Attitude Flying

Airspeed Control

Attitude flying is a simple concept which is used in both airplane and helicopter flying. The way it works is that the pitch attitude of the aircraft determines the forward speed, and power determines the altitude.

For instance, when flying a Robinson helicopter, the magnetic compass is mounted on the windshield in front of the pilot, and this can be referenced to the horizon to provide very accurate pitch information. For most pilots, holding the top of the compass on the horizon will cause the helicopter to fly along at about 60 knots. Holding the compass an inch below the horizon will cause it to fly at 70, and holding the compass an inch above the horizon will cause it to fly at 50 knots.

A Robinson R22 in a 60 knot attitude

Many people who are being introduced to helicopter flying assume they should use the airspeed indicator to control the speed of the aircraft. The problem with this approach is that there is a large time lag from the time that the pilot moves the cyclic control until the helicopter finally stabalizes at the commanded speed. This lag can be tens of seconds, and would make it very difficult to command the correct cyclic position, because feedback takes so long to occur.

Attitude flying on the other hand typically takes less than 1/2 second for the aircraft attitude to change. If the pilot knows the attitude required for the desired airspeed, the cyclic can be moved until the fuselage moves to the desired pitch attitude, and the pilot can be fairly sure the aircraft will accelerate/decellerate to the commanded airspeed within the next 10-15 seconds. After 10-15 seconds, the pilot can verify that the airspeed indicator shows the desired speed. If the airspeed indicator indicates a speed a few knots away from the desired speed, the pilot can make a small attitude change to bring it exactly to the desired value.

Altitude Control

Power setting determines whether the aircraft will stay in level flight, descend, or climb at the particular attitude the pilot has chosen. When attitude flying helicopters, large power changes do influence speed, so some compensation of attitude needs to be made for gross changes in power settings. This effect is fairly small, and pilots learn to do this easilly.

Pilots can quickly learn not only what attitudes will command a certain airspeed, but what power settings will give level flight at that airspeed. For instance, a Robinson R22 will take approximately 21 inches of manifold pressure to maintain level flight at 75 knots. This will be influenced by factors such as aircraft weight, density altitude, and the performance characteristics of the particular aircraft. Under most circumstances the value will be very close, and only a minor adjustment to power will be required to compensate for these factors.

By knowing what attitude will give 75 knot cruise, and what power setting is required, a pilot can very quickly make the pitch attitude and power setting adjustments needed to result in the desired performance. This is especially useful when converting from one flight configuration to another, such as from climb to cruise, or from cruise to descent.

Other examples of power settings for the Robinson are that 15 inches of manifold pressure at 60 knots will give between 300-500 feet per minute descent rates. This is a comfortable configuration for descending in the traffic pattern until approach angle intercept occurs.

Other helicopters have different power settings for the same flight configurations. Most pilots will quickly learn a few of the most commonly used configurations when they are first learning to fly a new make/model of helicopter. Interpolation will give them intermediate configurations which they have not memorized, and typically only 3 or 4 configurations need be memorized.

Turning (banking) Flight

A a pilot learns to attitude fly, he needs to learn how the pitch attitude should look during turning flight. Apart from attack helicopters, most helicopters have side by side crew seats, meaning the pilot is typically not flying from the middle of the aircraft, but is offset to the side.

A result of this seating is that the horizon will not roll about the center of the windshield during a level turn. Any reference point in the middle of the windshied (such as the Robinson compass, or a windshield vertical member such as in the Enstrom, Hughes 300, Bell 206, etc) will rotate up or down depending upon whether the bank is to the left or to the right, and whether the crewmember is sitting in the right or left seat.

The typical result of this is that pilots tend to pitch the nose up or down when entering a turn, and this will cause both the airspeed and the altitude control to be compromised. There are two ways to adjust for this. One is to simply learn through experience what the sight picture should look like in a turn. This tends to take a lot of trial and error, and changes depending on which seat you are sitting in. The other method is to pick a point on the windshield directly in front of the pilot's eyes, and rotate the horizon around this point while rolling into and out of a bank. This method is quick and easy to learn, and works from either seat. Focus on the horizon, not the windshield, but be aware of the out-of-focus windshield point as you roll into and out of banks.

Altitude Control during turning Flight

Both airplanes and helicopters have the problem that entering turning (banked) flight uses some of the lift component to perform the turn, and the reduction in vertical lift will cause the aircraft to lose altitude. There are two ways the helicopter pilot will typically compensate for this.

One possible way is to use some aft cyclic during the turn. This will cause a decrease in airspeed, but is normally acceptable for shallow banks. This technique has the advantage that since there is no torque change, no anti-torque pedal adjustment is required, decreasing the amount of inadvertent yawing that occurs.

Another possible technique to correct for this is to perform a power change. This is typically required if the bank is a steep one, or if the turn is made at an airspeed on the "back of the power curve" i.e. below the minimum sink airspeed. Power is increased during the roll into the turn, and decreased during the roll out. A proper adjustment maintains the vertical component of lift so that altitude remains constant.

Basic Hovering

Hovering is when the helicopter is flown so that it maintains a constant position over the ground. It is the main capability which differentiates helicopters from airplanes.

Basic Concepts

Hovering is one of those things that seems like it should be very simple. Hey, it's not like you're trying to go anywhere, you just want to sit in one spot. That should be simple, right? If most helicopters were dynamically stable, that wouldn't be a problem. Supposedly Mr. Hiller had his secretary hover one of his helicopters at a press meeting to demonstrate how stable his design was. Most helicopters are designed to be less stable than a Hiller. Bell 47s also seem to be very stable helicopters, the trend seems to be less stability in more modern designs.

The average person gets humbled pretty quickly trying to hover a helicopter for the first time. People who try to fly Remote Control helicopters have the same problem. Control is usually lost within a couple of seconds. This is a direct result of not having positive dynamic stability: the helicopter won't just sit there if you don't move the controls. Instead, constant control input is required in order to maintain a constant position and height above the ground.

Cyclic Control

The most difficult control is the cyclic which controls the position of the aircraft over the ground in both a longitudinal and lateral direction. This is made even more difficult in a 2 bladed teetering rotor system because the fuselage reacts very slowly to cyclic inputs (but the rotor disk reacts right away). The slow response causes new pilots to overcontrol. In rotor systems with non-zero hinge offset (fully articulated, or rigid) the fuselage reacts more quickly to cyclic inputs, and the tendency to overcontrol the cyclic is reduced (but not eliminated).

Part of the problem is that the cyclic is not a position control. You don't move the cyclic 1 inch to the right to move the helicopter 1 inch to the right. The cyclic also isn't a simple rate control. You don't move the cyclic 1 inch to the right to move to the right at 1 inch per second. The cyclic is an acceleration control. You move the cyclic 1/4 inch to the right if you want to slowly accelerate to the right. You move the cyclic 1 inch to the right if you want to accelerate extremely rapidly to the right. The problem is that usually in hovering flight we don't want to deal with accelerations, we just want to deal with absolute position over the ground.

If the cyclic were a position control, the pilot could look out the window, decide he wanted to be 1 inch to the right, move the cyclic 1 inch to the right and be done with it. The actual process the pilot needs to go through is more like this:

- Look out the window and decide he wants to be 1 inch to the right
- Input some right cyclic to start a bank to the right
- Judge the acceleration to the right
- When the helicopter has accelerated to the correct speed to the right, center the cyclic.
- As the helicopter approaches the desired position, move the cyclic to the left.
- Judge the decelleration. If the helicopter is decelerating too rapidly, reduce the amount of left cyclic. If the helicopter is not decelerating rapidly enough, increase the amount of cyclic.
- As the helicopter comes to a stop, center the cyclic. If you misjudged the deceleration and you are not exactly over your spot, start all over.

In a zero hinge offset rotor design (2 bladed teetering being the common example) the pilot's job is even worse. The pilot controls the rotor, but typically references his cyclic inputs to fuselage attitude. In a helicopter with zero hinge offset, the fuselage hangs like a pendulum under the rotor system and reacts not to rotor disk attitude, but to acceleration forces due to being dragged around by the rotor. Thus a cyclic input that causes the rotor to immediately tilt to the right has no immediate effect on the fuselage. This makes it very difficult for the pilot to know immediately whether he has input the correct amount of cyclic. Part of learning to fly one of these is learning to judge how much to move the cyclic without any visual feedback.

All this aside, the basic technique to cyclic control is fairly easy. If you have read the previous section on Attitude Flying you understand how the pilot uses the horizon to maintain a specific airspeed. This same mechanism is used in a hover. The pilot has to learn what pitch attitude will give him zero airspeed flight, and then simply maintains that attitude. If the helicopter drifts forward or backward, slight attitude changes are made to gain and lose forward or rearward speed until the desired position over the ground is achieved.

