Attitude Instrument Flying

From the "*Instrument Procedures Training Manual*" on RealCFI.com

Objective: Develop understanding of principles of attitude instrument flying

Elements:

- Instrument cross check (scan) techniques
- Instrument interpretation (what info are we getting from them)
- Aircraft Control
- Basic Flight Maneuvers

Schedule: 1:30 min **Equipment:** whiteboard, airplane,

Introduction: There are two general methods of instrument use to control the aircraft in IMC:

- **Primary and Supporting Method (FAA emphasized)**
- **Control and Performance Method.**

The method preferred by the FAA de-emphasizes the Attitude indicator and emphasizes use of instruments that tell the pilot what the aircraft WAS doing or already did, not what it is going to do. Consequently, the pilot will spend time chasing and correcting what the plane did. It is my opinion that the pilot is never really in control of the aircraft, except after many hours of experience.

Many Professional pilots, Military pilots and operators of performance aircraft prefer the second method which emphasizes use of the attitude indicator*, using specific and known power settings, aircraft attitudes, and aircraft configuration to command the aircraft.* The other instruments are briefly consulted to verify aircraft compliance. The aircraft will give the same performance (airspeed, climb, turn rate etc.) for a given power, attitude, and configuration ("PAC"). If the pilot develops a "PAC" for each phase of flight, then the aircraft will respond as anticipated. For example, in a typical GA aircraft, during a straight and level Vy climb on runway heading can be "commanded" with full power, 7 degrees pitch up, wings level in clean configuration. 90% of visual scan is on the attitude indicator (7 degrees pitch up, wings level) and only glancing at Airspeed indicator once to confirm performance, then occasionally checking DG and Altimeter. Consequently, this reduces the instrument scan, reduces time on the secondary instruments, and keeps your attention on the Attitude indicator with replication of VFR flight control.

The FAA method of Primary and supporting is also presented. Specifically, the instrument of reference for primary and secondary for each phase of flight is frequently a subject on the Instrument Knowledge Tests for the FAA certificates.

Control and Performance Method: (*preferred method*)

Attitude + Power = Performance

Control instruments - **attitude indicator** and Manifold/RPM

Performance Instruments- **DG, Altimeter +** remaining six pack instruments secondary.

Navigation Instruments –VOR, ILS, GPS

For any given aircraft, a set of Power, Attitude, and Configuration can be developed. Many General Aviation aircraft have similar settings to start with. After a couple of test flights, a "PAC" for each phase of flight can be determined. A table can then be made with the settings and used as reference until second nature. Be sure to reference the "Tips and Tricks" at the very end of this syllabus. Generally, *Power is used to initiate a descent and level off* (small altitude deviations in level flight can be adjusted with pitch and trim), bank to maintain lateral navigation. Typical settings that might be used in a retractable gear aircraft are provided as an example listed below:

Phase	MP	RPM	Pitch	Gear	Flaps	KIAS	VSI
Initial Climb	Full	Max	$+10^0$	UP	UP	Vx	
Cruise Climb	Full	2500	$+7^0$	UP	UP	Vy	
Cruise	23"	2300	Level	UP	UP		
Descent	18"	2300	-2^0	Up	UP		500fpm
Approach	18"	2300	$+2^0$	Up	10^0	100	
Precision descent	18"	2300	$+2^0$	Down	10^0	100	500fpm
Non-Precision Descent	15"	2300	$+2^0$	Down	10^0	100	800fpm
Level off MDA	22"	2300	$+2^0$	Down	10^0	100	0
Missed Approach	**Full**	**Max**	**$+7^0$**	**UP**	**UP**	**Vy**	

Climb: full power, 10 degrees for Vx until gear up. Then 6-7 degrees pitch up typically produces a Vy climb. Air speed is checked just briefly to verify performance. Emphasis is on attitude indicator. Check Altimeter for level off, Directional Gyro to hold course.

Turns and Climbing turns: 10% of IAS + 5 approximates a standard rate turn. If traveling at 100 kts, a standard rate turn = 15^0 on the attitude indicator. A climbing turn is accomplished with

7 degrees pitch up and 15 degrees of bank in a typical GA aircraft. The turn coordinator and Airspeed indicator are only referenced very briefly to verify performance.

