Notes on Engine Failure Inflight, on Takeoff Roll, Takeoff leg and Forced Landing
Or
When the whirly thing stops it is time to do some of that pilot stuff!

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EAA Chapter 175

A properly trained and practiced pilot is aware and comfortable with power off as well as power on control response and flight characteristics in his aircraft. We powered pilots spend time in the charts and plan our flights for the engine performance and practice our landing and takeoff procedures power on for safe approaches and landings as it is the higher risk area of single engine and light multiengine flight operations. At the upper end of the broad aircraft safety spectrum, we tend to damage aircraft and or kill ourselves when the only engine or an engine (multi) fails leaving us with a must do forced landing while flying in a smaller flight envelope due to lack of engine power. Glider pilots constantly observe, read and react to the conditions of wind, rate of sink, aimpoint control and plan their flight path to allow them a safe on field landing or safe off field landing. Glider pilots are not unlike sailboat owners who practice for when the engine is not available to arrive safely at the dock with no engine power. Powered boat owners and aircraft pilots tend to fly for enjoyment and rely heavily on the continuous output of the engine. The thought of engine failure is a concern, but the flight characteristics of the aircraft, the descent gradient/glide path or rate of sink are not routinely practiced nor ingrained in our memory banks. Most of our reactions in flight are from mental and muscle memory from our training and experience. Lack of sophisticated training programs means many civil pleasure fliers rarely practice or ever gain proficiency in power off characteristics of their airplane. Further, seldom do I witness pilots or instructors performing powered off landings. In the defense of power on landings, some aircraft have abysmal power off characteristics. However, most light aircraft have acceptable power off glides and are “land-able” from power off provided the pattern, pilot and conditions in the pattern are acceptable. Our reliance on our notably reliable engines means we don’t always spend the same time we should on power off flying and emergency landings as we should. To that end I am writing to reintroduce pilots to practice emergency engine out procedures and practice and become proficient in the aircrafts power off characteristics.

Young instructors only know what they have been taught. They preach the ABCs of engine failure such as A = Airspeed, B = Best Glide, C = Checklist, D = Decide on a landing site. However, how often do they practice and demonstrate these ABCs. These qualified pilots and instructors know their aircraft numbers and checklist by heart such as the L/D max Airspeed, the glide ratio, and minimum speed on final. Rarely do they consider where they would land if the engine failed at any point near the airfield, especially on takeoff. Questions such as, “how far should I lower the nose if I lose my engine, should I consider the “Impossible Turn Back”, or where can I land now from this point, should not be pondered in flight as an engine failure at low altitude can be mere seconds until a forced landing. Do the instructors impart their knowledge and procedures on their fellow pilots emphasizing what the power off sink rate is, what is the gliding pitch attitude is, what is the actual glide distance for the airplane we rent or train in vs what is in the POH, what is the effect of wind on my glide distance, or the rate of turn at my glide speeds and my control over it. Do they demonstrate and practice what the glide path looks like power off? Do they note where the aimpoint is for an 8 degree glidepath (about 8-1 glide ratio) power off? Frankly there are not enough hours in the day for most instructors to teach this nor are there bottomless funds available for the trainees to practice this with the instructor. However, the FAA considers the accident rate in landing accidents indicates that perhaps a long power on straight in approach that is well stabilized is the answer to a relatively tight maneuvering power off landing. Statistics show a stabilized approach is safer power on, but in fact is not always possible in an emergency pattern with power loss. Hence, there are no FAA training standards for loss of power patterns and landings. I guess we are on our own and "y'all be careful out there ya hear".

In 1970 when I was learning to fly, all patterns were planned so that in the event of an engine failure, one could make it to the runway / airport from anywhere in the pattern and even land on the runway. Instructors would actually pull the power on takeoff so you would have to react to and experience an engine failure immediately after liftoff. You learned how far to push the nose down to maintain speed, lower full flaps while adjusting the pitch attitude and if time and runway permitted round out power off and touch down.

For practicing enroute engine failure when flying with the instructor, you practiced engine loss over remote airfields, pastures and farm roads, often gliding down and landing at a grass strip, or doing a very low approach over the field of choice during a practice engine out drill. You learned that roads had power poles, bridges, ditches, cars and other hazards so use caution. During pattern practice, instructors would pull the power at various points in the pattern to drill home the actions necessary if the engine failed. Soon however, our nice quiet airports in the 70s encountered an explosion of personal airplanes throughout the 70's and 80's, traffic increased, the airports got control towers, and sequencing of traffic, wake turbulence spacing, and longer runways for even larger aircraft was changing the size and spacing for the landing approaches. No longer could a pilot depend on setting his own traffic spacing as some rich guy in a Barron or Bonanza would mow you over.

In my own training, after doing my first Engine Failure on Take Off (EFTO) drill, the post flight instructional discussion went like this. "Now we did this EFTO on the long runway (about 5000 feet), but if you were on the cross runway (RWY 36 was only 2800 feet) and you lost the engine where we did today, where you stopped at the 2000 foot remaining turnoff, you would have found that is 200 feet past the end of the short runway and that means you are in the fence on the departure end of the short runway at best." Also, the fence was just across the road from a housing subdivision on one end and a Monsanto Chemical Plant railroad yard on the other. So normal operations did not take place on the short runway except with strong northerly winds. He cautioned that if the engine quit even 500 feet farther down from where we practiced today on my engine failure drill, what would I do? He pulled out an aerial photo of the airport and we studied the various landing sites that were possible if an engine failed well into the takeoff leg. Then we briefed and then practiced power off, partial power, and best actions to glide back to the runway from various points in the pattern. I was thankful for that training as later I was faced with engine failures and poor engine performance on takeoff and found aborting early and avoiding unnecessary exposure to an EFTO was preferred to trying to make an airplane fly that just won't climb or accelerate with partial power.

This article is intended to prepare for and safely practice engine failures to gain experience and familiarity with your aircraft, and fine tune your reactions. It is meant to refine your procedures and promote "chair flying" your actions when flying out of your local airport and consider some options if the engine fails where it is most disadvantageous to your health.

I will discuss first the engine failure at altitude. I will provide some considerations and practice maneuvers power off and on that can prepare you for the muscle memory action required for a takeoff emergency as well as the inflight setup for a forced landing.

I will present the overhead engine failure (flameout) pattern for a typical single engine landplane such as the C-172. High key or overhead, Low key or abeam the intended landing site, Base Key or the distance and altitude for the final 90 degrees of turn to final approach and finally the Final or gliding approach, its aimpoint, glidepath and round out considerations.

I'll put that all together and go over the EFTO for a typical airport. First, I'll discuss the EFTO while on the runway to just getting airborne with runway still available, and without. Finally, I will break down the "Impossible Turn", from takeoff, to where only a forward quadrant forced landing is available to the minimum altitude for a turn back, the conditions that must be present for success. From planning in the area to execution of the plan when the failure occurs at rotation, liftoff, departure end, up to crosswind a pilot must be well versed in what action is prudent and safe for himself and his passengers. The airplane I don't care about.

Hopefully these sections can be put together to build up engine failure procedures, thoughts, discussions and techniques especially when encountering engine failures while flying your single engine aircraft. Although many light twin engine aircraft seem safer, normally these aircraft have so little single engine performance when fully loaded that in the event of an engine failure on takeoff you have only sufficient power to get you all the way to the crash site unless very lightly loaded. The best advice I received from an FAA inspector was, "think of a light twin as a partial power loss in a single engine airplane with a stuck rudder at 15 degrees. There are conditions in a fully loaded light twin when you will not be able to do anything but plan your forced landing."

Part 1
Basic inflight engine failure drills to determine best glide, turn rates, altitude loss and glidepath.

Planning your drills and some background:
Engine failure at cruise is not really that dangerous unless you are foolish enough to be flying well below 3000 feet AGL. I find once cruise is established below 3000 feet the average trainer and owner operated aircraft has a glide ratio of 8 to 1 optimum and normal glide ratio of closer to 6 to 1 as wheel pants aren't installed, planes aren't polished, and the rig is not always precise. If the prop is windmilling that too can actually decrease the glide performance. A fine pitch climb prop is more drag than a coarse pitch cruise prop. From math we know an 8 to 1 glide path from 3000 feet AGL is about 24,000 feet of forward motion to the impact point at L/D max for a Cessna 172 ish type plane. Why heck, that's 4 nautical miles. At 68-70 KIAS, that means I have just about 4 minutes (at a calculated 750 FPM rate of descent at 70KIAS) to work out my engine failure and plan. What's the beef?

