Soft-Field Takeoff and Climb

Objective

To ensure the applicant learns the purpose of and can exhibit a clear understanding of the soft-field takeoff maneuver and how to perform the maneuver properly.

Purpose

The soft field takeoff maneuver is used when departing from grass or other soft landing surfaces. It demonstrates how the airplane needs to be handled differently on these high-drag surfaces. Mastering this maneuver will help pilots become comfortable operating to and from grass strips.

Schedule

- **Ground Lesson**: 15 minutes
- Initial
  - **Flight 1**: 40 minutes - *Introduction to Maneuver*
  - **Flight 2**: 50 minutes - *Improve Proficiency (Dual)*
- Solo
  - **Flight 3**: 30 minutes - *Improve Proficiency*
- Pre-Checkride
  - **Flight 4**: 20 minutes - *Demonstrate Proficiency*
- **Debrief**: 10 minutes (*per flight*)

Equipment

- Airplane POH and Checklist
- Whiteboard / Markers (optional)
- Model Airplane (optional)

Student Actions

- Ask any questions, receive study material for the next lesson.
- Watch linked video.
- Review listed references.

Instructor Actions

- Deliver the ground lesson (below).
- Demonstrate the maneuver in flight.
- Debrief after each flight.

Completion Standards

- **Ground**: Student can explain the purpose of the maneuver and how to execute it properly.
  - Can explain how the nose wheel is protected, ground effect, and Vx vs Vy.
- **Flight**: Student can perform the maneuver to the applicable ACS standards.
  - Performs a pre-takeoff checklist and configures the airplane correctly.
  - Holds weight off of the nose wheel during taxi and aligns with the runway centerline without stopping.
  - Lifts off at the lowest possible speed and accelerates in ground effect to Vx.
  - Climbs out at Vx until clear of obstacles, then accelerates to and climbs at Vy.
  - See expanded Completion Standards below.

References

- ERAUSpecialVFR - “Soft Field Takeoff”
    - YouTube - https://www.youtube.com/watch?v=6OK-4tudazs
- FAA-H-8083-3C (Airplane Flying Handbook) - Chapter 6, Page 1-2 [Prior to Takeoff], Chapter 6, Page 3-6 [Normal Takeoff], Chapter 6, Page 6-10 [Crosswind Takeoff], Chapter 6, Page 10-11 [Ground Effect on Takeoff], Chapter 6, Page 13-14 [Soft/Rough-Field Takeoff and Climb], Chapter 6, Page 14 [Rejected Takeoff/Engine Failure]
- FAA-H-8083-25C (Pilot’s Handbook of Aeronautical Knowledge) - Chapter 5, Page 7 [Induced Drag], Chapter 5, Page 11-12 [Ground Effect], Chapter 11, Page 12-16 [Takeoff Performance], Chapter 11, Page 19-28 [Performance Charts]
- FAA-S-ACS-6C (Private Pilot ACS) - Area IV Task C
- FAA-S-ACS-7B (Commercial Pilot ACS) - Area IV Task C
- FAA-S-ACS-25 (CFI ACS) - Area VII Task C

Ground Lesson Outline

- What are Soft Field takeoffs?
    - Protecting the nose wheel
- Importance of Estimating Field Conditions
- Ground Effect
- Takeoff Performance
    - Density Altitude
    - Calculating takeoff performance data, proper aircraft configuration
    - Soft fields affect performance
    - Vx vs Vy, Left-turning tendencies
- Runway Safety
- Safety considerations
    - Use of checklists
    - Visual traffic scanning - awareness of obstacles and field condition
    - Runway incursion avoidance
    - Windshear, Tailwinds, Wake Turbulence
    - Be ready to abort!
- Maneuver Description - step-by-step
    - Entry position, airspeed, etc.
- Expanded Completion Standards

Common Errors

- Improper runway incursion avoidance procedures.
- Improper use of controls during a soft-field takeoff.
- **Improper lift-off procedures (climbing out of ground effect prematurely).**
- **Improper climb attitude, power setting, and airspeed (Vy or Vx).**
- Improper use of checklist

