_L).
13. As speed or AOA increases lift increases and the Center of Lift (Cp) moves forward
14. Cp needs to always be behind the Center of gravity (CG).
15. Purpose of the horizontal stabilizer – Provides tail downforce – keeps the wing from causing the airplane to rotate forward around its CG.

Drag and Thrust

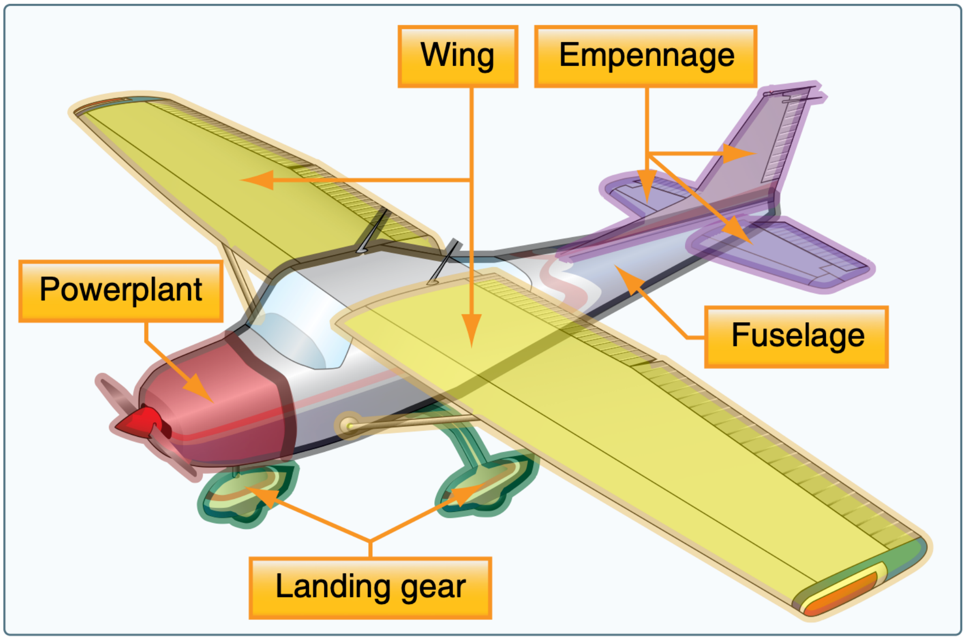
1. Thrust provides a means to create speed (Velocity)
2. Drag is a force that opposes thrust.
3. Parasite drag is caused by the airplane parts – A larger surface area will create more drag.
4. Parasite drag – Increases at the square of the speed – Show the graph, drag vs. speed.
5. Induced drag – As speed is slowed more AOA is needed – The lift vector is tilted rearward. A component of lift acting rearward has to be overcome by thrust or the speed will decrease..
6. Induced drag – Wingtip vortices increase with higher AOAs. At the wingtips, the high pressure below can corkscrew up toward the low-pressure area of the wing. It takes energy to create the vortices and this energy is taken from the airflow that causes lift, which means there will be more drag.
7. Induced drag – Show graph of drag vs speed – Induced drag increases as speed is reduced. (AOA is generating lift instead of velocity)
8. Total drag is the combination of Parasite and induced drag. (Show graph of drag vs speed with the total drag curve).
9. It is the point where the total drag is the least.
10. Drag must be overcome by thrust in order to both speed up, (Parasite drag), or to go slower, (due to induced drag), to maintain level flight.
11. In ground effect the air below the wing is compresses and this keeps the lift vector more vertical.

Wing Design and Planform

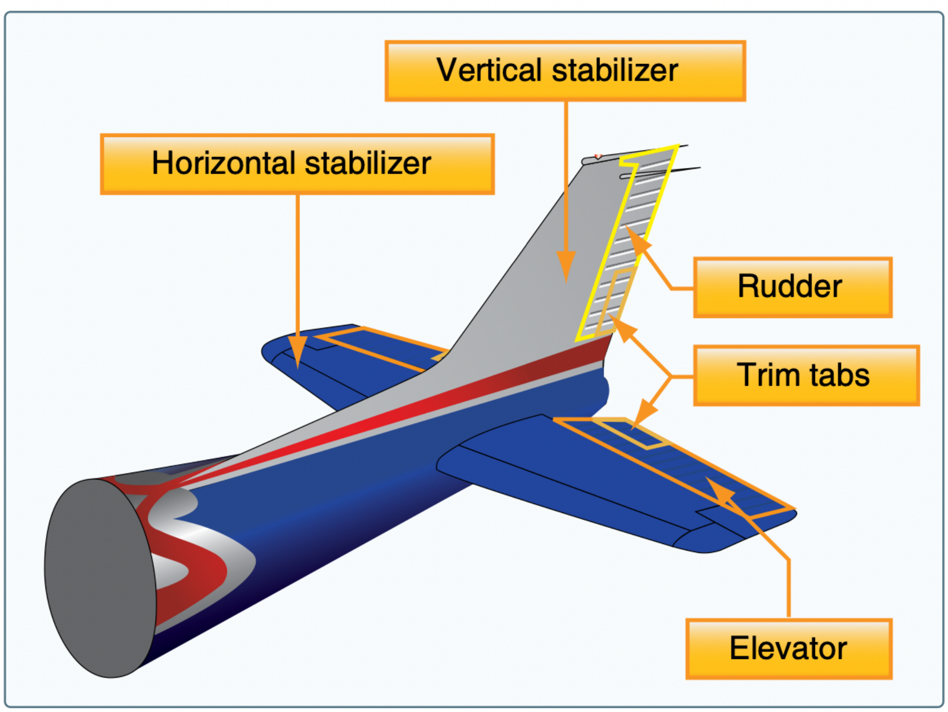
1. Aspect ratio as it relates to the production of lift and drag.
2. Design choices of various wing planforms for speed and handling.