Unfortunately, these purple line fliers (the ring on the electronic flight book calculating an 8/1 glide ratio) are flying a dirty old trainer with no pants thinking this is an 8 to 1 airplane. The glide ratio could be more like 6 or 7 to 1 and the rate of sink at 65-70 KIAS (old 172 vs new 172) is closer to 3 minutes to impact at a rate of sink of 1000 FPM. Also, many pilots have not thought about what a glide path at 1000 FPM or 6:1 glidepath, looks like from the cockpit with an approach angle of 9.5 degrees as they have never practiced power off approaches to landing. The aimpoint is just below the spinner in his old C-172 and he has never thought or practiced for that. Nor has he thought about the airspeed bleed off in the round out and flare in a full power off slightly steeper than normal approach. I have seen many videos of pilots gliding into a field but at the last moment they realize they are sinking fast with very high sink rates that cannot be stopped and make bone crushing impacts. Pulling up the nose too early because the ground is coming up fast is a killer in many LSA and Experimental Aircraft. Typically, this is caused by rounding out too early (because the ground is coming up faster than a powered final) or the pilot is attempting to stretch his glide and begins sinking. If attempting to arrest the descent too high usually results in a stall and impact at landing at worst and a horrible sink rate at least. Videos of off field forced landings indicate they are very often nose low heavy impacts rather than a flared-out touchdown and bumpy ride. The moral of the story is maintain glide speed and flare out into ground effect so as to level off while bleeding airspeed to the landing point while in complete control and minimum speed. Slowing to below L/D max in the power off steeper final can lead to rapidly depleting energy and the loss of propwash over the tail diminishes the elevator authority, affecting the flare. Especially if the round out well out of ground effect.

So, let's consider the landing at our airport from an 800-foot pattern downwind with the runway about 2/3 the way up the strut or about 1500 feet displaced from the runway on downwind.
Physics says our turn rate at 60-70 Knots for 180 degrees of turn in an aircraft at 30 degrees of bank is about 9 degrees/sec and our radius of turn is 735 feet which is a diameter of 1470 feet.
(Radius of turn = V Squared in Knots/11.26 tan Bank Angle), and

(Rate of turn = 1.091 tan Bank Angle/Velocity in Knots)

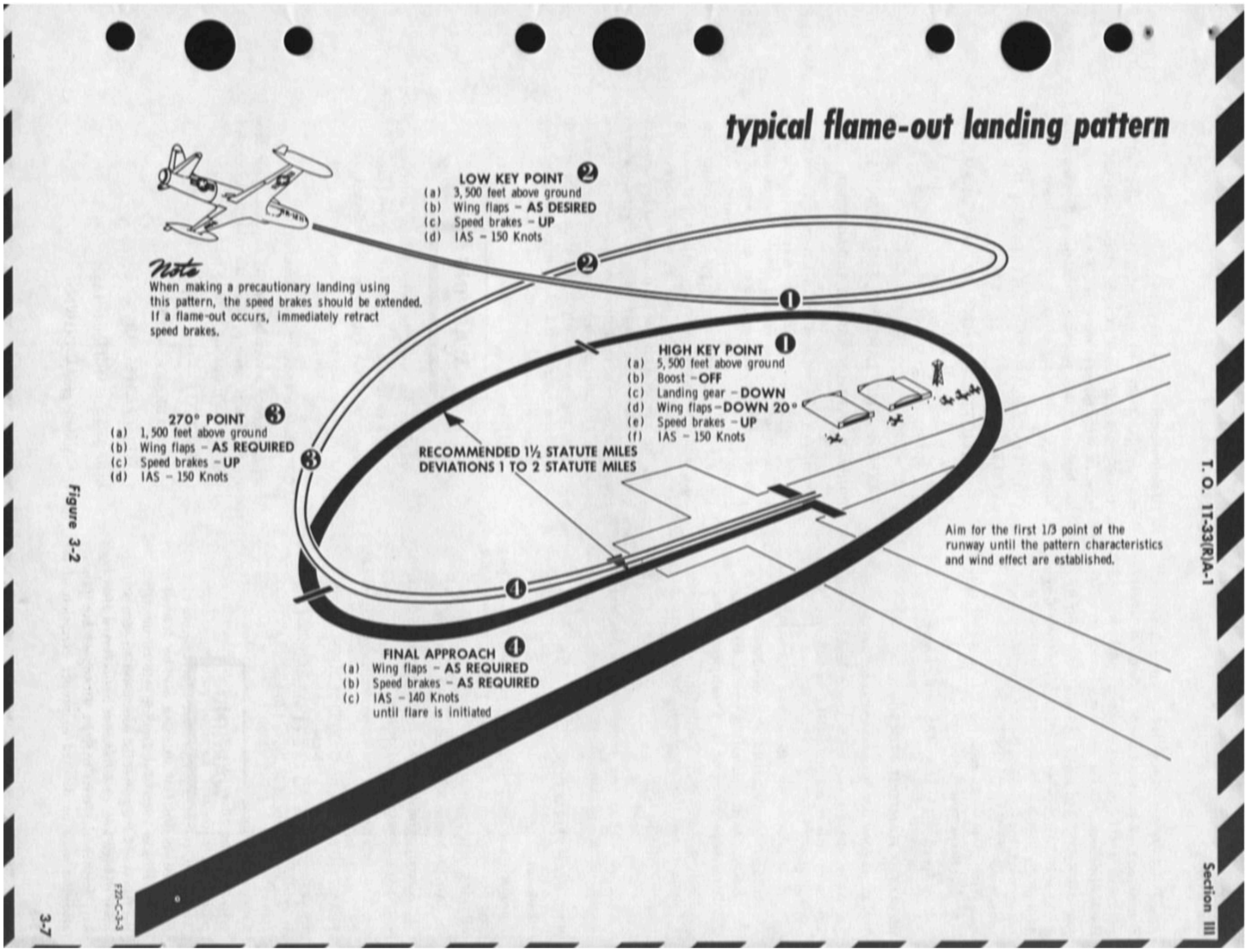
As a young engineering student with no money, I calculated how to get the most bang for the buck out of my flying time. I calculated that in the pattern abeam the touchdown point, if I begin a 30-degree bank turn about 1500 feet displaced on downwind from the touchdown point and am descending between 750-1000 fpm, it takes roughly 20 seconds to turn the 180 degrees and at 1000 fpm I should loose only 333 feet and end up about 467 feet above the threshold which is too high. Therefore, if I glide forward 10 seconds on downwind descending (about 1000 feet horizontal distance, that is 160 feet of altitude loss, then begin my final turn at 30 degrees of bank and I would end up 140 feet above the ground 1000 feet from the runway or about an 8 degree glidepath and that should allow a few seconds for dropping the flaps as required and or a slip to a round out and touchdown easily in the first third of my 3000-5000 foot strip. Total time from downwind to touchdown will be about 40 seconds to a minute. The touch and go was planned for a 500 FPM ROC at an average of 75 knots climb speed . I figured I could climb back to my power off downwind point in 2.5 minutes. So, in a Cessna 150, theoretically I could do at least 10 patterns and landings in my one hour of Hobbs flying time (remember you pay for taxi time) with nobody else in the pattern.

My instructor was impressed with my math drill and let me try it and it did work, but of course there was no time to clear for other traffic or do anything but concentrate on airspeed, runway, altitude and keeping control speed. He also brought out how knowing these basics, I could easily make the mental calculations to easily adjust for winds, traffic and slight misjudgments. Then, he showed me how I could apply this same planning for my engine out forced landing planning off field. Since most new pilots fly about a standard rate turn (why they are afraid to bank I didn't know) they fly wider patterns and greater distances in the pattern and that is not a bad thing as it gives time for observation and pattern adjustments but it will take continuous power to accomplish this as the added distance and sink rate will force them to keep power on to slow the effects of the persistent problem of gravity.

However, in an engine out pattern practice I could use my calculations and set up over the intended landing site at 1500 feet above my intended mid field landing area and if pointed into the wind (if possible) use my calculations from my power off short pattern drill. He called the overhead position the HIGH KEY position. At this point, roll into a circular pattern using 30 degrees of bank and loose about 350-400 feet in the first 180 degree turn to downwind, look and evaluate my downwind leg and continue to plan the turn to final. He noted that starting from overhead of the middle of the planned field allowed you time to analyze the winds and your rate of sink. Using the 30 degrees of bank to turn the 180 degrees to downwind should lose you about 333 feet more but figure a bit more say 350 feet with the roll in and roll out time. Rolling out on downwind to ensure satisfactory displacement for wind and turning room, I should be able to extend the downwind about 15 to 20 seconds losing another 333 to 350 feet placing me now about 800 AGL. This LOW KEY is abeam the intended flare point (initial aim point) and should be about 800-900 feet by eyeball (remember you don't know the exact field elevation of your landing point) from the beginning of the landing site or threshold.

Extending my downwind until the abeam the touchdown zone is about 30 degrees back off my shoulder I should be losing another 350 feet with this outbound leg for zero wind. Turn toward the runway at 30 degrees of bank to check the winds and your displacement. A BASE KEY is about 500-650 feet AGL and now with the extended downwind of about 2000 feet and turn radius of 750 feet you are now only 500-650 feet above the ground on base still at L/D max airspeed. Finish the turn to final will cost you another 170 to 200 feet and now you should be rolling out about 300-450 feet at a distance of about 3000 feet from your flare out point <u>no wind</u>, no flaps or slip. Why so high? He figured that is a glide path of 450/3000 or an angle of 8.5 degrees (about 6-7 to one glide ratio), but that will aid you if you misjudge the winds, it also allows for full flap use and a touchdown at least at that midfield point. Never aim initially for the field edge/fence line or threshold initially so aim long as it beats landing short in a stall or spin. Evaluate your sink and maintain glide airspeed until the flare out adjusting your glide path via a slip or with flaps. Your landing roll in a field will not be very long in a rough field unlike touching down at 45 knots on an asphalt runway. Hold it off as long as you can as the airspeed will bleed fast power off. One thing you can never do is stretch the glide by slowing down. Without even idle power, the aircraft will bleed speed faster than normal with a dead engine. If a normal final is 60 KIAS consider a minimum of 65KIAS to account for the slightly faster bleed off of airspeed in the flare. Once committed to a landing fly the plane down to as low as you can, and aim for something soft or between hard objects and fly the plane holding it off until it stops."

