Attention

How is that something so big can stay in the air?

Schedule

Ground instruction – 10 minutes

Reference Material

The Pilot's Manual PM 2 Ground School by ASA
PHAK FAA-H-8083-25B

Material

Like all things, an airplane has weight, the force of gravity that acts through the center of the airplane in a vertical direction toward the center of the earth. While the airplane is on the ground, its weight is supported by the force of the ground on the airplane, which acts upward through the wheels. During the takeoff roll, the task of supporting the weight of the airplane is transferred from the ground to the wings (and vice versa during the landing). While in level flight, the weight of the airplane is supported by the lift force, which is generated aerodynamically by the flow of air around the wings. In addition, as the airplane moves through the air it will experience a retarding force known as drag, which, unless counteracted, will cause the airplane to decelerate and lose speed. In unaccelerated straight-and-level flight, the drag is neutralized by the thrust (Figure 1). In smaller airplanes, thrust is produced by the engine–propeller combination; in pure-jet airplanes, the thrust is produced by the gas efflux, without the need for a propeller.

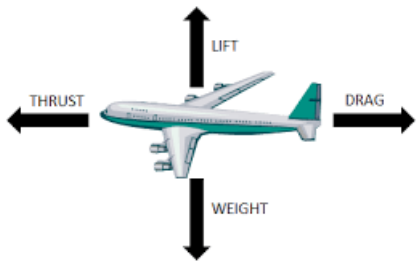

Figure 1

Gravity is the downward force attracting all bodies vertically toward the center of the earth. The name given to the gravitational force is weight, and for our purposes it is the total weight of the loaded airplane. This weight is called gross weight, and it may be considered to act as a single force through the center of gravity (CG).

The CG is the point of balance. Its position depends on the weight and position of the various parts of the airplane and the load that it is carrying. If the airplane were supported at its center of gravity, the airplane would be balanced.

The weight of an airplane varies depending on the load it has to carry (cargo, baggage, passengers) and the amount of fuel on board. Airplane gross weight will gradually decrease as the flight progresses and fuel is burned off. The magnitude of the weight is important and there are certain limitations placed on it—for instance, a maximum takeoff weight will be specified for the airplane. Weight limitations depend on the structural strength of the components making up the airplane and the operational requirements the airplane is designed to meet.

The balance point (center of gravity) is very important during flight because of its effect on the stability and performance of the airplane. It must remain within carefully defined limits at all stages of the flight.

The location of the CG depends on the weight and the location of the load placed in the airplane. The CG will move if the distribution of the load changes, for instance by transferring load from one position to another by passengers moving about or by transferring fuel from one tank to another. The CG may shift forward or aft as the aircraft weight reduces in flight, such as when fuel burns off or parachutists jump out.

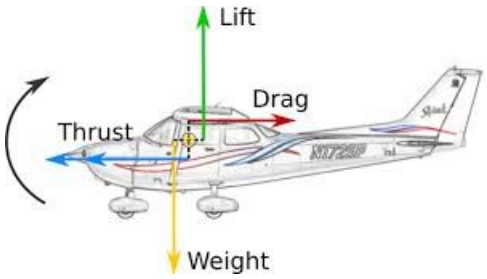

Figure 2

In Figure 3, the forces are equal and opposite, canceling each other out, so that the resultant force acting on the airplane is zero, and it will neither accelerate nor decelerate. In this situation the airplane is in a state of equilibrium:
• weight is equal to lift, and acts in the opposite direction
• drag is equal to thrust, and acts in the opposite direction.

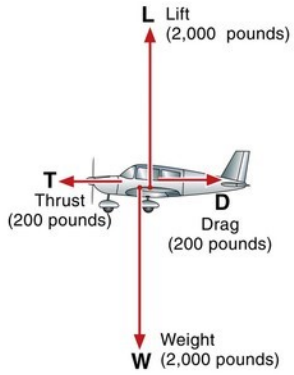

Figure 3

For the type of airplane you are likely to be flying during your training, the amount of the lift (and therefore the weight) during cruise flight will be approximately 10 times greater than the drag (and thrust). This relationship of lift to drag is very important and is referred to as the lift/drag ratio. The L/D ratio in this case is 10 to 1.

If the airplane is to accelerate in level flight, the thrust must exceed the drag; if the airplane is to be slowed down in level flight, the thrust must be less than the drag. A state of equilibrium does not exist during acceleration or deceleration.

Types of Drag

Drag is the force that resists movement of an aircraft through the air. There are two basic types: parasite drag and induced drag. The first is called parasite because it in no way functions to aid flight, while the second, induced drag, is a result of an airfoil developing lift.

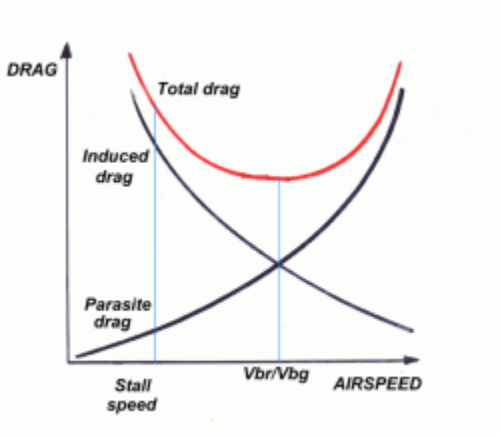

Figure 4

Parasite drag is comprised of all the forces that work to slow an aircraft's movement. As the term parasite implies, it is the drag that is not associated with the production of lift. This includes the displacement of the air by the aircraft, turbulence generated in the airstream, or a hindrance of air moving over the surface of the aircraft and airfoil. There are three types of parasite drag: form drag, interference drag, and skin friction.

Form drag is the portion of parasite drag generated by the aircraft due to its shape and airflow around it. Examples include the engine cowlings, antennas, and the aerodynamic shape of other components.

Interference drag comes from the intersection of airstreams that creates eddy currents, turbulence, or restricts smooth airflow. For example, the intersection of the wing and the fuselage at the wing root has significant interference drag.

Skin friction drag is the aerodynamic resistance due to the contact of moving air with the surface of an aircraft. Every surface, no matter how apparently smooth, has a rough, ragged surface when viewed under a microscope.

The second basic type of drag is induced drag. It is an established physical fact that no system that does work in the mechanical sense can be 100 percent efficient. This means that whatever the nature of the system, the required work is obtained at the expense of certain additional work that is dissipated or lost in the system. The more efficient the system, the smaller this loss.

In level flight, the aerodynamic properties of a wing or rotor produce a required lift, but this can be obtained only at the expense of a certain penalty. The name given to this penalty is induced drag. Induced drag is inherent whenever an airfoil is producing lift and, in fact, this type of drag is inseparable from the production of lift. Consequently, it is always present if lift is produced.

Total drag = Parasite Drag + Induced Drag

The airspeed at which total drag is lowest will determine the best glide speed of that plane.