Lesson Additional Images

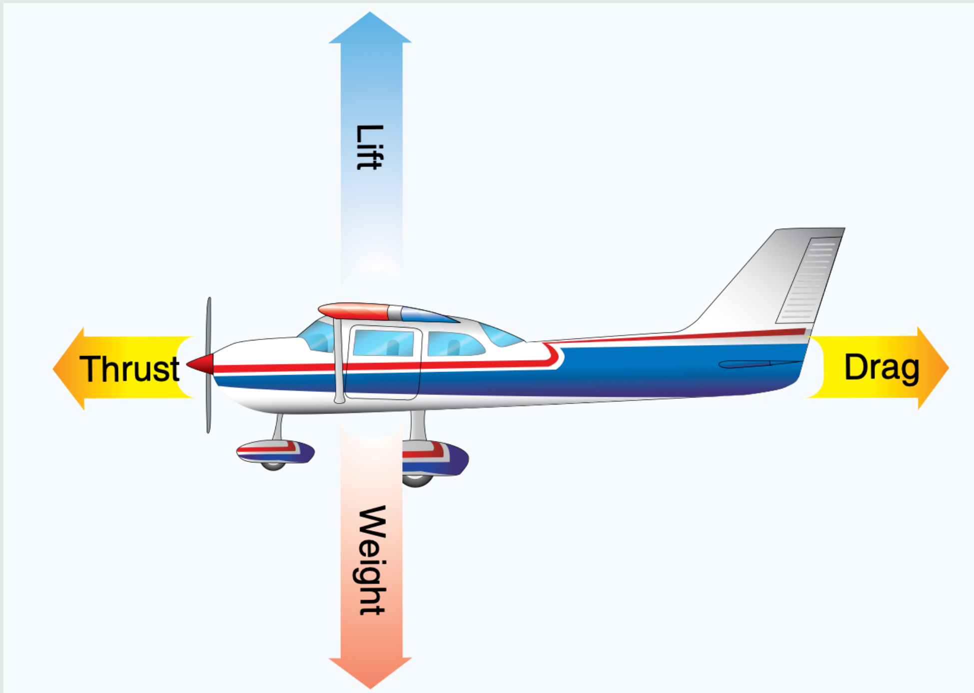
Components of an airplane



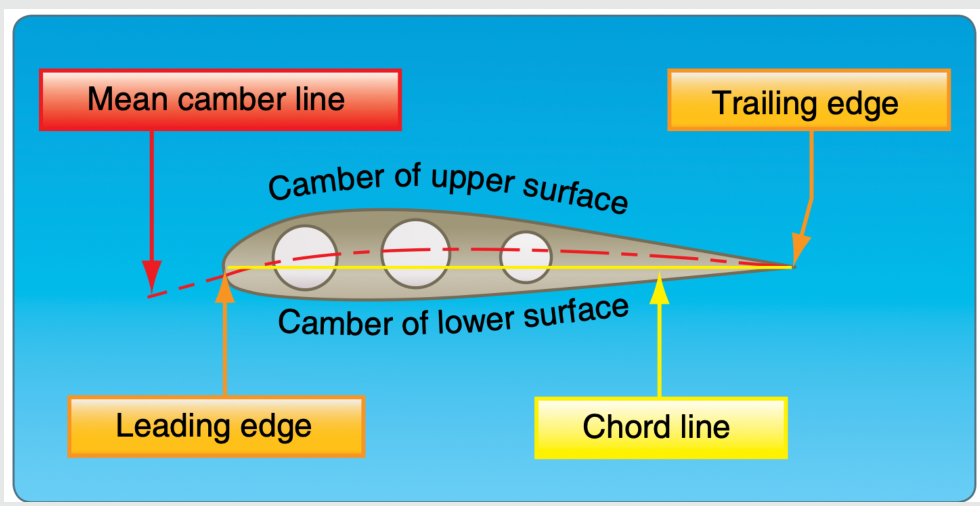
Horizontal Stabilizer



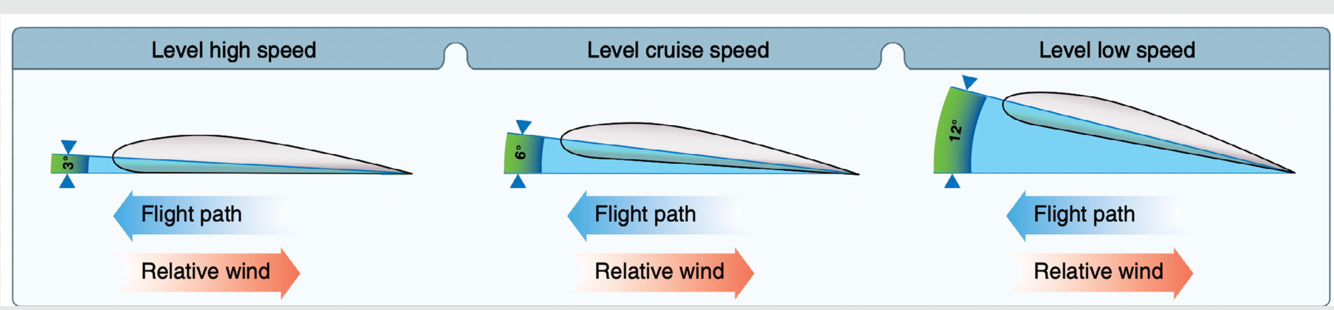
Four-Forces Acting on an Airplane



Airfoil



Relative wind as speed changes along the same flight path



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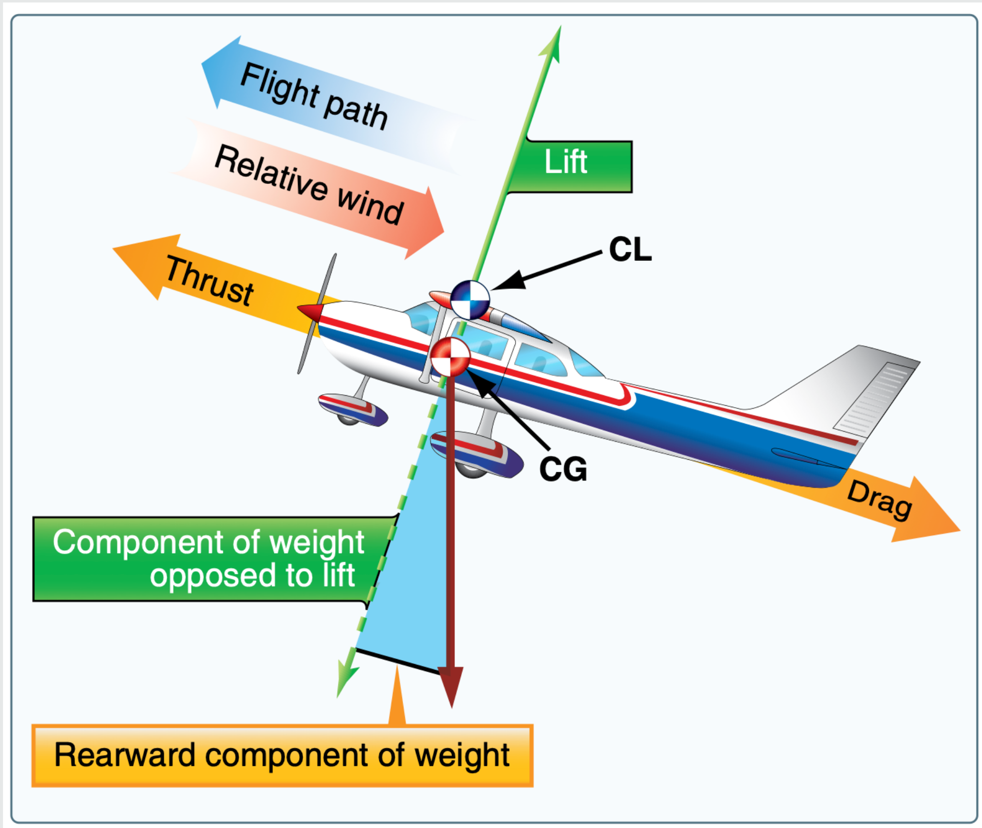
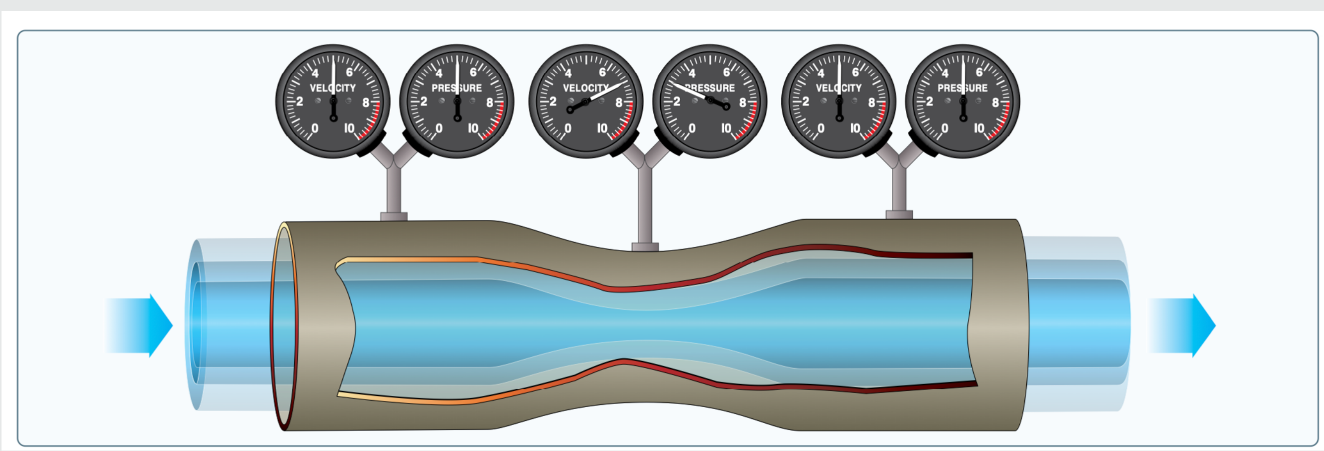
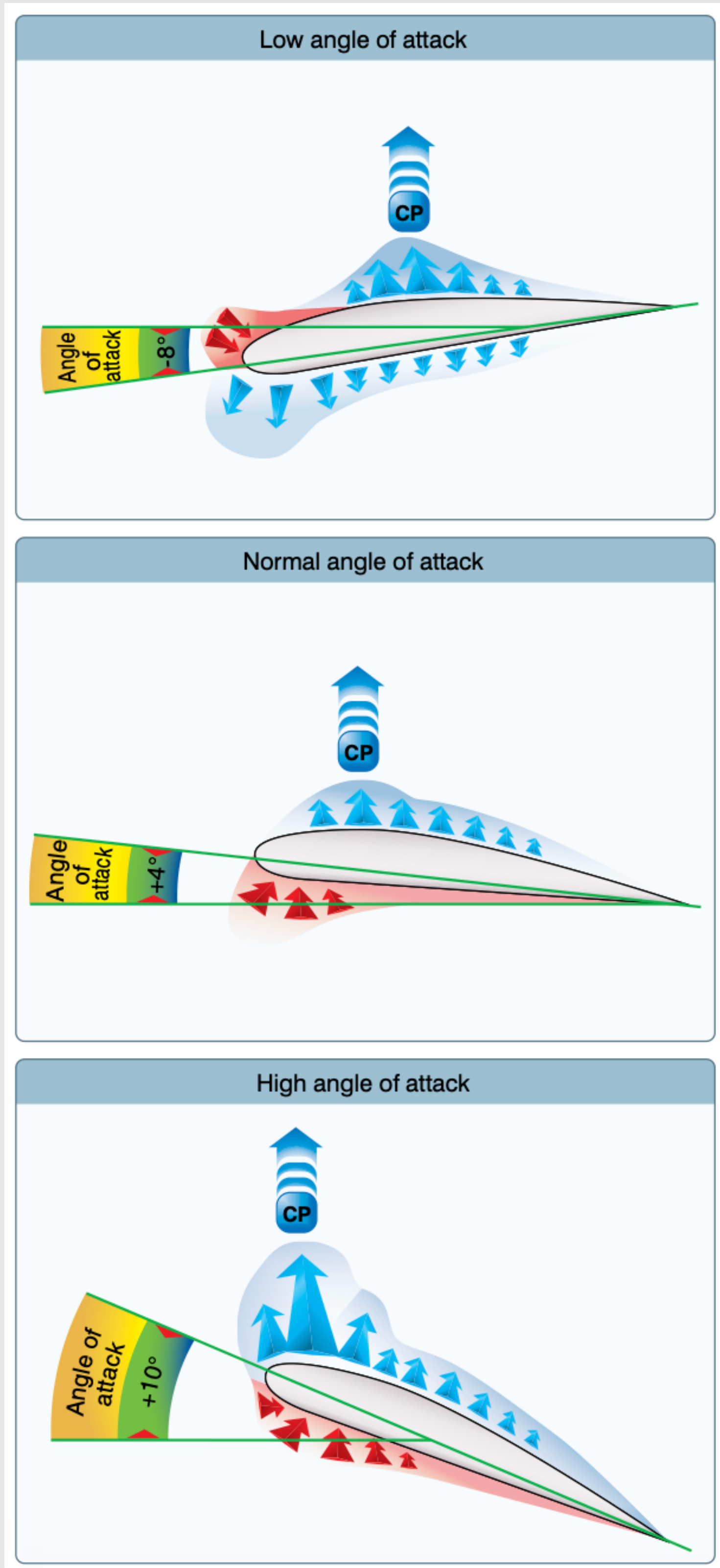
Relative wind in a climb



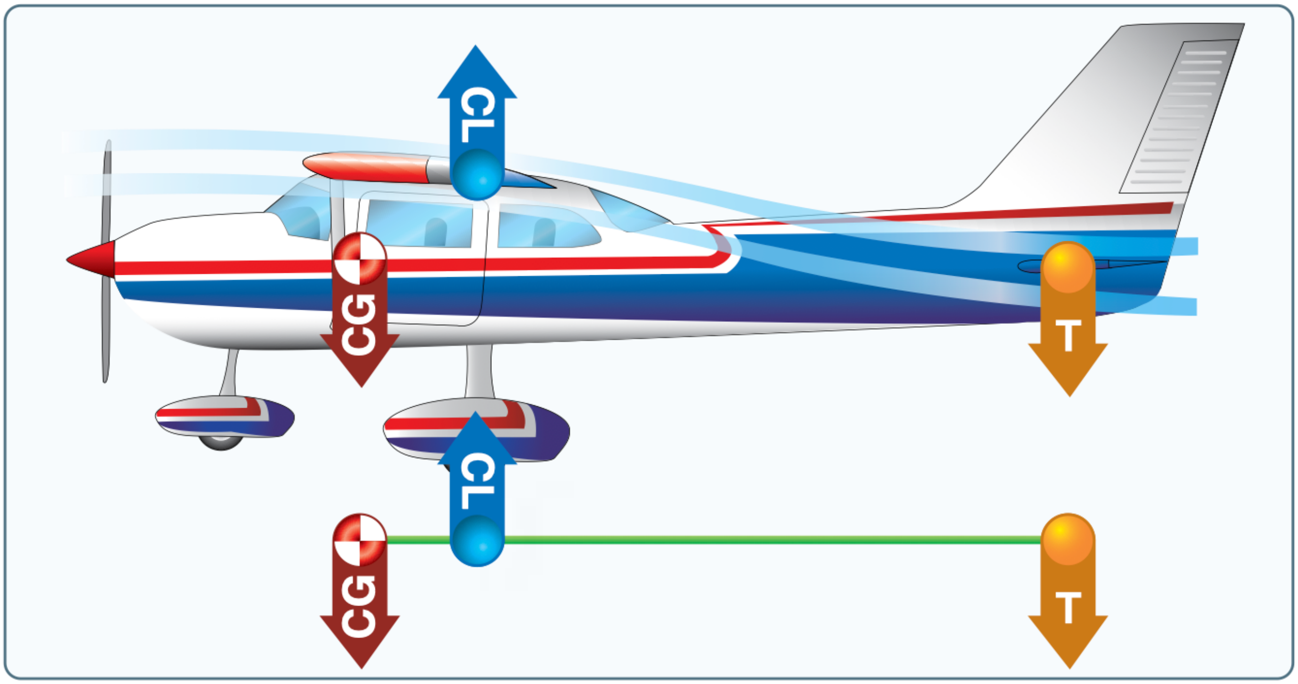
Pressure and Velocity Relationship - Bernoulli's Principle



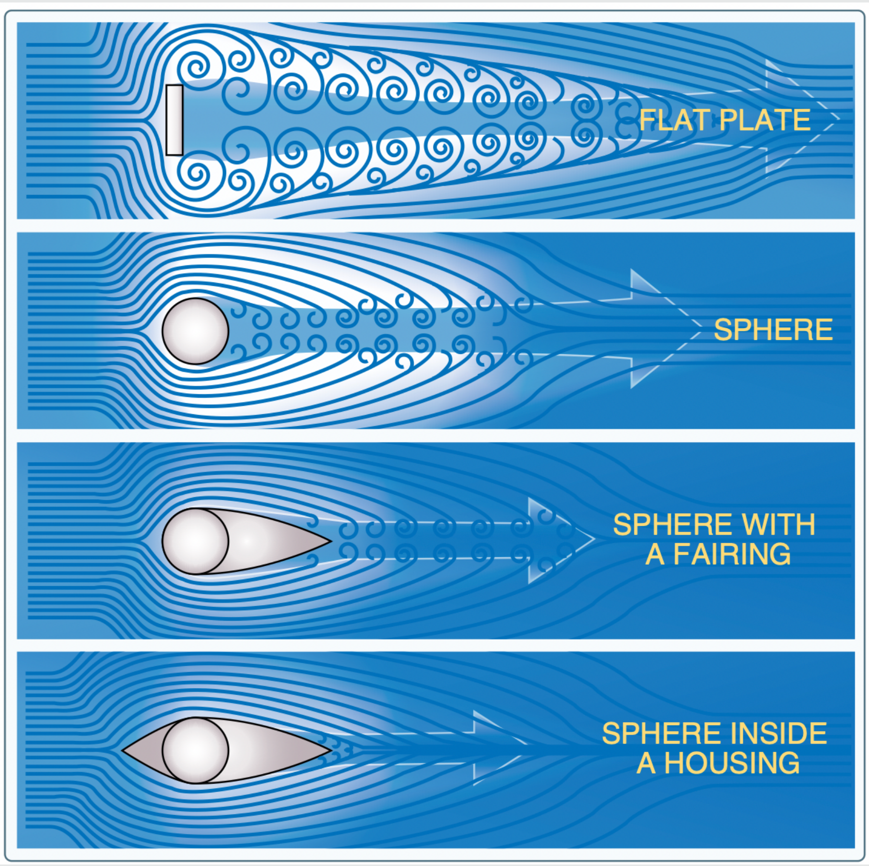
Center of pressure changes with angle of attack



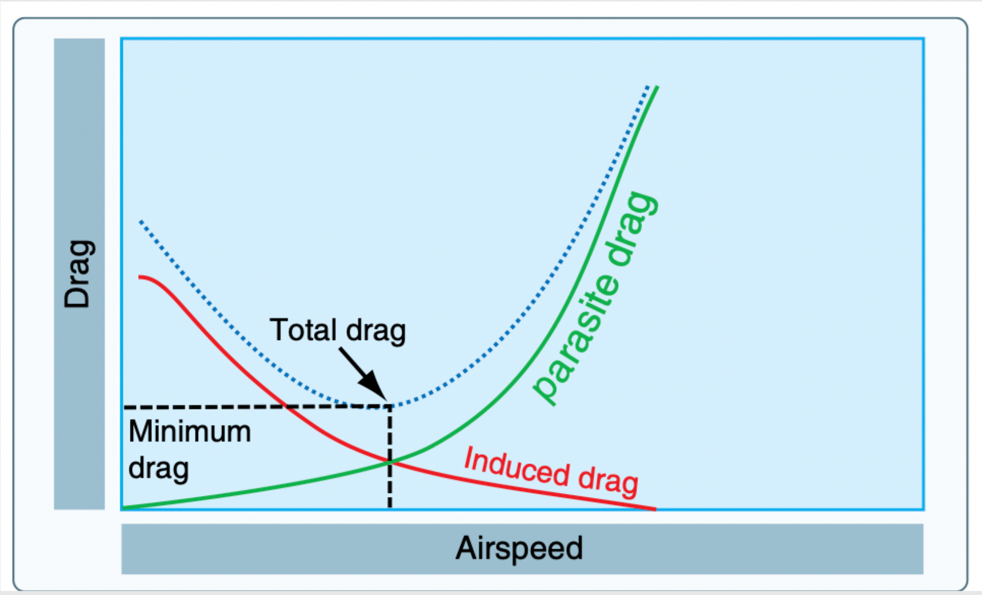
Taildown Force Balancing the CL to CG Differences