Little did I know I would see this later in the military as a flameout pattern for the T-33 (with different speeds and heights of course). High Key, Low Key, Base Key were all the same visual as the glide ratio was nearly the same as I used in the Cessna, but the turn rate was lower and the height, radius and speeds were a lot larger. We trained and practiced at least a few times a year and it was a required proficiency flight check item. Little did I know I'd get to do one for real.



Practice drills for determining your aircrafts best glide and turn performance:

To determine how many feet you loose and how fast energy bleeds consider the following practice maneuvers to try at altitude. It is your first chance to learn test flying.

Caution:
It is always best to practice new maneuvers with an instructor on board to monitor your actions and be a safety as well as instructional observer. Be at least 3 mistakes high as I say or about 3000 AGL for stalls and low speed air work maneuvering. Just in case you unintentionally stall or drop a wing.

Warning:
If you have never practiced or been trained to fly a 45 degree bank turn, get training!

Maneuvering at lower altitudes and higher bank angles can lead to disorientation, fear, over correction and the possibility for stalls or other out of control possibilities.

In a Cessna 172 begin by establishing a 75 knot (L/D max for your aircraft) level flight, then pull the power and glide straight ahead and record your rate of descent, the gliding pitch attitude. Then still power off, pull the nose up to stop the descent until nearing the stall and recover. Have your instructor or fellow pilot observer record the time it takes to lose the airspeed in the level off attempt.

Release back pressure, add power and climb back up and repeat the 75 knot level slow flight.
Now for the turning altitude loss data. Reduce power to idle and begin a 30 degree bank turn holding 75 knots for 180 degrees of turn. Note your pitch attitude, back pressure, time to turn 180 degrees, altitude loss and rate of descent. Roll out and flare out again to level flight. Note that you will have a higher rate of descent in the turn than in the wings level descent and practice the unloaded roll out then raise the nose to simulate a flare out if you like. The main thing is simulating the base to final turn pitch, pull and rate of turn.

Note:
There is a precedent for practicing a 270 degree turn or even 360 degree of turn as the 180 may end up being more like 225 degree turn because a full 45 degree turn to align with the runway may be necessary. Some say make a full 360 degree turn as a light wing loaded airplane can rapidly turn and leaving you making a turn to the runway in 270 degrees, aiming at the threshold then turn back 90 degrees to the runway. From glider type aircraft I find 180 degrees of turn is a reasonable practice.

Climb back up and do the same turning drill at 45 degrees of bank. Record the time to turn 180 degrees, the altitude lost and rate of descent, backpressure required, etc. Then try the same at 60 degrees of bank. It is not uncommon for more experienced or commercial pilots used to the higher bank angles to prefer a 45 banked turn as they are proficient at it. I've even seen and practiced a 90 degree bank turn as these "aerobatic" turns are very fast but the aircraft is no longer flying around the turn but is falling at 32.2 Ft Per Second squared for about 4 seconds of turn. From physics that is an altitude drop in the turn of 260 feet. The consequence of this is the nose tends to drop significantly (to about 25 degrees nose low) requiring a longer time and distance to recover from the dive. The higher bank angle also requires a turn of greater back pressure to a point very near the stall angle. Therefore, it is not recommended and favors a 45 degree bank turn with an aggressive pull as in level 45 degree bank turns. Again, these aerobatics are not normally taught in pilot training and present a firm case for not doing a turn back to the runway.

Although the rate of turn is higher at 45 degrees of bank, note the altitude loss, the larger nose down pitch attitude required to maintain airspeed and don't forget gravity works 24/7. You are not falling at 32.2 feet/second squared at 45 degrees. At 45 degrees of bank 50% of the lift is being used for the turn rate and 50% for lift. 60 degrees of bank puts 87% to turn rate and 30% to lift. The higher bank angles can lower the altitude loss over a shorter time in the turn due to the much higher turn rate. However, the steeper the bank, the lower the nose attitude are necessary to preserve airspeed. At bank angles above 45 degrees the round out will take longer unless the wing is unloaded to about ¼ G loading. A fully loaded wing will not roll as fast as the unloaded wing with the benefit of less to virtually no adverse yaw. Therefore bank angles of over 45 degees will bleed airspeed faster than most expect, the round out from the steeper dive requires a nose low, low speed dive recovery from 30 degrees whereas for a 45 degree bank the round out is only slightly steeper than normal from a max of 15 degrees of dive in a very tight turn. An in-flight video recording of these drills will be a superior way to debrief your findings. I find once I know my glide pitch attitude out over the nose, I simply roll into a 45 degree bank at L/D max airspeed and hold that pitch and record.

Note:
This impossible turn is not a level turn, so stall speed is not increasing as it would in a level turn. However, it is imperative that back pressure be increased significantly but not to the stall. If the stall warning horn/light or AOA indicates you are nearing the stall, relax a small amount of back pressure and keep the turn up will minimize the altitude lost and increase the rate of turn dramatically.

Warning:
Without advanced upset training and practice, making the impossible turn in a high performance aircraft such as a Bonanza, Mooney, Cessna 210/206 to name a few, should not be attempted until practical training standards for that aircraft are done and then practiced first at altitude and in steps to lower altitudes before accomplishing the turn cold.

Return to the pattern in your Cessna 172 all warmed up. You may want to land from a normal pattern as you have abused your aircraft and engine enough. Treat your cold idling engine in flight with kid gloves and add power slowly to prevent shock heating. I can’t help the shock cooling on power off, but at 75 Kts or your aircrafts L/D max you will be at idle power and at this speed less draw is out of the cowl thereby reducing shock cooling of your Lycoming when doing these drills.

In the debrief review your findings and with an airport overlay one can predict about how far you can turn to find a safer forced landing site on takeoff leg. Later we will use some of this data to determine if the impossible turn is even prudent for your airport, and aircraft. Plan your next flight to further practice engine out in the traffic pattern.

The next drill is the power off approach to a go around in the pattern. My favorite plane for power off in the pattern approaches is the Piper Tri-Pacer. One client complained that at best glide speed just look between your feet because that is where you will hit. Of course, the sink rate of a short wing Piper will get your attention, but it is not quite that bad. However, if transitioning from a Piper Long wing Arrow or Cessna 172 to the

Tri-Pacer, one must be aware and practice as no two brand aircraft will perform the same. The same lesson is true for many experimental aircraft. Know your aircraft and practice at altitude to find out things first rather than in your first pattern and landing attempt.

On to the drills. I like to plan this on the ground and will do this on the same flight as the turns.
Considering an aircraft with an 8 to 1 glide ratio with a best glide speed of 75 KIAS, preplan your event. From 800 AGL one should expect at the L/D max of 75 KIAS, a gliding distance of about 6400 feet or about 1.1 nautical miles of wings level no wind glide. Lay out a ruler on the photo of the airport from google maps and mark that position of 1 mile from the end of the intended touchdown point (I like to aim about 1000 to 1500 feet down the runway for the initial practice drill). Place yourself at 800 feet AGL and abeam the 1 nm mile point and pull the power and simply maintain your L/D max until approaching the runway. Concentrate on where the aimpoint is (it is very low for some aircraft so some stretching and or seat raising may make the aimpoint view more comfortable, and on others is clearly visible in the windscreen). Normally I go around from this glide rather than trying to land. Record your findings as many see they are going to be short. Repeat as necessary.

Since there is always wind, the above is a no wind drill. For every 10 knots of headwind how much do you adjust your glidepath? 10 knots of headwind is roughly 17 feet per second and your final from one mile out at 75 knots is about 48-50 seconds. Therefore, we must shorten our final about 17fps x 50 seconds or 850 feet. This should also key you into thinking just how far you normally have to adjust your aimpoint for wind and why not aiming for the threshold when in an emergency power off approach is prudent until your landing is assured with full flaps. Stretching a glide never works. Since a misjudgment of the wind can make you disastrously short of your intended landing point I'd rather slip a bit than crash 1000 feet short of my intended touchdown. Hence in a simulated off field landing, it is important to plan your base turn not at your intended landing point but in the middle of the field. Go around from this once the landing is assured. Climb up to your downwind.

Why would I not land from the practice glide in. Simple, many pilots will try to force a landing and deploy flaps too early or two late, and some never catch up to the trim changes and rate of deceleration until the aircraft is well known without a practice drill. The landing out of an unstable approach is not recommended. Go around and repeat.

Once on downwind again, I then retard power to idle from downwind perch abeam the touchdown point so as to practice the power off turning approach to roll out. Remember to clear for traffic as a power off approach is tighter than most pilots were trained to fly and are disconcerting for some of the tower controllers as they are not used to seeing these tight turning approaches. I prefer to find airports that are less busy and if a towered airport is used, I make a phone call to the tower and pre-brief the controllers. They may have some ideal information on best time to practice your tight patterns.