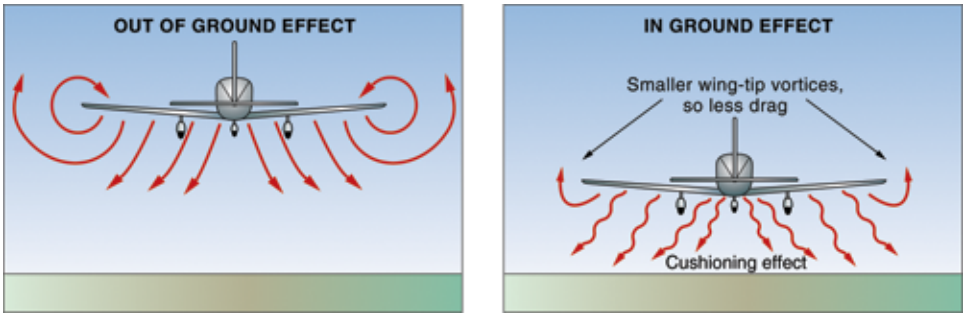
Ground Lesson Content

- **What are Soft Field takeoffs?** Taking off from a grass or other soft-surface runway (*soft field*) has a few important differences from normal landings made on paved runways. Pilots may generally assume that paved runways are maintained in acceptable conditions, however soft fields have no such guarantees. Soft fields may be contaminated with water, mud, rocks, or covered in potholes or other hazards. Even fields which may from a distance appear quite dry can be unexpectedly muddy or wet.

- Because most common training airplanes have *tricycle* landing gear, with heavy engines resting above small nose wheels, special care must be taken to prevent the nose wheel from sinking into the grass or mud and slowing the airplane excessively.

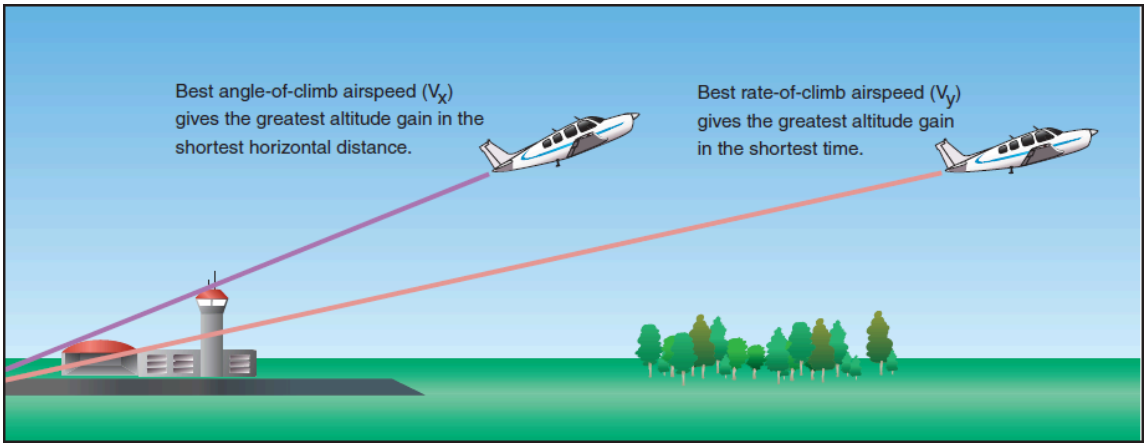
- Grass and other soft surfaces, such as dirt, provide a significant amount of increased drag or rolling resistance as compared to paved runway surfaces. Therefore, landing distances will be improved, however takeoff distances can be lengthened dramatically. Taxiing will also require considerably more power, and require careful attention to keeping weight off of the nosewheel!
- The best way to protect the nose wheel on soft-surface fields is to keep **full back elevator pressure** whenever in motion on the soft surface, **avoiding wheel braking**, and avoiding coming to a complete stop whenever possible.
- **Importance of Estimating Field Conditions** - If the condition of a soft field is not already known, it is generally a good idea to inspect it closely to assess the field conditions. The surface should appear **dry**, the **grass properly mowed**, and **free of potholes and rocks**.

