P-factor©

Early in flight training the peculiarities of rudder control should be explained and demonstrated. If a student fully understands the 'why' of doing something he is more likely to recognize whether or not it has been performed correctly. The most obvious student deficiency caused by lack of aerodynamic understanding is in using the rudder. Modern aircraft design has decreased the 'rudder' requirement and made is misuse or non-use less obvious. Understanding how the rudder is integrated with power and other controls is essential. Failure to correctly use the rudder is the most dangerous defect in flight maneuvering.

The C-150 and later aircraft have decreased adverse yaw caused by banking through the used of differential linkage and Frise ailerons. Ailerons no longer move as far up as they do down. The nose of the Frise aileron sticks down as the rear rises to offset adverse yaw. The need for rudder coordination thus becomes less noticeable and less easily demonstrated.

Power transmitted through the propeller and the rudder have a symbiotic relationship. The first gives the second both purpose and function. The propeller with a power increase will turn the aircraft to the left and raise the nose. The turning tendency, caused by P-factor, can be anticipated and prevented by judicious use of the rudder in proportion to the amount of power applied, the airspeed, and the raising of the nose. Ideally an aircraft in level cruise is ‘rigged’ and trimmed for hands-off flight. From this initial configuration most maneuvers other than a straight ahead descent will require some degree of rudder application.

Banking an aircraft with aileron movement causes unbalanced lift. The wing making the greater radius of turn must travel faster and thereby it is accelerated. The increased speed causes increased lift. With increased lift you get increased drag. The lowered aileron increases camber, (wing curve) lift, and drag.; the raised aileron reduces camber and lift. Lift causes drag and the lift difference between the two wings causes one wing to lag behind the other. The nose is pulled toward the outside of the turn. The amount of yaw depends on the amount of aileron and how quickly applied. You need to use rudder to counter this pull on the nose and keep the tail behind the nose. Thus, the rudder is used to move the outboard wing forward and faster. Done properly the ball will remain centered throughout the turn.

With the effects of P-factor and adverse yaw we find that in certain climbing left turns that the adverse yaw is effectively canceled by the P-facor. Thus to come out of the left turn we must apply right rudder. Correspondingly, since in making a right climbing turn we must counter both the adverse yaw and the P-factor, we will find it necessary to lead the turn by anticipating with the application of right rudder. We can come out of the right turn by just relaxing some of the right rudder pressure. To make the turns smooth and coordinated the rudder applications must be anticipated.

Once the bank is stabilized, adverse yaw ceases and the need for rudder correction of the yaw ceases. To fly in a line you must have coordinated control of the rudder. Poor rudder use shows most in landings and in turbulence.

Rudder Exercises

A few level left and right turns at a 30 degree bank will reveal any lazy rudder habits. Begin by having the student make the turns without using rudder at all. Watch the movement of the nose. Adverse yaw is caused by the down aileron. Now make the turns using rudder so as to note that proper rudder pressures allows the nose to follow the turn. A coordinated return to level flight requires that rudder pressure be applied with aileron. Excessive rudder causes jerky nose movement that does not go with the flow of the turn. Practice your turns with eyes outside the cockpit.

A more advanced exercise with the rudder can be practiced in level flight. Many students seem reluctant to let go of the yoke. Get the aircraft well trimmed and then have the student make some shallow turns with the rudder alone. To level off on a heading will require considerable lead time and rudder. The rudder must be worked to get level on course. Have the student hold a pad of paper up and write on it while making turns only with the rudder. Because of the p-factor the rudder must be used differently in coming out of left turns than when coming out of right turns. Students may not be aware that 3 or 4 knot fluctuations in airspeed may be caused by rudder as well as nose attitude. Demonstrate.

Gee and Haw

WHY PILOTS WALK FUNNY

Ever wonder why propeller pilots walk funny? The P-factor explanation from the instructors handbook tells the instructor. How to explain this to the student as having nothing to do with the factor of how much liquid is consumed? P-factor stress reduction while flying means to pee at every opportunity. That's a different factor. Part of the difficulty comes from having two or more generations of pilots, none of whom have had the opportunity to drive a team of mules.

This educational and experience deficiency can be partially overcome while explaining the P-factor. Thereby leading to the ultimate answer of the initial question. The instructor might start with an airplane which has the training wheel under the nose. A Cessna 150 will do. With all three wheels on the ground the student should be carefully walked around the propeller and told to note that, when horizontal, the blades each form an approximate 11 degree angle in pitch from the vertical. The airplane should be imagined as a wagon and the painted tips of the blades as harnessed to two half-grown mules of identical size and strength. In this configuration the wagon airplane) would be pulled straight ahead until made to gee or haw. Gee meaning right and haw meaning left. O.K. so far?

Now we enter a climb and by magic the mule on the left becomes a donkey and the mule on the right a Missouri Canary of twice the size of before. This change in aircraft attitude is accomplished by having the instructor hold the aircraft tail down while the student observes the angle from vertical, the pitch of each propeller blade. The left blade is near vertical while the right blade has doubled its angle. Now the airplane wagon suddenly has two completely different modes of power. Now which way will the wagon, nee airplane, go? Will it gee or haw? More often than not our last two generations of student pilots will chose the wrong direction. The odoriferous experience of mule driving having been denied them.

Most students say, incorrectly, to the right because the larger horse is on the right. Here it actually helps to pull the plane by the wing struts to illustrate the left turning pull of the larger (pitch) mule.

Then it follows as the night the day that in a climb attitude an appropriate application of right rudder is needed to keep the airplane on the straight if not narrow. The right right is required to prevent a "haw" Which, of course, leads us in the great cyclonic circle to the answer of the initial question. It takes a lot of "Gee" Leg to prevent a "Haw". Thus, the necessity of right rudder when power is added or the nose raised.