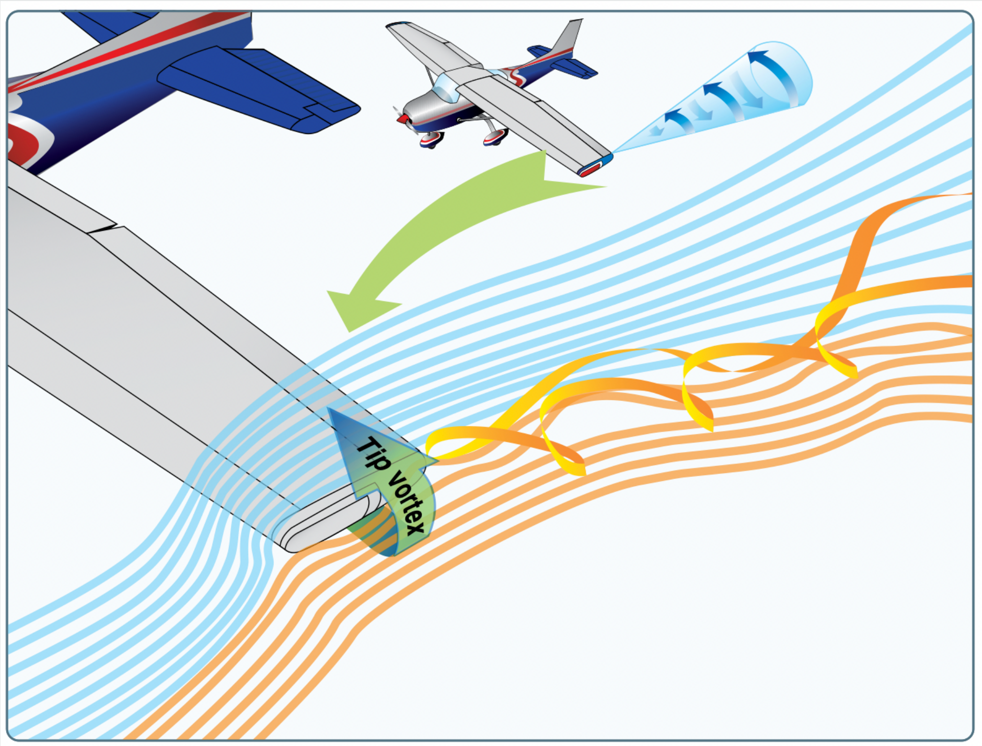
Parasite Drag



Drag vs. Speed



Wingtip Vortices Causing Induced Drag



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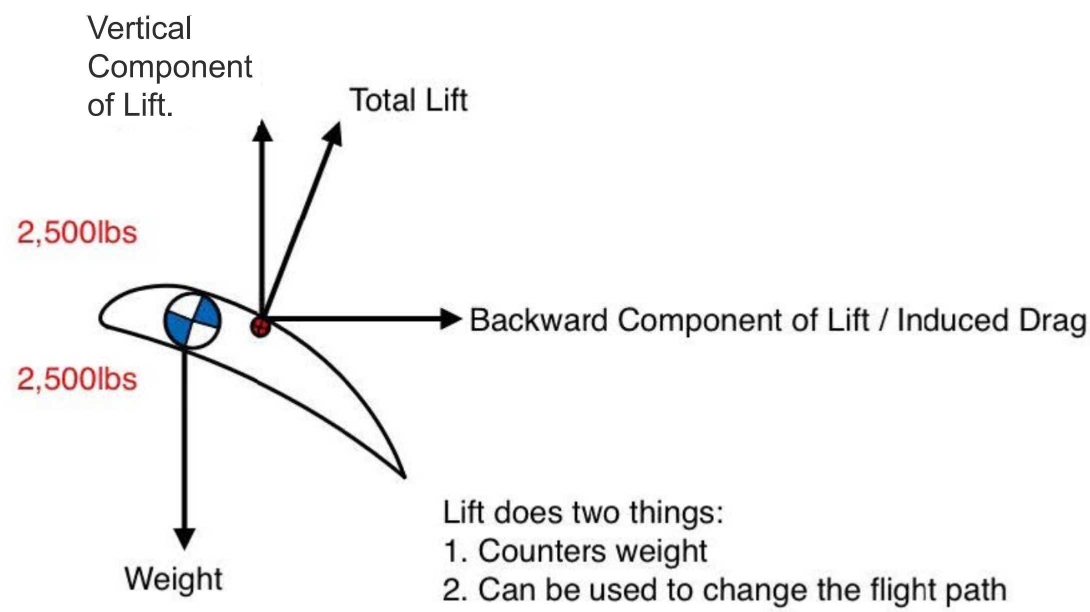
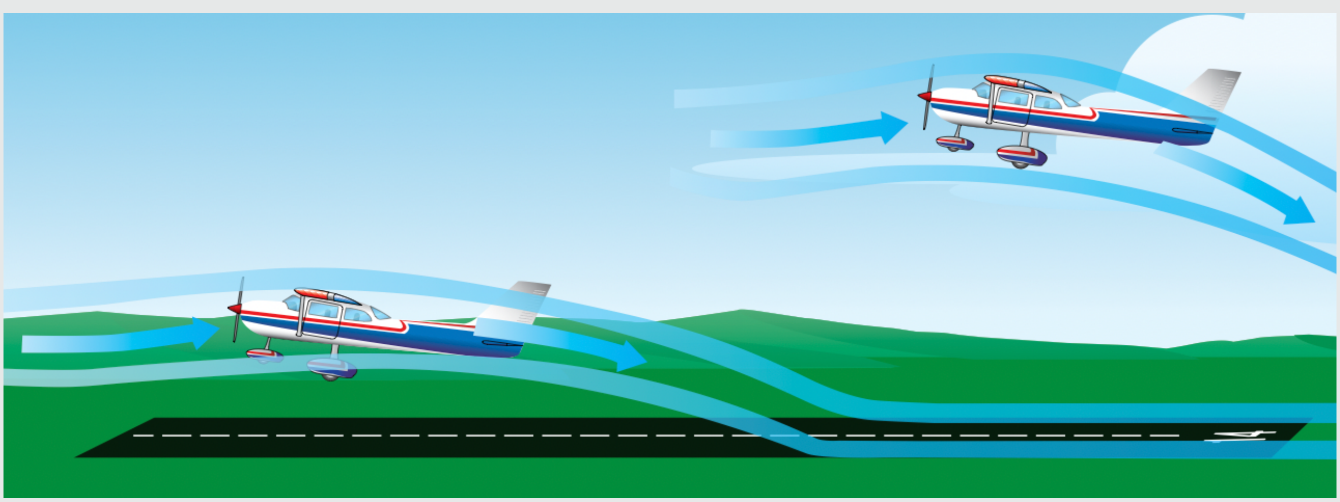
Induced Drag

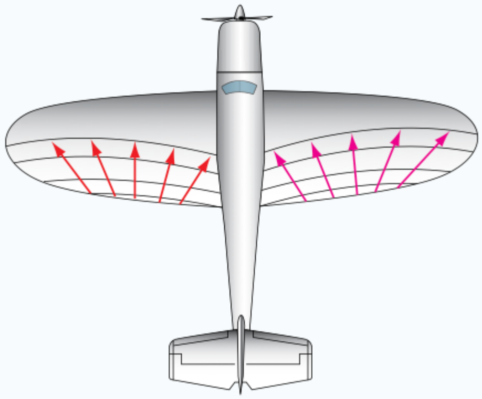


Thrust causes an airplane to climb, Lift causes flight path to be redirected.

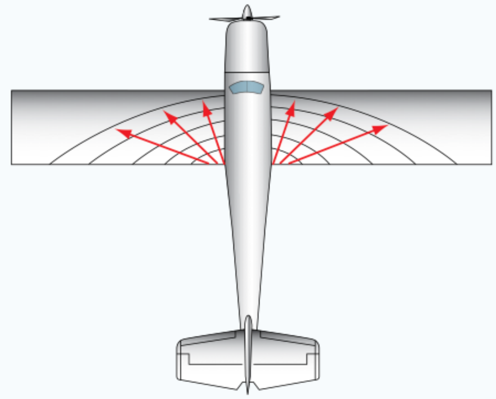
Ground effect changes the airflow



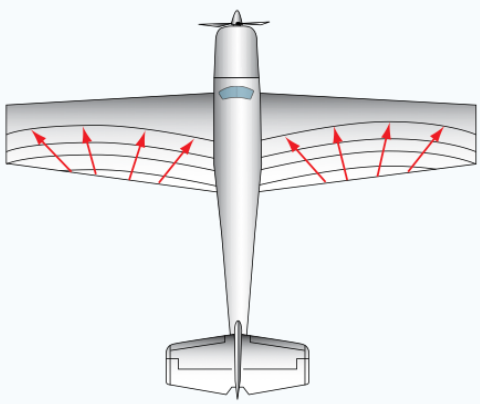
Wing Planforms



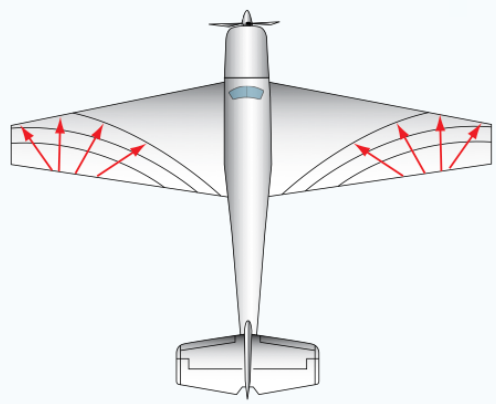
Elliptical wing



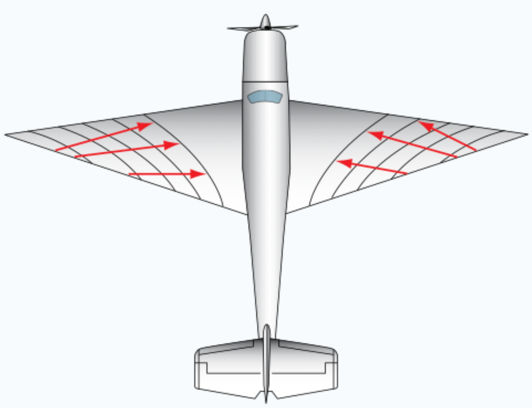
Regular wing



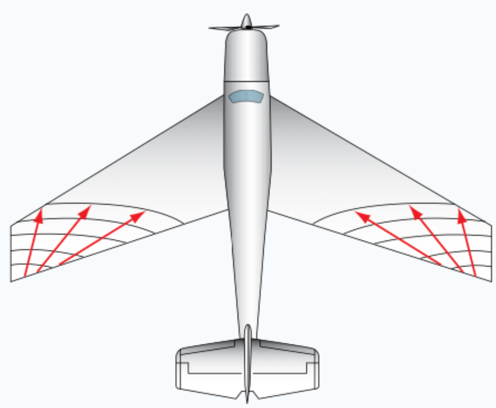
Moderate taper wing



High taper wing



Pointed tip wing



Sweepback wing

Aerodynamics - Stability and Controllability

Objective:

The student will understand how a training or transport airplane achieves stability around its three axes. The student will also understand how the center of gravity affects the control over the airplane the pilot has.

Motivation:

Understanding stability will help the pilot understand when and to the extent a control input may be necessary after the airplane is disturbed by the environment such as turbulence. Understanding how the center of gravity determines how controllable the airplane is will also help the pilot load the airplane in a safe manner where controllability is assured.

Presentation (30 minutes):

Stability

1. Airplane stability relates to how the airplane behaves if disturbed from its flight path.
2. Static stability – The initial tendency of the movement of the airplane once disturbed.
3. Types of static stability – Positive, Neutral, and Negative.
4. Dynamic stability – The tendency of the airplane's movement over time.
5. Types of dynamic stability – Positive, Neutral, and Negative.
6. Longitudinal stability (Pitching) – Achieved by more or less taildown force due to downwash. Also, the thrust line will affect the stability when the power is changed.
7. Lateral stability (Rolling) – Achieved in a high wing airplane by pendulous effect and keel effect.
8. Lateral stability (Rolling) – Achieved in a low wing airplane by Dihedral.
9. Vertical stability (Yawing) – Achieved by the fuselage aft of the CG and the vertical stabilizer.
10. Free directional Oscillations (Dutch Roll) – Dihedral brings the wings level before the nose is aligned with the relative wind. This causes the airplane to form a figure eight along the horizon. Dampens down eventually.
11. Spiral instability – Caused by good directional stability – Strong directional stability on the airplane results in the nose aligning to the relative wind quickly compared to the weak dihedral causing the airplane to bank. The outside wing travels faster than the inside wing and the bank increases. Easy for a pilot to fix. Better control than Dutch roll, so most airplanes are designed with spiral instability rather than Dutch roll.

Controllability

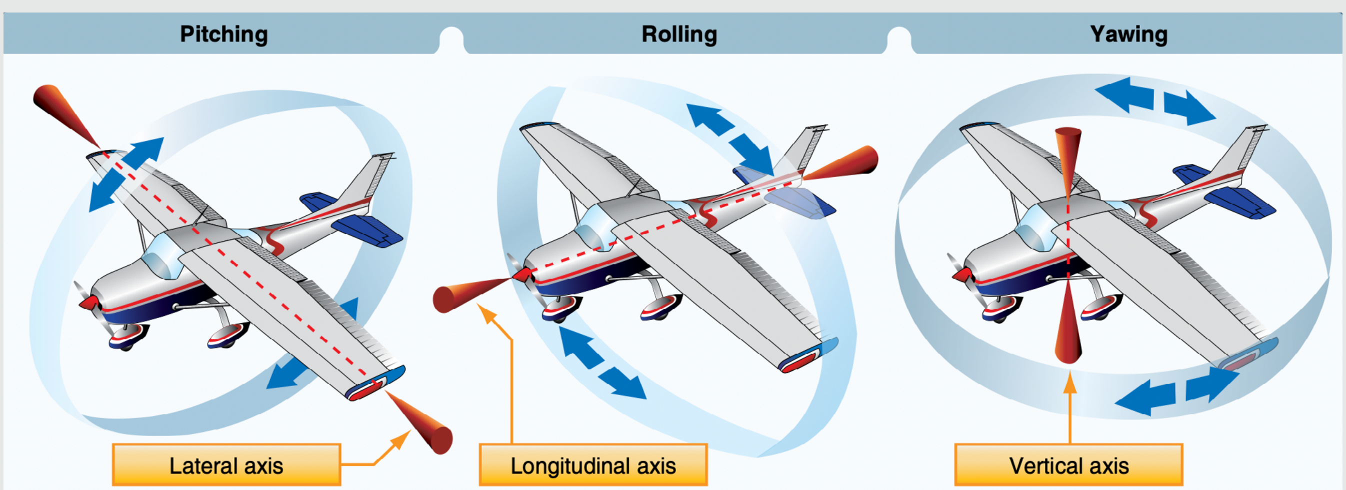
1. Controllability – The CG to the Cp is the determining factor. The design of the CG limits considers the amount of elevator control available to operate over all of the airplane's speed ranges.
2. If the CG location is too far forward, it means less elevator travel upward - Not enough taildown force. (Difficult ot impossible to flare). Very stable as a stall results and will unstall quickly due to the CG pulling the nose down.
3. If the CG location is too far aft, it means there is too much tailup force. The elevator many not be able to produce enough taildown force to keep the airplane from stalling.

Completion Standards:

The student will be able to show how an airplane achieves stability around its three axes using a model airplane or whiteboard. The student will also explain why an airplanes center of gravity is important for controllability.