- Very early in the takeoff roll the nose wheel will come off the surface. Some back elevator pressure will need to be released to allow the airplane to accelerate some, but eventually the airplane will want to begin to lift off.
- **Ground Effect** - As the airplane lifts off, and remains just above the ground, it is flying in *ground effect*. *Ground effect* is a phenomenon where the proximity of an airplane's wing to the ground interrupts the usual wing tip vortices and provides a cushioning effect.



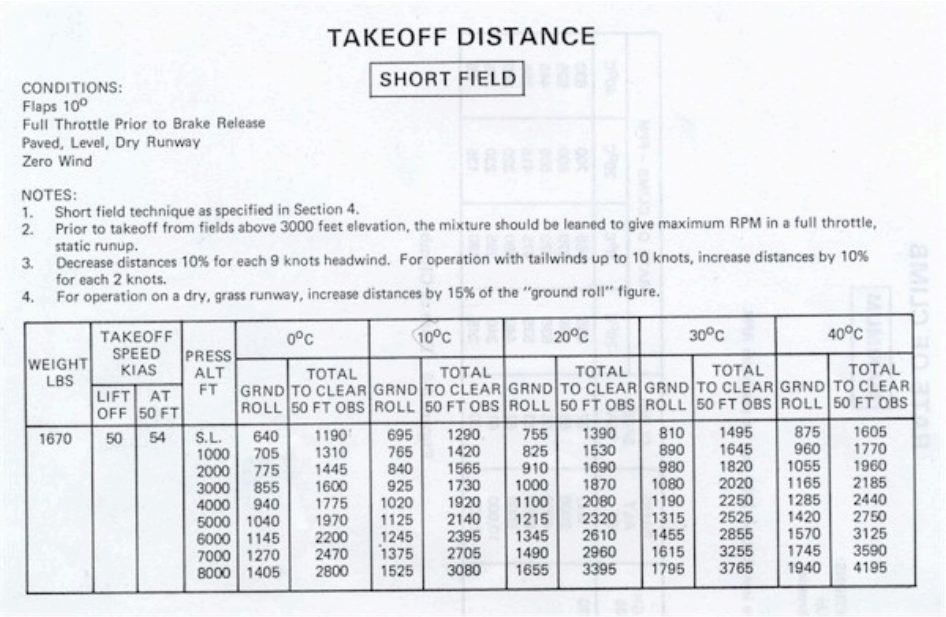
- Flying in ground effect will allow the airplane to **lift off at a lower than normal speed**. It will also allow the airplane to continue to accelerate to an airspeed which will allow it to climb away from the ground safely.
    - **On many soft surfaces, the rolling resistance is so great it may be impossible to accelerate to flying speed without getting into ground effect!**
    - In these situations, it may be necessary to 'unstick' the airplane from the soft surface by briskly pulling back on the elevator to get airborne and into ground effect.
    - It is important to realize that **if the airplane tries to climb out of ground effect before it accelerates to a normal climb airspeed** (usually Vx), **it may enter a stall or settle back to the surface!**
- Ground effect only occurs within a very short distance above the surface. Generally, the effect is almost completely gone by 1 wingspan distance from the ground, and is strongest within ½ a wingspan from the ground.
- **Takeoff Performance** - Determining exactly how much distance will be required for takeoff is crucial to ensure the chosen runway will be long enough to depart safely. An airplane's takeoff performance is highly dependent on several changing factors, such as **weight, wind, and density altitude.** Aircraft performance at heavier weights or higher altitudes is greatly reduced.