In this drill, note your necessary bank and turn rate, the descent gradient, and more importantly pay attention to what the picture looks like out the canopy. Concentrate on holding airspeed, noting the pitch and watch the runway. Learn what your airplanes characteristics are.

"There is only two things to look at in the final turn, Runway and Airspeed."
John Bolyard, WWII ace, flight instructor, and Master Aviator.

As John put it, maintain your airspeed and control your bank to roll out precisely where you want. There is no excuse for stalling the airplane. Abeam the touchdown point you may need to begin your 30 degree bank or bank as required to be able to roll out on a final of 1000-1200 feet from the threshold. If you find you are increasing bank to roll out on final, you are too tight. Go around and reattempt correcting your downwind position. If the winds are light, you may simply let the landing point slip aft over your shoulder until you have lost altitude and given yourself a comfortable ¼ mile final and a roll out for a 3-5 second stabilized final approach calmly adding flap to adjust your aimpoint. It is not uncommon to add flaps on the base leg once proficient and well versed. Depending on the plane you are flying you may find half way around the turn that a 15-30 degree bank shallowing turn to final will float you down to a comfortable final approach about 1200 feet out aligned with the runway on speed and simply lowering ½ flaps to bleed speed and cross your numbers at a comfortable flare out. If you have a healthy 15 knot headwind to correct for, you will need a shorter final power off or higher roll out. Practice, practice, practice.

Only practice, discipline, and a keen eye on the winds will improve your performance and provide consistent results. Below are the abbreviated training drills for convenience. Part 2 of this document will lay out the engine failure during the initial takeoff. Part 3 will give some practical starting points for the engine failure in the pattern from the overhead to the perch and landing. Part 3 will discuss the impossible turn back on takeoff leg.

Part 2
Engine Failure During Takeoff (EFTO) Intro and Drills.

Know your takeoff and abort distances. Then practice.
Total EFTO prior to rotation is a simple abort. Note your distances.
Total EFTO after rotation requires practice to be fully proficient.

I learned an acronym PADAC rather than the ABCDE engine failure procedure taught today, but they are very similar. PADAC or <u>Push over</u> for <u>Airspeed</u>, and <u>Determine</u> your Landing Area, then <u>Accomplish your engine out Checklist</u> if time allows.

It is painful to teach an abort but until the new pilot is familiar with the acceleration to takeoff, the procedures and can practice his maximum braking and steering, it is a necessary item to practice at least once. Those of us with racing experience understand the incipient skid and how to smoothly apply brake pressure to achieve maximum braking. A first-time pilot in the aircraft will not be as well informed or experienced in the smooth steady application of the brakes to maximum without skidding and practice will save flat spots on the tires and maintenance down time.

Practice Drills for sharpening the pilot skills:

Aborted Takeoff Drill:

1. Apply full power.
2. Accelerate to nose wheel liftoff.
3. Pull the power and apply checklist procedure.
   (Normally power idle, flaps up, brakes apply)
4. Note the distance it takes (new pilots are surprised it can take nearly 1500 to 2000 feet on asphalt in a Cessna the first time).
5. Discuss runway departure off the runway end with the trainee/examinee pointing out the hazards of lights, ditches, and other local obstacles at his training field while taxiing back for takeoff.

Note:

Concentrate on how much runway a simple acceleration to rotation and abort takes. I normally see 1200-2000 feet of runway used for the first practice with an aggressive pilot and up to 3000 feet for a timid novice.

In the event of engine failure after liftoff I have two methods for pilots to practice. My EFTO loss of power on takeoff is more realistic but can cause a hard nose down impact if the trainee is of low skill levels and or the airplane power off nose authority is poor. This drill requires much pre-brief, and a very alert instructor. It is quite realistic. The second method for the failure after landing is to teach a “Crow Hop”. The best of the two normally is the crow hop but the airfield may be too short for initial training. Again, a 4000-5000 foot field is minimum for a normal Cessna training in this type of drill with an inexperienced trainee.

Engine failure just at liftoff (practice only at a long runway of over 4000 to 5000 feet):

Note:

This has to be a planned and practiced event to be done safely. Pilots should be well versed and practiced on landings before practicing this transition from takeoff to an emergency landing training. I prefer using a long runway (5000 foot or better) and set up a practice for a normal acceleration to takeoff and just at liftoff speed plus no more than three seconds or 10 feet in the air, immediately pull the power and accomplish a settling to the runway, if time permits lower the flaps, then accomplish a flared attitude while holding the nose wheel off. The objective is to perform a soft main wheel touchdown then lower the nose and accomplish a maximum braking rollout while retracting the flaps. Once clear of the runway, do a thorough analysis of your actions.

Rarely do instructors teach the why of the POH numbers. Let’s look at Vx for the Cessna 172:

Vx is

Warning:

The pilot must know instinctively how to fly the aircraft back to the runway. The instructor must assure that the trainee or checkout pilot is well briefed and practiced in their landings and aircraft handling before ever attempting this drill. The drill must be fully briefed and the instructor proficient. For another safer method: See crow hop below.

In my opinion, once a student has had sufficient landing experience demonstrating the ability to slow flight down the runway in complete control a foot or so off the runway for 1000 feet, then go around, the trainee is ready to practice late takeoff engine failure and emergency landings.

Engine Failure After Takeoff Pre-brief:

1. Full power and accelerate to rotation speed.
2. Rotate and just at liftoff as the wheels break ground and before air speed exceeds 65 KIAS pull the power. (Normally no more than 3 seconds after breaking ground.)
3. Adjust the pitch slightly down to preserve airspeed and then <u>establish the landing attitude.</u> The normal flap up or 10 degree flap takeoff is similar to the no flap landing approach glide path and touchdown airspeed listed in the POH. Most trainees have done no flap landings and are comfortable with landing attitude (which is higher). The recommended EFTO airspeed may not be reached (65-70 KIAS) and putting the plane down in ground effect without hitting the nose wheel is essential. Note that there is no time to do a checklist for restart. I consider this action to be a memorized bold face action.
4. After touchdown, retract the flaps (if applied) and apply full braking to the stop. (It can be a surprisingly long distance.)
5. Stop the aircraft and taxi back. Review the actions.

Warning:

If the pilot trainee pulls the aircraft rapidly off the runway, is having directional control or gets well off the ground, abort the drill. (On a normal takeoff, most pilots lower the nose after liftoff and accelerate rather than continuing pulling up to a Vx climb attitude as in a short field takeoff. Some pilots climb away very abruptly and once out of ground effect must nose over to recover the depleting airspeed.) Normally it is recommended to climb out between Vx and Vy initially until out of ground effect and continue accelerating to Vy plus or the recommended best operational cooling and visibility over the nose speed.

In this drill, just as the trainee clears the ground, immediately pull the power and time permitting lower full flaps and accomplish a landing. Once firmly on the runway, aerobrake if necessary, then as in an abort or short field landing, lower the nose, retract the flaps, and apply maximum braking. It can be exciting making that slight relaxation of pitch (not really a push over) to maintain airspeed, then get the back in with the pressure to arrest the descent, establish the landing attitude, and make a main wheel touchdown attitude, and land. Lower the nose and begin high performance braking. I've seen experienced pilots work extremely hard to do this well.

In some aircraft with high power and light weight, you may be over 50 feet high in only 3 seconds after liftoff, so use common sense. Imagine being in a slick airplane, crossing the threshold at 50 feet, floating about 1500 feet and then touchdown and maximum brake on a short field. Many pilots would not even consider landing on a 2500 foot runway and would go around if during the approach the pilot crossed the threshold at 50 feet in the air even if established on the POH short field final approach speed. Having a long runway is necessary for practice.

Actual examples indicate that pilots startled by a sagging engine or even total engine failure just after liftoff hold a nose high pitch attitude similar to the takeoff attitude and if out of ground effect, often end up encountering a stall and nose pitch down and or wing drop as they run out of airspeed and porpoise the aircraft ripping off the nose gear or have a hard landing because they fail to act properly. Engine problems are startling only because they were not prepared for and the engine fails, it is imperative to fly the aircraft back to the runway which requires the pilot to lower the nose immediately to roughly the rotation attitude. Once practiced pilots remember and when the engine sags just after breaking ground he prudently will lower the nose begin the flare, add flaps and retard the throttle and land rather than climbing out on a sickly engine, hoping to get back to land. Hence, I recommend pilots calculate their personal minimum operational field length and live by it. Later in this paper I present a recommended method for determining the minimum field length for safe training and flight school operations.

Warning:
Airspeeds are critical to know but more importantly understand the consequences of the normal operational airspeeds and emergency airspeeds.

Example: The Cessna 172N has a stall speed Vs of 53 KCAS. A best angle of climb speed Vx of 56 KCAS clean and 48 KCAS with flaps. An EFTO recommended glide speed of 70 KIAS Flaps up and 65 KIAS Flaps down. Yet best glide or L/Dmax of 68 KIAS. Note the differences and the calibration of the airspeed. The difference in a Cessna calibrated airspeed to indicated airspeed can be as much as 10 knots depending on configuration.