Lesson Additional Images

Axes of an airplane



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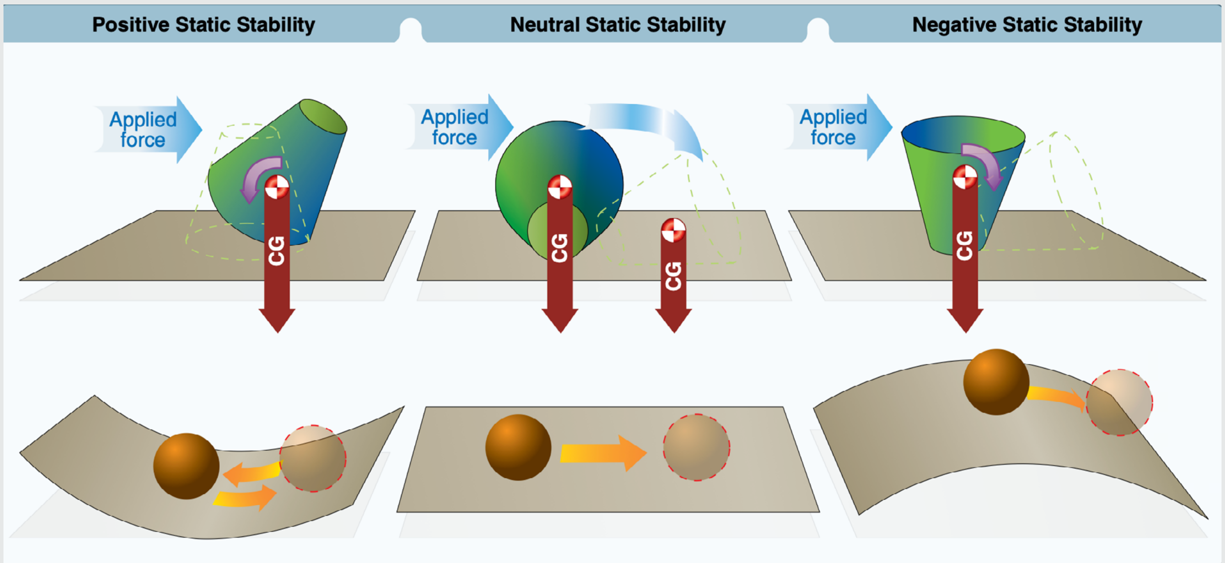
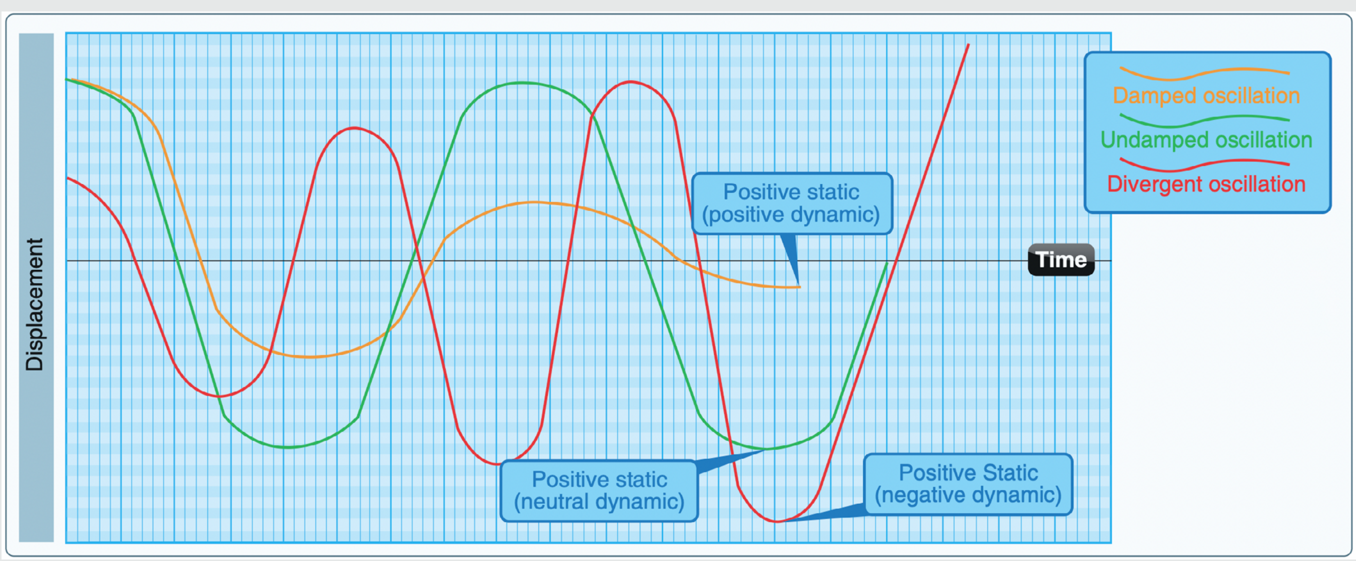
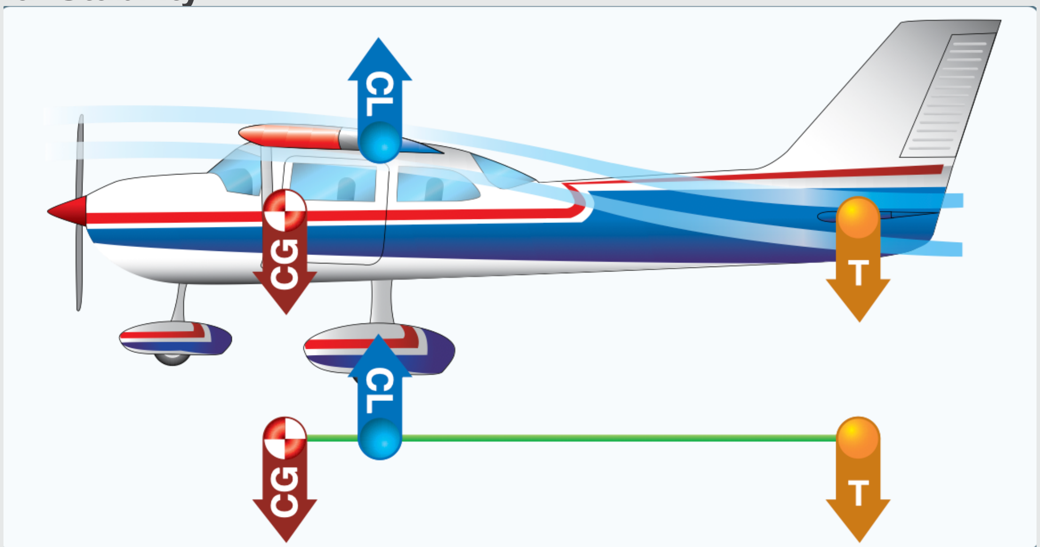
Types of static stability



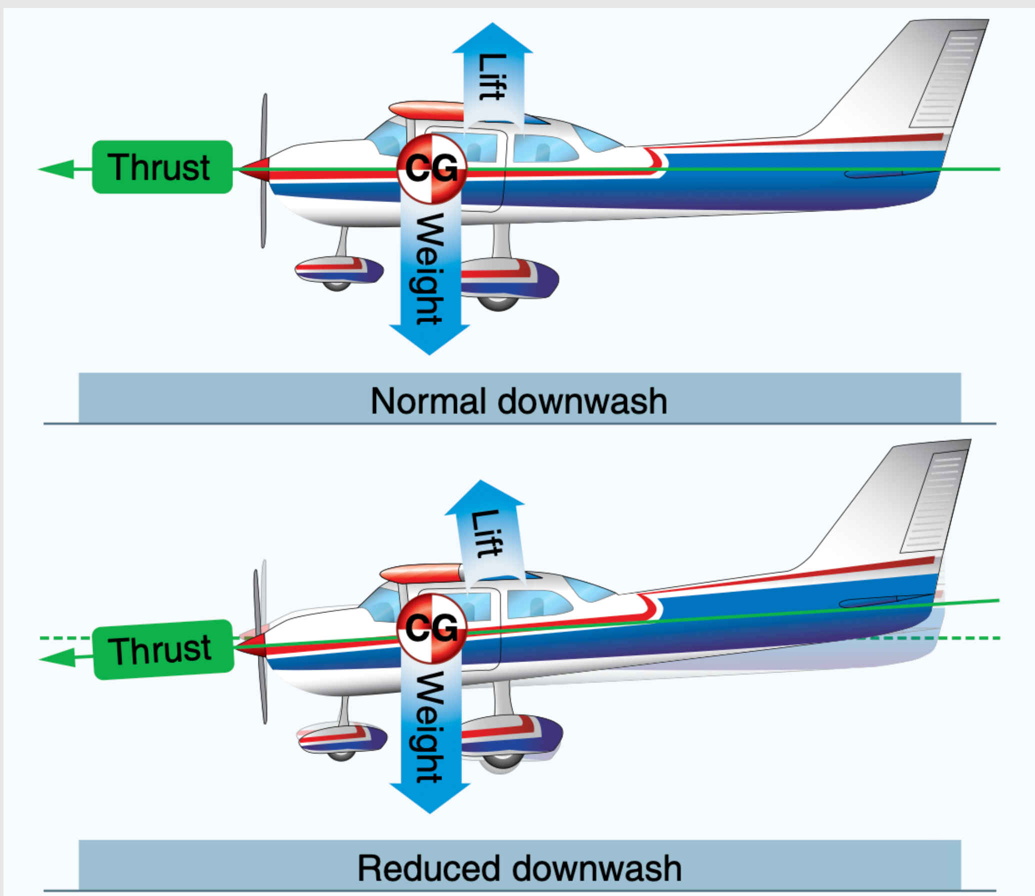
Dynamic stability and the effects of dampening



Longitudinal Stability



Downwash effect on longitudinal stability



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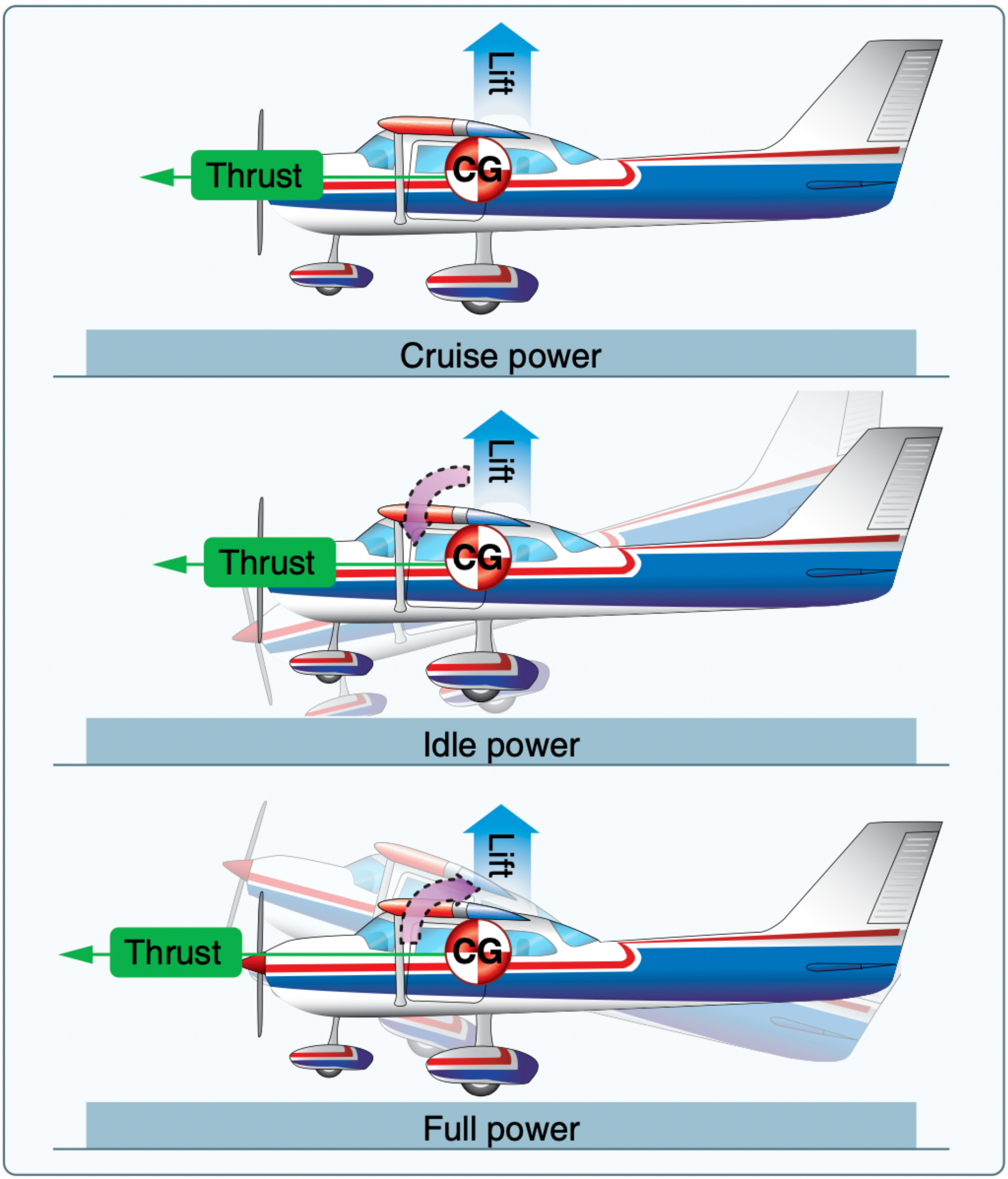
How the thrust line affects longitudinal stability



