

XI.A-D. BASIC ATTITUDE INSTRUMENT FLIGHT

OBJECTIVE & COMPLETION STANDARDS

To develop an understanding of BAI flight and the skills necessary for the task. The learner can apply the concepts in the plane.

The learner smoothly and steadily controls the plane by instrument reference. They establish, trim, maintain a thorough crosscheck, and adjust attitude all to ACS standards.

KEY POINTS

- Pitch + Power = Performance
- Establish, Trim, Crosscheck, Adjust
- Control: Attitude Indicator & Power

ELEMENTS

- | | |
|------------------------------|-------------------------------|
| 1. Instrument Flying Hazards | 7. Straight-and-Level Flight |
| 2. Control & Performance | 8. Turns to Headings |
| 3. Establish | 9. Constant Airspeed Climb |
| 4. Trim | 10. Constant Airspeed Descent |
| 5. Crosscheck | 11. Common Errors |
| 6. Adjust | 12. Hazards |

REFERENCES

- Airplane Flying Handbook
- Instrument Flying Handbook

SCHEDULE

- Introduction
- Development
- Conclusion

EQUIPMENT

- Board & Markers
- References
- Model airplane

INSTRUCTOR

- Present Content
- Ask/Answer Questions
- Assign Homework

STUDENT

- Participate in learning
- Take notes
- Ask/Answer Questions

LEGEND & ABBREVIATIONS

SECTION HEADER FOR EACH LESSON ELEMENT

Light blue for Main points and/or brief section summary

- **Orange** text is used for mnemonics or things to remember
- **RM**: Teal RM denotes an ACS Risk Management concept
- **CE**: Red CE shows an Airplane Flying Handbook listed Common Error

IA: Instructor Action (ex. hop out of the lesson & review a checklist) – Coming soon!

Light gray for notes, examples, extra details & explanations, etc.

INTRODUCTION

ATTENTION

Interesting fact or attention-grabbing story

As you're flying 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, Elements, and Key Points

Every single Knowledge & Risk Management task is annotated! Find whatever info you need.

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 case that you mistakenly fly into adverse weather, or don't have an outside horizon (night over water, haze, etc.) it is essential to be proficient flying the airplane without outside, visual references.

HOW

Note: Lessons XI.A.-D. are often taught together & therefore have been combined into a single lesson here

1. RM: INSTRUMENT FLYING HAZARDS

AI.XI.A.R1

A. Failure to Maintain VFR

- i. Risks include disorientation, loss of control, getting lost, icing, stress, midair/terrain collision, & more

B. Spatial Disorientation & Loss of Control

- i. Lack of orientation about the position, attitude, or movement of the airplane in space
- ii. In visual flight, the eyes prevail over any false sensations
- iii. In IMC, the eyes cannot correct for false sensations which can lead to disorientation
 - For more details, see [II.A. Human Factors](#)

C. Stress & Fatigue

- i. Inadvertent IMC is a stressful and mentally fatiguing exercise, especially to the non-proficient pilot

D. Pilot Actions (Mitigation)

- i. Keep proficient in flight by reference to instruments
 - Statistics show that a pilot who isn't trained in instrument flying, or has let their skills erode, loses control after about 10 minutes once forced to rely solely on instruments
 - "We don't rise to the level of our expectations; we fall to the level of our training"
- ii. Thorough preflight planning & weather briefings (weather reports/charts, alternates, terrain avoidance)
- iii. Have a general plan (automation, ATC, GPS, etc.) to safely navigate to an airport

- iv. In the case unexpected weather results in less than VMC, use all options to safely exit:
 - Flight Instruments – Transition to & trust the instruments
 - Automation – Use it to make your job easier
 - ATC – Request assistance (Other options: Guard, FSS, other aircraft, cell phone, etc.)
 - GPS – The moving map & magenta line can be great for SA

E. RM: Assistance & Emergencies

AI.XI.A.R2

- i. An emergency can either be a **distress or urgency condition**
 - **Distress:** Threatened by serious and/or imminent danger and of requiring immediate assistance
 - Do not hesitate to declare an emergency (ex: fire, mechanical failure, structural damage)
 - **Urgency:** Concerned about safety, requiring timely but not immediate help; potential distress condition
- ii. An aircraft is at least in an urgency condition **the moment the pilot becomes doubtful about position, fuel endurance, weather, or any other condition that could adversely affect flight safety**
 - *This* is the time to ask for help, not after it develops into a distress situation

