

The ATPL Cheat Sheet

022 Instrumentation

The facts that actually get tested, stripped to the bone: definitions, key numbers, formulas, mnemonics and the classic exam traps for each subject. Built for the night before, the commute, and the last scroll before you walk into the exam hall.

022 Instrumentation

54 memory items

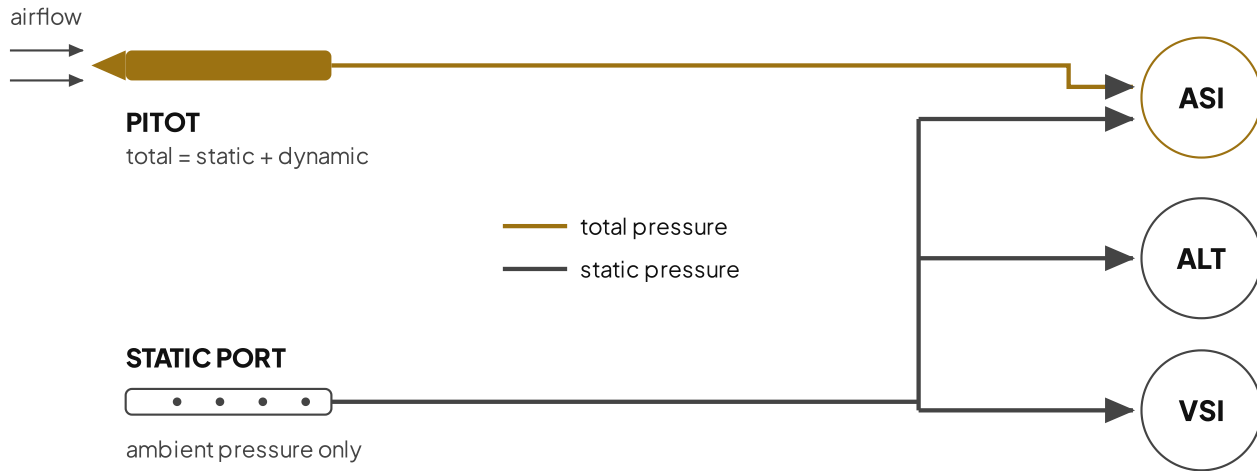
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Pitot-static, gyroscopes, magnetic compass, IRS/AHRS, EFIS, warning systems.

◆ PITOT-STATIC SYSTEM AND ITS INSTRUMENTS



ASI needs both total and static; the **altimeter** and **VSI** use static only. Blocked static: altimeter freezes and VSI reads zero, ASI over-reads in a descent and under-reads in a climb. Blocked pitot (drain blocked): the ASI behaves like an altimeter.

◆ MUST-KNOW DEFINITIONS AND CONCEPTS

- Pitot pressure = static (ambient) + dynamic (impact); the pitot tube senses total pressure, static ports sense ambient only.
- **IAS** is the raw reading; **CAS** = IAS corrected for instrument and position error.
- **EAS** = CAS corrected for compressibility (significant only at high speed/altitude).
- **TAS** = EAS corrected for density (temperature and altitude); TAS exceeds CAS increasingly with altitude.
- The altimeter is an aneroid capsule sensing static pressure, calibrated to ISA; QNH reads elevation AMSL, QFE reads zero on the field, QNE (1013.25 set) gives pressure altitude.
- The VSI senses rate of change of static pressure through a calibrated leak; an IVSI adds an accelerometer pump to remove lag.
- The Machmeter compares dynamic to static pressure for Mach number and needs no temperature input, unlike a TAS computation.
- **Rigidity in space**: a spinning mass resists change to its plane of rotation, proportional to spin speed and moment of inertia.
- **Precession**: a force applied to a spinning gyro is felt 90 degrees later in the direction of rotation.
- **Real (Earth) wander** is apparent drift from Earth rotating beneath a space-fixed gyro; **transport wander** is drift from the aircraft moving over the curved Earth.
- The attitude indicator uses an earth gyro with a pendulous erection system for the gravity vertical.
- The directional gyro/HSI uses a tied gyro that must be reset against the magnetic compass because it is not Earth-referenced.
- The turn indicator is a rate gyro precessing against a spring in proportion to turn rate; the

slip ball beside it is a simple pendulum, not gyroscopic.

- **Magnetic dip** is the angle between the local field vector and the horizontal; it causes direct-reading compass turning and acceleration errors.
- **IRS** uses strapdown ring-laser or fibre-optic gyros (Sagnac effect, no spinning mass) plus accelerometers, deriving position by double integration.
- **AHRS** gives attitude and heading only (no navigation), using strapdown sensors plus a magnetometer.
- The radio altimeter measures true height above the terrain directly below (AGL), not AMSL.
- The **Air Data Computer** turns pitot, static and total-air-temperature inputs into altitude, CAS, TAS, Mach and VS for displays, autopilot, transponder and FMS.
- **EFIS** splits into the PFD (attitude, speed, altitude) and ND (navigation/map). The FMS adds a nav database and performance computer for lateral and vertical navigation (LNAV/VNAV).