Besides pitch attitude, the pilot needs to also control the helicopter laterally with the cyclic control. He does this by banking the aircraft. In forward flight, banking the aircraft causes the helicopter to turn. In hovering flight, banking the aircraft simply translates the helicopter laterally. By maintaining a no-bank attitude, the pilot will maintain a zero drift rate.

Collective Control

The collective control adjusts the altitude of the aircraft during hovering flight. This is a simple control because it *is* a position control. Due to ground effect moving the collective a set amount will change altitude by a set amount. For instance, if you are at a 5 foot hover, and you lower collective 1/4 of an inch, the helicopter will descend about a half a foot and then stop there. Thus, within limits, there is a direct correlation between how far you move the collective and how much your altitude will change.

Most collective controls also effect engine power output. This is because the change in pitch angle of the main rotor almost always requires a change in engine power to maintain a constant main rotor RPM. There are three basic configurations:

The most basic is when there is not a connection. In this case, the pilot is required to roll the throttle on and off while making collective pitch adjustments. This takes quite a bit of practice to become proficient.

The next step up is a "correlated" collective in which the collective is mechanically connected to the engine throttle such that moving the collective also moves the throttle. Correlators can be very effective if the engine power output can be accurately matched to collective position. Some correlators are not well matched, or are misrigged, and can end up being worse than no correlator at all, because the pilot still ends up having to make throttle adjustments, but has to compensate for the amount of throttle that the correlator is adjusting.

The final way that collective and engine can be connected is with a governor. This is a device which actively tries to maintain rotor RPM at a preset value. A governor would typically sense the change in main rotor RPM caused by a collective pitch adjustment, and would increase or decrease throttle as required to maintain desired RPM. Some governors sense collective movement and start adding or removing fuel right away in anticipation of the effect the movement will have on RPM. This is called a "compensator" and is typical in turbine engines which are slow to accelerate and decelerate (and therefore would experience large RPM fluctuations without the compensator).

All this talk about the collective being connected to the engine is because the throttle is typically mounted on the end of the collective control (but is sometimes on the overhead panel on machines with governors). You can think of the two controls together as the "power" control, or you can think of them seperately. Which makes more sense depends on the type of helicopter you are flying, and what maneuver you are trying to perform.

Anti-Torque Pedals

The anti-torque (not rudder!) pedals are used to yaw the helicopter during hovering flight. The helicopter can be pivoted by pushing on either pedal. The left pedal yaws the nose to the left, the right pedal yaws it to the right, just as do rudder pedals in airplanes.

Most single main rotor helicopters require the pilot to manipulate the pedals during torque changes. Failure to do so will result in yawing the aircraft. Exceptions are helicopters such as the MDHC Notar helicopters which will automatically increase anti-torque force by the nature of the way the anti-torque force is developed, and also helicopters with Stability Augmentation Systems which incorporate a yaw damper, which is typically a gyroscopic driven device which automatically changes the tail rotor pitch in response to the aircraft yawing (it's a simple auto-pilot).

During hovering flight, the pedals are a *rate* device. Pushing on the left or right pedal a certain amount will cause the helicopter to yaw right or left at a particular rate. The more you push the pedal, the faster the helicopter will yaw.

On a calm day, the pedals will hardly move in a hover except to counter torque changes, or to yaw the aircraft on purpose. On a windy day however, the pedals will be in constant motion as tail rotor thrust varies due to wind and main rotor downwash effects.

On most helicopters, the tail rotor is not mounted at the vertical CG. Changes in tail rotor thrust will cause a right or left rolling tendency depending on which pedal is being pushed, and whether the tail rotor is mounted above or below the CG. The rolling tendency has to be countered by the pilot moving the cyclic control. This cross coupling adds to the pilot's workload.

Takeoff to a Hover

This maneuver is used to transition the helicopter from a parked position on the ground, into a normal hover.

Maneuver Description

With the RPM within the normal operating range, the pilot performs the maneuver by increasing power. As power is increased, more anti-torque pedal will be required in most single rotor helicopters. The increase in tail rotor thrust will typically require a cyclic input to counter tail rotor roll tendency. The problem with these required adjustments is that since the fuselage is sitting on the ground, there is no visual feedback to the pilot that he is making the proper inputs.

As the power is increased enough to get the helicopter light on the skids, the pilot will begin to receive feedback about whether his control positions are correct. For instance, sliding around on the ground, or pitching and rolling motions may all be signs that the cyclic is not centered. Yawing on the ground is an indication that the pedals are incorrectly set.

You will have to continue to manipulate the controls in order to hold position on the ground during the liftoff. Failure to do so can result in a dynamic rollover situation which can destroy the aircraft. Continue to raise collective until the helicopter transitions into the air. Continue to slowly and smoothly increase collective until the desired hover height is achieved.

As the helicopter leaves the ground, don't be in the habit of pausing at 1/2 inch skid height to get the controls centered before climbing to a normal hover height. Wallowing around at a low skid height is asking to catch a skid on something. Just continue smoothly up to your normal hover height. On the other hand, don't be in the habit of "popping" the helicopter up to a normal hover height. This is a common technique with inexperienced pilots who are trying to get away from the ground. If you are getting your controls centered, there should be no reason to rapidly climb to your hover height, and there are several good reasons not to. The climb to a hover should be slow, and at a steady rate. By going slowly, you have time to identify and correct problems as they occur.

How to center the controls properly

This seems to be a constant problem for many pilots. Many pilots I fly with have never been taught how to properly do this (and thus many of them revert to the "pop it off" technique).

Pedals

The pedals are pretty easy to learn how to do. First of all, go find a smooth paved area which can allow you to yaw the aircraft on the ground without risk of rollover. Be careful. From flat pitch, being increasing power until you are starting to get a little light. Play with your pedals. If you push enough on the right pedal, the helicopter will try to yaw right on the ground. If you push enough on the left pedal, the helicopter will try to yaw left on the ground. Halfway in between is where the pedals are neutralizing engine torque.

Now increase power a bit, and repeat the exercise.The amount you will have to push the pedals before the helicopter wants to yaw is reduced. The lighter you get, the less you have to push the pedals to yaw, and the narrower the range is where the pedals must be to keep the helicopter straight. If you keep doing this until the helicopter is lifting off, you will be able to judge exactly where the pedals have to be to prevent any yaw during liftoff. Of course, since you are adding more and more engine torque, the centered position will be moving more and more toward the left as you perform the exercize. With practice, you will be able to neutralize pedals without any large yaw forces being placed on the helicopter.

Keep in mind that this is an exercise. As a normal procedure, you don't want to be yawing the aircraft while it is on the ground. This can result in an accident. The trick is to learn how to move the pedals just a little bit, watch for small indications of yaw on the aircraft, and therefore learn exactly where to put the pedals so no yaw takes place. If you have access to a pontoon equipped helicopter, practicing pickups on the water will really teach you to use the anti-torque pedals.

Cyclic, Pitch Axis

This exercise is similar to what we did with the pedals. Instead of yawing, we will be practicing pitching the helicopter forward and backward. Be extremely careful with backward, since skids are not designed to slide that way, and you could hit the tail rotor if you allow the helicopter to rock back.

Get the helicopter light on the skids. Push some forward cyclic, and then some rearward cyclic. Feel the helicopter attempt to rock (or slide) forward and backward. Halfway in between is where the cyclic is centered. As you get lighter and lighter, the amount you have to move the cyclic is reduced. As the helicopter is ready to lift off, any movement of the cyclic will cause the helicopter to rock or slide. You have found the center position if you can prevent it from rocking and sliding as the helicopter is ready to pick up.

Now comes the difficult part. All helicopters will want to pitch nose up or down into whatever attitude they want to hover in. This is usually a different attitude from the skids level attitude. If you try to prevent this from occuring, the helicopter will slide forwards or backwards depending on the attitude it wants to hover in. Many things will influence the hover attitude, including the CG of the helicopter. The trick is to figure out which attitude it wants to hover in, given that you are sitting on the ground. Of course, experience will tell you to some degree how a helicopter wants to hover given it's CG, but you should be able to walk up to a strange helicopter and still perform a good liftoff.

The key is to realize that the helicopter will side forward or backward unless it is in the correct pitch attitude. As power is increased, position the cyclic so that the helicopter won't slide. Add more power and notice whether the nose or tail wants to raise. Let the aircraft pitch up or down, but as it does counter the motion with cyclic, just as you do on a slope landing. The idea is not to stop the pitching motion, but to prevent the rotating swashplate (and therefore the main rotor) from pitching with the fuselage. If you have input the correct amount of cyclic, the aircraft has pitched, but still does not want to slide on the ground. Continue adding power, and countering fuselage pitch until the helicopter lifts off. If you do a really good job, you will first feel the front or rear of the aircraft lift off, then one of the remaining skids, and then finally the heel or toe of the remaining skid, all without any sliding around on the ground.