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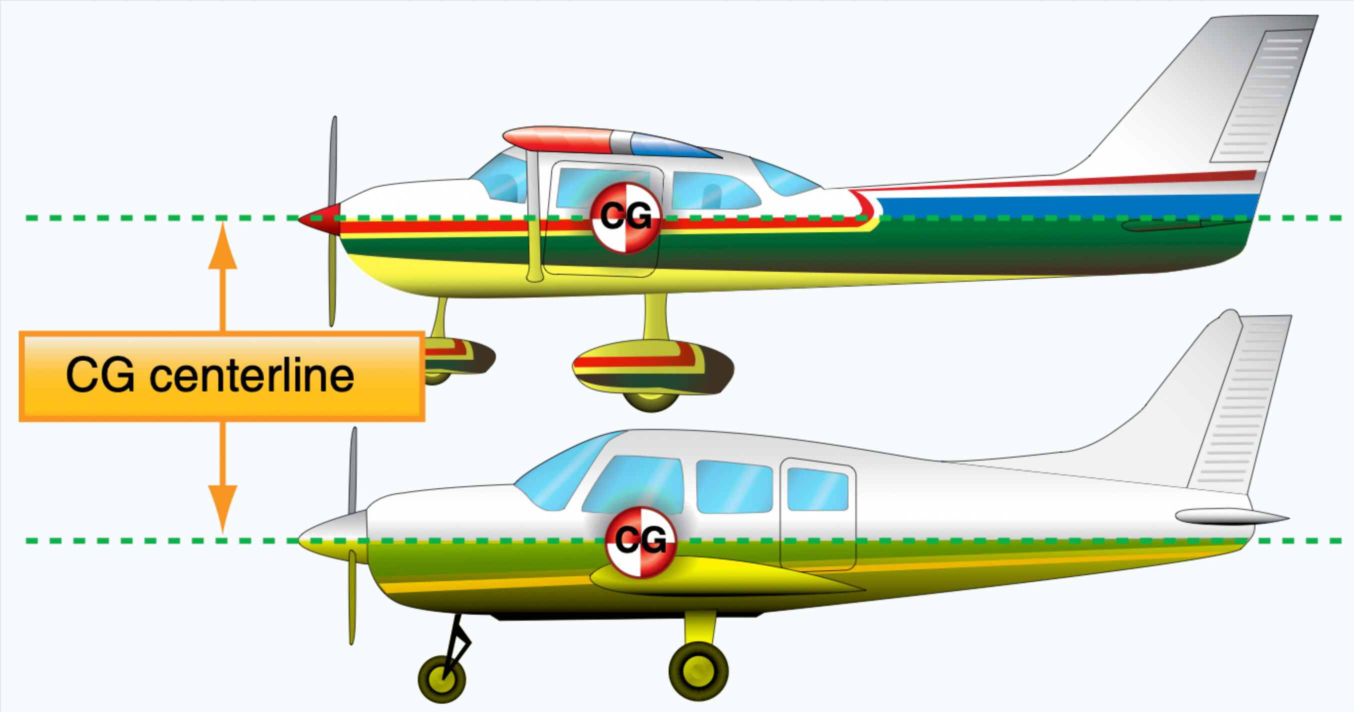
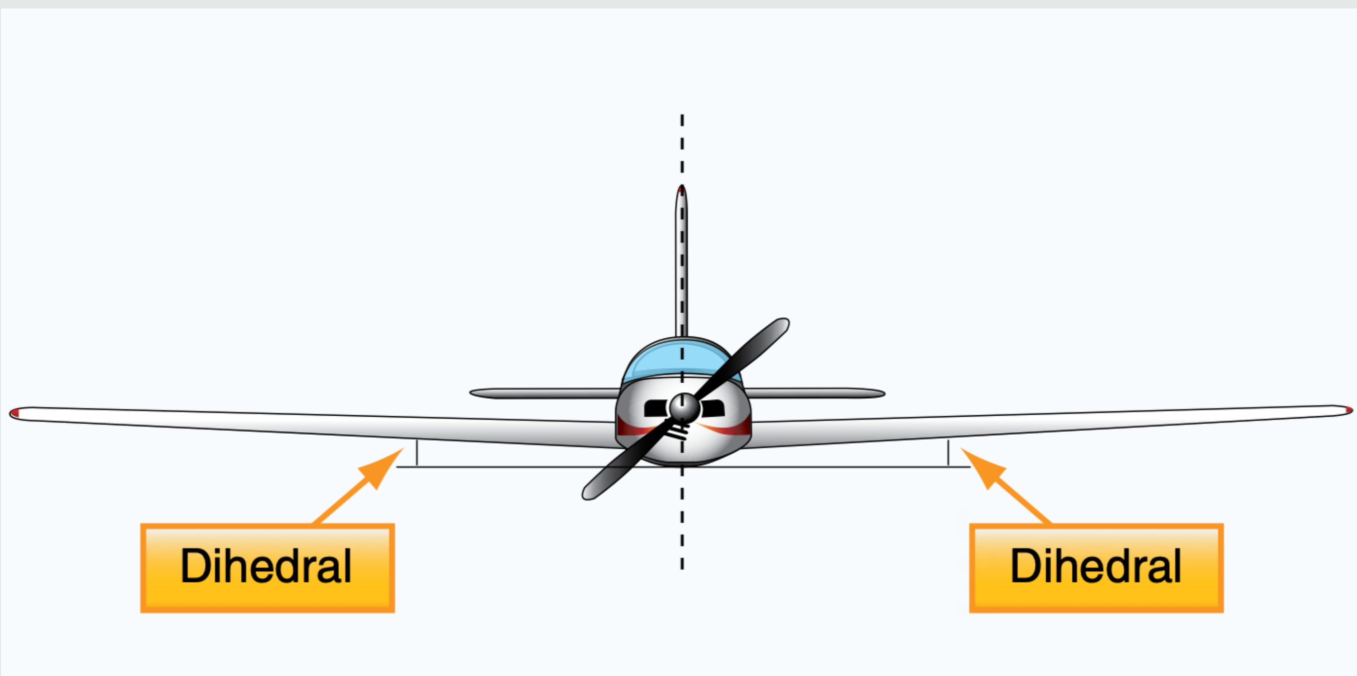
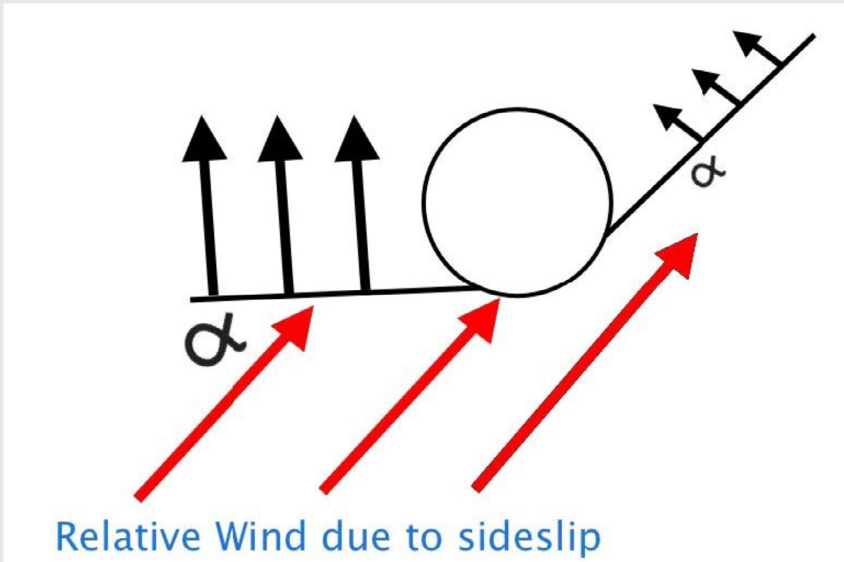
Keel effect



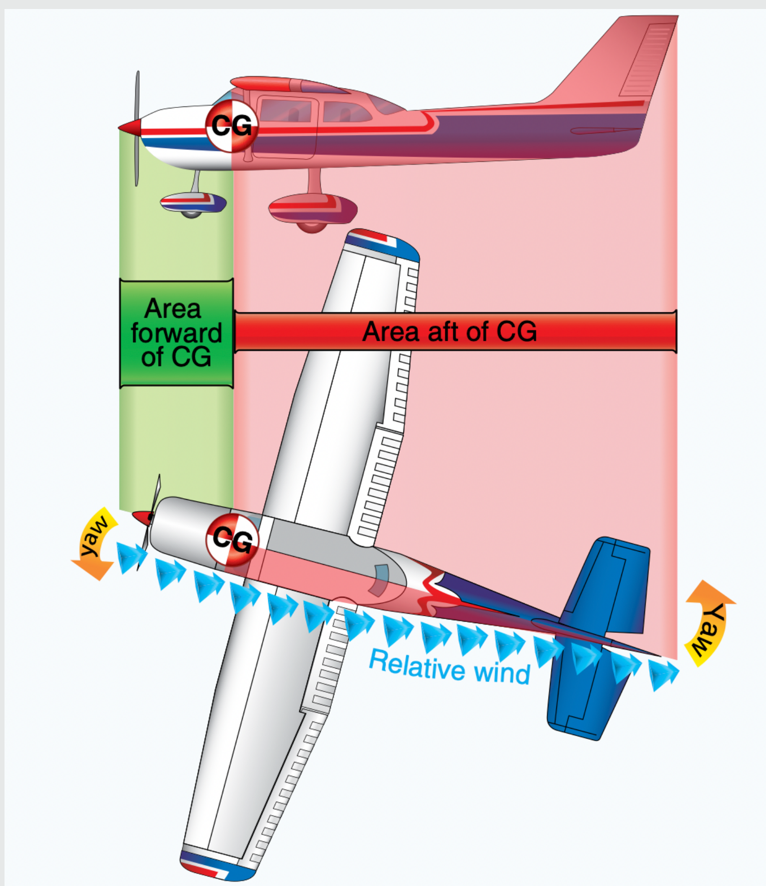
Dihedral



Increase of lift due to Slip



Fuselage and fin for directional stability



Aerodynamics - Turning Tendencies and Forces Acting on an Airplane

Objective:

The student will understand the forces that tend to turn the airplane, and how to prevent the airplane from turning or rolling. The student will also understand how the forces in a climb, descent and turn are different than in straight and level unaccelerated flight.

Motivation:

Understanding the forces acting on an airplane allows the pilot to anticipate and control the forces that cause an airplane to takeoff, climb, descend, and turn.

Presentation (45 minutes):

Forces in unaccelerated straight and level flight

1. Lift is equal to weight.
2. Thrust is equal to drag.
3. The airplane is not accelerating so there is no change in the flight path.

Forces in a climb

1. Initially, more lift is needed to change the flight path.
2. Once the new flight path is achieved lift returns to normal and the airplane climbs on excess thrust.
3. There is now a rearward component of lift and weight due to the climb – These forces cause the airplane to lose speed.

Forces in a descent

1. Initially, the flight path is changed downward causing a reduction in lift.
2. Once the flight path is steady lift returns to normal.
3. There is now a forward component of lift and weight – These forces cause the airplane to increase in speed.

Forces in a turn

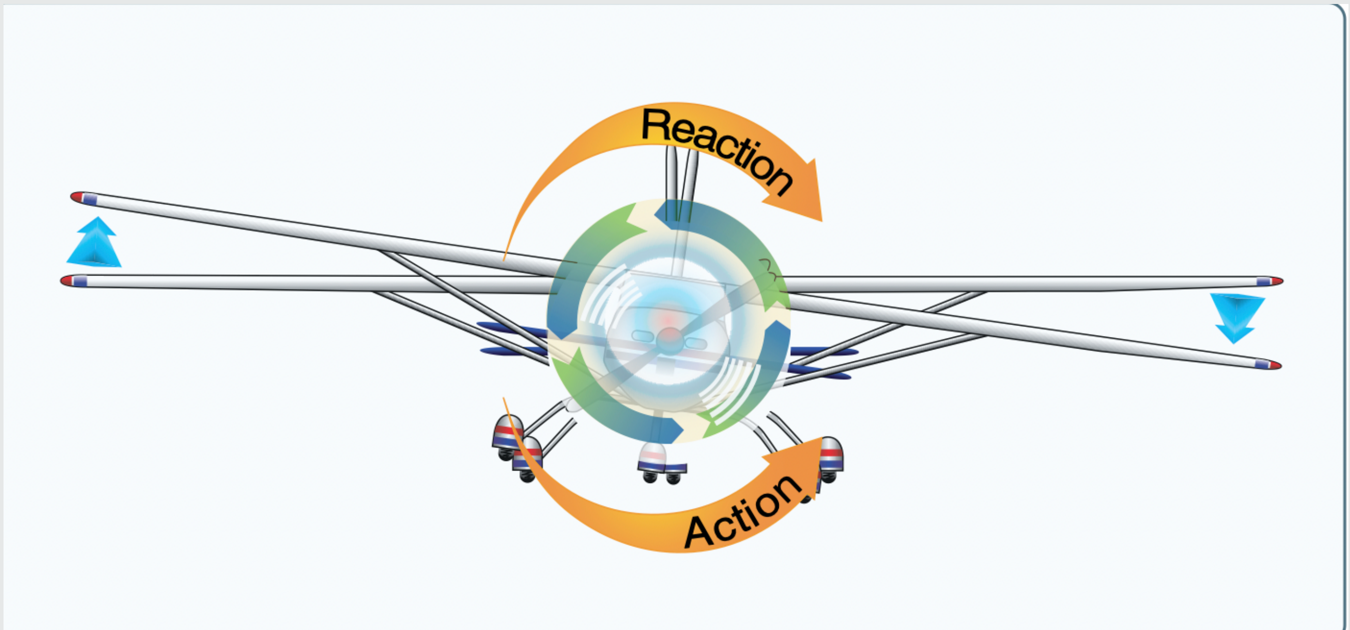
1. The airplane is banked to start a turn.
2. The lift vector is turned in the direction of the bank.
3. The lift vector has a horizontal and vertical component – The horizontal component turns the airplane and the vertical component causes it to climb or descend.
4. Because the lift vector is tilted more lift must be generated to both turn the airplane and stop it from descending – The amount of lift needed depends on the bank angle.
5. When the airplane turns weight remains acting downward – the force that opposes the total lift is the weight that opposes lift which is called load factor.
6. As the bank angle increases the amount of lift required increases as well as the load factor.
7. At 60 degrees of bank, the lift required doubles and so does the load factor.
8. From 0 to 60 degrees of bank load factor increased 2 times – From 60 to 75 degrees load factor increases to approximately 4.5 which is beyond most non-aerobatic airplane limits.
9. Small changes in bank angles over 60 degrees create load factor quickly.
10. The airplane's stall speed increases with increased bank angles – at 60 degrees of bank, the stall speed is more than 40 percent higher than in level flight.
11. In a turn, the airplane is constantly accelerating (changing its flight path) so load factor is always present, as long as altitude is being maintained.
12. With higher bank angles the risk of an accelerated stall increases – most noticeable stall symptoms happen quickly with little to no warning.
13. When starting a turn adverse yaw will be present – caused by the downward aileron producing more lift to roll the plane, thus more drag slowing the wing which causes the nose to swing opposite of the bank - Rudder is used to prevent adverse yaw when starting and stopping turns.
14. When established in a turn the left-turning tendencies are present and rudder is needed to prevent the airplane from skidding in a turn to the left and slipping in a turn to the right – In either turn right rudder is needed.
15. When there is no skidding or slipping the horizontal component of lift and centrifugal forces are equal.

Completion Standards:

The student will be able to explain the turning tendencies, torque, p-factor, slipstream and gyroscopic action in addition to the forces in a climb, descent and turn using a model airplane and whiteboard.