◆ KEY NUMBERS, LIMITS AND VALUES

- ISA sea level: **15 C** (288 K), **1013.25 hPa**, 29.92 inHg, 760 mmHg.
- ISA lapse rate **1.98 C per 1000 ft** (rounded to 2) to the tropopause.
- ISA tropopause: **36,090 ft** (11,000 m), **-56.5 C**, constant above.
- Speed of sound at ISA sea level about **661.5 kt** (340.3 m/s).
- Rate 1** standard turn = **3 deg/sec** (360 in 2 minutes); Rate half = 1.5 deg/sec at high TAS **VERIFY**.
- RVSM**: FL290 to FL410 inclusive, 1000 ft separation; 2000 ft above FL410.
- Magnetic dip: **0 deg at the magnetic equator, 90 deg at the magnetic poles**.
- Compass turning error is maximum turning through **North or South**, zero through East or West.
- Compass acceleration error is maximum on **East/West** headings, zero on North/South.
- Radio altimeter usable range roughly **0 to 2500 ft AGL** **VERIFY**.
- GPWS classic modes 1 to 6; EGPWS adds a forward-looking terrain database and windshear mode **VERIFY**.
- TCAS II issues Resolution Advisories in the final seconds, Traffic Advisories earlier; RAs are vertical only **VERIFY**.
- Stall warning (stick shaker) triggers at a set margin above the stalling angle of attack, not from IAS alone **VERIFY**.

◆ FORMULAS AND RELATIONSHIPS

- Mach number = TAS / Local Speed of Sound.
- LSS (kt) is about $38.95 \times \sqrt{\text{absolute temperature in K}}$; it depends on temperature only.
- Rule of thumb: TAS is about 2% above CAS per 1000 ft for a constant CAS (an ISA approximation).
- Standard-rate (Rate 1) bank angle is about $\text{TAS(kt)} / 10 + 7$ degrees.
- Precession rate is proportional to applied torque and inversely proportional to angular momentum (spin x moment of inertia); more momentum means more rigidity.
- Pressure altitude is what the altimeter reads with 1013.25 set; true altitude equals indicated only in ISA conditions, else high to low, look out below.

◆ MNEMONICS AND MEMORY ITEMS

- ONUS**: Overshoot North, Undershoot South, the compass turning error (Northern Hemisphere; reverses in the South).
- ANDS**: Accelerate North, Decelerate South, the compass acceleration error (Northern Hemisphere; reverses in the South).
- High to low, look out below**: flying into lower pressure or colder air, true altitude is below indicated.
- Turning error worst on **N/S**, acceleration error worst on **E/W**: complementary, not the same axis.
- Precession is felt 90 degrees later** in the direction of spin: the key to every gyro-error question.
- Rigidity** keeps a gyro pointing the same way; **precession** is the only thing that moves it.

◆ COMMON EXAM TRAPS

- A blocked **static** freezes the altimeter and zeroes the VSI; the ASI then under-reads in a climb and over-reads in a descent.
- A blocked **pitot with the drain also blocked** makes the ASI act like an altimeter: it over-reads in a climb, under-reads in a descent.
- A blocked pitot with the **drain clear** lets the ASI fall toward zero.
- Compressibility error depends on speed **and** altitude (a dynamic-to-static pressure ratio), not speed alone.
- The Machmeter needs no temperature correction; do not apply the TAS temperature correction to it.
- Compass dip errors affect the **direct-reading compass only**; gyro instruments suffer real/transport wander and drift instead.
- Do not confuse VSI lag during rapid pitch changes with an actual fault.
- The radio altimeter reads AGL over the terrain below, so over rising or falling ground it will not track the pressure altimeter.
- TCAS/ACAS resolution advisories are **vertical only**; TCAS never gives turn guidance.
- Stall warning triggers from **angle of attack**, not IAS; an iced or mis-rigged AoA vane is the classic failure cause.

◆ EXAM FIGURES FROM THE SKYSTUDY QUESTION BANK



Airspeed indicator

Dynamic pressure -> speed; pitot + static



Attitude indicator

Gyro -> pitch & bank; topples on power loss



Altimeter

Static pressure -> altitude; static line



Turn coordinator

Gyro -> turn rate & balance; electric



Heading indicator

Gyro -> heading; drifts, realign to compass



Vertical speed

Static change -> climb/descent; it lags

Standard "basic-T": attitude indicator top-centre; airspeed and altimeter flank it, heading indicator sits directly below. Diagrams drawn to scale in code.

SCENARIO	AIRSPEED (ASI)	ALTIMETER	VERTICAL SPEED	
OVER-READS	UNDER-READS	FROZEN	ZERO	normal
Pitot blocked, drain OPEN	ZERO falls toward 0	normal unaffected	normal unaffected	
Pitot+drain blocked, CLIMB	OVER-READS acts like an altimeter	normal unaffected	normal unaffected	
Pitot+drain blocked, DESCENT	UNDER-READS acts like an altimeter	normal unaffected	normal unaffected	
Static blocked, CLIMB	UNDER-READS trapped static too high	FROZEN stuck at block height	ZERO no static change	
Static blocked, DESCENT	OVER-READS trapped static too low	FROZEN stuck at block height	ZERO no static change	
Alternate static selected	OVER-READS cabin static lower	OVER-READS reads a bit high	normal brief blip	

Pitot feeds the ASI only; static feeds all three. A trapped pitot makes the ASI mimic an altimeter; a blocked static freezes the altimeter and zeroes the VSI.

Two of the 369 code-drawn study figures inside the SkyStudy question bank. Try them with the free demo at skystudyatpl.com/demo.

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