2. CONTROL & PERFORMANCE

Pitch + Power = Performance

A. 3 Instrument Categories:

- i. **Control** - Display immediate attitude and power indications and permit precise adjustments
 - Control is determined by reference to the attitude indicator & power indicators
 - Control covers the Pitch + Power portion of the equation
- ii. **Performance** - Indicate the aircraft's actual performance
 - Altimeter, airspeed indicator, VSI, heading indicator, and turn coordinator
- iii. **Navigation** - Indicate the position in relation to a selected navigation facility or fix
 - Determined by course / range indicators, glide-slope indicators, and bearing pointers

B. Procedural Steps

- i. **Establish** - an attitude and power setting on the control instruments to obtain desired performance
- ii. **Trim** - until control pressures are neutralized
- iii. **Crosscheck** - the performance instruments to determine if the desired performance is being obtained
- iv. **Adjust** - the attitude or power setting on the control instruments as necessary, trim and repeat

3. ESTABLISH

AI.XI.A.K1A, AI.XI.A.K1B, AI.XI.A.K1C

Set known/approximate pitch and power settings for the desired performance

A. Control instruments are used to set the pitch & bank attitude and power setting

- i. Attitude Indicator: Pitch & Bank Control

- Operation
 - Horizon disk is attached to double gimbal
 - Remains in the same plane as the gyro and the plane pitches/rolls about it
 - Adjustable mini aircraft appears to be flying relative to the horizon
- Limitations & Errors
 - Can spill if subjected to excessive pitch/bank attitudes (n/a to solid state/G1000 systems)
 - May be a slight nose-up indication during a rapid acceleration and vice versa
 - Possibility of a small bank angle and pitch error after a 180° turn
 - Tiny amounts of friction over time can cause precession/tilting
 - Erection mechanism (pull the knob) returns the gyro to the proper position

ii. Throttle: Power Control

B. Pitch Control

- i. Changes are made by changing the pitch attitude by precise amounts in relation to the horizon
 - Measured in degrees or bar widths

C. Bank Control

- i. Changes are made by changing the bank attitude by precise amounts in relation to the bank scale

D. Power Control

- i. Made by throttle adjustments and reference to the power indicators
- ii. Make changes with the throttle and then crosscheck the engine indicators
 - Don't fixate on the engine indicators while setting the power

4. RM: TRIM

AI.XI.A.R8

A. Trim for hands off flight

- i. Don't fly with trim – Set pitch & power, then trim the control pressures away

5. CROSSCHECK

AI.XI.A.K1D

The continuous and logical observation of instruments for attitude and performance information

A. Select Radial Crosscheck (most popular method)

- i. **“Hub and Spoke” Method** (based off attitude indicator)
 - Attitude indicator is the hub/primary reference, performance instruments are the spokes
 - Move from the hub out to a spoke, back to the hub and repeat to another spoke, etc.

XI.A-D. Basic Attitude Instrument Flight



B. Crosscheck & Bank

- i. Establish, then check the heading indicator and turn coordinator for desired performance

C. Crosscheck & Pitch

- i. Establish, then check the altimeter, VSI, and airspeed indicator for desired performance

D. Crosscheck Errors

i. **RM: Fixation**

AI.XI.A.R5

- Staring at a single instrument
- Occurs for a variety of reasons and eliminates the crosscheck of other pertinent instruments

ii. **RM: Omission**

AI.XI.A.R5

- Omitting an instrument from the crosscheck
- May be caused by failure to anticipate major instrument indications following attitude changes

iii. **Emphasis** (VSI chasing is common as is emphasizing pitch or bank instruments)

- Putting emphasis on a single instrument, instead of the necessary combination of instruments
- We naturally tend to rely on the instrument most understood

E. **RM: Instrument Interpretation**

AI.XI.A.R6

- i. For the crosscheck to be effective, you must understand the information being received
- ii. Understand each instrument's operation and the application of that knowledge to performance