Level off to Cruise: Pitch to level on AI and trim off pressure as aircraft accelerates. Reduce power to cruise once reach desired cruise speed. Check DG and Altimeter as needed.

Descents: Descend with power reduction, typically 5" manifold or 300 RPM = 500 fpm, attitude indicator may settle at or just below horizon. Verify descent rate using VSI. The air speed will be maintained as trim should not have to change. (Trim sets air speed in normal flight regimes, power determines climb, descent, or level off).

Level off from a Descent: Return power to same setting as before descent about 100 ft prior to target altitude. For example, if power reduced from 23" manifold to 18" for descent, return power to 23" and level off will not require pitch change nor re-trim. For fixed pitched prop, use RPM as power indicator.

Approach phase: 5 to 8 miles before Initial approach fix, reduce power to approach. Typically, 17-18" manifold, or if in a fixed pitch aircraft about 2100 RPM (c-172). Re-trim. Attitude indicator may show level to +2 degrees. This will typically get you into flap and gear speed and slow aircraft for the approach.

Precision Final Approach Fix: "Gear down to come down." Typically, gear +/- approach flaps will initiate a descent that is close to the 3 percent gradient on a precision approach (about 500-600 fpm). Power can be left alone. In a fixed gear aircraft, reducing the power approximately 5" of manifold pressure (3-400 RPM) will give a 500-fpm descent rate. The required descent rate should be 5 times the ground speed for precision approaches (100 kts=500 fpm descent). Adjust power (or pitch) in small increments using VSI to check descent rate to stay on glide slope (if above glide path, increase descent rate by 200-300 ft/min till recaptured, then maintain descent rate on VSI that holds glide slope/path.

Non-Precision Final Approach Fix: Typical descent rate should be 50% more than precision to "dive and drive" each step-down fix (if descent gradient more than 3^0 a greater descent rate will be required). Typical descent rate should be about 800 fpm at 100-110 kts. In complex aircraft, drop the gear and decrease manifold about 2-3", adjust per VSI for the desired rate. In fixed gear aircraft, decrease Manifold 8" for 800 fpm descent. IAS should stay the same.

MDA Level Off: In retractable gear, add about 7-8" manifold to level off 100 ft prior to MDA. In fixed gear, return power setting to the same as prior to the descent (also about 8" manifold).

Missed Approach: Typically, aircraft will be significantly above stall speed. To avoid descent below MDA or DA, it is recommended to Pitch up to Vy ATTITUDE (typically 7 degrees), then "cram" mixture, prop, carb heat, and throttle. Then clean up – gear up, flaps up, cowl flaps open- **"Climb, Cram, Clean."**

Notice the Attitude indicator pitch reference is near level (+2 to -2, depending on aircraft) from approach phase up to the missed approach. The VSI is used to aid in small power/pitch changes to adjust descent rate. Gear deployment typically yields about 500-600 fpm descent.

Primary and Supporting Method *(FAA method)*

Instrument cross check (scan) techniques

Scan patterns: Inverted V, Radial x check, Rectangular. Emphasis on task see below

Determining a failed instrument: compare AI with TC, static instruments. Use alt air.

Instrument interpretation (what info are we getting from them)

Direct and non-direct indicators, Precession vs rigidity

Pitch: Attitude indicator, Altimeter, VSI, Airspeed indicator

Power: Airspeed indicator, MP/RPM

Bank: Attitude & Heading indicators, Compass, Turn coordinator.

TRIM: do it often and frequently

Primary vs support instruments: Pitch, Power, and Bank

Aircraft Control –how much is too much?

Pitch, power and bank adjustments

Trim, Trim, Trim!!

Flight Regime	Primary Pitch	Supporting Pitch	Primary Bank	Supporting Bank
Straight-And-Level	ALT	AI/VSI	DG	AI/TC
Constant Airspeed Climb/Descent	ASI	AI/VSI	DG	AI/TC
Constant Rate Climb/Descent	VSI	AI	DG	AI/TC
Standard Rate Turn	ALT	AI/VSI	TC	AI

Airspeed Indicator is primary for power except in a constant airspeed climb/descent.