The point is Vx is shown in KCAS with by the chart is more like 5-10 knots less flaps up vs 10 degrees. So, climbing at 53 KIAS is actually 5 to 10 knots below your KCAS. Since the stall speed is in KCAS also, that is OK for most instructors to still teach over the obstacle climb at 53 KIAS in practice which is underperforming the rate of climb but far safer.

Warning:
Climbing a Cessna 172 N at Vx of 53KIAS vs KCAS is a nose high pitch of 20 degrees or more depending on engine, and only about 5 knots above a stall

power off. Therefore, the push over to prevent the stall is about 25 degrees and the airspeed bleed off per second is 3-5 KIAS per second (flaps up vs 10 degrees). This is critical because it is possible that once a push over is complete, the aircraft may be at or below stall speed if the push over is very slow. Attempting to round out at or near stall may end up in a very hard nose low crash.

Note:
The recommended glide speed in an EFTO in a C-172N is 70 KIAS flaps up and 65 KIAS flaps down to allow for a round out an landing. Know your aircrafts speeds in IAS as that is what you have in front of you. Unless confronted with a very short runway with obstacles consider a climb speed minimum of best glide at 68 KIAS and once airborne consider accelerating to an operational speed allowing better over the nose visibility and cooling such as 80 KIAS.

The Crow Hop:
The alternative and less heart racing practice maneuver which allows a pilot to practice close proximity to the runway issues of a sagging engine (partial power loss) or failed engine occurrence just out of ground effect while over the runway is the Crow Hop or the takeoff, slow flight down the runway, and landing drill.

Many pilots have never done what is called a “Crow Hop”. A Crow Hop is a takeoff to just airborne, then pull the power back so as to slow flight above the runway a foot or two high, no faster than final approach speed, and then pull off the power and establish a glide back to the round out, and landing to a full stop roll out. A crow hop is easier for some pilots rather than the drill of immediately pulling the power after just breaking ground. Some instructors prefer this practice drill as pulling off power just after liftoff presents little time to lower the nose down toward a flare attitude or glide/float as required while deploying flaps and may present more problems rather than a flying maneuver like the crow hop where the instructor can easily control the situation providing the runway is long enough. The crow hop also is a confidence builder for the practicing pilot to hone his feel for what is required when the engine suddenly stops or misbehaves as in a partial power loss. It allows the pilot to be able to see what the best option is to an engine that sags right at liftoff and practice the feel and sight picture of how to simply land rather than try to nurse a sick airplane off the ground.

I have had three engine issues on takeoff from about 5-50 feet above the ground and knowing exactly what to do makes this loss of power a no sweat activity but still does raise the heartrate a bit.

How long of a runway is acceptable for these drills is easy to figure out and is explained below.

Minimum Field Length Considerations:

For Instructors and pilots: The crow hop or aborted takeoff practice allows a flight school instructor and or aircraft owner operator to set parameters for airport minimum field lengths for normal operations in a high performance airplane as well as trainer. (Normal operations are defined as student practice touch and goes, emergency landings, air traffic servicing availability and typical traffic spacing.) Personally, my minimum operational runway length is calculated as follows: Takeoff Distance plus 3 seconds reaction climbing at Vy, loose the engine and transition to land from roughly 20 to 25 feet above the ground, round out to a normal approach and landing, with normal braking.

> Example: C-172, C-150 or Europa XS: Takeoff Distance (TOD) is 600 feet, Min landing roll is 600 feet. Takeoff speed is 50-55 Knots but I add 5 to 60 Knots, Vx is rounded to 65 Knots at 10 degrees of flap:
>
> TOD + 3 second climb to 10-25 feet at 60 knots is based on a rate of climb of 500 FPM. Mathematically the altitude gained ((500 fpm/60)x3 sec= 25) means I should be 25 feet high. The horizontal distance traveled after liftoff at 60 KTAS or GS (3 sec x 60 knots x 6080/3600 =304) is 304 feet from liftoff. Since the plane will climb to 25 foot high, the landing distance from a 25-foot altitude must be tested as there is flare out distance. Normally it's 1000 feet minimum for most pilots. Normally most of us know how long our roll out is if we cross the end of the runway at 25 feet, it just needs to be recorded. Therefore, our takeoff to liftoff, glide, flare, and landing distance should be: 600 + 1304 + 600 = 2504 feet minimum with perfect execution on a standard day. On a typical sunny day in Florida my 25 foot to flare and landing is about 1500 feet at a hot 2500 foot density altitude day: 800 + 1500 + 800 = 3100 feet. That's the minimum for max braking. Add about a thousand for normal braking rather than max braking to save the tires and brakes. <u>That minimum recommended runway length is now 4000 feet.</u> Your minimums are based on your field elevation, weather conditions and the amount of risk you are willing to take in the event of an engine failure for your aircraft.

It should be obvious by now that prior to accomplishing any takeoff emergency practice, one must be proficient at slow flight and be comfortable in all patterns from short field to the no flap. Knowing the runway distance from touchdown to turn off to determine your comfort level is essential. There are other precision drills I teach. The best landing proficiency drill is the low approach precision drill. AKA flying formation with the runway. It is a great confidence maneuver to warm my clients up to the pitch and control pressures to use in landing the particular landing. It forces a new pilot to not force the aircraft to land (or just let it flop to the runway) and control the aircraft to a very slow touchdown in a positive manner.

The Low Approach Confidence Drill (AKA flying formation with the runway):
The low approach drill is flying a normal approach to the runway, then round out to a flare and rather than pulling power and bashing the runway, simply add a bit of power sufficient to slow flight about 10 knots above the stall (55-60 Knots) flying an inch to a

foot above the runway in complete control and level flight. Once the initial fear of the runway subsides and they stop squeezing the stick so hart it's bending the tube, I expand this to a maneuvering slow flight down the runway to move the nose off the centerline to the right main on the centerline, then back to left main on the centerline and back to the nose on the centerline and go around. I am very hard on trainees that can't precisely fly straight and aligned with the runway. This drill is a confidence maneuver that pays dividends. It saves wear and tear on the aircraft and the pilots are gaining or regaining confidence in control handling in close proximity to the runway. Students, instructors, and transitioning pilots find after this drill they are more comfortable in the flare, and no longer abruptly over control approaching the runway. They precisely fly into ground effect on the runway centerline even in crosswind conditions often maintaining a wing low attitude and one wheel touchdown. They also are very comfortable with the power, flap and trim changes accompanied with the go around.

Part 3.

Preparing for the power off landing approach and emergency landing drills.

An abbreviated checklist on the low approach as a practice to consider for takeoff emergencies and landing control:

This starts with maneuvers in the practice area:
Drill 1: At a safe altitude practice power-off slow flight to note the pitch and power at the short field approach speed and configuration, no flap speed, and 10 knots below all three wings level. Next from wings level slow flight clean, pull the power and begin a power off glide. Record the rate and sink for L/D max glide, then calculate the glide path as well as noting the pitch attitude.

Drill 2: Do the same drill at L/D max and record your altitude lost for 30 degree bank, 45 degree bank and if possible demo a 60 degree bank for 180 degrees of turn while maintaining the turning glide at L/Dmax. Record the altitude lost for the180 degrees of turn while maintaining airspeed at L/D max, and the turn rate in seconds. Record the results for each bank angle and determine what pitch is necessary to allow you to maintain maximizing the turn rate minimizing excessive nose down pitch and altitude loss.

Return to the pattern and then get the prebriefed final approach power off glide path picture gliding in from about ½ to 1 mile out below.

Drill 3: Perform a straight in traffic permitting and find the glide path to achieve L/D max airspeed, at the appropriate glide distance. This is now your nose attitude, aimpoint, and glide path for a power off landing approach during an EFTO.

Here are some planning aids: Considering an aircraft with an 8 to 1 glide ratio with a best glide speed of 75 KIAS, to preplan your event. From 800

AGL one should expect at the L/D max of 70-75 KIAS, a gliding distance of about 6400 feet or about 1.1 nautical miles of wings level no wind glide. Concentrate on the glide path, the aim point and adjust. If you miscalculated the winds power up and adjust to get a ½ mile point and power off altitude at L/D max for a new glidepath for the conditions.

Drill 4:
Transition to the over the field High Key to Low Key to flare out and go around over the airfield or practice area.

I like to enter this drill over the airfield as if accomplishing an engine failure 360 degree turn from over a forced landing field to a downwind then base and final. Instead of doing it over a farmer's field, do it over the airport if traffic permits. If you did your air work in the practice area correctly and prepared and knew your 180 degree altitude loss drills from the working area, this is just a descending turn to downwind or the LOW KEY position for the student. It is just closer to the ground.

If the descent rate drill in the area was 750 fpm in a 180 degree 30 degree bank turn and you lost 350 feet it took 20 seconds in the turn you should be prepared for the power off pattern.

1. AT HIGH KEY Enter the pattern at 1200 feet (or as needed) over the landing zone. HIGH KEY 1200 AGL, Roll out about 950, and a bit of a descent to abeam the runway numbers. Anylize the winds.
2. LOW KEY of about 800 feet AGL.
3. BASE KEY of about 600 AGL and finally a roll out on final of 300 feet AGL at 1/3 mile (1800 feet) or so for a 6-1 glide ratio. This should allow a convenient transition to allow the trainee to make a decision on when to lower additional flap to transition to what is a normal landing while being introduced to how to slow the plane down also so as to be over the numbers at 55-60 KIAS in a 172 with ½ to full flaps and actually land (however a go around is normal to expedite training depending on the trainees proficiency). That should be a good start.