F. Instrument Operation & Limitations

AI.XI.A.K1a, AI.XI.A.K1c

i. **Heading Indicator**

- Gyro turns in a vertical plane, sensing rotation about the plane's vertical axis
- Compass is used to set the appropriate heading, and rigidity causes it to maintain this heading
- Precession causes heading to drift & Earth rotates 15° per hour
 - Precession + rotation means heading should be checked/reset every 15 min

ii. **Turn Coordinator**

- Canted gimbal allowing the gyro to sense both rate of roll as well as rate of turn
 - A rapid roll rate causes the mini aircraft to bank more steeply than a slow roll rate

- Used to establish and maintain a standard-rate turn (3° per second)
 - Align the wing of the mini aircraft with the turn index

iii. **Airspeed Indicator**

- Differential pressure gauge indicating the difference between pitot and static pressure
- Diaphragm receives pressure from pitot tube & instrument case receives pressure from static port
- Increasing pitot pressure/decreasing static pressure expands the diaphragm and vice versa
- Gearing indicates changes in airspeed

iv. **Altimeter**

- Measures absolute pressure of the ambient air, displays it as feet above selected pressure level
 - Air pressure tries to compress aneroid wafers while natural springiness tries to expand them
 - Compression and expansion move gears/linkages to change the altitude displayed
 - Adjustable barometric scale (Kollsman window)
- **Errors** (Mechanical and Inherent)
 - **Nonstandard Temperature**
 - Warmer than standard air is less dense, pressure levels are farther apart
 - True altitude > Indicated altitude
 - Colder than standard air is denser, pressure levels are closer together
 - True altitude < Indicated altitude
 - **Nonstandard Pressure**
 - High pressure to Low pressure
 - As pressure decreases, the altimeter registers it as a climb
 - Pilot descends to maintain altitude
 - True altitude < Indicated altitude
 - The opposite applies from Low pressure to High pressure – True alt > Indicated alt
 - **From hot to cold, or from high to low, look out below!**

v. **Vertical Speed Indicator**

- Differential pressure instrument
- Diaphragm and casing are connected to static pressure
 - Diaphragm is directly connected while the case has a delayed connection
- During a climb/descent, the diaphragm expands/contracts immediately, while pressure in the case remains the same for a short period
 - The difference in pressure is displayed as rate of climb

6. ADJUST

A. Make the necessary adjustments on the attitude indicator, then repeat the process again

- i. The amount of deviation from the desired performance will determine the magnitude of correction
 - Restrict the attitude indicator's pitch displacement to 1 bar or ½ bar width up or down

- Use a bank angle that approximates the degrees to turn, not to exceed 30°
- ii. Smooth, small adjustments lead to smooth, steady control

7. STRAIGHT-AND-LEVEL FLIGHT

AI.XI.A.K1B

- A. Establish:** Establish wings level/nose on the horizon on the attitude indicator; adjust power for cruise
- B. Trim:** Trim to relieve the control pressures
- C. Crosscheck:** Monitor the instruments for any performance deviations from straight-and-level flight
- D. Adjust:** Re-establish pitch and/or power to correct for deviations, trim, and repeat

Pitch + Power = Desired Performance
Nose on Horizon/Wings Level + Cruise Power = Straight-and-Level

CONTROL		PERFORMANCE	
Pitch	On Horizon	Altimeter	Constant
Bank	Constant	VSI	0 fpm
Power	Cruise	Airspeed	Constant
		Heading	Constant
		Turn Coord	Level / Coordinated

8. TURNS TO HEADINGS

AI.XI.D.K1B

NOTE: Prior to entering the turn, determine turn direction and the angle of bank required

- A. Establish:** Use coordinated aileron and rudder to establish the desired bank on the attitude indicator
 - i. If a standard rate turn, use the turn coordinator
 - ii. Adjust pitch to maintain altitude
- B. Trim:** Relieve the control pressures
- C. Crosscheck:** Monitor the instruments for any performance deviations from the turn
- D. Adjust:** Re-establish pitch and/or power to correct for deviations, trim, and repeat
- E. Roll Out**
 - i. Apply coordinated rudder and aileron pressure to level the wings on the attitude indicator
 - Depending on the rate of turn, rollout 5-10° before the desired heading
 - Or use ½ the bank angle or less as a reference for small turns
 - ii. Adjust pitch and power for straight-and-level flight at cruise, crosscheck, adjust, and repeat