This takes a lot of practice, but will allow you to make very accurate, smooth takeoffs.

Cyclic, Roll Axis

This part of the exercise is similar to what we just discussed in the pitch axis, however you need to use even more caution. If you allow the helicopter to skid laterally, you risk dynamic rollover. If you allow the helicopter to come up on one skid (which it normally wants to do) and then slide toward that skid, you are *really* asking for dynamic rollover. You might want to have an instructor along while you practice this...

Again, the problem is similar to that of the pitch axis. The helicopter in a hover will normally hover one skid lower than the other because of various factors including CG. Your job is to transition from skids on the ground (presumably level) to skids at the hover attitude. You don't know what the hover attitude is yet. So you increase power a bit, and play carefully with lateral cyclic to try and determine where it is centered. You continue to increase power to get light on the skids, and adjust the cyclic to prevent sliding. At some point the helicopter is going to want to roll, and you have to let it, but you do want to counter with opposite cyclic so that the rotating swashplate doesn't roll with the helicopter.

If you do this correctly, the helicopter will roll but not slide, until it is left with one skid in the air, and one skid on the ground, ready to lift off. Continued up collective will cause the final skid to leave the ground with no rolling motion at all, simply a straight up motion. If the helicopter wobbles as it leaves the ground, you didn't have the cyclic centered and you need more practice!

Helicopters with oleo (shocks/struts) equipped landing gear

Pilots who fly helicopters with oleos (such as Enstroms, MDHC/Hughes) have an advantage in that they can "fly" the fuselage while the skids are still on the ground. Since you can rock the aircraft on the oleos, it is much more obvious when the cyclic is centered.

Helicopters that dance when light on the skids

Some fully articulated aircraft perform a little (or huge!) dance when light on the skids. This is like ground resonance, only it hasn't diverged yet. It is caused by an interaction of the dampers and struts, and can get so bad in some aircraft that you can't read the gauges. Sometimes this is an indication that you've got a bad damper, or that the dampers aren't all adjusted to the same force. You can check the dampers with a fish scale, seeing that it takes the same force to move each blade. Our Enstrom does this, and my advice is that it isn't good (or comfortable!) to sit with the skids banging away on the ground. Either find some soft ground that damps the motion, or simply avoid it by minimizing the amount of time that you sit light on the skids.

All together now

You can normally practice all these simultaneously. Get the helicopter light, and play with the pedals. Play with the cyclic in the pitch axis. Play with the cyclic in the roll axis. Increase the power slightly and repeat.

Keep in mind during all this that I'm not advocating sliding around on the ground. That is a very dangerous thing to do. What I am suggesting is that you look for the cues that tell you when the aircraft controls are centered versus displaced. By learning those cues, you can center the controls and perform a perfect takeoff to a hover every time.

Landing from a Hover

This maneuver is used to transition the helicopter from a hover to a landing on the ground.

Maneuver Description

From a normal hover, decrease power to approach the ground. Inexperienced pilots should avoid the normal tendance to look directly in front of the helicopter. Better results will be obtained if you either look up at the horizon, or halfway between the ground in front of the helicopter and the horizon (normally this would be a spot 50-100 feet in front of the helicopter). It is critical to be aware of the horizon, and looking too close to the helicopter removes this from your vision.

You don't normally need to look down to judge your height above the ground. Your peripheral vision will do this for you. When the ground seems to be about level with your ears, you're about to touch down. When landing on an elevated platform, your peripheral vision may not give you this feedback, and you may have to glance down to judge altitude. The trick is not to stare down, but to just take quick looks to monitor your progress toward the ground.

As you descend, ground effect will decrease your descent rate, and you will have to continue to lower collective to maintain a steady descent rate. As you are approaching the ground, allow ground effect to decrease your descent rate for a softer touchdown. Don't allow your descent rate to stop, however. You don't want to wallow around at a low skid height. Make sure you continue to descend toward the ground.

Eventually a skid is going to touch the ground. If the helicopter is not hovering perfectly level, this will cause the helicopter to pitch, roll, or both as the fuselage transitions from hover attitude to the attitude it assumes sitting on the skids. As it pitches and rolls, input opposite cyclic just as you would on a slope landing, in order to prevent drift.

Many pilots will quickly get the collective *down* in order to get weight on the skids, as this will stop any sliding motion. This is a bad technique for a couple reasons. One, if the ground isn't level enough, the helicopter could roll over (I've landed in tall grass that makes it impossible to see the ground - one time there was a hole under the rear of one of the skids. The helicopter started to tip over backward, but the fact that we were slowly decreasing collective gave us plenty of time to abort the landing and find a different spot to land on). Another bad thing about lowering collective too quickly is that you are rapidly lowering the blades toward the fuselage, and you increase the chance of rotor to airframe contact on a gusty day.

The better technique is almost the reverse of the technique I described in Takeoff to a Hover. Hover slowly down until a skid touches. Balance there for a few seconds without allowing the helicopter to drift around on the ground. Lower some more collective and put a little more skid on the ground, while compensating for drift. Keep doing this a stage at a time until you have slowly lowered the helicopter all the way onto the ground. Practicing this will allow you to land accurately every time.

Typical Mistakes

Going for it!

A very common mistake is for pilots to descend until they estimate they are almost on the ground, and then rapidly lower collective. It's the reaction to the feeling "I just want to be on the ground". There are multiple problems, the most typical being that sometimes you are higher than you think you are, and you can get a fairly hard landing if you just lower a lot of collective. Advice: descend until you think you are close to the ground. Continue to descend at a slow rate until you feel a skid touch. Continue to slowly lower collective, while making cyclic pitch adjustments for any pitch and roll necessary to get onto the skids.

Overcontrolling near the ground

Lots of pilots start to over control when they are near the ground. A pilot who is holding a good hover will suddenly start wobbling all over as he gets near the ground. The problem is that people get concious of the ground, and want to have a perfect hover in preparation for landing. Just hold the best hover you can during the descent, and don't make any special efforts as you touch down. Unless you are *really* bad at hovering, this will give you a safer landing.

Not countering pitch and roll

Some pilots never learn to use the cyclic to counter pitch and roll during the transition onto the skids. The result is sliding around on the parking space, which is dangerous. Go out and practice your slope landings, both parallel to the hill, and facing uphill (watch your tailrotor!) and you'll be practicing the same elements required for landing on level ground. My observation is that every takeoff and landing, even from a level area, is really a slope takeoff and landing because of CG causing roll and pitch.

Landing next to another helicopter at low RPM

A pet peeve of mine. Helicopters are susceptible to rotor->airframe contact while they are at low rotor RPM. They are at low rotor RPM during startup and shutdown. Therefore, don't land next to a helicopter that is just starting up, or has just shut down with it's blades still turning. If you are about to pick up to a hover, don't do it if the pilot in the next aircraft over is about to enage his rotors or has just killed his engine. Wait until the other aircraft's rotors are either stopped, or are up to operating RPM before you subject that aircraft to your downwash.

Proper orientation to land with respect to wind direction

Although it is certainly easier to land pointed into the wind, if the wind is really strong or gusty you increase the chance of a tailboom strike during shutdown or subsequent start up by landing into the wind. The problem is that the rotor blade is flapping down and reaches maximum downward deflection when it is over the tailboom when you land pointed into the wind. Instead, if you either land tail into the wind (not such a hot idea for a turbine aircraft) or with a cross wind, the blades will not be at maximum down flap as they pass over the tailboom. Some manufacturers recommend having the wind at your 7-8 o'clock position in this situation.

If you are an inexperienced pilot, you might not want to attempt tail into the wind takeoffs and landings, since they are slightly more difficult to perform. Hopefully an inexperienced pilot won't be flying on days where the wind is strong enough to make boom strikes a concern..

Takeoff to a Hover from a Slope

This maneuver is used to transition the helicopter from a parked position on a slope, into a normal hover.

Maneuver Description

With the RPM within the normal operating range, the pilot displaces the cyclic toward the slope. Depending on the circumstances, he might put just the amount he thinks is required, or on a steeper slope he may elect to put all available cyclic into the hill to start with. The intent is not to tip the rotor toward the hill, but to have the main rotor disk level with the horizon, or tipped just slightly into the hill.