  - *Density altitude,* which is a correction for atmospheric conditions, is the altitude that an airplane 'feels'.
  - At higher altitudes or on hot days, the density of the air will be less and therefore the airplane will need to move more air to stay aloft. Because the airspeed indicator is also affected by density altitude, it will show the same values, however the true airspeed will be higher.
  - **The difference between field altitude and the density altitude can be significant!**
    - See the related lesson on Density Altitude.
- **Best Angle of Climb and Best Rate of Climb** - When climbing out of small airstrips, which are often in confined areas, there are two important speeds that pilots must memorize for their aircraft:
  - **Vx** - The best *angle* of climb.
  - **Vy** - The best *rate* of climb.
- Climbing at the best *angle* of climb means that the airplane will climb more steeply away from the ground, and is **usually used for avoiding obstacles** which may be present especially near small runways.
- Climbing at the best *rate* of climb is more commonly used, and it means the airplane will climb faster, but at a shallower angle. This is used to gain the most altitude in the shortest amount of time.



- **Remember the Left Turning Tendencies** - Recall the 4 left-turning tendencies described in previous lessons. It is important for pilots to keep these in mind while climbing, especially at low airspeeds (as in a Vx climb), to maintain proper coordination.
- The POH for every aircraft will contain performance charts that detail how many feet of takeoff distance is required for various weights, winds, and weather conditions. It also prescribes an airplane configuration that should be used.
  - To use the performance charts, first find the *pressure altitude*, by setting the altimeter to 29.92" or using the conversion. Then, find the cell in the table that matches the airplane gross weight with the pressure altitude and the current temperature. **Make sure to read the notes, in case distances need to be adjusted for wind or other conditions!** Remember that a soft field will always require more takeoff distance than a paved runway, so takeoff performance figures need to be adjusted.
  - It is best to add a 'safety factor' to the performance figures obtained from the POH performance charts. Generally, it is a good idea to overestimate the pressure altitude and temperature for a worst case scenario, and add 20-30% to account for the possibility of imperfect technique.
  - **Don't forget to consider wind!** A tailwind dramatically increases takeoff and landing distances. Likewise, a strong headwind can greatly improve performance.

- **Pay attention to aircraft configuration** - Some POHs call for flaps, so do not. The performance numbers are only valid for the given configuration!



TAKEOFF DISTANCE

SHORT FIELD

CONDITIONS:
Flaps 10°
Full Throttle Prior to Brake Release
Paved, Level, Dry Runway
Zero Wind

NOTES:
1. Short field technique as specified in Section 4.
2. Prior to takeoff from fields above 3000 feet elevation, the mixture should be leaned to give maximum RPM in a full throttle, static runup.
3. Decrease distances 10% for each 9 knots headwind. For operation with tailwinds up to 10 knots, increase distances by 10% for each 2 knots.
4. For operation on a dry, grass runway, increase distances by 15% of the "ground roll" figure.

