

Task XII.A-D: Basic Attitude Instrument Flight

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Lesson Overview

Objective

The student should develop knowledge of the elements related to attitude flight and have the ability to smoothly and steadily control the aircraft without the use of outside references. The student will be able to perform this as required in the ACS/PTS.

Reference

- Aircraft Flight Manual / Pilot's Operating Handbook
- Airplane Flying Handbook (FAA-H-8083-3B, page(s) 17-15)
- Instrument Flying Handbook

Key Elements

1. Pitch + Power = Performance
2. Trim
3. Crosscheck
4. Adjust

Elements

1. Control and Performance
2. Procedural Steps
3. Establish
4. Trim
5. Crosscheck
6. Adjust
7. Straight-and-Level Flight
8. Constant Airspeed Climbs
9. Constant Airspeed Descents
10. Turns to Headings
11. Common Errors

Equipment

1. White board and markers
2. References
3. iPad

Instructor Actions

1. Discuss lesson objectives
2. Present Lecture
3. Ask and Answer Questions
4. Assign homework

Student Actions

1. Participate in discussion
2. Take notes
3. Ask and respond to questions

Schedule

1. Discuss Objectives
2. Review material
3. Development
4. Conclusion

Completion Standards

The student can smoothly and steadily control the airplane by reference to the instruments only. He or she will be able to establish and maintain a thorough crosscheck and make the required adjustments to the flight attitude.

Instructor Notes

Introduction

Note

Basic instrument maneuver lessons A-D are often taught together, and therefore have been combined into a single lesson plan.

Attention

As you're flying along you can see that the weather ahead looks like it might be getting worse. You think you can 'scud run' the rest of the way but lo and behold you unexpectedly enter a cloud and need to get out safely.

Overview

- Review Objectives and Elements/Key ideas

What

Attitude instrument flying may be defined as the control of an aircraft's spatial position by using instruments rather than outside visual references.

Why

In the instance that you mistakenly fly into adverse weather it is important to be comfortable flying the airplane without outside references

Lesson Details

Learning the basics of attitude instrument flying is part of the private pilot training syllabus due to the possibility of inadvertently flying into instrument conditions. It is beyond the scope of this lesson to create an instrument proficient pilot, but it is desired to teach the student enough that they can have the tools needed to exit accidental IFR conditions.

Control and Performance

The goal is to always strive to get the desired performance out of the aircraft, and it is a truism that Pitch + Power == Performance. So controlling the aircraft attitude and power (therefore the AOA and thrust-to-drag) the pilot achieves the desired performance.

In instrument flight there are three different categories of instruments : control, performance, and navigation. The control instruments display immediate attitude and power settings and tend to permit precise adjustments. The performance instruments indicate the aircraft's actual performance such as altitude, airspeed, vertical speed, heading, and turn. The navigation instruments indicate the position of the aircraft in relation to a selected navigation facility or fix.

Procedural Steps

The basic procedure for attitude instrument flying is the same whether flying straight and level, climbing, descending, or turning. There are four general steps : Establish, Trim, Crosscheck, and Adjust.

The pilot first Establishes an attitude/power setting on the control instruments resulting in the desired performance. Known or computed altitude changes and approximate power settings will help reduce workload in this step.

The pilot then trims to re leave control pressures. Trimming is essential for smooth, precise control and to allow the pilot to more effectively divide their attention to other activities.

Once established and trimmed, a crosscheck against other indications is used to verify that the desired performance has been achieved. This involves actively looking and interpreting what is seen. If deviations are noticed then the pilot must determine the magnitude of the deviation and direction of required correction.

The, when needed, the pilot must adjust the attitude or power setting to correct for any deviations. An adjustment may entail another trim adjustment, then another round of crosschecking. The establish, trim, crosscheck, adjust cycle continues to maintain precise control.

Establish

The pilot uses the control instruments to set up the necessary pitch and bank attitudes for the performance desired. Aircraft control is accompanied by proper use of the attitude indicator, which provides an immediate, direct, and corresponding indication of any change in pitch or bank.

Pitch is changed in precise amounts, measured in degrees, and are generally indicated by bar widths on the instrument. The amount of deviation from that desired will determine the magnitude of the correction.

Bank is also changed by precise amounts in relation to the bank scale on the attitude indicator. Normally use a bank angle, when flying on instruments, that does not exceed a standard rate turn.

Power is made by throttle adjustments, and reference to the power indicators. Fortunately little attention is required to insure that a power setting stays constant once set. Over time experience will inform the pilot of how much travel is needed to change the power by a desired amount. Make the power changes, and then crosscheck to insure that the desired result has been achieved. Do not fixate on the indicators while setting the power.