As power is increased, the downhill skid will eventually lift up. During this phase of the maneuver, collective is controlling the height of the skid, and cyclic is simply trying to maintain the rotor system level with the horizon. As the fuselage rolls uphill, the swashplate and therefore the rotor system tip with it, and the pilot has to take out some of his uphill cyclic in order to maintain the rotor level with the horizon.

The collective should be slowly raised until the downhill skid is level with the uphill skid. Cyclic should continue to be manipulated to maintain a level rotor system. It is critical that the downhill skid does not get raised above the uphill skid. Doing so starts biasing the equation toward dynamic rollover *a lot*. This is because not only may some main rotor thrust be trying to roll us uphill, but the CG is shifting toward the uphill skid, and thus any restoring force preventing dynamic rollover is being reduced.

Once the skids are level, remove any remaining uphill rotor thrust by moving the cyclic away from the hill. It is normally very apparent when there is no main rotor thrust into the hill, because the helicopter will suddenly become much less stable on the hillside. Continue to center the cyclic, and increase power to cause the helicopter to lift straight up. Continue up to your desired hover height.

Typical Mistakes

Not using enough uphill cyclic

If you don't have enough uphill cyclic, such that the rotor is tipped downhill, the uphill skid may be the first to lift off, or the helicopter may try to slide downhill, or it may simply dynamically roll downhill. Needless to say, none of these are fun, and it's probably safer to carry too much uphill cyclic at the start of the maneuver rather than not enough uphill cyclic.

Using too much uphill cyclic

This usually happens because people put in a certain amount of uphill cyclic, and then as the helicopter rolls to a level attitude they either don't take out any of the uphill cyclic, or they just don't take out enough. This leaves you with a lot of thrust toward the uphill side, which can easilly turn into a dynamic rollover uphill. Practice will show you just the right amount of uphill cyclic you should be holding when skids level.

Rolling uphill too fast

Hamfisted manipulation of the collective can induce a very fast uphill roll which may be difficult to arrest. In extreme circumstances, there may be enough uphill roll momentum to cause an uphill dynamic rollover. The downhill skid should be brought up very slowly. I usually teach bringing it up a few inches and pausing, then a few more inches and pausing, and so forth until the skids are level. This insures no roll momentum gets built up.

Overcontrolling the cyclic

People who are nervous on a slope will tend to overcontrol. Moving the cyclic forward and backward will tend to unlock the uphill skid, making the helicopter unstable on the slope. This happens when only one part of the skid is left in contact with the ground. This could be either a heel or a toe, and creates a pivot point which requires lots of pedal work to handle. A properly locked in uphill skid has both toe and heel planted, and provides a very stable platform with almost no pedal work required.

Overcontrolling the cyclic in roll almost always means the person is confused about what control commands the height of the downhill skid. The cyclic can wobble the downhill skid up and down a bit, and this may lead people to think they are on the right track, especially since this is the proper control input in normal flight. It is important to realize that as long as one skid is planted, the height of the other skid is controlled by rotor thrust, i.e. the collective.

Not centering the cyclic before vertical liftoff to a hover

If the cyclic is still displaced into the hillside when a vertical liftoff is attempted, the helicopter will perform a distinct wobble as it leaves the ground. While not particularly dangerous in small amounts, it leaves some doubts as to the ability of the pilot to properly operate on a slope.

Allowing the tail rotor to swing toward the slope

Once in a hover, the pilot has to remain concious of the tail rotor and avoid swinging it toward the hillside.

Landing on a Slope

This maneuver is used to transition the helicopter from hover to a landing on a slope.

Maneuver Description

First the helicopter must be positioned over the slope. Care must be taken not to place the tail rotor in a position where it will strike the ground. Most slope landings are performed parallel to the slope. Landings can be done nose in to the slope if tail rotor clearance is assured. We will describe a parallel approach here.

With the helicopter positioned above the intended landing area, and aligned parallel to the slope, the pilot should descend by lowering collective. When the uphill skid contacts the slope, pause, and add just a little cyclic into the hill. This will help to lock in the landing gear. Both the front and rear (toe and heel) of the gear should be in contact with the ground. If not, the helicopter will tend to yaw around the single pivot point in contact with the slope. If the slope and the skid are not at the same angle, the helicopter can be pivoted slightly using pedal to find an angle where the skid will be alighned with the slope. Care must be taken not to swing the tail rotor into the hillside. The landing can be done with only a single contact point on the uphill skid, but it will be much harder. The pilot should first see if there isn't another section of slope that will allow the skid to be properly planted.

Once the skid is planted, the pilot lowers the downhill skid toward the ground by lowering collective. Rather than a continuous rolling motion, an iterative process of lowering the skid a few inches then pausing before lowering it some more prevents too much of a rolling momentum from building up. This is important if the slope turns out to be too steep to land on.

As the downhill skid is lowered, the cyclic needs to be deflected into the hillside in order to keep the rotor disk horizontal. Since the swashplate is connected to the fuselage, failure to displace the cyclic into the hillside will cause the rotor to tilt toward the downhill side, and the usual result will be skidding the helicopter sideways down the hill (not such a great idea!). Cyclic inputs should be coordinated with fuselage roll, not with collective pitch motions.

After the downhill skid makes contact, the pilot should continue to use caution lowering the collective in case there is any tendency for the helicopter to tilt toward the downhill side. Some people recommend centering the cyclic after the collective reaches flat pitch, other people recommend keeping it displaced into the hillside for the entire duration of the slope landing (including shutdown if the helicopter is to be parked on the slope).

Pilots who fly helicopters with twin, cross feeding fuel tanks mounted high on the fuselage (like the Bell 47) need to consider the fact that while parked on the hill the fuel will cross feed from the upper tank to the lower tank, and the CG shift may be severe enough to roll the helicopter over while it is parked, or to prevent a safe liftoff later on.

Center of Gravity Considerations

If passengers or cargo are to be loaded or unloaded while parked on the hillside, the pilot needs to take into account the effect the shift in CG will have on his ability to take off again. Unloading weight from the uphill side and then trying to take off could cause the pilot to run out of uphill cyclic authority and could cause a dynamic rollover downhill to occur. Generally, if weight is going to be offloaded, it's a good idea to land with that side of the helicopter downhill. Similarly, if weight is going to be added to the helicopter, it's a good idea to add it to the uphill side.

Wind and Tail Rotor Considerations

The factor which usually defines the slope limit for a helicopter is the amount of cyclic authority available to the pilot. If the wind is blowing downhill, less cyclic authority will be available to the pilot, because some of it will have to be used to counter the downslope wind.

Similarly, if tail rotor translating tendency requires left cyclic to counter, less left cyclic authority will be available. Thus landing on a slope right skid upslope may allow a steeper slope landing. Manufacturers tend to tilt the masts to counter translating tendency, so this guideline may be more or less true given different makes and models of helicopters.

Common Mistakes

First of all, the same mistakes pointed out in Slope Takeoffs are common during landings, namely not using enough uphill cyclic, using too much uphill cyclic, rolling downhill too fast, or overcontrolling the cyclic. Also, the following unique errors are often made:

Failure to lock in the uphill skid before lowering the downhill skid

People in a hurry will often just try to plant the uphill skid quickly and then start lowering collective. If the uphill skid is not properly planted both front and rear, the result is usually a wobbly landing. It makes sense to take the time to properly plant the uphill skid.

Normal Takeoff

This maneuver is used to transition from a hover into forward flight.

Maneuver Description

Assuming Negative Translational Lift

Assume that the wind is calm, and that the helicopter is not in translational lift at a hover. The power setting will normally be very high in this case. The takeoff can be initiated by lowering the nose slightly (a couple degrees). A very slow acceleration should take place, with the skids still basically level with respect to the ground. Some altitude will normally be lost as the front vortex is overrun by the rotor system. The collective should not normally be raised. If the pilot is patient and uses good technique, translational lift will be achieved before the helicopter touches down. There should be no problem if the helicopter does touch down assuming a normal surface, because the skids are level.

During this acceleration, the anti-torque pedals should be manipulated such that the skids remain alighned with the ground track. This insures that a touchdown onto the landing gear will not result in a rollover.

As the helicopter accelerates into translational lift, an aggressive lowering of the nose with cyclic will be required to avoid initiating a climb. Also, as the tail rotor goes through it's own effective translational lift, anti-torque thrust will increase greatly, and the pilot will have to make a pedal adjustment to maintain his skids aligned with the ground track.

Assuming Effective Translational Lift at a Hover

Assuming that the wind is strong enough that the helicopter is in effective translational lift at a hover, the initial part of the takeoff will be slightly different. Typically, the power setting will be quite low in this situation, and the pilot will want to increase power as he lowers the nose to begin the takeoff. Power should be brought up to a normal power setting for takeoff. Skids should be maintained alighned with the ground track using the pedals. The nose will be lowered more than for the previous case, since translational lift is providing us with an excess of vertical lift, and we still want to avoid begining the climb too early.