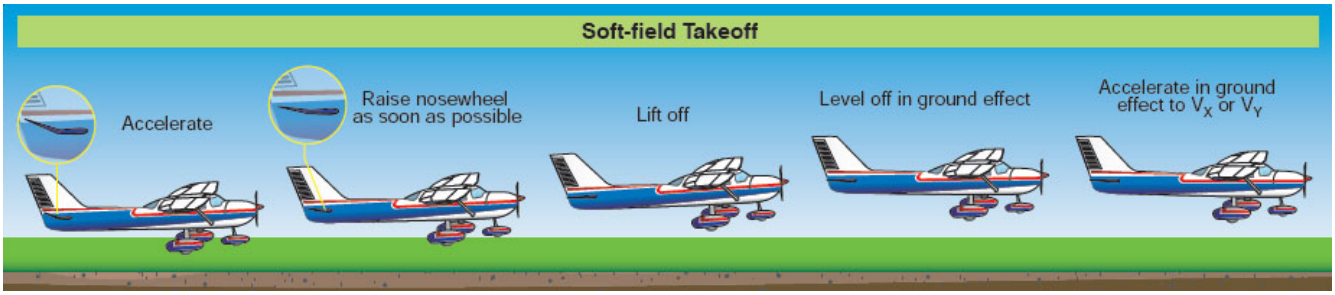
WEIGHT LBS	TAKEOFF SPEED KIAS		PRESS ALT FT	0°C		10°C		20°C		30°C		40°C	
	LIFT OFF	AT 50 FT		GRND ROLL	TOTAL TO CLEAR 50 FT OBS	GRND ROLL	TOTAL TO CLEAR 50 FT OBS	GRND ROLL	TOTAL TO CLEAR 50 FT OBS	GRND ROLL	TOTAL TO CLEAR 50 FT OBS	GRND ROLL	TOTAL TO CLEAR 50 FT OBS
1670	50	54	S.L.	640	1190	695	1290	755	1390	810	1495	875	1605
			1000	705	1310	765	1420	825	1530	890	1645	960	1770
			2000	775	1445	840	1565	910	1690	980	1820	1055	1960
			3000	855	1600	925	1730	1000	1870	1080	2020	1165	2185
			4000	940	1775	1020	1920	1100	2080	1190	2250	1285	2440
			5000	1040	1970	1125	2140	1215	2320	1315	2525	1420	2750
			6000	1145	2200	1245	2395	1345	2610	1455	2855	1570	3125
			7000	1270	2470	1375	2705	1490	2960	1615	3255	1745	3590
			8000	1405	2800	1525	3080	1655	3395	1795	3765	1940	4195

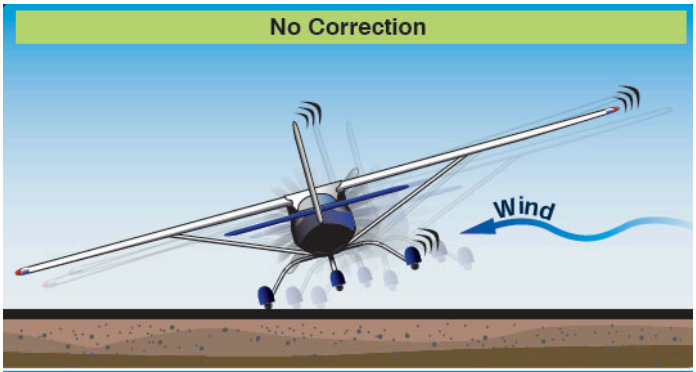
- **Runway Safety** - All takeoffs generally start with the airplane crossing over a *hold short* line, which is the line that indicates where the runway area begins. Hold short lines should be taken very seriously!
  - Before crossing a hold short line:
    - At a towered airport, the pilot must have received a taxi, runway crossing, or takeoff clearance for the runway they are about to enter.
    - At a non-towered airport, the pilot has communicated their intentions over the radio (Common Traffic Advisory Frequency--CTAF), and has visually verified that there is no traffic on final approach for the runway, or on the runway itself, which would conflict.
- **Safety Considerations**
  - As with any takeoff, the **use of checklists is important**. Before entering the runway area, the before takeoff checklist must be completed.
  - **Soft-field takeoffs require special caution to be exercised for adequate field surface conditions and watching for obstacles on or near the field!** Powerlines, tall trees, or other obstacles may be quite close to the runway environment! These obstacles may be difficult to see in a nose-high attitude after takeoff, so a thorough takeoff briefing which highlights these hazards should be conducted before every takeoff.
  - It is crucial to not become so focused on performing the maneuver that an unsafe situation is created. Maintain situational awareness, make appropriate radio calls, and ensure that takeoff clearance is obtained before entering any runways, if at a controlled field. **Vigilance must be maintained to avoid taxiing onto any intersecting runways beyond other hold short lines.** At uncontrolled fields, clearly communicate your taxi and takeoff intentions on the radio. Remember that uncontrolled fields often have no-radio (NORDO) pattern traffic, so **always visually verify the runway and final approach path is clear!**
  - If the airplane is not accelerating as expected and the takeoff is in doubt, **abort!** This is especially important on soft fields, where an unexpectedly wet or soft runway surface may produce enough rolling resistance that takeoff is impossible!