Pitch + Power = Desired Performance
Wings Banked/Nose Slightly High + Cruise Power = Turn to Heading

CONTROL		PERFORMANCE	
Pitch	Nose Slightly High	Altimeter	Constant
Bank	Wings Banked	VSI	0 fpm
Power	Cruise	Airspeed	Constant
		Heading	Turning
		Turn Coord	Banked/Coordinated

9. CONSTANT AIRSPEED CLIMB

AI.XI.B.K1B

- A. Establish:** Raise the nose to the approximate pitch attitude for the desired climb speed
 - i. Approaching climb speed, set power to the climb setting (full)
- B. Trim:** Relieve the control pressures
- C. Crosscheck:** Monitor the instruments for any performance deviations from the climb

Pitch + Power = Desired Performance
10° Nose Up + Full Power = Constant Airspeed Climb

CONTROL		PERFORMANCE	
Pitch	10° Nose Up	Altimeter	Climbing
Bank	Level	VSI	Positive Climb
Power	Climb Power	Airspeed	Constant
		Heading	Constant
		Turn Coord	Level / Coordinated

- D. Adjust:** Re-establish pitch and/or power to correct for deviations, trim, and repeat
 - i. Adjust pitch to maintain the desired climb airspeed (1 bar or ½ bar width movements)
- E. Level Off**
 - i. Lead the altitude by 10% of the vertical speed (Ex: 500 fpm climb is led by 50')
 - ii. Establish - Reduce power, apply elevator pressure toward level flight on the attitude indicator
 - iii. Trim – Relieve control pressures
 - iv. Crosscheck - VSI, altimeter and attitude indicator should show level flight – repeat the process
- F. Turning Climbs**
 - i. Apply the climb procedures above, and establish the desired bank angle on the attitude indicator
 - ii. Monitor turn performance on the heading indicator and turn coordinator
 - iii. Small adjustments to pitch and power may be necessary to maintain airspeed in the turn
 - iv. The instrument crosscheck will have to be accelerated as there is more information to take in

10. CONSTANT AIRSPEED DESCENT

AI.XI.C.K1B

- A. Establish:** Reduce power for the descent and maintain straight-and-level flight as airspeed decreases
 - i. Approaching descent speed, lower the nose with the attitude indicator to maintain descent speed
- B. Trim:** Relieve the control pressures
- C. Crosscheck:** Monitor the instruments for any performance deviations from the desired descent

Pitch + Power = Desired Performance
3° Nose Down + Descent Power = Constant Airspeed Descent

CONTROL		PERFORMANCE	
Pitch	3° Nose Down	Altimeter	Descending
Bank	Level	VSI	Negative Climb
Power	Descent Power	Airspeed	Constant
		Heading	Constant
		Turn Coord	Level/Coordinated

D. Adjust: Re-establish pitch and/or power to correct for deviations, trim, and repeat

- i. Adjust the pitch attitude to maintain the desired climb airspeed

E. Level Off

- i. Lead the altitude by 10% of the vertical speed (EX: 500 fpm descent is led by 50')
- ii. Establish - Introduce power and apply smooth steady elevator pressure toward a level attitude
- iii. Trim – Relieve control pressures
- iv. Crosscheck - VSI, altimeter and attitude indicator should show level flight – repeat the process

F. Turning Descents

- i. Apply the same procedures as above, and establish the desired bank angle on the attitude indicator
- ii. Monitor turn performance on the heading indicator and turn coordinator
- iii. Small adjustments to pitch and power may be necessary to maintain airspeed in the turn
- iv. The instrument crosscheck will have to be accelerated as there is more information to take in

11. COMMON ERRORS

AI.XI.A.K2

- 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, speed corrections
- E. Improper entry or level-off procedure (specific to Constant Airspeed Climbs and Descents)
- F. Improper entry or roll-out procedure (specific to Turns to Headings)
- G. Faulty trim procedure