Drill 5.

1. Begin from downwind at L/D max and pull the power abeam the touchdown point.
2. Plan a complete power off descent to base turn to final for additional practice for the power off picture and muscle memory needed to flare out.

Keep in mind that these drills could be a continuous turn from downwind to final if misjudged and result in high finals, low finals and poor alignment or even an overshoot.

Note:

T*he trainee may be so focused the instructor or safety pilot will have to clear the approach for the practicing pilot. Through practice, ideal turning room, judgement of the wind and feedback from the instructor, a smooth slightly* *tight, power off pattern can be flown safely in only a couple of attempts. Do a thorough debrief.*

What about takeoff leg engine failure too low to do anything?

In most takeoff once airborne the pilot is confronted with the sickening realization that if the engine failed at this moment, I can't do anything.

THAT IS NOT TRUE:

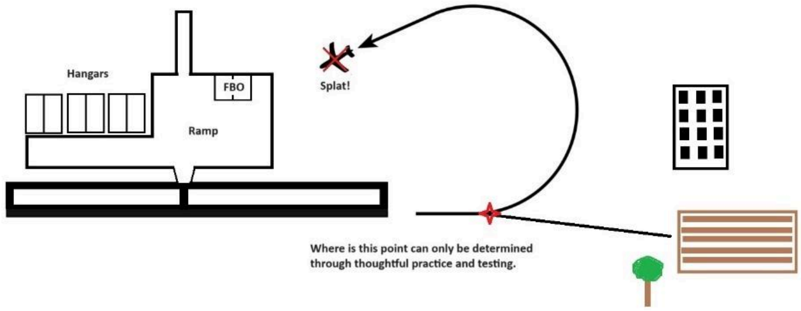
In the event of an engine failure just as the runway goes under the nose you have one choice.

1. Fly the airplane!
2. Pitch for best glide and look for something dead ahead to slightly left or right. There may be a crossing runway, grassy area or semi smooth area to push over and set up for a landing.
3. Maintain minimum POH EFTO recommended airspeed and maneuver to align yourself with something flat and hopefully soft and fly to the slowest touchdown just before it.
4. Steer and keep the aircraft on the path to your spot as best as you can.
5. Don't stop flying until the plane stops.
6. Emergency Ground Egress. Normally Master Mags off, open the door and unstrap as quickly as possible egressing the aircraft.

There is a point where a slight turn within 45 degrees to even 90 degrees off the runway heading to an on or off the field forced landing can be accomplished. The height of this is determined by preflight study and then attempting the turn flying at a safe height. Normally I do these at 1000 feet above the airdrome, simulate the takeoff to climb, pull power at about 1300 AGL, turn to the desired heading to the preferred landing area and flare out to arrest the descent at 1000 feet. That way the neighbors do not get alarmed.

There comes an altitude where the distance from the airfield, the wind conditions are right, where a full turn back toward the runway can be accomplished. For some that point is 500 feet on crosswind. Others, it is on takeoff leg at 500 feet. Still others will never commit to a turn back ever and will take their chances.

Airplane controls, pilot practice and technique means the aircraft even power off is capable of maneuvering. I prefer to take advantage of that. However, not all airplanes are equal in performance so there is no hard and fast rule on when a straight ahead, vs turn back is possible. Only through careful testing and practice can the decision be made on what course of action is best.


Hangars
FBO
Ramp
Splat!
Where is this point can only be determined
through thoughtful practice and testing.

Partial Power EFTO or another engine failure to consider “the sagging engine”:

1. Failure to note the engine is not up to full TO RPM and or MP is an ABORT.

   Note:
   Mag check smoothness and drop are often perfectly fine even with an engine with 4 bad cylinders, or even with a crankshaft or cam shaft worn and soon to fail. Rushed or Rolling Takeoffs do not allow a competent engine full power check prior to liftoff.

   Technique: Run up while on the runway to full power and note the proper static Takeoff RPM, MP and note oil/fuel pressures at a minimum. Then release brakes. Early in the roll note the RPM, MP, Temps and pressures, then EGT differences if available. If any are off by more than 5-10% from normal, the engine is having issues, or maintenance has changed something such as induction, prop pitch, turbo settings etc. Abort and investigate. Example: RPM on takeoff is normally 2500 RPM and it is at 2375 or even lower like 2250 RPM, that is ugly, ABORT early and avoid the rush.

2. If not rotated by your normal distance on takeoff (roughly 200 feet prior to takeoff) or if the acceleration doesn’t feel right - ABORT. This is the most common point of interest in test flying after maintenance. If it doesn’t feel right, abort. The slower acceleration is possibly normal if operating at a high density altitudes, the prop is set to a climb pitch, or the engine compression is low.

3. If not airborne by TO distance, + or – a bit, thinking about it is normally not a good idea. It is best to abort and investigate.

   Technique:
   If on a grass strip with no markings, where do you abort if not airborne? I use Runway length minus twice the takeoff distance. Say you are at a 3000 foot grass strip with a 800 foot takeoff roll computed for a grass runway, that means 1400 feet (3000-1600=1400) which is half way down the runway. Look where that point is and that is your abort the takeoff if not airborne point. Although you calculated your takeoff for grass, actual field conditions vary. This method should allow an abort before the end of the runway in time to stop and still allow a comfortable takeoff and climb out.

4. Once airborne but below 500 feet in a single engine light aircraft, a sick or poor performing engine is now a serious emergency and requires your immediate attention.
   a. Fly the airplane!
   b. Accelerate to L/D max as soon as possible and establish as clean a configuration as possible.
   c. Maneuver the aircraft in preparation for a forced landing somewhere over the nose.

d. Investigate the engine issue only if time and control permit. Note the carb heat, alternate air intake, MP or turbo boost and prop settings if a constant speed prop is used.

Note:

If you are using the tank that you taxied out with and accomplished the run then changed tanks you are a fool. If you did change fuel tanks, change back, activate the aux boost pump if equipped and follow the POH. Continue to fly to a safe forced landing area.

e. If able to maintain level to climbing flight at L/D max make a decision. Turn further back to the airport for landing or land straight ahead. If able to maintain level flight with some climb, gain and maintain the highest altitude possible. Losing climb rate or even a bit of altitude to make a turn may be necessary to preserve L/D max airspeed.

f. Plan for as tight pattern as your condition will allow. Keep bank angles shallow to preserve altitude and speed (that is your energy potential).

g. Continue to look for areas to make a forced landing while maneuvering back to the airport as the engine may fail at any time.

Engine Failure General Comments:
We've practiced power off approaches but the turn back to the airport or "Impossible Turn" is a serious emergency procedure and must be practiced at altitude and all facets of the operation must be studied, practiced and then a procedure with minimums can be worked into a practical checklist that is memorized for the specific aircraft you are flying.

Engine Failure from any position in the pattern must be considered a real possibility as the throttle is moving constantly. Planning and practice are necessary to gain proficiency in the event of a forced landing. In the event of an engine failure in the pattern the most controversial is the turn back or impossible turn:

An introduction to the Impossible Turn

Airports in or near metropolitan areas, heavily forested areas or remote mountain strips present very difficult decisions in the event of an engine failure. Crashing into school yards, parking lots, parks, trees, power lines, hills and roads is a major concern and not without injury or death. Many pilots know that in the event of an engine failure it is very tempting to attempt a turn back rather than picking a landing spot over the nose between houses, powerlines, trees and cars.

Turning around during a takeoff leg engine failure must be studied and practices before attempting. The pilot must be well practiced in the aircraft he is flying at altitude first then over the runway and finally at the runway.

Routinely, I here that a Cessna 172 or Cessna 150, lightly loaded, low wind, at an airport that is near sea level can be accomplished. Videos have been made showing it done by simply turning around anytime above 500 feet! Let's look at that assumption first.

What must be considered:

What does the FAA say?

In a FAAST pamphlet FAA-P-8740-44 • AFS–920 (2017) the EFTO pilot procedures are:

1. Immediately depress the nose and trim into the glide at optimum speed;
2. Look through an arc of about 60 degrees left and right of aircraft heading and select the best available landing area (see Figure 2);
3. Turn off the fuel and mags. Pull the mixture to idle-cutoff to minimize fire risk;
4. If yours is a tailwheel aircraft, avoid risk of turning over during the landing by retracting the gear (if applicable). It is better to leave the nose gear extended on tri-gear aircraft to absorb the first shock of arrival.
5. Make gentle turns to avoid obstacles.
6. When you are sure of reaching the chosen landing area, lower the flaps, in stages, if necessary, but aim to have full flaps before touchdown. Do not allow the airspeed to increase.
7. On short final, turn off the master switch and unlatch the cabin doors (to guard against risk of being trapped in the cabin through the doors jamming).
8. Resist the temptation to turn back to the field!

