Longitudinal stability is the quality that makes an airplane stable about its lateral axis. It involves the pitching motion as the airplane's nose moves up and down in flight. A longitudinally unstable airplane has a tendency to dive or climb progressively into a very steep dive or climb, or even a stall. Thus, an airplane with longitudinal instability becomes difficult and sometimes dangerous to fly.

Static longitudinal stability or instability in an airplane, is dependent upon three factors:

1. Location of the wing with respect to the center of gravity;

2. Location of the horizontal tail surfaces with respect to the center of gravity; and

3. The area or size of the tail surfaces.

In analyzing stability, it should be recalled that a body that is free to rotate will always turn about its center of gravity.

To obtain static longitudinal stability, the relation of the wing and tail moments must be such that, if the moments are initially balanced and the airplane is suddenly nosed up, the wing moments and tail moments will change so that the sum of their forces will provide an unbalanced but restoring moment which, in turn, will bring the nose down again. Similarly, if the airplane is nosed down, the resulting change in moments will bring the nose back up.

The center of lift, sometimes called the center of pressure, in most unsymmetrical airfoils has a tendency to change its fore and aft position with a change in the angle of attack. The center of pressure tends to move forward with an increase in angle of attack and to move aft with a decrease in angle of attack. This means that when the angle of attack of an airfoil is increased, the center of pressure (lift) by moving forward, tends to lift the leading edge of the wing still more. This tendency gives the wing an inherent quality of instability.

Figure 3-12 shows an airplane in straight-and-level flight. The line CG-CL-T represents the airplane's longitudinal axis from the center of gravity (CG) to a point T on the horizontal stabilizer. The center of lift (or center of pressure) is represented by the point CL.

Most airplanes are designed so that the wing's center of lift (CL) is to the rear of the center of gravity. This makes the airplane "nose heavy" and requires that there be a slight downward force on the horizontal stabilizer in order to balance the airplane and keep

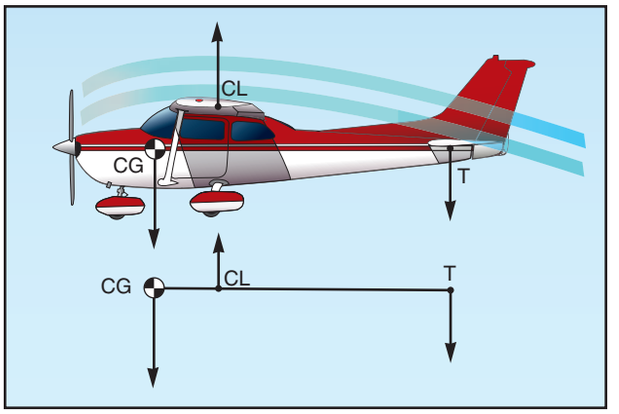

Figure 3-12. Longitudinal stability.

the nose from continually pitching downward. Compensation for this nose heaviness is provided by setting the horizontal stabilizer at a slight negative angle of attack. The downward force thus produced, holds the tail down, counterbalancing the "heavy" nose. It is as if the line CG-CL-T was a lever with an upward force at CL and two downward forces balancing each other, one a strong force at the CG point and the other, a much lesser force, at point T (downward air pressure on the stabilizer). Applying simple physics principles, it can be seen that if an iron bar were suspended at point CL with a heavy weight hanging on it at the CG, it would take some downward pressure at point T to keep the "lever" in balance.

Even though the horizontal stabilizer may be level when the airplane is in level flight, there is a downwash of air from the wings. This downwash strikes the top of the stabilizer and produces a downward pressure, which at a certain speed will be just enough to balance the "lever." The faster the airplane is flying, the greater this downwash and the greater the downward force on the horizontal stabilizer (except "T" tails). [Figure 3-13] In airplanes with fixed position horizontal stabilizers, the airplane manufacturer sets the stabilizer at an angle that will provide the best stability (or balance) during flight at the design cruising speed and power setting. [Figure 3-14]

If the airplane's speed decreases, the speed of the airflow over the wing is decreased. As a result of this decreased flow of air over the wing, the downwash is reduced, causing a lesser downward force on the horizontal stabilizer. In turn, the characteristic nose heaviness is accentuated, causing the airplane's nose to pitch down more. This places the airplane in a nose-low attitude, lessening the wing's angle of attack and drag and allowing the airspeed to increase. As the airplane continues in the nose-low attitude and its speed increases, the downward force on the horizontal stabilizer is once again increased.