Lesson Additional Images

Torque Reaction



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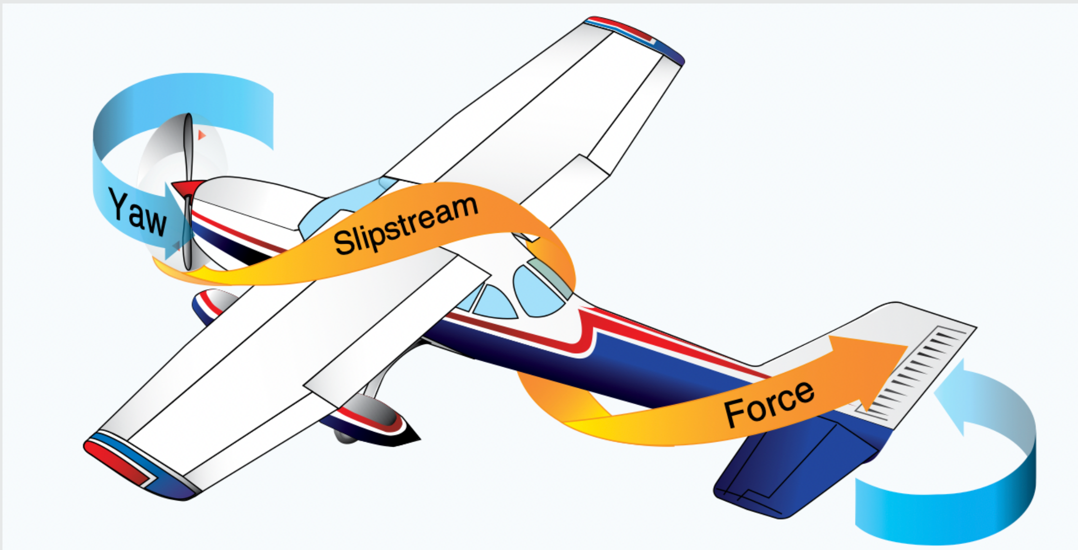
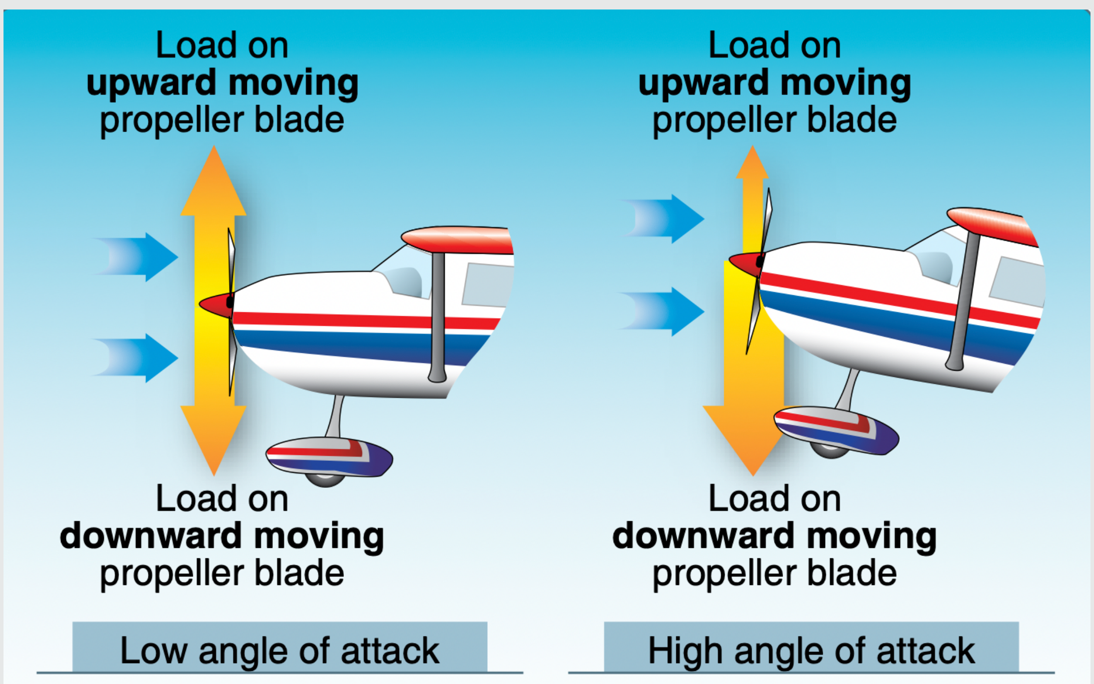
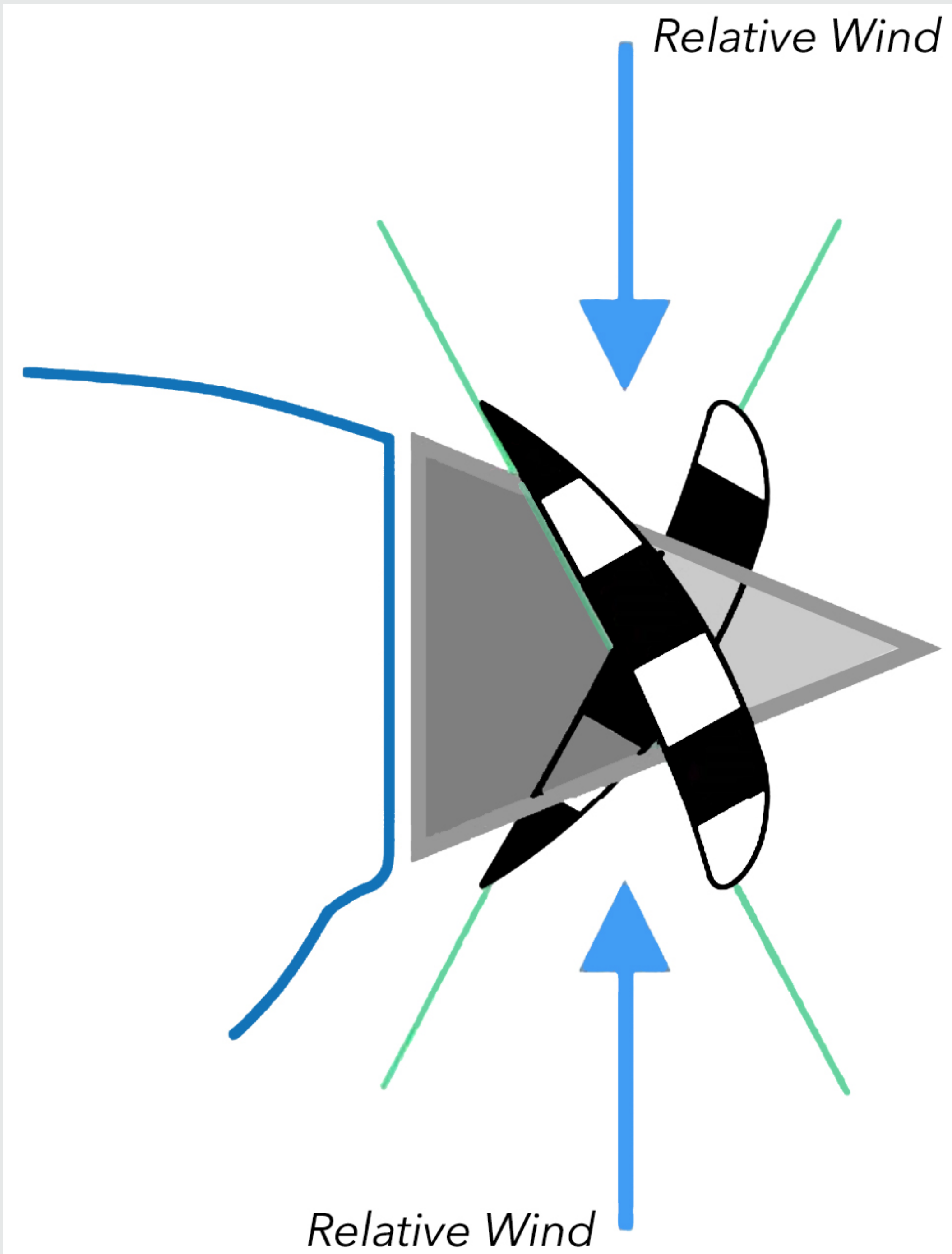
Slipstream



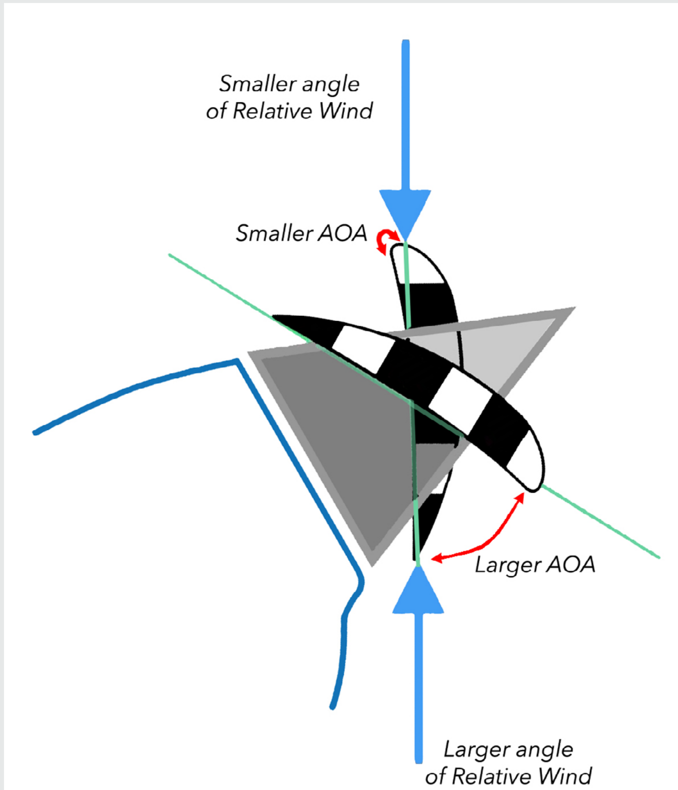
Asymmetric loading of the propeller (P-factor)



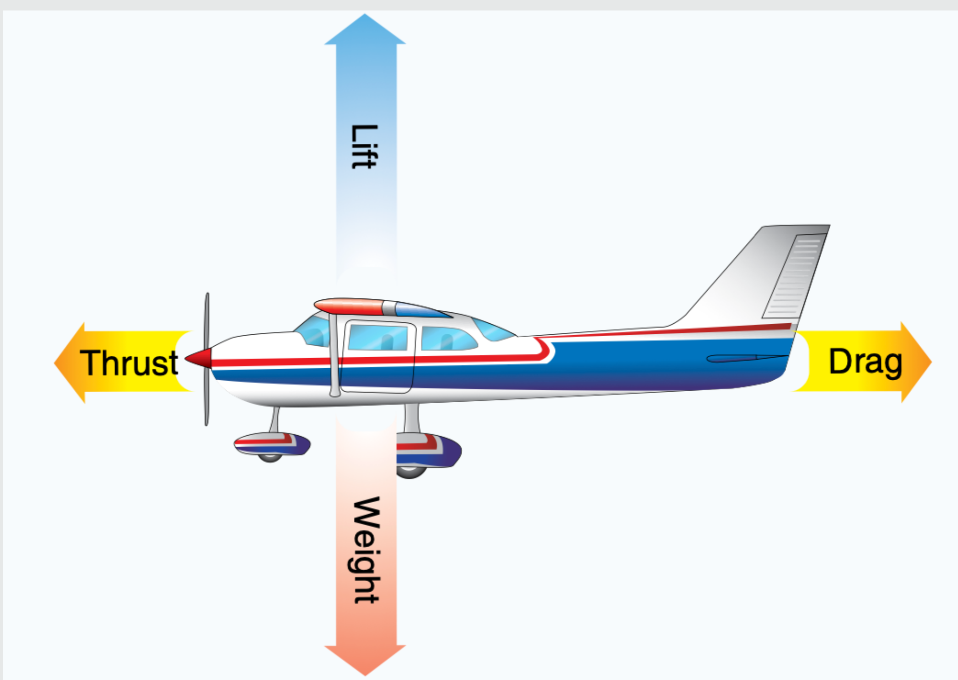
Low AOA - No P-Factor - Blade bites equally



High - AOA - P-Factor - Blade bites not equal - More bite on descending lade



Four forces in straight and level unaccelerated flight



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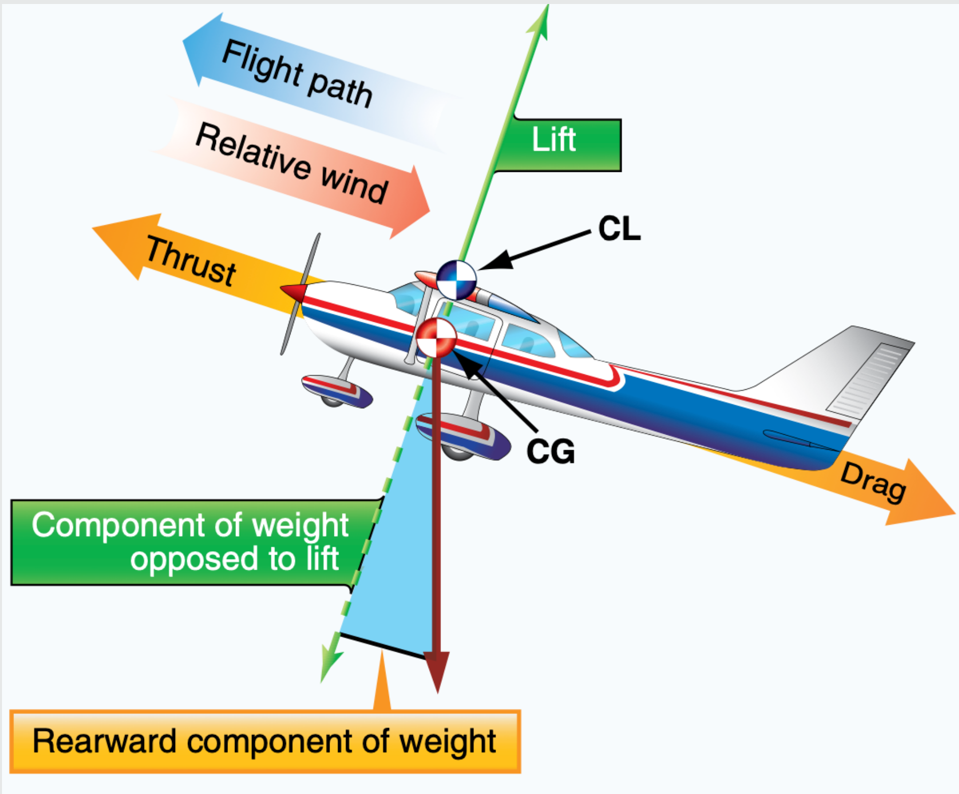
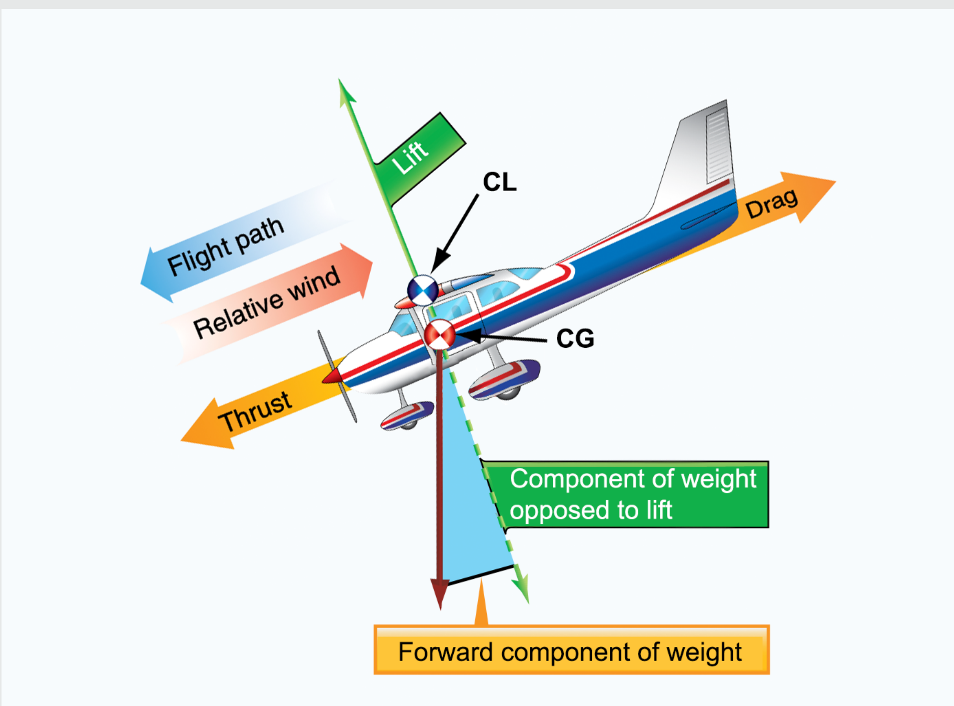
Forces in a Climb



