CFI to CFI

Authority of the Rudder

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An airplane is maneuvered around its three axes by the three primary flight controls. The ailerons control roll, the elevator controls pitch, and the rudder controls yaw. It seems practical to say the rudder is provided to let the pilot yaw the airplane. The reality is that there is rarely a time when the pilot would need to do so. Rather than to initiate yaw movements, the rudder's primary purpose is to compensate for factors that make the airplane yaw on its on -- undesirably on its own.

Airplane manufactures understand the need for a rudder, and therefore, attach on the airplane and give it the authority to reign over all undesirable yawing tendencies. Initiators of these tendencies include: aileron drag, asymmetrical thrust, pitch changes, and the spiraling stream of air flowing around the airplane. This article will describe these yawing movements and the proper rudder input that should be applied for each. The aerodynamic principles discussed here apply to typical single-engine airplanes with a nose-mounted propeller.

Moving the control wheel or control stick to the right causes the right aileron to deflect upward and the left aileron to deflect downward. The downward deflected aileron produces more lift and therefore more drag than the rising aileron. Thus, the increased lift and drag on the left wing will cause the airplane to roll to the right but yaw slightly to the left. Yaw due to asymmetrical aileron deflection is referred to as aileron drag, or adverse yaw. To overcome aileron drag, apply a little bit of rudder in the direction of the turn until the bank angle is established. Also apply rudder when rolling out of the turn or any other time you use the ailerons.

Asymmetrical thrust is produced when an airplane is flown at a high angle-of-attack (AOA). Tthe AOA of the downward moving blade is greater than the AOA of the upward moving blade. This moves the center of thrust to the right of the propeller hub, causing a yawing moment toward the left. The pilot should anticipate the need for right rudder any time the airplane is flown at a high power setting and a high AOA, such as while climbing after takeoff.

When an airplane changes pitch, a corresponding yaw movement is produced due to a phenomenon known as gyroscopic precession. The rotating propeller of an airplane makes a very good gyroscope. When a force is applied to a gyroscope or a propeller, the resulting force takes effect 90° ahead of and in the direction of rotation. This causes an airplane to pitch or yaw depending upon the point at which the force was applied. This effect has always been associated with tailwheel-type aircraft when the tail is being raised during the takeoff roll. This change in pitch attitude has the same effect as applying a force to the top of the propeller's plane of rotation. The resultant force acting 90° ahead causes a yawing moment to the left around the vertical axis. To counteract this tendency, right rudder pressure should be applied to keep the airplane aligned with the runway centerline.

The rotation of the propeller gives a spiraling rotation to the air flowing around the airplane. This spiraling rotation exerts a strong sideward force on the vertical tail surface, causing the airplane to yaw to the left. The more compact the spiral, the more prominent this force is. As forward speed increases, the spiral elongates and becomes less apparent. Anytime the airplane is flown at a high power setting and slow airspeed, such as during takeoff, the pilot should apply right rudder to counteract this effect.

Most of these tendencies work together to aw the airplane to the left. Airplane manufactures can design an airplane to counteract these tendencies by offsetting the leading edge of the vertical stabilizer, by offsetting the engine, by putting a ground adjustable trim tab on the rudder, or by any number of other ways which are of no real concern to the pilot. What is of concern is that the airplane is only designed to counteract the left turning tendencies at a normal cruise speed and power setting. Any power setting higher or a speed lower than that of a normal cruise will make it necessary for the pilot to maintain right rudder pressure to compensate for an increased left turning tendency.

As noted in the first paragraph, there is rarely a time when the pilot would need to induce a yawing movement. However, there are times when the pilot will apply rudder deflection when not correcting for the discussed factors. When landing in a crosswind for instance, there is a need for the pilot to apply rudder pressure to align the airplane's longitudinal axis with the runway centerline before touching down. The only other maneuver useful to the non-aerobatic pilot is the forward-slip to a landing, where the airplane is purposely cross-controlled to allow it to

descend at a higher-than-normal rate until established on the normal descent path.