The rest of the maneuver

Now that the helicopter is accelerating well past effective translational lift, the trick is to prevent an early climb. Before the flight, examine the manufacturers H/V curve in the performance section of the pilot handbook. There will be an airspeed at which you can start gaining altitude without entering the shaded areas of the HV curve. This should be your target airspeed on a normal takeoff. You can choose to accelerate to a faster airspeed, as long as you don't hit the high speed shaded section of the H/V curve. Also, it usually does not make sense to accelerate much past the minimum sink airspeed.

While the helicopter is accelerating from low airspeed to high airspeed, transverse flow effect will require lateral cyclic adjustment. At very low airspeed the cyclic will have to move to the left, and then as airspeed is gained the cyclic will move back to the right again.

As you encounter the target airspeed, bring the nose up until the helicopter is in an attitude that will eventually result in the target climbout airspeed. Holding the nose down until the airspeed indicator reads the target airspeed will almost always result in an airspeed overshoot. By rotating to the target attitude, the helicopter will slowly gain airspeed until it stabalizes at the desired airspeed.

As the helicopter begins to climb out, trim the aircraft into the wind with the anti-torque pedals. Continue the climb out until you reach your desired altitude.

Common Mistakes

Dumping the nose to accelerate

Many pilots begin the maneuver by dropping the nose many degrees. While this will give a quick acceleration, it also decreases vertical lift substantially. Most pilots raise collective to compensate. The problem occurs on the day when you are already at maximum torque and you try a maneuver like this. Either you exceed torque limits trying to avoid hitting the ground, or bleed down rotor RPM, or hit the ground in a nose low attitude. None of these are desirable. Dropping the nose a little, gaining airspeed and lift, and then dropping the nose more to prevent a climb is a more conservative way to initiate a takeoff. If the helicopter touches down, the skids are level, and the helicopter will usually just skip off the runway and then climb out. Usually the helicopter won't touch down because more vertical lift remains available during the entire maneuver.

Failure to keep the skids alighned

As the helicopter accelerates, the tail rotor is going through it's own translational lift, plus main rotor downwash will have an influence on tail rotor thrust. It is important that the pilot be in the habit of preventing any yaw in case the helicopter touches down during the takeoff roll. Also, in the event of an engine failure any yaw will be immediately apparent, and if the pilot is automatically keeping the skids alighned, the helicopter can set back down without risking a rollover.

Early Climbout

Allowing the helicopter to climb out early, and thus going through the height velocity curve's shaded area invites disaster if the engine quits. The "knee" of the HV curve is the most difficult portion to recover from, even for pilots who are current in autorotations in make/model. Making life more difficult by actually flying the knee portion in the shaded area just makes things worse. Of course, if you have to clear an obstacle, you have to climb out early. But if there is no reason for it, accelerate low until you have passed the "knee" airspeed.

Late Climbout

There are other pilots who will accelerate well past minimum sink before they start their climb. This has the effect of keeping you lower over any given point downrange than you would be if you climbed out closer to minimum sink airspeed. Since altitude is useful in the event of an autorotation, most pilots would rather climb at a steeper angle if it is possible. Usually a steeper climb is benificial from a noise standpoint as well, by being higher before overflying other property.

Normal Approach

This maneuver is used to transition from forward flight to a hover or a landing. A JPEG and GIF sequence of photographs of a normal approach are available.

Maneuver Description

Approach Angle

We usually consider a normal approach to be a 10 degree approach. More than 10 degrees is considered to be a "steep" approach, and less than that is considered to be "shallow". For reference, 10 degrees is about what you get in a Cessna 172 with engine at idle and 40 degrees of flaps hung out.

We initiate the maneuver by intercepting the 10 degree approach angle. Normally a collective pitch adjustment will be required to start the helicopter descending on the 10 degree angle. The exact power setting will depend on things such as wind, density altitude, and helicopter weight.

The way that a helicopter pilot judges whether he is maintaining the desired angle is similar to what an airplane pilot does. There are multiple cues which will tell you whether you are changing approach angle. These include:

- Shape of the landing area changes on different angles (shapes get distorted by perspective more at lower approach angles).
- Position of the landing zone in the windshield. The LZ will be lower in the windshield on a steep aproach, higher on a shallow approach.

Closure Rate

Unlike an airplane, helicopters do not fly constant airspeed approaches. That's partly because they don't have to. If an airplane attempts to decelerate too much on approach, it stalls. A helicopter doesn't have that problem. Normally, inside of a mile of the landing zone the helicopter is decelerating at the same rate it is losing altitude so that by the time the altitude of the helicopter approaches zero, the ground speed will also be approaching zero. One way for helicopter pilots to judge this is to look at apparent ground speed. From high up, the ground seems to be going by very slowly. As we descend, the ground appears to speed up. Helicopter pilots simply hold the apparent ground speed to approximately a jogging pace, and that will insure that as they approach the ground they will be moving forward at a jogging pace. The last few knots of ground speed can be killed as the helicopter transitions into a hover.

Power Requirements

During the deceleration from approach speed to minimum sink airspeed, less power is required as the helicopter slows. This will require the helicopter pilot to be decreasing collective initially. However, from minimum sink airspeed until reaching the LZ, the power required will be going up, because the helicopter is on the back side of the power curve.

During the last portion of the approach, typically begining around 40 knots of airspeed, the helicopter is on the part of the power required curve where power requirements are going up very quickly. The pilot will normally notice a sudden tendency for the helicopter to sink below the approach angle. The pilot will have to increase collective substantially to maintain angle.

Because the helicopter is in a slightly flared attitude, this increase in thrust will increase the deceleration force (because the rearward component of thrust will be increased). If the pilot does not push forward on the cyclic at this time, the helicopter will generally come to a stop well short of the LZ, typically at a height of 25-35 feet. By adding forward cyclic, the pilot will keep the helicopter moving forward at a slowly declerating rate, losing altitude at the same time, until the helicopter reaches the LZ at the desired hover height.

Termination

The maneuver can terminate either in a hover, which is the usual case, or can be flown right to the surface. Approaches to the surface are typically used when the pilot wants to minimize downwash, or does not want to hover for one reason or another (poor visibility is one reason that comes to mind). The pilot will find that a large amount of left pedal is required to maintain skid alignment as the helicopter decelerates through translational lift.

Whether the maneuver is going to terminate in a hover or to the ground, the pilot should align the skids with the ground track at approximately 100' AGL. This prevents a rollover accident should the skids touch down with forward speed.

Common Mistakes

Failure to maintain approach angle

Until the pilot can judge approach angle accurately, he may deviate from approach angle and not realize it. While overshooting onto steeper angles certainly occurs, the more common problem is failure to increase power to account for the back side of the power curve. Especially below 40 knot, the power required increases quickly, and the pilot may simply not raise collective fast enough.

Failure to decelerate properly

Airplane pilots who solo in helicopters are famous for flying very fast approaches (because of their trained in behavior to avoid low airspeed which can stall an airplane). Even non-pilots have this problem, though. Maintaining too high an airspeed until on short final causes a couple problems. Usually a flare is required to decrease ground speed, and if this is done too low a tail rotor strike is possible. Another problem is the pilot who flares and reduces his airspeed while keeping a high descent rate may encounter settling with power.

Failure to reach the LZ

As described above, on short final the power increase required will cause the helicopter to stop short of the LZ unless the pilot adds forward cyclic at the same time. Indeed, it's not unusual for student pilots to come to a hover well short of the LZ at about 35 feet, and then begin spinning around because as translational lift is lost the tail rotor loses substantial thrust, and a large increase in left pedal is normally required to counter this effect.

Running Takeoff

This maneuver is used to transition from the surface into forward flight when there is not sufficient power available to sustain a hover. This might occur if the helicopter is underpowered, is at high gross weight, or high density altitude.

This maneuver can be performed with either wheeled or skid equipped landing gear. In the case of skid equipped helicopters, the skids are equipped with skid "shoes" which are made of a very hard material. The shoe can be replaced when it is worn through, preventing any wear of the landing gear itself, which would typically be made of soft aluminium.

This description assumes skid gear, but is generally the same for wheels.

Maneuver Description

The helicopter is typically surface taxied into position. The skids are alighned with the direction of takeoff, and power is increased until the aircraft is light on the skids. Slight forward cyclic is used to start moving the helicopter forward.