Forces in a Descent



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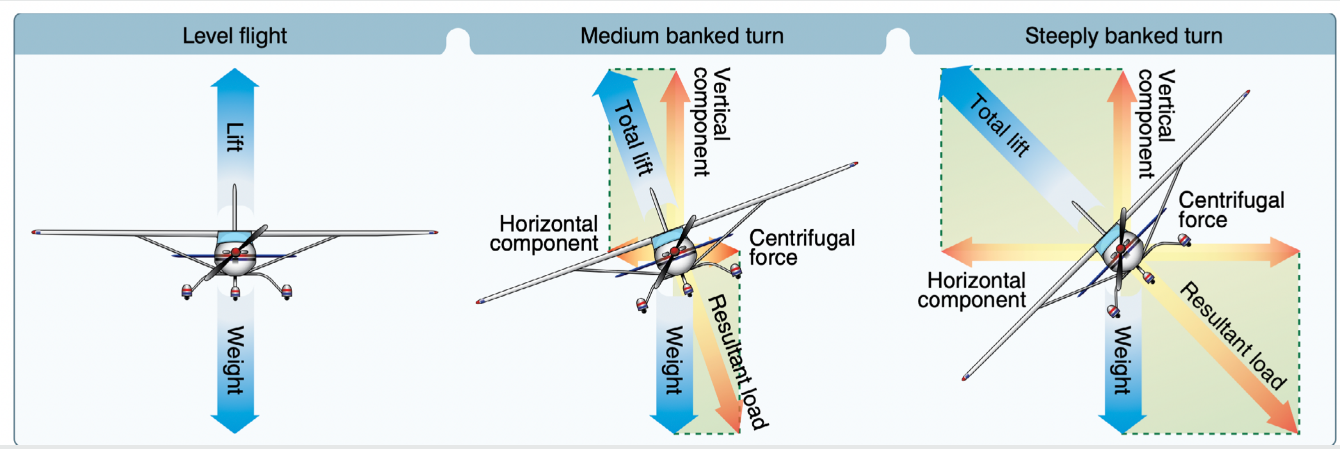
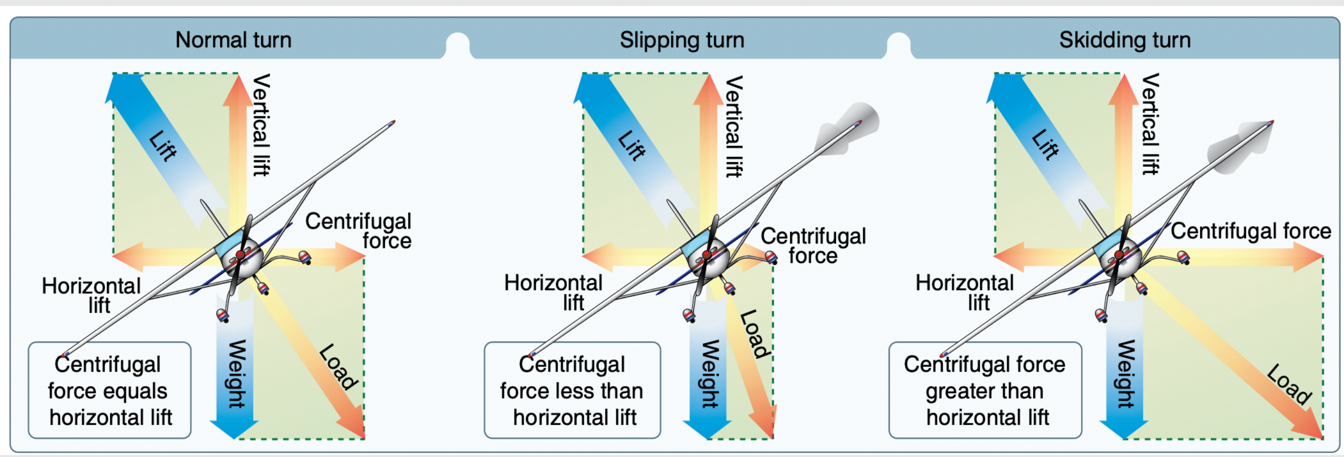
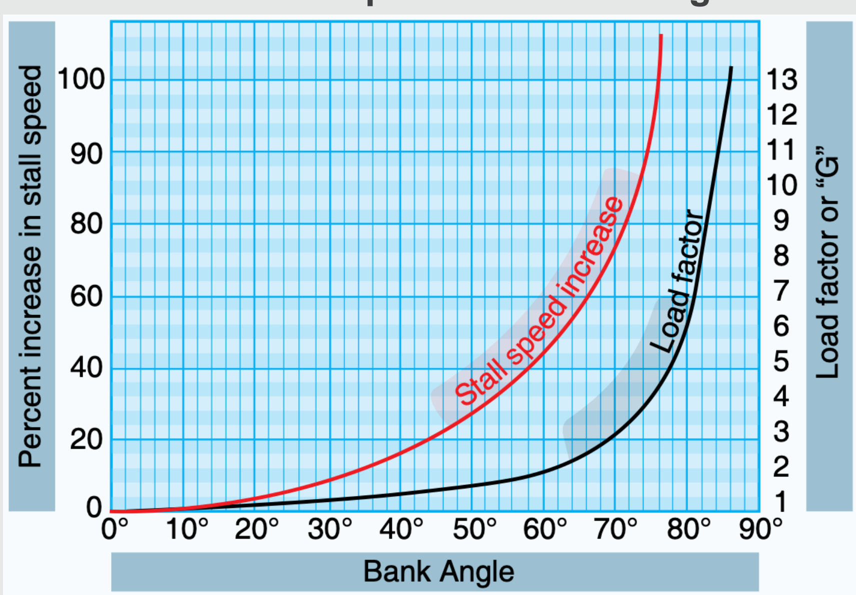
Forces in a stabilized turn at a constant altitude



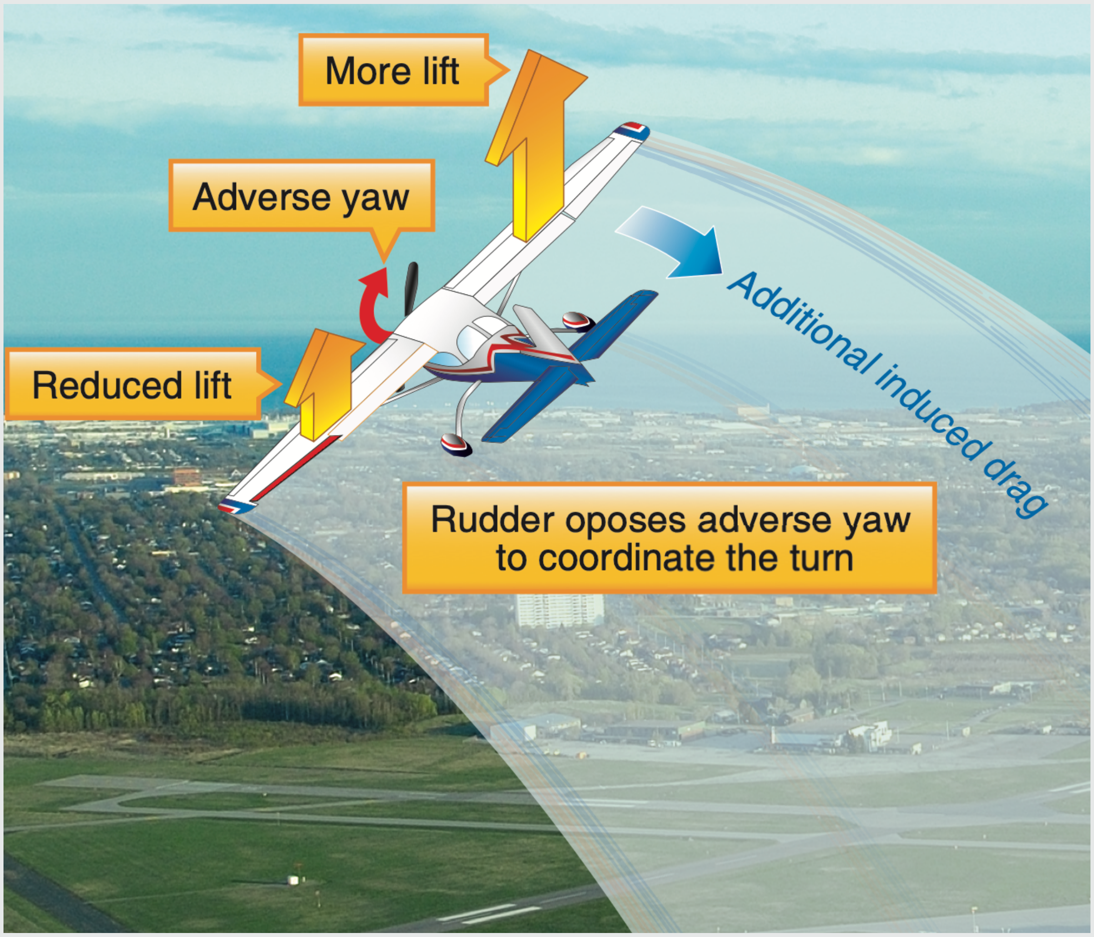
Normal, slipping and skidding turns at a constant altitude



Increases in load factor and stall speed with bank angle



Adverse Yaw


More lift
Adverse yaw
Reduced lift
Additional induced drag
Rudder oposes adverse yaw
to coordinate the turn

Aerodynamics - Load Factor, V_a and Wingtip Vortices

Objective

To understand how a pilot or the environment can generate unwanted forces called load factor on an airplane, measured in terms of G force. The pilot will recognize when load factor can be generated and what can be done about it. The pilot will also understand how an airplane generates wingtip vortices which can be dangerous when operating near other airplanes.

Motivation

Pilots need to understand how to avoid high G force that can damage the airplane. There are speeds that limit the amount of G force that can be generated. Pilot's need to understand these speeds' purpose and when to use them. Also, encounters with wake turbulence from wingtip vortices can result in an uncontrollable rolling force. Knowing how and where vortices are will avoid this situation.

Presentation (45 minutes):

1. Load factor is the result of weight and centrifugal force.
2. Any force that causes the airplane to deviate from a straight line, while holding level flight, will cause load factor.
3. Load factor is expressed in G's. (Acceleration of Gravity)
4. It's possible for a pilot to impose dangerous loads on the airplane.
5. Increased load factors cause an increase in stall speed which can cause a stall at a seemingly safe airspeed.
6. Limit load factors – Set by the manufacturer – FARs mandate the airplane be able to withstand 1.5 times the Limit load factor.
7. Gusts can induce loads on the airplane as well as maneuvering by the pilot.
8. Categories are Normal, Utility, and Aerobatic – Airplanes may be capable of only Normal or all.
9. Normal 3.8 to -1.52, Utility 4.4 to -1.76, Aerobatic 6.00 to -3.00.
10. Load factor categories are placarded in the airplane – Except older designed airplanes.
11. Load factors induced by turning are caused by the result of two forces: Weight and Centrifugal force.
12. Load factors are caused by the need to generate more lift to keep the airplane at the same altitude or climbing while turning.

13. For any given bank angle - The rate of turn varies with the airspeed. The higher the speed the lower the rate of turn – This compensates for centrifugal force which allows the load factor to remain the same as the airspeed varies.

14. Design maneuvering speed (V_a) is the speed at which the airplane would stall before exceeding its load limit – Good for a single axis, single direction, one time.

15. Turns – Bank angles of over 50 degrees increase load factor at a terrific rate with small increases past 50 degrees – The stall speed also increases rapidly above this bank angle as well.

16. Stalls – Pilots can induce high load factors in stall recovery if airspeed is allowed to build to high amounts during stall recovery – Because the pilot will want to return the airplane to a climb – Inducing load factor.

17. Spins – Low G maneuver at first – Airplane is stalled and pivoting – recovery attitude is more nose down than a regular stall which results in approximately 2.5Gs in the recovery from the dive.

18. High-speed stalls – Stalls from high airspeed require a pilot to induce more load factor – results in a quick stall at high G force that is dangerous.

19. Chandelles and Lazy Eights – Chandelle requires load factor due to the climb and turn – Lazy eight requires load factor due to the climbing and descending turns from V_a to near the stalling speed at the 90-degree point – High loads can be avoided by making smooth control inputs.

20. Rough Air – Turbulence causes acceleration on the airplane which causes load factor – Pilots can choose V_a or slower speeds to reduce loads on the airplane and avoid structural damage.

21. V_g diagram shows loads vs airspeed for a given airplane at a given weight.

Wingtip vortices and precautions to be taken:

1. Caused by the production of lift – High pressure under the wing moves toward the low pressure on top of the wing – results in a swirling roll-up of air called a vortex that moves behind the airplane.
2. Vortices on each end of the wing rotate in opposite directions to one another.
3. Vortex strength – Produced most when an airplane is heavy, Clean and Slow.
4. Airplanes in the dirty configuration hasten vortex decay.
5. Wake turbulence is what the pilot experiences if the airplane is flown into the vortex.
6. The vortex descends at several hundred feet per minute and drifts with the winds aloft – It tends to move laterally across the ground with the surface wind.
7. A light quartering tailwind causes the greatest threat on the ground.
8. Delay takeoff if a crosswind is present from a parallel runway where a large airplane is departing.
9. Wait at least 2 minutes prior to taking off after a large airplane has departed on the same runway.
10. An airplane on takeoff generates the vortex at the rotation point – If taking off behind, become airborne prior to that point and out-climb or turn away from the flight path of the vortex.
11. An airplane that is landing generates the vortex until touchdown – plan to land after the point the airplane touched down.
12. When airborne avoid wake turbulence by maintaining at least 1000 feet from the airplane if below.

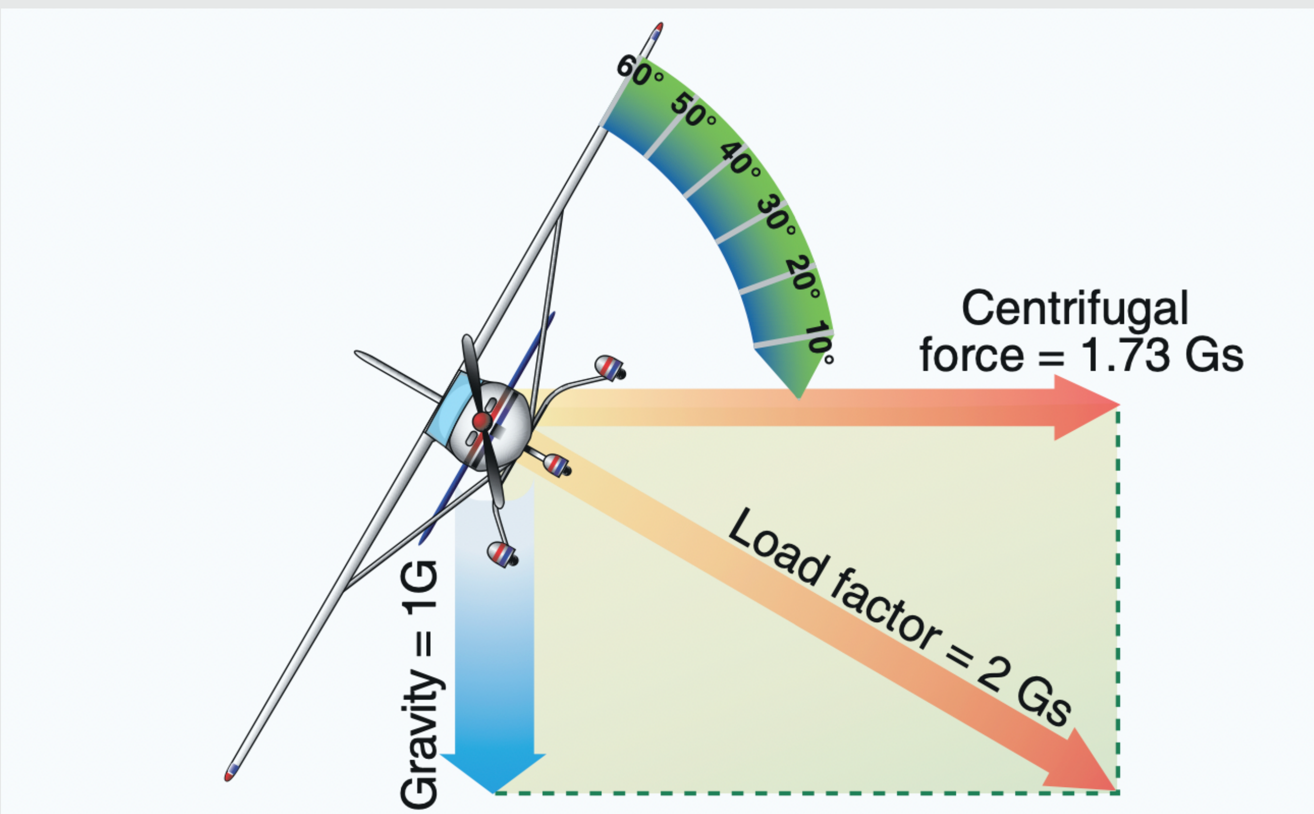
Completion Standards:

The student will be able to describe how load factor affects the way a pilot controls the airplane and what the safety speeds are and how they change with weight. The student will also understand how to avoid wake turbulence in all phases of flight by explaining and using a model airplane.