12. RM: HAZARDS

A. Collision Hazards

AI.XI.A.R3

i. **Collision Avoidance**

- **Clearing Procedures** – As able in instrument flight (AIM 4-4-15 Clearing & Scanning Techniques)
 - Climb/Descent: Use gentle banks to scan above/below the wings as well as other blind spots
 - Prior to any turn: Clear in the direction of the turn
 - Pre-Maneuver: Clearing turns – clear above/below, in front/behind
 - Clearly communicate intentions & location in practice areas
- **Scanning** – As able during instrument flight (AIM 4-4-14)
 - Short, regularly spaced eye movements bringing successive areas into the central visual field
 - Movements should not exceed 10°, each area should be observed for at least one second
- **Operation Lights On** (voluntary FAA safety program)

- Turn on landing lights during takeoff and when operating below 10,000', day or night
- **Right-of-Way Rules (FAR 91.113)**
 - An aircraft in distress has the right-of-way over all other traffic
 - Converging Aircraft
 - Same Category Aircraft: The aircraft to the right has the right-of-way
 - Different Categories: Basically, the less maneuverable aircraft has the right-of-way
 - Balloons, gliders, and airships have the right of way over airplanes
 - An aircraft towing or refueling an aircraft has the right-of-way over engine driven aircraft
 - Approaching Head-on: Each pilot shall alter course to the right
 - Overtaking: Aircraft being overtaken has the right-of-way; when overtaking, pass on the right
 - Landing
 - Aircraft landing/on final to land have the right-of-way over those in flight or on the surface
 - When 2 or more aircraft are approaching for landing, the lower aircraft has the right-of-way
 - Don't take advantage of either of these rules

ii. Terrain

- Study terminal charts and IFR/VFR chart altitudes, use Max Elevation Figures (MEFs)
- Be extra vigilant at night, when terrain may be impossible to see until it is too late
- Minimum Safe Altitudes (FAR 91.119)
 - Anywhere: Altitude allowing an emergency landing without undue hazard to persons or property
 - Congested Areas: 1,000' above the highest obstacle within 2,000'
 - Other than Congested Areas: 500' above the surface, except when over open water/sparsely populated areas, then no closer than 500' to any person, vessel, vehicle, or structure

iii. Obstacles & Wire Strike (AIM 7-6-4 Obstructions to Flight)

- Be familiar with any obstacles near the airport(s) – Charts, Terminal procedures, & NOTAMs
- Antenna Towers can reach > 1,000-2,000' AGL
 - Supporting guy wire can extend 1,500' horizontally
- Overhead Wires (may not be lit) span departures & landmarks pilots often follow
 - Lakes, highways, railroad tracks, etc.

B. Distractions, SA & Disorientation, Task Prioritization

AI.XI.A.R4

i. Distractions

- They're dangerous - Remove them from view or, if a person, explain the situation & ask them to stop
- Focus on performance, especially without visual references
- If distracted, recognize the problem, and fix it

ii. Situational awareness (SA) & Disorientation

- Extremely important, lost SA has led to unsafe situations, mishaps, and incursions
- Maintain SA
 - Starts with pre-flight planning - Know what's coming next and stay ahead of the airplane

- If SA is lost, admit it, and fix the problem
 - Disorientation can be caused by, or lead to, an upset
 - **Push:** Apply forward pressure to unload the plane
 - **Roll:** Roll aggressively to the nearest horizon
 - **Thrust:** Adjust as required
 - **Stabilize:** Return to a safe flight condition
 - Lack of Visual References
 - Can be very disorienting: Trust the instruments, use automation, ask for help, return to VMC
 - For more details, see [II.B. Visual Scanning & Collision Avoidance](#) and [II.M. Night Operations](#)
- iii. Task Prioritization
- Divide attention between the aircraft, scanning, and communicating (ATC or CTAF)
 - Understand what tasks need to be accomplished and when (use SOPs & checklists)
 - Recognize when you are getting behind and find a way to catch up
 - “Attack the closest alligator” – handle the most pressing problem and go from there
 - Proper task management can help prevent distractions, loss of SA, and disorientation
 - Safety is the number one priority – Aviate, Navigate, Communicate

RM: CONTROL APPLICATION SOLELY BY REFERENCE TO INSTRUMENTS

AI.XI.A.R7

The lesson as a whole is basically an RM discussion of control solely by reference to instruments

Conclusion: Brief review of the main points