During the slide, lateral cyclic is used to hold the centerline, and the anti-torque pedals are used to keep the skid gear aligned with the ground track. As the helicopter gains airspeed, the rotor system becomes more efficient, which makes the helicopter lighter, which reduces friction with the runway and allows the helicopter to gain airspeed even faster.

As the helicopter approaches translational lift, the pilot can use some aft cyclic to bring the helicopter off the ground. The reduction in friction will allow the helicopter to accelerate forward. If the pilot pulls back too far on the cyclic, airspeed will be lost and the helicopter will settle back onto the runway.

Eventually translational lift is attained, and the helicopter has enough excess lift to gain altitude and airspeed. The helicopter is kept low to the ground while it accelerates to best rate of climb airspeed. This ensures that if the helicopter loses airspeed and settles back onto the surface, that it will be a gentle touchdown, typically followed by a short slide and then a climb back into the air.

Once best rate of climb airspeed is achieved, the pilot can climb to altitude.

Common Mistakes

Not using maximum allowable rotor RPM

Helicopter rotor systems are more efficient at higher RPM, so using anything less than maximum allowable rotor RPM means there is less performance available. Since we are in a performance critical maneuver, it makes sense to maximize power available by bringing RPM up to the highest allowable value.

Piston helicopters also benefit because power available is directly proportional to RPM. If the engine is run at 95% of maximum allowable RPM, power available is 5% lower than if the engine is run at 100% of allowable RPM. This combined with the rotor system efficiency issue means that it is critical to maintain maximum RPM during any maximum performance maneuver.

If the helicopter has no excess power to spare, the pilot needs to be careful to avoid raising collective during the slide. Doing so may cause RPM to decay, reducing total power available. The pilot should not be in the habit of using collective during this maneuver. Instead, the power should be set to maximum, and all control inputs should use the cyclic. If the helicopter settles back toward the surface, minor collective inputs can be used to cushion the touchdown, but the pilot should be careful not to bleed down his rotor RPM with these inputs.

Failure to keep the skids alighned

It is critical, especially on turf or other soft and rough surfaces, to keep the skid gear alighned with the direction the helicopter is sliding. Allowing the helicopter to yaw can cause a sideways rollover.

Early Climbout

If altitude is gained too early, the pilot loses ground effect and will be unable to accelerate as rapidly as if he stays low. Also, if he attempts to climb out at too low an airspeed, the helicopter might not have enough power available, and could settle back onto the runway, possibly resulting in a hard landing.

We generally train people to remain below 10 feet until they have at least 45 knots of airspeed.

Too much forward cyclic

Many pilots will use a *lot* of forward cyclic in an attempt to get the helicopter to slide. This has two negative effects. One is that less vertical lift is available, because so much of the main rotor thrust is tilted forward. This increases the weight on the skids, and therefore the friction.

An even worse problem is that as the helicopter hits translational lift, the sudden increase in thrust will tend to nose the helicopter over forward. With the skids in contact with the ground, this pitch motion combined with the drag of the landing gear can cause the tips of the landing gear to dig in and flip the helicopter over forward.

The proper technique uses only a very little bit of forward cyclic, keeping most of the lift vertical, such that when translational lift occurs, the helicopter lifts off the ground in a skids level attitude. If the pilot can't get the helicopter to slide forward without excessive cyclic inputs, either he isn't using enough power, or the helicopter simply does not have enough power available for the conditions.

Failure to maintain runway centerline

A common mistake is to not correct for lateral drift during the slide. Failure to correct for lateral drift could potentially cause a dynamic rollover, but in any case it imposes side loads on the landing gear and is not good pilot technique.

The cyclic must be used to maintain centerline during the slide. If the helicopter is sliding to the right of centerline, left cyclic is required to bring it back. Generally you would not want to yaw the helicopter with pedal to regain centerline. Exceptions to this would be when gross lateral corrections are required at low speed. That shouldn't be required if the pilot uses good technique in the first place.

Trying to take off with too little power

If the helicopter is ridiculously underpowered, or the pilot does not use nearly enough power, the slide is going to be very long. Indeed it is possible to run out of runway in such a situation. If the slide is really going to be that long, the pilot should be examining whether the helicopter is safe for flight under the current circumstances. Possibilities are to offload some weight or wait until density altitudes are lower (ie. lower temperatures).

The pilot needs to keep in mind that if the helicopter can't hover, autorotational performance is going to be marginal.

Running Landing

This maneuver is used to transition from forward flight to a landing on the surface when there may not be sufficient power available to sustain a hover. This might occur if the helicopter is underpowered, is at high gross weight, or high density altitude. The helicopter might be underpowered if it has sustained a partial engine failure in flight. This maneuver is also useful in some helicopters for some emergency situations such as certain tail rotor failures or stuck pedals.

This maneuver can be performed with either wheeled or skid equipped landing gear. In the case of skid equipped helicopters, the skids are equipped with skid "shoes" which are made of a very hard material. The shoe can be replaced when it is worn through, preventing any wear of the landing gear itself, which would typically be made of soft aluminium.

This description assumes skid gear, but is generally the same for wheels.

Maneuver Description

This maneuver can be performed using any approach angle, however a shallow approach of 5 degrees or less is desirable because it minimizes the amount of power required to arrest the descent rate prior to touchdown.

The shallow approach is normal in every way except that the pilot plans his decelleration such that he arrives at his touchdown spot just above translational lift airspeed. This insures that adequate power will be available. The helicopter is transitioned onto the landing gear, and then forward ground speed is bled off during the slide. In some helicopters you can lower some collective to put additional weight on the landing gear. The increased friction acts as a braking force to slow the helicopter down more rapidly. Other helicopters require that the collective not be lowered during the slide.

During the slide, the cylic controls the ground track, the pedals control the heading, and the collective controls the braking force. The cyclic should typically be frozen in longitudinal pitch during the slide.

Depending on power available, the pilot may want to maintain some speed and surface taxi clear of the runway, otherwise the helicopter could become stuck on the runway with insufficient power to move it.

The amount of slide and the touchdown speed are dependent on the wind. A strong headwind will mean that there will be little if any slide. No headwind, or even a tailwind can dramatically lengthen the slide. Touchdown should be at the lowest possible airspeed above translational lift to minimize the slide ground speed and length.

It may be possible to decelerate the helicopter below translational lift with the skids just above the ground, in order to minimize the actual slide. If this is done from too high an altitude, the helicopter may settle hard onto the surface, and even flip over forward if the skids dig in.

Common Mistakes

First of all, many of the mistakes pointed out in Running Takeoffs apply, namely allowing rotor RPM to get low, not keeping the skids alighned, and not maintaining runway centerline.

Additional errors are:

Slowing below translational lift before touchdown

By slowing below translational lift before touchdown, the pilot risks a hard landing if power available is insufficient to hover below translational lift airspeed. Low time pilots are especially prone to this because they are unused to touching down with forward speed and therefore have a tendance to hold the aircraft off the surface while bringing their ground speed to a halt.

Touchdown in a non-level skid attitude

The skids must be level during touchdown. Touching down tail low can cause tailboom strikes, while touching down nose low can cause the helicopter to tumble over forward.

Many helicopters are not in a level attitude during the final deceleration, and the pilot often has to make a cyclic pitch adjustment before touchdown to level the skids. The adjustment required will depend on the helicopter make/model as well as the particular helicopter and it's center of gravity.

Moving the cyclic aft after touchdown

Pilots have a natural tendance to move the cyclic aft to help slow the helicopter down after touchdown. However, while this is a natural thing to do in the air, on the surface the tailboom can not move out of the way and an exaggerated aft cyclic input could cause the main rotor to tip back and strike the tailboom.

Moving the cyclic forward after touchdown

This is less common, but is sometimes done. It has the effect of making the helicopter slide faster and further, therefore it is counter productive.

Rotor RPM - Robinson R22

The Robinson R22 has a particular problem with low rotor RPM during the slide. At the low power settings encountered during the touchdown and slide, the R22 correlator typically rolls off too much throttle, bringing the RPM down low enough to activate the low RPM warning systems. This can cause the pilot to overreact and roll on a lot of throttle, possibly yawing the helicopter during the slide. Failure to increase the RPM however, decreases tail rotor authority and increases main rotor flapping. Therefore R22 pilots should be monitoring RPM during approach, and hopefully adjusting throttle before touchdown occurs.

Maximum Performance Takeoff

This maneuver is used to transition from a hover into forward flight when obstacles prevent the use of a normal takeoff.

Maneuver Description

Position the helicopter

First of all, we want to use the shallowest takeoff angle which gives us safe obstacle clearance. The shallower the takeoff, the less we get into the shaded area of the HV curve.

The helicopter should be placed light on the skids if the terrain allows. This maximizes ground effect which will give us some extra forward and upward momentum. If the terrain does not allow touchdown, maintain the lowest safe hover you can.