Lesson Additional Images

CATEGORY	LIMIT LOAD FACTOR
Normal[1]	3.8 to −1.52
Utility (mild acrobatics, including spins)	4.4 to −1.76
Acrobatic	6.0 to −3.00

Load Limits and Load Factor



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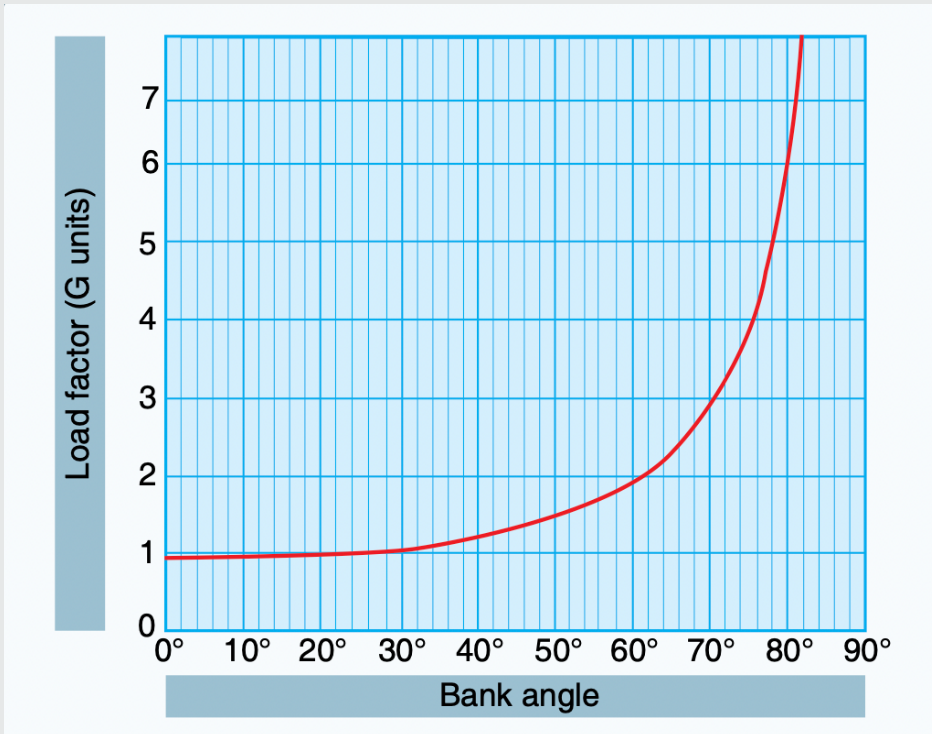
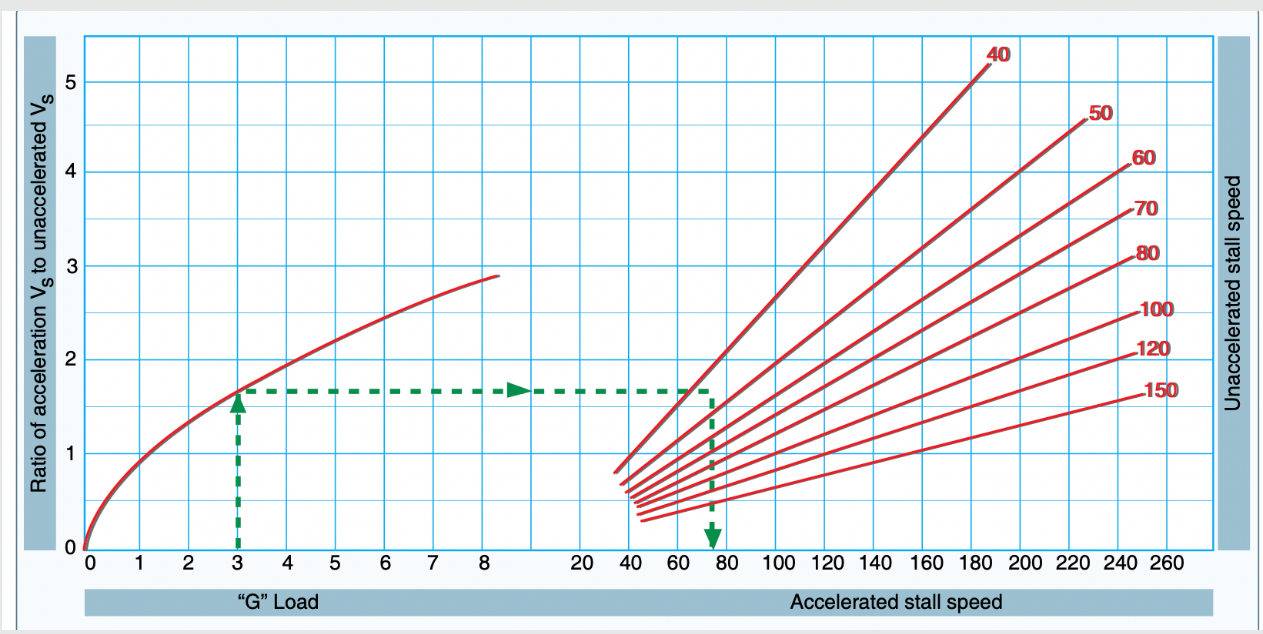
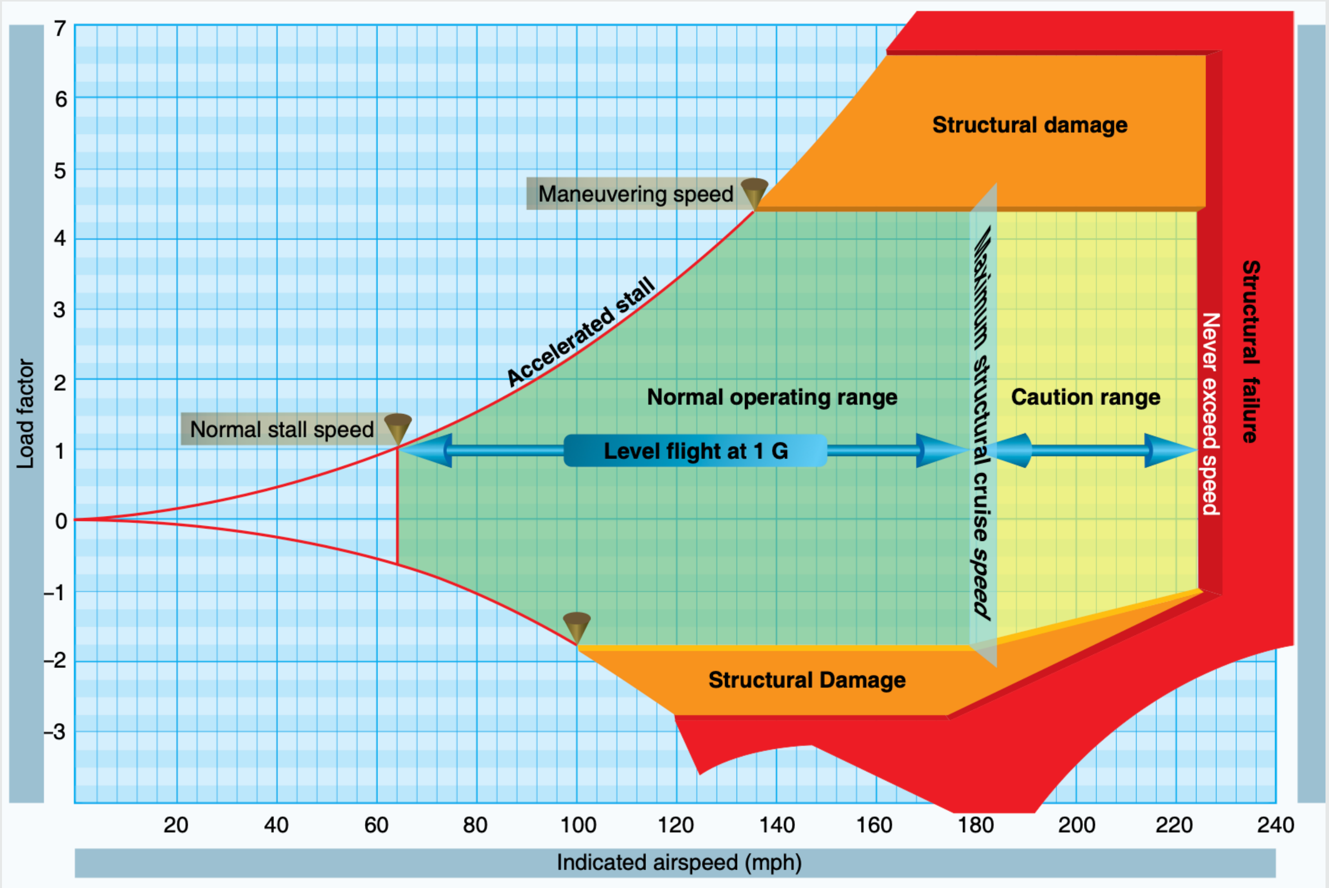
Load Factor vs Bank Angle



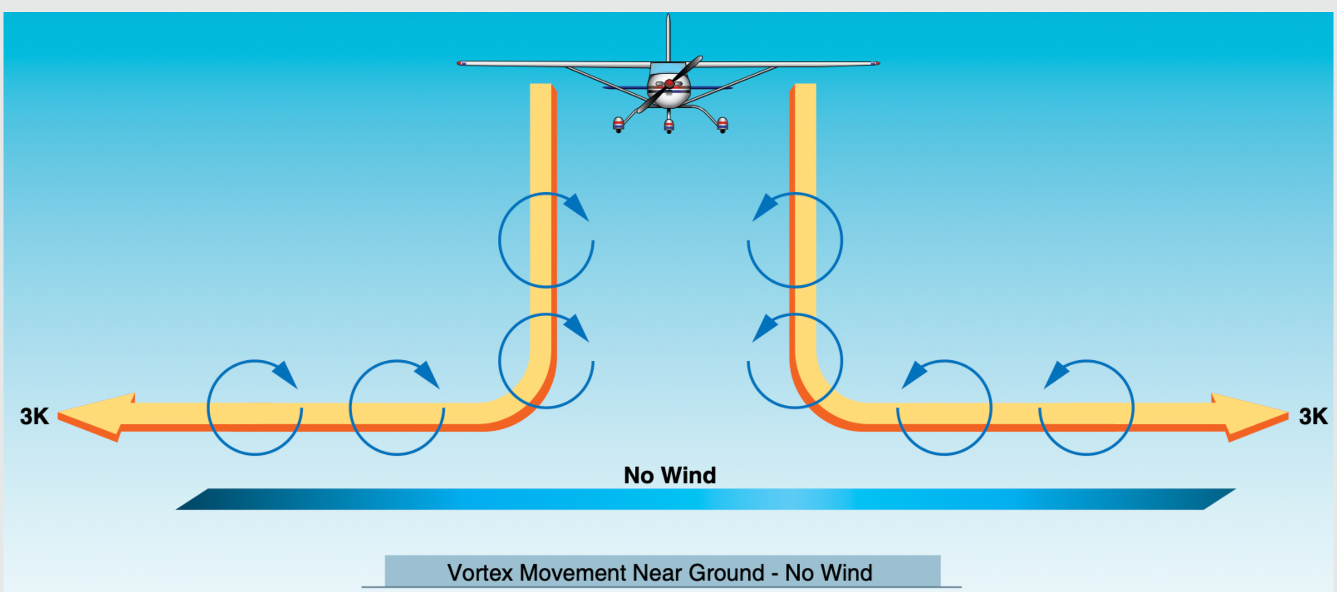
How Load Factor and Stalling Speed Vary with the Angle of Bank



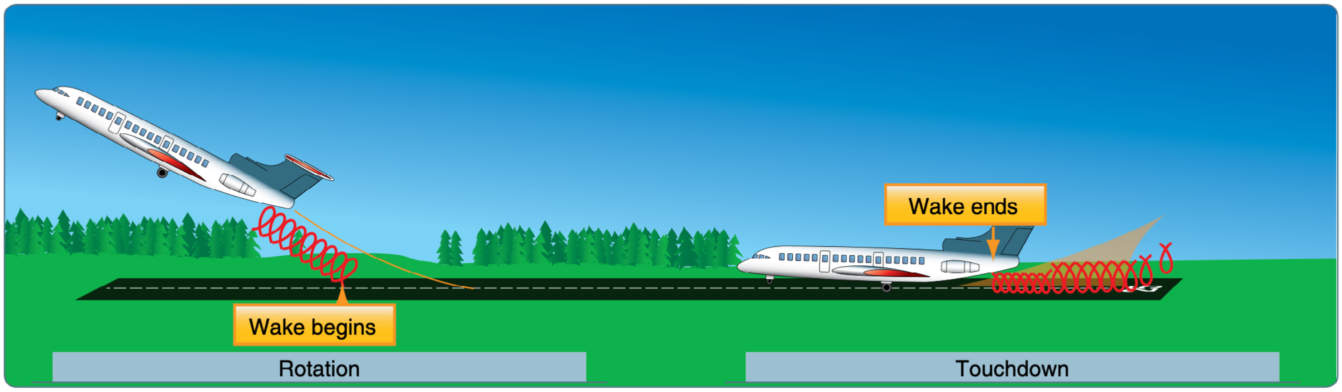
Vg Diagram



Vortex Generation



Wake Turbulence Avoidance



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