

PRIVATE PILOT GROUND SCHOOL

MODULE 1-5 — AERODYNAMICS AND SPIN AWARENESS

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MNEMONICS

PARE — Power idle, Ailerons neutral, Rudder full opposite the rotation, Elevator forward

The first four steps of the generic spin recovery, in order. The Warrior's handbook adds two more: rudder neutral when the rotation stops, then control wheel as required to regain level flight. A pilot who stops at E flies the recovery into a dive with the rudder still in. Say all six.

FACTS TO REMEMBER

KNOW THESE COLD

- The four forces on an airplane are lift, weight, thrust, and drag; in steady unaccelerated flight the opposing pairs are in balance.

Source: PHAK ch. 4

- Angle of attack is the angle between the wing's chord line and the relative wind — not the angle to the horizon.

Source: PHAK ch. 4

- A wing stalls when it exceeds its critical angle of attack — and only then. It can happen at any airspeed, any attitude, and any weight.

Source: PHAK ch. 5

- Lift comes from the wing deflecting air downward and the pressure difference across the wing — increasing angle of attack or airspeed increases lift until the critical angle.

Source: PHAK ch. 4

- Parasite drag grows with the square of airspeed; induced drag (the price of lift) grows as airspeed decreases. Total drag is least where the two curves cross.

Source: PHAK ch. 5

- Load factor is lift divided by weight, measured in Gs; in a level 60-degree-bank turn it is 2.0 regardless of airplane type.

Source: PHAK ch. 5

- Stall speed rises with the square root of load factor — at 60 degrees of bank, stall speed is about 1.41 times the wings-level number.

Source: PHAK ch. 5

- The Warrior proves the math in its own book: flaps-up stall 64.5 MPH level becomes 91 MPH at 60 degrees of bank (64.5×1.41).

Source: PA-28-151 AFM 3-7

- Weight raises stall speed; forward CG raises it slightly more (the tail must pull down harder); aft CG lowers stall speed but reduces stability and makes stall/spin recovery harder.

Source: PHAK ch. 5, ch. 10

– Uncoordinated flight (ball out of center) means the airplane is slipping or skidding — and a stall in uncoordinated flight is how spins start.

Source: PHAK ch. 5; AFH ch. 5

– The left-turning tendencies are torque, P-factor, spiraling slipstream, and gyroscopic precession; right rudder is the answer.

Source: PHAK ch. 5

– P-factor is strongest at high power and high angle of attack — takeoff and departure stalls — because the descending blade takes a bigger bite.

Source: PHAK ch. 5

– Adverse yaw is the nose yawing away from the turn as the raised wing's aileron adds drag; coordinated rudder cancels it.

Source: PHAK ch. 5; AFH ch. 3

– Ground effect within about one wingspan of the surface reduces induced drag: the airplane can lift off before it can climb, and it floats in the flare.

Source: PHAK ch. 5

– In slow flight, controls feel mushy, more right rudder is needed, and the airplane sits behind the power curve — configuration (flaps, gear) changes the speeds but not the logic.

Source: AFH ch. 5

– An impending stall announces itself by sight (nose attitude), sound (quieting slipstream, stall horn), and feel (buffet, mushy controls, reduced control effectiveness).

Source: AFH ch. 5

– Stall warning devices fire before the stall, but the warning margin shrinks with abrupt inputs and load factor — the horn is a boundary, not a countdown.

Source: AFH ch. 5; AC 61-67

– Stall recovery fundamentals, in order: reduce angle of attack (pitch down), level the wings with coordinated controls, add power as needed, return to the desired flightpath.

Source: AFH ch. 5

– Power-off (approach) stalls happen where approaches happen: the skidding base-to-final turn, stretching a glide, distraction in the pattern.

Source: AFH ch. 5

– The base-to-final cross-control stall is the classic fatal spin entry: overshooting final, holding bank off with opposite aileron while skidding with inside rudder, slow — the inside wing stalls first with no altitude to recover.

Source: AFH ch. 5

– A secondary stall is a second stall caused by recovering from the first one too aggressively — relax the pull, recover again.

Source: AFH ch. 5

– An accelerated stall is a stall above normal stall speed from added load factor — steep turns and abrupt pull-ups.

Source: AFH ch. 5

– An elevator trim stall is the go-around trap: full power with landing trim pitches the nose hard up — push forward, retrim, then climb.

Source: AFH ch. 5

– Power-on (departure) stalls happen at high power and low speed: liftoff, initial climb, go-around — with strong left-turning tendencies loading the stall with yaw.

Source: AFH ch. 5

- A spin is an aggravated stall with autorotation: one wing more deeply stalled than the other. No stall, no spin — and the yaw came from somewhere.