Begin the takeoff

With the helicopter light on the skids, increase power to maximum. For training, we teach approximately a 40 knot pitch attitude, but in actual confined area operations the attitude will be determined by the angle required to clear obstacles.

A word about Rotor RPM and MP/Torque

One critical part of a maximum performance takeoff is that rotor RPM must be at maximum allowable RPM. There are two reasons for this. The first is that the rotor system is more efficient at higher RPM than at lower RPM because of the reduction in induced drag. The other reason is that the powerplant can typically put out more horsepower at higher RPM versus lower RPM.

In our Robinson R22 helicopters (without a governor) I tell people to calculate their limit manifold pressure setting, while sitting on the ground. Then during the takeoff I advise pilots to pull collective until they reach a power setting 1" less than maximum. A quick glance at their rotor tachometer will tell them whether the rotor RPM has drooped. If it is slightly low, the last 1" of manifold pressure can be used by rolling on throttle, thus increasing RPM to the top of the green. On the other hand, if the rotor tach indicates maximum rotor RPM, the last inch of manifold pressure can be used by simply raising collective.

In our non-correlated Enstrom, it's even easier. Coordinate throttle and collective until throttle hits the stop (!). If the rotor RPM droops below the top of the green, you've pulled too much collective and you simply need to lower it slightly to allow rotor RPM to recover.

In our JetRanger, I increase power until I reach my limit of torque or temperature. I usually leave myself a little leeway so that a quick jab of left pedal won't spike me past redline (even though there is a margin, I don't like to use it). If N1 topping causes an RPM decrease, lower the collective to maintain maximum rotor RPM.

Clearing the obstacle

Continue to accelerate and climb until the obstacle is cleared, and then adjust the attitude of the aircraft to accelerate to normal climb out speed.

Common Mistakes

Not starting from within maximum ground effect

If the helicopter has plenty of power to spare, a maximum performance takeoff can be started from a normal hover. When power is marginal and we need to get every bit of performance from the helicopter, starting from the lowest hover possible will give us extra performance during the first few seconds of the maneuver.

Rushing, and using too much power

People seem to think they have to increase the power rapidly. This tends to make them overshoot their target, and pull more than maximum allowable power. While the power increase shouldn't be *too* slow, it should be slow enough for the pilot to be smooth and precise.

Dragging down the rotor RPM

This is probably the most common mistake pilots make. Especially when that tree is getting too close! However a pilot needs to fight the urge to raise collective, and instead maintain maximum power on RPM and concentrate on smooth cyclic work to get up and over the obstacle.

Using too shallow a takeoff angle

Some pilots have a tendance to keep the angle shallow, try to gain speed, and then use aft cyclic to "zoom" over the obstacle. Most of us find this technique a little frightening. I'd rather be *gaining* airspeed in the climb than trying a zoom where I'm *losing* airspeed as I try to make it over the obstacle. That could cause me to mush into the obstacle if airspeed got too low.

There is one technique I use which looks a little like this, but isn't really the same thing. On some hot days, the helicopter simply may not have the power to hover higher than a foot or two. This simply isn't going to get you over a 40 foot tree! One technique is to accelerate forward into translational lift and *then* bring the nose up into a 40 knot attitude. The idea is that with translational lift, the helicopter has enough excess power to gain altitude. However, we are *not* gaining airspeed and then bleeding it back off for altitude. Instead, as soon as we reach ETL, we begin a climb, still accelerating and gaining altitude.

Pitching the nose up when an obstacle gets near

As you climb toward your obstacle, a natural reaction is to pull back on the cyclic to try to get some extra height above the obstacle. You don't normally want to do this. Remember that as you accelerate toward your best climb speed drag is decreasing, giving you more power availble. Pulling back on the cyclic slows you, and gives you *less* power available. You want to continue to hold enough forward cyclic to be in an attitude which gains (or at least maintains) airspeed as you climb out. If it becomes obvious that you are not going to clear the obstacle, abort the takeoff and land where you took off from. Until then, resist the urge to pull back on cyclic because you could easilly lose enough airspeed to actually start to sink into the obstacle you are trying to clear.

A word about aborting maximum performance takeoffs

Any pilot should always have a few options. One of the really nice things about helicopters is that you can abort almost any takeoff, land where you took off from, and then try the takeoff again. This takes proper planning, and recognizing that the abort is required before it is too late. If you have been taught maximum performance takeoffs, but not how to abort the takeoff, you should get some more training. Under normal circumstances, you should never have to commit yourself to making it over the obstacle.

Steep Approach

This maneuver is used to transition from forward flight to a hover or a landing when a normal 10 degree approach will not clear obstacles.

Maneuver Description

Approach Angle

We usually consider a normal approach to be a 10 degree approach. More than 10 degrees is considered to be a "steep" approach. You can fly any steep angle you have the power for, up to 90 degrees. However, for the purposes of teaching we use 15 degrees as a "steep" approach.

The maneuver is similar to a normal approach except that at a given altitude you will intercept the 15 degree approach angle closer to your landing area than you would while intercepting a shallower angle. This typically requires a slightly more aggressive decelleration than for a normal approach, since you have to get rid of the same amount of airspeed, but over a shorter distance.

You will also notice that the collective will initially have to be at a lower position than for a normal aproach, and you will be holding more right pedal as well.

The approach and deceleration are exactly the same as for a normal approach, simply at a steeper angle. The controls are manipulated the same as during a normal approach.

The next big difference you will notice is that you will be at a higher altitude when losing translational lift than during a normal approach. This will require more power than a normal approach would, and needs to be included in your pre-approach planning.

Settling with Power

The steeper the approach is, the more likely the pilot is to encounter settling with power. Remember that descent rate should be below 300 feet per minute before you lose ETL (Effective Translational Lift).

A common mistake people make is to keep their airspeed high in an attempt to avoid settling with power. This actually makes things worse, since your descent rate is dependent on your ground speed. A higher airspeed means a higher ground speed, means a higher descent rate. You are actually much better to fly a slow approach in order to keep your descent rate low. The key is to make sure you decrease your descent rate below 300 feet per minute before you slow below ETL.

Common Mistakes

Failure to maintain approach angle

Until the pilot can judge approach angle accurately, he may deviate from approach angle and not realize it. While overshooting onto steeper angles certainly occurs, the more common problem is failure to increase power to account for the back side of the power curve. Especially below 40 knot, the power required increases quickly, and the pilot may simply not raise collective fast enough. If you are using a steep approach to clear obstacles, a descent below approach angle may settle you into the obstacle you are trying to avoid. Therefore it is important to immediately counter any tendency to settle with immediate application of power. This also will help prevent an entry into settling with power if airspeed is below ETL.

Failure to decelerate properly

A common mistake is to have too much air/ground speed on short final during a steep approach. This is caused by a number of things: less time to decelerate, higher altitude above terrain making the speed *seem* slower, fear of an engine failure. This tendency toward high speed needs to be fought. It is much better to be a little slow and have to add a little extra power to maintain altitude, than it is to be fast and have to flare. A steep approach is being used because of obstacle clearance concerns, and a flare drops your tail rotor right into the obstacles you are trying to miss.

Confined Area Approach

This procedure is used when landing almost anywhere off airport, but especially when the area is fairly small.

Maneuver Description

The maneuver starts long before the approach. The pilot needs to come up with a strategy of how best to get in, and then out, of the confined area. One mneumonic is "SBATT" which stands for *Suitability, Barriers, Approach, Touchdown, Takeoff.*

When determining Suitability, the pilot is examining many factors. Some of these would be issues like "do I have permission", "is it legal", "is the area big enough", "will the helicopter be a nuisance". If the answer to any of these is "no", the pilot should consider another landing area.

Barriers refers to the identification of anything we don't want to fly over or through. This could be physical objects such as mountains, tall towers or buildings, wires, and also non-physical barriers such as noise sensitive areas, areas with large number of people outdoors (athletic fields, schools), or some kind of restricted or prohibited airspace. After finding all the barriers, what is left over can be used for the approach and departure.

Approach means determining the *best* way in and out of a landing area. There are almost always many ways to approach a landing, but some ways may be better than others. New pilots often just set up the approach to be into the wind, and leave it at that. But the wind is only one small part of figuring out the approach. Factors that should be considered are approach paths which are within reach of good emergency landing areas if the engine should quit, the possibility of turbulence, the height of obstacles which will have to be cleared on approach, and the annoyance factor of the people on the ground. Although a downwind approach usually should be avoided, by taking a crosswind the pilot may gain many other advantages.