This is not bad advice, but an engine failure cannot be an OH HUM I'll depress the nose, to something, look over the area, take the time to shut off the fuel and mags, possibly retract my gear, make gentle turns, and lower the flaps in stages if necessary and not allow the airspeed to increase and resist the temptation to turn back. **Holy Cow!**

I have a problem with that as I am a proactive pilot. Therefore, we need to be far more creative and thoughtful than the above. Here are my training actions for takeoff emergencies after getting airborne and clear of the runway but not yet to pattern altitude:

I believe in the following:
If you train like you fight, you will fight like you were trained. So, if you never practice emergencies and analyze emergencies you will never perform properly in an emergency.

To train for an emergency, first you must have a plan, the plan has to be briefed, reviewed and debated, then the plan is readjusted and then accomplished first in a safe environment, then in a more demanding environment.

You can perform well in an emergency situation, if you have thoroughly thought out your emergency, devised a checklist for your aircraft and operating field, set limits, then go up at least 3 mistakes high, and practice the emergency with an instructor or experienced pilot on board.

First the Aircraft (say a Cessna 172):
Is this a 150 HP or 180 HP Cessna 172. Power matters.
What is the wing loading (aspect ratio, glide ratio, wing loading type stuff affects the glide.)
What is the glide speed vs the stall speed? (Narrow margin, or larger margin.)
What is the payload? (A full gross aircraft doesn't climb as well as a lightly loaded aircraft.)
What is the desired/required climb speed? (Vx, Vy in between or higher?)
What is the state of the engine? (Climb rate between a minimum 60/80 compression checked engine vs a 75/80 compression engine is a very big difference.) It's about power.
Is it a fixed climb prop, cruise prop or Constant Speed? Faster Climb rate vs windmilling drag.
What is the weather? (Wind Direction, density altitude, temperature).
What kind of gas is being burned? (STC'd for 87 octane or 100LL). It's about power.

Next the pilot:
Is the pilot knowledgeable of the emergency procedure for engine failure in the aircraft?
Does the pilot know the sink rates, glide path and turn rates engine off in the aircraft?
Is the pilot well versed in slow flight maneuvering i.e. near the stall?
Is the pilot well versed in power off landings in the pattern?
Is the pilot comfortable making steeper turns approaching the ground at low speeds?
Has the pilot reviewed the weather, aircraft condition, computed takeoff data to ensure takeoff performance?
Has the pilot reviewed his airfield for possible alternative landing sites and hazards?
When practicing for the Impossible Turn is a delay anticipated from time of failure to start the turn back of 3-5 seconds (normal reaction time) or is the push over and roll done immediately.
Has the pilot practiced this maneuver previously?
Practicing or training like you will fly is how you will fly in an emergency.

Then there is the airport:
How long is the runway?
What is the condition of the landing surface, is there a slope, obstacles and overruns?
What obstacles are at the departure end?
Are there alternative crossing runways?
Is there a large infield or only trees, houses and hangars on each side of the runway. (There is a high probability if the impossible turn is completed the combination of nerves, winds, altitude, and the above factors may force a long landing and runway end departure which may be more disastrous than simply landing straight ahead and trusting your luck with that.)

How is the turn back accomplished:
The turn back or "impossible turn" requires study, practice, a properly operating aircraft up to the failure, discipline, and confidence at low altitude maneuvering. There are a number of videos of practice turn backs after engine reduction to idle, as well as a few

videos of actual impossible turns. Not all work out well. Many actual EFTOs end in injuries and death of at least one or both occupants.

In the crude drawing at Figure 1 we see a left crosswind and a drifting off centerline departure. The engine fails at an altitude that allows an aggressive turn back at L/D Max. The roll out of the turn will be slightly off centerline with the pilot aiming at the threshold with altitude to spare, and a slight 20 degree turn on short final to roll out on runway centerline.

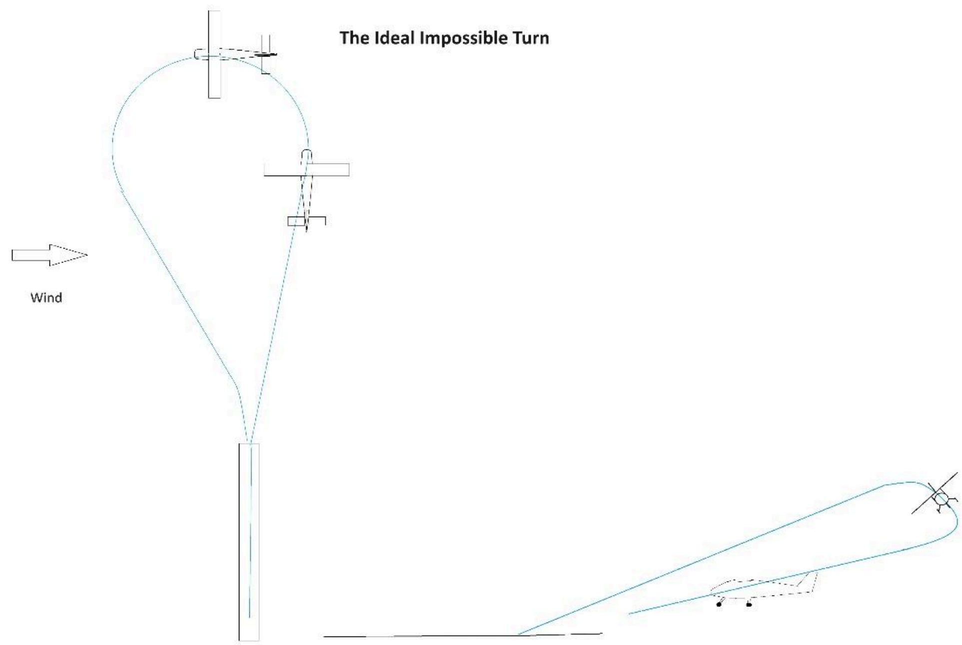


Figure 1

For all this to happen many things must go absolutely correct for the impossible turn.

1. Engine performance is optimum on takeoff to failure.
2. Climb is executed at or above L/D max.
3. Engine failure is sudden, and the pilot pushes over immediately to preserve glide speed.
4. The roll to 45 degrees of bank is performed simultaneously with the push over into the crosswind if any.
5. Back pressure to initiate in an aggressive turn at 45 degrees of bank with the nose lowered to maintain L/D max airspeed and pulling back pressure maintaining the nose low attitude (about 5 degrees lower than the straight ahead glide) and increasing back pressure until approaching the stall warning horn or at an angle of attack that is within a couple degrees of the stalling angle to maintain airspeed and G loading in the turn.
6. The pilot unloads and rolls wings level once pointed at the desired point to land but no closer than the threshold.
7. Pull out of the descent and readjust the pitch immediately to slow to the POH engine failure on takeoff glide speed (typically slightly slower than L/D max) and hold that airspeed.

8. Flaps or a slip is deployed to correct the glide path.
9. An alignment turn is necessary to achieve the desired runway or landing direction while still holding POH engine failure speed. This can be up to a full 90 degrees in a higher performance aircraft or if the turn back was wide and slow.
10. A side slip is made to compensate for the crosswind (now from the opposite side).
11. Although on a slightly steeper approach round out and landing are nearly normal, except for a tail wind on landing increasing the landing GS.
12. Braking applied as necessary to roll out. This can be maximum braking to a runway end departure or off field terrane excursion.

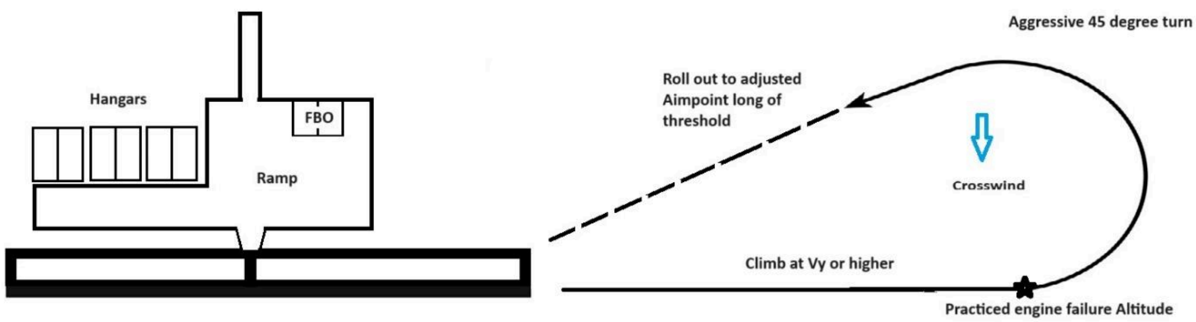


Figure 2

The precisely accomplished pattern will look similar to this in figure 2.

This picture below depicts what typically happens unfortunately:
Now typically the pilot takes off with a headwind, has the engine failure at altitudes that prevent a turn back, the pilot banks too little as he is close to the runway. During the now downwind turn his ground speed picks up, altitude is insufficient, and the higher ground speed alarms the pilot and he pulls back on the stick and slows trying to stretch the glide. The realization hits the pilot he can't make the runway and will be well short of any runway. His high ground speed from the tailwind from turning around gives the illusion he has speed and unfortunately, he doesn't have indicated airspeed, he stalls the aircraft, and a stall/spin occurs possibly killing all on board.