AI = Attitude Indicator
DG = Directional Gyro
ALT = Altimeter
VSI = Vertical Speed Indicator
ASI = Airspeed Indicator
TC = Turn Coordinator

Basic Flight Maneuvers *(Control and Performance Method)*

Straight and Level flight:

Set power (rpm/manifold)- for cruise or approach speed

Maintain heading with wings level on attitude indicator

Maintain Altitude with Pitch level AI (wings on horizon).

Verify performance and adjust with Heading indicator, altimeter/VSI.

Turns to a new heading

Set Power (rpm/manifold)

Set bug to new heading (turn Heading bug to target before initiate turn)

Initiate bank with Attitude Indicator:

10% of IAS+ 5^0 bank =STD rate turn (15^0 in a 172)

Briefly verify STD rate turn on Turn Coordinator

Roll out ½ of bank angle

Practice Turns while changing configuration with gear, flaps, and power. Maintain air speed.

Climb:

adjust power for climb (full)

set pitch up on attitude indicator (max 5 to 7 degrees)

Verify performance with airspeed, Altimeter, VSI

Level off and accelerate to cruise, then reduce power to original setting

trim generally will not have to be reset.

Descent:

Reduce power for desired descent rate.

5" of manifold pressure = 500 ft/min descent

Pitch on attitude indicator typically 2^0 below horizon.

Verify performance with altimeter/VSI

Level off by returning power to original setting 100 ft before

Trim will not have to be reset.

Constant speed climbs/descents

As above for climb/descent

Primary Pitch: Airspeed Indicator

Use power to level off, pitch and trim will generally not need to change

Constant rate descents (for approach descents)

As above for climb/descent, reduce power

1" hg manifold pressure = 100 ft/min

300 to 400 RPM =500 foot/min in fixed pitch aircraft

Verify descent rate on VSI

level off 100' above by returning power to original setting

Unusual attitudes- instrument failure, turbulence, inattention, autopilot dysfunction. These should be *practiced partial panel* once basic mechanics are mastered. Avoid instinct and sensations. Rely on instruments. **AI** may be unreliable.

Nose high- low airspeed, Altimeter/VSI show climb. Prevent a stall:

Add power
Nose Down (till VSI reverses)
Correct bank (TC, Attitude Indicator in op)

Nose Low- High air speed, altimeter/VSI show descent. Prevent Accel. Stall, Spiral.

Reduce power
Correct bank (TC, Attitude indicator in op)
Nose up (till VSI reverses)

Note: these procedures are much simpler when the back up instrument is another attitude indicator as is typical in many glass cockpits.

Tip: *during partial panel unusual attitudes, VSI reversal (not "0") indicates level pitch, then relax pitch input and use altimeter to maintain level pitch and turn coordinator to maintain wings level.*

Basic Instrument Procedure turns

Racetrack- 1 min legs

Procedure turn: 45-degree left turn x 60 seconds, 180 degree inbound to intercept a course

Teardrop pattern: 30-degree outbound x 1 min, 180 degree inbound to intercept a course

Putting it all together. An exercise:

1) 19” MP, 2300 RPM. Initiate STD rate turn to left, lower gear, lower flaps before 360 degrees. Then turn in opposite direction and clean up before 360 degrees. Maintain Altitude and STD Rate.
2) Start Climbing turn to left at STD rate and 500 ft/min from 3000 ft to 4000 ft. Should make 360 turn coincident with 1000 ft climb. Then turn in the opposite direction and descend 500 ft/min at standard rate.

Common Errors:

1. Fixation and omission errors during instrument cross-check.
2. Failure to use Attitude indicator
3. Improper (over) control applications.
4. Failure to establish proper pitch, bank, and power adjustments during altitude, bank, and air speed corrections.
5. In adequate trim technique.
6. Failure to recognize an unusual flight attitude.
7. Consequences of attempting to recover from an unusual flight attitude by "feel" rather than by instrument indications.
8. Inappropriate control applications during recovery.

References: FAA-H-8083-15 B. Instrument Flying Handbook.