Source: AFH ch. 5; AC 61-67

- A spin has three phases: entry (stall plus yaw), incipient (first turns, spin not yet stabilized, recovery quickest here), and developed (stabilized rotation and descent).

Source: AFH ch. 5

- Generic spin recovery is PARE: Power idle, Ailerons neutral, Rudder full opposite the rotation, Elevator briskly forward — then rudder neutral when rotation stops, and ease out of the dive. (Mnemonic object.)

Source: AFH ch. 5; AC 61-67

- Intentional spins are prohibited in the Warrior in both Normal and Utility categories — prohibited is not the same as impossible, which is why recovery is memorized anyway.

Source: PA-28-151 AFM 3-4, 3-5

- Va, maneuvering speed, is the maximum speed for full deflection of a single control — 124 MPH placarded in the Warrior.

Source: PA-28-151 AFM 3-2

- Key Warrior limit speeds: Vne 176 MPH (never exceed, red line), Vno 140 (top of green, smooth air only above), Vs1 64.5 (clean stall), Vso 58 (landing configuration stall). All MPH calibrated.

Source: PA-28-151 AFM 3-2

- Warrior climb speeds: Vy 87 MPH best rate; the short-field procedure holds 66 MPH to clear the obstacle (the book never labels a Vx — the procedure on POH 7-5 is the answer).

Source: PA-28-151 POH 1-1, 7-5

- High density altitude degrades everything at once — engine power, propeller thrust, and lift — so the same indicated airspeeds produce longer rolls and shallower climbs.

Source: PHAK ch. 11

- Turbulence, gusts, and windshear can spike angle of attack without any pilot input — the margin above stall must grow when the air gets rough.

Source: AFH ch. 5; PHAK ch. 12

- Stall practice altitude rule: recover no lower than 1,500 ft AGL in a single-engine airplane (the ACS completion standard).

Source: FAA-S-ACS-6C VII

- Clear the area before stall or spin practice — collision vigilance does not pause for maneuvers.

Source: FAA-S-ACS-6C VII; AFH ch. 5

- Distraction is the documented first link in most inadvertent stall/spin chains — the defense is dividing attention deliberately and letting the maneuver wait.

Source: AFH ch. 5; AC 61-67

- Inadvertent slow flight with the stall warning on — low, slow, dragging it in — is itself the emergency: lower the nose and add power before anything else.

Source: AFH ch. 5

- In a steep turn the outside wing travels faster and makes more lift, creating an overbanking tendency the pilot holds off with aileron against the turn.

Source: PHAK ch. 5 (pin-needed); AFH ch. 9 (pin-needed)

- Rate and radius of turn are set by bank and speed: steeper bank quickens and tightens the turn; more speed slows the rate and widens the radius — over the ground, it is groundspeed that sets the track.

Source: PHAK ch. 5 (pin-needed)

GOING DEEPER

- Flying slower than best-glide/max-endurance speed puts the airplane in the region of reversed command: more power is needed to fly slower.

Source: PHAK ch. 11; AFH ch. 5

- The Warrior's book recovery has six steps, not four: after throttle idle, ailerons neutral, full opposite rudder, control wheel full forward — then rudder neutral when rotation stops, and smooth back pressure to level. Stopping at "stick forward" flies the recovery into a split-S.

Source: PA-28-151 AFM 3-5

- The Warrior's Utility category (1,950 lb, no baggage, no aft passengers) exists for higher load factors, not for spins.

Source: PA-28-151 AFM 3-4

- V_a decreases as weight decreases: a lighter airplane stalls at a lower speed, so it can reach damaging load factors at lower airspeeds.

Source: PHAK ch. 5

- V_a protects against a single full input on one axis — full alternating inputs, or full inputs on more than one axis at once, can break the airplane below V_a .

Source: PHAK ch. 5; AIM 7-4 (structural awareness)

- Warrior flap limit speed splits by serial number: V_{fe} 125 MPH on serials 7415001–7515449, 115 MPH on 7615001 and up — check the airplane you are flying.

Source: PA-28-151 AFM 3-2

THE REGULATIONS BEHIND THIS MODULE

14 CFR 91.9 – Civil aircraft flight manual, marking, and placard requirements

No person can operate a civil airplane without complying with the operating limitations in the approved flight manual, the markings, and the placards. The Warrior's placards prohibit spins and set maneuvering speed at 124 mph.

Where it goes deeper: This module reads the Warrior's Section III limitations. Module 1-4 taught where the limitations live.

14 CFR 61.105(b)(10) and (11) – Aeronautical knowledge: aerodynamics and stall/spin awareness

The knowledge a private pilot applicant must have includes the principles of aerodynamics, and stall awareness, spin entry, spins, and spin recovery techniques.

Where it goes deeper: This module. The ACS tests it as Area of Operation VII.