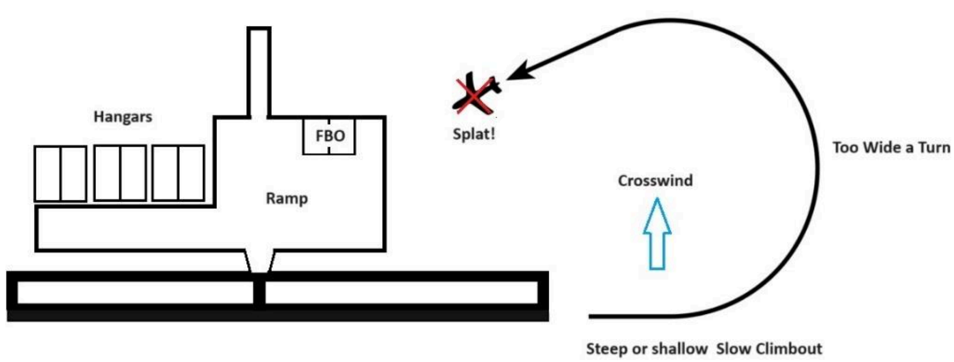


Figure 3

The picture below picture depicts a turn back with a strong headwind.
Even when practiced weather factors will be a significant issue in determining if a turnback is even possible. Prior planning is a must. If taking off from a short airstrip with a strong headwind, typically the pilot is still very near the departure end of the runway. Even with an aggressive turn back and what should be sufficient altitude, there is no way to turn now nearly 270 degrees and land on the runway he took off from. If the airport has a cross runway, he may be able to land on a runway nearly 90 degrees to his original takeoff.

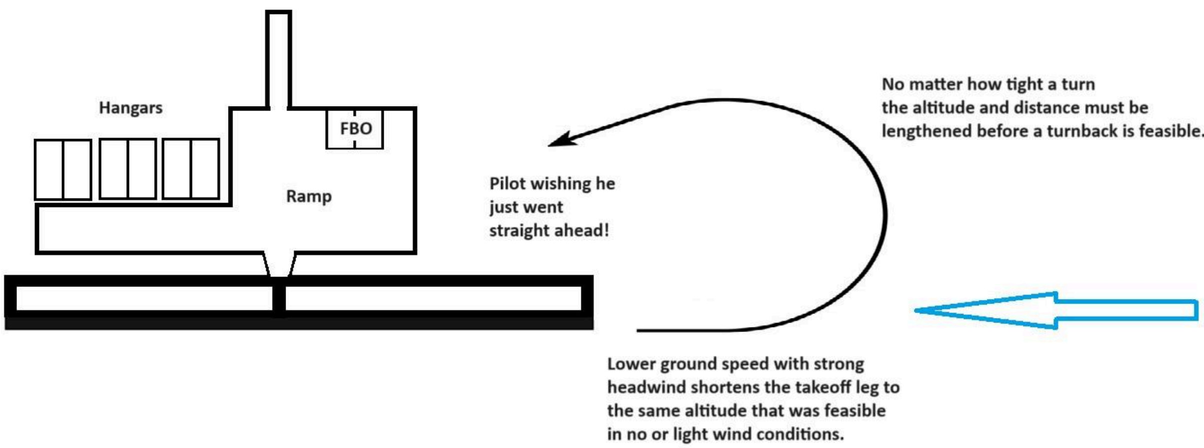


Figure 4

The short runway verses a long runway, and the considerations are similar to a strong headwind departure:
A long runway for departure allows the pilot to be 300-800 feet in altitude climbing at Vy, but he is over the departure end with altitude to spare, and if attempting a turn back, the excessive altitude must be aggressively dealt with or there is the likelihood of a long landing and departure end departure.

A short runway (especially with trees) is a terrible problem. Similar to a strong headwind condition. The steeper climb at Vx leaves the pilot close to the runway end. When climbing at Vx if the engine fails, the push over to maintain L/D max or even Vx is extremely violent for some pilots. It can be as much as a 30 degree nose down pitch over. Confronted with this nose low attitude and runway no longer remaining and no cross runway, the options are now very limited. The best option may be to aim for something soft you want to hit and fly to hit the area as slow as possible. Assume the turtle position (head down and trying to protect yourself) and fly until the plane stops.

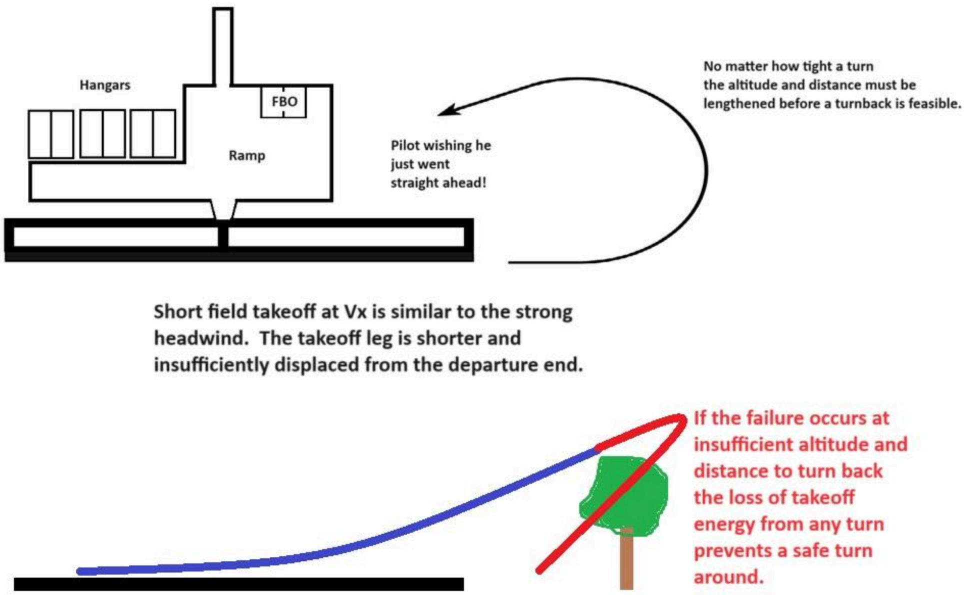


Figure 5

The ideal situation is a multiple runway airport with crossing runways.
If the airport has parallel runways (even short runways) or a crossing runway at 90 degrees or less, the conditions for a turn back improve somewhat. Again, depending on conditions such as crosswind, climb speed, engine failure altitude, traffic and of course pilot proficiency and practice. Many successful engine failure turnback's were accomplished in a multiple runway environment. Multiple runways present many options for the pilot. Prior planning can mitigate many of the turnback issues. The picture below shows some of the options:

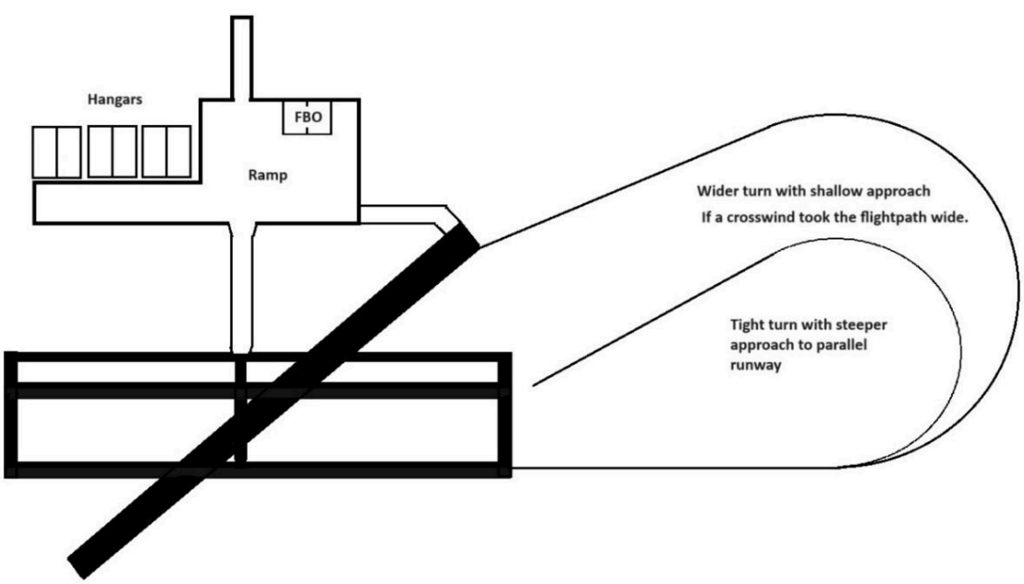


Figure 6

Pilots must always consider the winds, obstructions, runway layout, aircraft performance and his own proficiency when planning a takeoff. Having a preflight checklist briefing on what actions are to be taken at what point for the existing conditions will be necessary. There is nothing worse than starting a maneuver and realizing you can't make it and have to scramble to try to make a decision to save your life when the ground is rapidly approaching.

Stress of an engine failure, other system malfunctions, desire to save the aircraft, fear of losing one's life, and ego all affect the performance of the successful landing in the event of an engine failure on takeoff, enroute or on landing. There are times when we just can't save the airplane, but every action we take must try to successfully make a forced landing that hopefully ends up by unstrapping and walking away from the crash site.