Trim

Always trim the plane for hands-off flight. Use the trim procedures learned in earlier lessons, remembering to trim off pressures and not attempt to fly the plane with the trim. Check the trim by momentarily letting go of the controls, and if the plane does not hold attitude then reset and re-trim.

Crosscheck

This is a process of continually and logical observation of instruments for attitude and performance information. This process is often also called a "scan". The pilot maintains an attitude by reference to the instruments that will give the desired performance. It is impossible to establish an attitude and have performance remain constant for a long period of time. Therefore it is necessary to constantly check the instruments and make appropriate adjustments.

There are various styles of crosschecks (or scans) that can be utilized. They are described and characterized here.

Crosscheck Styles

Select Radial

This scan is based off of the attitude indicator, and in it the eyes never move directly between the flight instruments, but always travel by way of the attitude indicator. Begin with the attitude indicator, scan an instrument, and then return to the attitude indicator. Then do the same with the next instrument. This is the most popular scan style, and is often called the "Hub and Spoke" method.

Inverted V

In this style of scan the eyes are moved from the attitude indicator to the turn coordinator, up to the attitude indicator, to the VSI, and back to the attitude indicator. (This assumes a standard "six pack" style of instrument layout.)

Rectangular

In this technique the eyes first scan the top three instruments, then drop down and scan the bottom three instruments. (Again, this assumes the standard "six pack" layout.) This gives equal weight to all instruments, but may lengthen the time for the pilot's eyes to return to an instrument critical for a given maneuver.

When banking, crosscheck against the heading indicator and turn coordinator to ensure that the airplane is performing as desired. When pitching, crosscheck against the altimeter, the VSI, and the airspeed indicator to ensure that the airplane is performing as desired.

There are three common forms of crosscheck errors.

Crosscheck Errors

Fixation

This is the practice of staring at an individual instrument for an extended period of time (with the attitude indicator being the most common). This occurs for various reasons, and eliminates the crosscheck of other instruments when it occurs.

Omission

This is the practice of skipping or omitting an instrument from the scan. This may be caused by a failure to anticipate major instrument indications following an attitude change.

Emphasis

This is the practice of putting too much emphasis on a single instrument instead of maintaining the steady scan. The VSI is a major culprit in this error. This often occurs when the pilot is more comfortable with one instrument over some other(s).

Instrument Interpretation

It is important to understand each instrument's construction, operating principles, and applying this knowledge to the interpretation of the information being displayed. For instance, there is a tendency to fixate on the VSI because it is mistakenly believed to be an instantaneous reading instrument, when that isn't the case.

As the performance capabilities of the aircraft are learned the instrument indications will be interpreted appropriately in terms of the attitude of the aircraft. For each maneuver the pilot will learn what performance to expect and the combination of instruments to interpret to control the aircraft.

Adjust

This is the process of making the small, deliberate, and smooth control changes necessary in response to deviations from the desired performance. The amount of deviation will determine the amount of adjustment. When making adjustments limit the change on the attitude indicator to 1 or 1/2 a bar, and never let the bank angle exceed a standard rate turn.

Straight and Level Flight

Nose on Horizon + Cruise Power = Straight and Level

Pitch

Bank

On Horizon

Alt

Constant

VSI

0

Airspeed

Cruise Constant / No Change

Bank

A/I

Wings Level

DG

Constant

Compass

Constant

T/C

Level//Cordinated

- Establish : Use the attitude to establish a wings level, nose on the horizon attitude adjusting power as needed
- Trim : Adjust the trim to relieve control pressures
- Crosscheck
- Adjust : Correct any performance errors as necessary and re-trim the airplane, then crosscheck again.

Constant Airspeed Climbs

10° Nose Up + Full Power = Constant Airspeed Climb

Pitch**Bank**

10° Nose Up

Alt

Climbing

VSI

Positive Climb

Airspeed

Constant Climb AS

Bank**A/I**

Wings Level

DG

Constant

Compass

Constant

T/C

Level//Cordinated

- Establish : Raise the nose of the aircraft to the approximate pitch attitude for the desired climb speed. As the airspeed approaches the desired climb speed, set the power to the climb setting (full).
- Trim : Adjust the trim to relieve control pressures
- Crosscheck
- Adjust : Correct any performance errors as necessary and re-trim the airplane, then crosscheck again.

Leveling Off

When leveling off lead the altitude by 10% of the vertical speed. Use the procedure followed for leveling off from a normal climb (reduce power smoothly, steady elevator pressure toward a level attitude, etc.). Once level, crosscheck and then re-trim.

