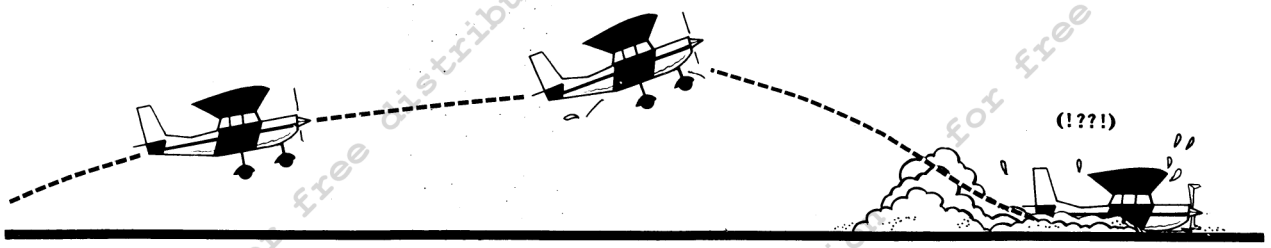
DEPARTMENT OF TRANSPORTATION
Federal Aviation Administration

VFR PILOT EXAM-O-GRAM* NO. 47

GROUND EFFECT



It is possible to fly an aircraft a few feet above the ground at an airspeed lower than that required to sustain level flight at an altitude only slightly higher. This is the result of a phenomenon called ground effect -- apparently better known than understood by many pilots. In terms as nontechnical as possible, we will here define and discuss the major problems associated with this rather complex subject.

WHAT IS GROUND EFFECT? It is not possible, nor would it serve our purpose, to attempt in the space available an indepth discussion of the precise aerodynamics of ground effect. Suffice it to say, that in simple terms, it is the result of interaction between wing airflow patterns and the surface of the earth. All airfoils such as wings, rotor blades, etc., produce tip vortices and exhibit distinct airstream downwash characteristics when developing lift. The vertical components of such tip vortices and downwash velocities are progressively reduced as the airfoil nears the surface, and at touchdown are almost completely canceled by surface interference. This alteration in airflow pattern decreases induced drag (the drag produced by lift). The closer the airfoil to the surface, the greater the reduction. Induced drag, at a height of approximately one-tenth of a wing span above the surface, may be 47% less than when the airplane is operating out of ground effect. It is this decrease in drag which explains basic airplane reactions when in ground effect.

HOW DOES A REDUCTION IN INDUCED DRAG AFFECT PERFORMANCE? To the pilot the reduction in drag means increased performance. That is, lift will increase with no increase in angle of attack, or the same lift can be obtained at a smaller angle of attack. This can be useful since it allows the pilot to either decrease angle of attack/power to maintain level flight, or as on most landings, to maintain wing lift while reducing power. A word of caution is in order, however. A full stall landing will require several more degrees of up elevator deflection than would a full stall when done free of ground effect. This is true because ground effect usually changes horizontal tail effectiveness in airplanes of conventional configuration.

UP TO WHAT ALTITUDE CAN GROUND EFFECT BE DETECTED? A pilot is unlikely to detect ground effect if his height above the surface exceeds the airplane's wing span. In fact, there is appreciable ground effect only if height is less than half the wing span. At this or lower altitudes, ground effect is quite pronounced.

WHAT MAJOR PROBLEMS CAN BE CAUSED BY GROUND EFFECT? Floating during landing is, in part, a result of ground effect. An airplane will continue to remain airborne just above the surface at a speed which would have produced an immediate stall had the airplane been a bit higher. Therefore, a pilot may run out of both runway and options if he carries excess speed in the approach, or does not allow for at least a small margin of float after the flare from a normal approach.

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Another and perhaps more serious problem, can develop during takeoff and climb out, especially when using a runway of marginal length. Deluded into believing that he has climb-out capability simply because he was able to get in the air, a pilot may raise the gear the instant he is airborne or initiate an immediate climb. For a few feet, all may go well but he may really have only marginal climb performance even in ground effect, and therefore, an acute need for added thrust as he begins to move out of ground effect. Moving out of ground effect, even if it only slightly increases the effectiveness of the elevators, the nose will usually tend to pitch up. At the resultant high angle of attack, the pilot finds he cannot climb, or even worse, may begin to sink. Desperately holding his nose-high attitude in a futile effort to gain altitude, he steadily mushes or stalls back to the runway or into obstructions if no excess power is available to correct the situation. Add high gross weight and density altitude and a bit of turbulence to this scene and an accident is even more likely.

Airspeed indicator unreliability in ground effect is another though less critical problem. Usually it will indicate slightly higher as you leave and slightly lower as you enter ground effect.

Just remember, ground effect is always there; it may prolong the glide or permit an aircraft to get airborne with insufficient power to sustain flight outside the area of ground effect. If this occurs the pilot must allow the airplane to accelerate while still in ground effect, before attempting to continue the climb. Panic attempts to force a climb can only make lift/climb problems worse.

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