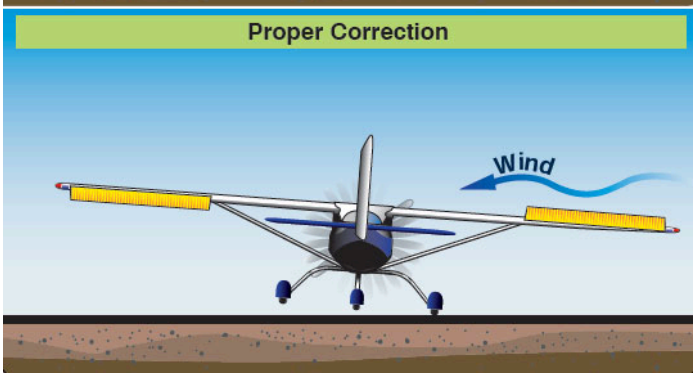
- **Windshear, Tailwinds, Wake Turbulence** - During takeoffs and landings, we are operating near the ground at low speed. Pilots should exercise caution if there are indications of windshear, pay attention to situations where wake turbulence will be a factor. Additionally, taking off or landing with a tailwind creates a much higher ground speed, lengthening the ground roll, and increasing the danger.

Maneuver Description

- **Selecting a Suitable Surface** - Select a runway or suitable soft field surface that will allow takeoff into the wind, or with a manageable crosswind. When using an actual soft-field, it is best to first inspect the field to verify that it is free from large potholes, ruts, mud, or other debris that may damage the airplane.
- **Checklists** - Pilots must perform a before-takeoff checklist before beginning the maneuver, and thoroughly brief any hazards that may be present on departure.
- **Taxiing** - Taxi with full elevator backpressure to keep weight off of the nose wheel and avoid use of brakes or coming to a complete stop.
- **Before Takeoff** - Configure the airplane for soft-field takeoff (per the POH), usually requiring flaps.
- **Entering the Runway** - Taxi into the runway and smoothly line up with the centerline without stopping. Apply full power while holding elevator backpressure.
- **Takeoff Roll and Liftoff** - The nose wheel should come up very early in the takeoff roll. Gently release elevator pressure to allow the airplane to accelerate while keeping the nose wheel off the ground. Positive aircraft control must be maintained at all times! **Apply *and hold* proper crosswind corrections to avoid sidewards drifting.** Allow the airplane to lift off and **quickly push forward on the elevator to enter ground effect** and fly level in ground effect while accelerating.







- **Climbout** - Once the airplane has accelerated to Vx in ground effect, climb at Vx until any obstacles are cleared. After all obstacles are cleared, reduce pitch, retract flaps, and accelerate to Vy. Make sure to fly coordinated. **More right rudder!**
- **This is a visual maneuver!** Eyes should remain outside the cockpit as much as possible to scan for traffic and ensure proper tracking of the centerline. *Monitoring for other traffic is especially critical when performing this maneuver at uncontrolled airfields.*

Expanded Completion Standards

- The pilot can explain the purpose of the soft-field takeoff maneuver and how the various factors affect the performance of the maneuver.
- The pilot can perform the maneuver to the following standards:
    - Pilot configures the airplane properly for takeoff, performs a pre-takeoff checklist, ensures that takeoff clearance is obtained (at a towered airport) or that the runway and final approach path is clear (at a non-towered airport), and makes the appropriate radio calls.
    - Pilot maintains full elevator backpressure while taxiing, avoiding coming to complete stops, and smoothly taxis onto the runway area and aligns with the centerline.
    - Pilot raises the nosewheel on takeoff roll, lifts off early, and remains in ground effect.
    - Pilot accelerates to Vx in ground effect, and climbs out at Vx until clear of obstacles.
    - After clear of obstacles, pilot properly reconfigures airplane and accelerates to Vy.
    - Pilot divides attention between accurate, *coordinated airplane control* and outside visual references.