Turning Climbs

In the case of the turn apply the same procedures as above and establish the desired bank angle in the desired direction on the attitude indicator. Monitor performance (i.e. continue the scan) of the turn on the heading indicator and turn coordinator. Small adjustments to pitch and power may be needed to maintain airspeed with the additional bank.

It is likely that the instrument scan may need to be accelerated as there is more changing information to take in. Plan for the level off, as well as the roll out from the turn, and realize they may not happen at the same time.

Constant Airspeed Descents

3° Nose Down + Descent Power = Constant Airspeed Descent

Pitch

Bank

3° Nose Up

Alt

Descending

VSI

Negative Climb

Airspeed

Constant Descent AS

Bank**A/I**

Wings Level

DG

Constant

Compass

Constant

T/C

Level//Cordinated

- Establish : Reduce power to a predetermined setting for the descent and maintain straight and level flight as airspeed decreases. As the airspeed approaches the desired descent speed, lower the nose with the attitude indicator to maintain a constant speed.
- Trim : Adjust the trim to relieve control pressures
- Crosscheck
- Adjust : Correct any performance errors as necessary and re-trim the airplane, then crosscheck again.

Leveling Off

When leveling off lead the altitude by 10% of the vertical speed. Use the procedure followed for leveling off from a normal descent (increase power smoothly, steady elevator pressure toward a level attitude, etc.). Once level, crosscheck and then re-trim.

Turning Descents In the case of the turn apply the same procedures as above and establish the desired bank angle in the desired direction on the attitude indicator. Monitor performance (i.e. continue the scan) of the turn on the heading indicator and turn coordinator. Small adjustments to pitch and power may be needed to maintain airspeed with the additional bank.

It is likely that the instrument scan may need to be accelerated as there is more changing information to take in. Plan for the level off, as well as the roll out from the turn, and realize they may not happen at the same time.

Turns to Headings

Nose Slightly High + Cruise Power = Turn to Heading

Pitch**Bank**

Nose Slightly High

Alt

Constant

VSI

0

Airspeed

Constant Cruise AS

Bank**A/I**

Wings Banked

DG

Turning to Heading

Compass

Constant

T/C

Banked/Coordinated

Prior to entering determine which direction the turn should be made and the angle of bank required. Use an angle of bank equal to the number of degrees to turn, not to exceed a standard rate turn.

- Establish : Use coordinated aileron and rudder pressure to establish the desired bank angle on the attitude indicator. If a standard rate turn, use the turn coordinator to check. Adjust pitch as needed (probably increase) to maintain level flight.
- Trim : Adjust the trim to relieve control pressures
- Crosscheck
- Adjust : Correct any performance errors as necessary and re-trim the airplane, then crosscheck again.

Rolling Out

Apply coordinated rudder and aileron pressure to level the wings on the attitude indicator. Depending upon the amount of turn, roll out about 10° before the desired heading (or use 1/2 the bank angle or less for small turns). Adjust the pitch to maintain level flight. As always, re-trim when done.

Common Errors

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- “Fixation,” “Omission,” and “Emphasis” errors during instrument cross-check
- Improper instrument interpretation

- Improper control applications
- Failure to establish proper pitch, bank, or power adjustments during altitude, heading, or airspeed corrections
- Improper entry or level-off procedure (specific to Constant Airspeed Climbs)
- Improper entry or roll-out procedure (specific to Turns to Headings)
- Faulty trim procedure

Conclusion

In visual flight, you control aircraft attitude in relation to the natural horizon by using certain reference points on the aircraft. In instrument flight, you control aircraft attitude by reference to the flight instruments. A proper interpretation of the flight instruments will give you essentially the same information that outside references provide in visual flight.

ACS Requirements

CFI PTS Standards

Straight-and-Level Flight

To determine that the applicant

1. Exhibits instructional knowledge of the elements of straight-and-level flight, solely by reference to instruments by describing:
 - a. Instrument cross-check, instrument interpretation, and aircraft control.
 - b. Instruments used for pitch, bank, and power control, and how those instruments are used to maintain altitude, heading, and airspeed.
 - c. Trim procedure.
2. Exhibits instructional knowledge of common errors related to straight-and-level flight solely by reference to instruments by describing:
 - a. “Fixation,” “omission,” and “emphasis” errors during instrument cross-check.
 - b. Improper instrument interpretation.
 - c. Improper control applications.
 - d. Failure to establish proper pitch, bank, or power adjustments during altitude, heading, or airspeed corrections.
 - e. Faulty trim procedure.
3. Demonstrates and simultaneously explains straight-and-level flight, solely by reference to instruments, from an instructional standpoint.
4. Analyzes and corrects simulated common errors related to straight-and-level flight, solely by reference to instruments.

Constant Airspeed Climbs

To determine that the applicant

1. Exhibits instructional knowledge of the elements of straight and turning, constant airspeed climbs, solely by reference to instruments by describing:
 - a. Instrument cross-check, instrument interpretation, and aircraft control.
 - b. Instruments used for pitch, bank, and power control during entry, during the climb, and during level-off, and how those instruments are used to maintain climb heading and airspeed.
 - c. Trim procedure.
2. Exhibits instructional knowledge of common errors related to straight and turning, constant airspeed climbs solely by reference to instruments by describing:
 - a. “Fixation,” “omission,” and “emphasis” errors during instrument cross-check.
 - b. Improper instrument interpretation.
 - c. Improper control applications.
 - d. Failure to establish proper pitch, bank, or power adjustments during heading, and airspeed corrections.
 - e. Improper entry or level-off procedure.
 - f. Faulty trim procedure.
3. Demonstrates and simultaneously explains a straight and turning, constant airspeed climb, solely by reference to instruments, from an instructional standpoint.
4. Analyzes and corrects simulated common errors related to straight and turning, constant airspeed climbs, solely by reference to instruments.

Constant Airspeed Descents

To determine that the applicant

1. Exhibits instructional knowledge of the elements of straight and turning, constant airspeed descents, solely by reference to instruments by describing:
 - a. Instrument cross-check, instrument interpretation, and aircraft control.
 - b. Instruments used for pitch, bank, and power control during entry, during the descent, and during level-off, and how those instruments are used to maintain descent heading and airspeed.
 - c. Trim procedure.
2. Exhibits instructional knowledge of common errors related to straight and turning, constant airspeed descents, solely by reference to instruments by describing:
 - a. “Fixation,” “omission,” and “emphasis” errors during instrument cross-check.
 - b. Improper instrument interpretation.

- c. Improper control applications.
 - d. Failure to establish proper pitch, bank, or power adjustments during heading and airspeed corrections.
 - e. Faulty trim procedure.
3. Demonstrates and simultaneously explains a straight and turning, constant airspeed descent, solely by reference to instruments, from an instructional standpoint.
 4. Analyzes and corrects simulated common errors related to straight and turning, constant airspeed descents, solely by reference to instruments.

Turns to Headings

To determine that the applicant

1. Exhibits instructional knowledge of the elements of turns to headings, solely by reference to instruments by describing:
 - a. Instrument cross-check, instrument interpretation, and aircraft control.
 - b. Instruments used for pitch, bank, and power control during turn entry, during the turn, and during the turn roll-out, and how those instruments are used.
 - c. Trim procedure.
2. Exhibits instructional knowledge of common errors related to turns to headings, solely by reference to instruments by describing:
 - a. “Fixation,” “omission,” and “emphasis” errors during instrument cross-check.
 - b. Improper instrument interpretation.
 - c. Improper control applications.
 - d. Failure to establish proper pitch, bank, and power adjustments during altitude, bank, and airspeed corrections.
 - e. Improper entry or roll-out procedure.
 - f. Faulty trim procedure.
3. Demonstrates and simultaneously explains a turn to a heading, solely by reference to instruments, from an instructional standpoint.
4. Analyzes and corrects simulated common errors related to turns to headings, solely by reference to instruments.

Private Pilot ACS Skills Standards

Straight-and-Level Flight

1. Maintain straight-and-level flight solely by reference to instruments using proper instrument cross-check and interpretation, and coordinated control application.

2. Maintain altitude ± 200 feet, heading $\pm 20^\circ$, and airspeed ± 10 knots.

Constant Airspeed Climbs

1. Transition to the climb pitch attitude and power setting on an assigned heading using proper instrument cross-check and interpretation, and coordinated flight control application.
2. Demonstrate climbs solely by reference to instruments at a constant airspeed to specific altitudes in straight flight and turns.
3. Level off at the assigned altitude and maintain altitude ± 200 feet, heading $\pm 20^\circ$ and airspeed ± 10 knots.

Constant Airspeed Descents

1. Transition to the descent pitch attitude and power setting on an assigned heading using proper instrument cross-check and interpretation, and coordinated flight control application.
2. Demonstrate descents solely by reference to instruments at a constant airspeed to specific altitudes in straight flight and turns.
3. Level off at the assigned altitude and maintain altitude ± 200 feet, heading $\pm 20^\circ$ and airspeed ± 10 knots.

Turns to Headings

1. Demonstrate turns to headings solely by reference to instruments, maintain altitude ± 200 feet and maintain a standard rate turn and rolls out on the assigned heading $\pm 10^\circ$; maintain airspeed ± 10 knots.