Touchdown means selecting the touchdown spot. Usually we try to select an area in the last 1/3 of the LZ because this makes our approach angle shallower, and increases the chance of us making the landing zone if the engine quits on short final. There are other factors which may make us select a different touchdown area, though. For instance, the touchdown spot needs to be one we can either perform a takeoff from, or which lets us hover to a spot from which a takeoff can succeed.

Takeoff means plan the route of takeoff so that it is not downwind, doesn't fly through or into any of the barriers we have identified, and has good emergency landing areas available.

The High Recon

Keep in mind that all this planning is going on well before the pilot starts the approach. Usually this is done from a *high recon*, which is often done by overflying the LZ at 500 feet. As the pilot overflies the spot, he goes through *SBATT* and comes up with a strategy. Once the approach path is determined, the pilot can figure out his relation to that approach path, and fly a standard traffic pattern which will align final approach with the chosen approach path. Some pilots don't fly a traffic pattern, they just sort of spiral into the approach, but I like to fly a rectangular traffic pattern so that all the things that go on during approach occur at their normal time. The largest difference is that I usually fly a much tighter, slower traffic pattern than at an airport.

The Low Recon

There are several different ideas out there of what constitutes a *low recon*. I have always been taught that the low recon occurs while on approach, the idea being that as the pilot gets lower and slower he is constantly re-evaluating his plans based on new information he gets.

I know some pilots who believe a low recon means overflying the LZ at 100-200 feet in order to spot details which are not visible from higher altitude. While I like the idea of giving the area a closer look, flying 100-200 feet over houses, schools, and shopping centers doesn't seem like such a good idea to me, from a community relations standpoint. I would use this option if I was out in the boonies, or I had good reason to believe that I needed a close look before setting up my approach.

Final Approach

My general rule is that the tighter the spot, or the less familiar I am with the area, the slower I fly final. This gives me more time to see and avoid surprises. Also, the steeper the approach angle, the slower I fly, because I'm trying to avoid settling with power. The descent rate required on approach is directly proportional to the speed and angle. To keep a low descent rate (below 300 feet per minute before losing effective translational lift), either the angle or the speed needs to be low. Therefore a high angle requires a low speed.

Depending on the place we are landing, my descision to commit to a landing is dependent on a few major factors: power available and obstacle clearance. If I have lots of power so I can go straight up if I need to, I don't have to commit to a landing because of obstacles. I can always just pull up on collective and climb right out. It's pretty rare to have that much power, though. Usually I need to have ETL (effective translational lift), and a reasonable amount of obstacle clearance. As a rule of thumb, once I'm below the tops of the obstacles, I'm committed to land. Like any rule of thumb, it doesn't apply to all circumstances, but the point is to be thinking about this on short final, and to *have a plan of action* if something goes wrong.

Landing

Confined area landings usually require the pilot to be alert to a few things. The first is that extreme caution needs to be used with regard to the tail rotor. Confined areas often have lots of bushes or other obstacles which can destroy a tail rotor. Part of selecting the landing area is to select the exact spot the pilot is going to place the tail rotor. The main rotor will usually be above the smaller obstacles, and in the event it does contact an obstacle, it's usually much more able to stand up to the abuse than a tailrotor would be. If the helicopter has to be hovered around inside the landing area, the pilot should be devoting much of his attention to where the tailrotor is.

Takeoff

Usually a maximum performance takeoff will be used to depart a confined area. It is important for the pilot to have planned the departure route while doing the high recon, because often when he is inside the confined area he can't see the surrounding area well enough to plan a good departure. Generally the takeoff should be with a head or cross wind, and the ground track should avoid the barriers identified on the high recon. If the helicopter is unable to clear the obstacles, the pilot should abort the takeoff early enough to allow him to land back on the spot he just took off from.

Quick Stop (Rapid Deceleration)

This maneuver is used to decelerate from forward flight to a hover. It is often used to abort takeoffs, stop if something blocks the helicopter flight path, or simply to terminate an air taxi maneuver.

Maneuver Description

The maneuver can begin from just about any combination of airspeed and altitude, but is typically practiced from around 25 feet AGL and 40 knots. The maneuver can be broken down into 3 parts: the flare, the deceleration, an the approach to a hover.

The Flare

To begin the maneuver the pilot flares the helicopter by pitching the nose up with aft cyclic. The flare would normally cause the helicopter to gain altitude, but in this case the pilot reduces collective to prevent a climb from occuring. The power decrease will require right pedal to be applied as well. The pilot can adjust how quickly the helicopter will decelerate by how aggresively he flares. The more aggresive the flare, the faster the helicopter will stop. Too agressive a flare will cause a tach needle split (the rotor will spin faster than the powerplant), and this is generally not the way the maneuver is flown, although nothing harmful will result from this.

The Deceleration

The helicopter will decelerate as the pilot holds the flare. Because the airspeed is decreasing, the flare will immediately start to lose energy, and the helicopter will try to settle. Instead of allowing the helicopter to settle, the pilot can increase the flare. This will maintain altitude, and cause the helicopter to decelerate even faster. There is an upper limit to how much the pilot should flare the helicopter. The deceleration becomes so fast it is more difficult to judge, plus the helicopter ends up in an extremely tail low attitude.

Instead of continueing to pitch the nose up, the pilot can start adding power to maintain altitude. He does this by raising collective. This not only maintains altitude, but it maintains rotor thrust and keeps the helicopter decelerating quickly. The pilot should continue to hold altitude and attitude until he is about to lose ETL (effective translational lift).

Approach to a Hover

Before ETL is lost, the pilot pitches the nose of the helicopter back down into an approach attitude using forward cyclic. The attitude is still slightly nose high, as on a normal approach, but is not in a flared attitude. The pilot can simply look ahead of the helicopter and pick a spot aligned with a 10 degree approach angle. He then flys a normal approach to the spot.

Common Mistakes

Descending while in the flare

Many pilots actually allow the helicopter to descend during the deceleration phase of the maneuver. Many instructors teach the maneuver that way. I don't personally like that method for a couple reasons.

One reason is that I don't think the helicopter should approach the ground tail low. Although pilots are generally aware of their tail rotor, occasionally people forget and wipe out the helicopter with a tail rotor strike. I feel that if the maneuver can be flown in a way to minimize this hazard, it *should* be flown that way.

Another reason I don't like descending in the flare is that it means the helicopter is descending directly into it's downwash as it goes through ETL. This is a classic way to set up settling with power. Pilots normally think of high vertical descent rates as causing settling with power, but a more accurate description is a high velocity aligned with the rotor vortex. You can settle with power sideways if you try hard enough. If you watch a pilot performing a quick stop who descends while in the flare, you can see that he is settling directly into his vortex. Usually the helicopter reaches ground effect in time to avoid power settling.

My belief is that by maintaining altitude during the deceleration, the pilot stays above his vortex (similar to an out of ground effect hover) and eliminates the chance of settling with power, as well as eliminating the chance of a tail rotor strike. The termination of the maneuver is a normal approach, so if the helicopter has enough power to fly a normal approach, it has enough power to terminate this maneuver.

Ballooning

A common mistake is to flare, but not lower enough collective to compensate for the increased lift. This will cause the helicopter to balloon, or gain altitude. If the flare is *really* aggressive, full down collective will not be enough to prevent altitude gain. Altitude gain is not desirable because it puts you deeper in the HV curve.

Incorrect anti-torque pedal manipulation

One of the reasons instructors love to have students work on quick stops is that it really helps them get the hang of the anti-torque pedals. This is because during the entire maneuver, torque is changing constantly. Failure to do this will cause the helicopter to yaw during the maneuver.

Losing ETL

A pilot who holds the flare so long that effective translational lift is lost may have a problem if the helicopter does not have enough excess power available to hover out of ground effect. If the helicopter loses ETL 30 feet in the air, this is equivalent to attempting a 30 foot OGE (out of ground effect) hover. If the helicopter does not have adequate power for the hover it will descend and very likely hit the ground hard. It may even enter settling with power. If it does that it will hit *really* hard.

Failure to totally stop

A common mistake is to enter the desired hover height with some forward speed. This often occurs when the pilot does not use sufficient power, and the helicopter descends to a hover height while it still hasn't had time to fully stop. The problem with this is that aft cyclic is now required which is going to cause the tail to drop, and little altitude is available so that too much aft cyclic could cause a tail strike.

Failure to hold centerline

Another problem that student pilots often have is holding centerline during a quick stop. The helicopter goes through transverse flow effect while decelerating in a quick stop, and failure to correct for it with lateral cyclic will cause the helicopter to veer to the side while in the flare.

Hover Out Of Ground Effect (OGE)

Hovering out of ground effect is the same as hovering in ground effect except that it will generally require more power due to not being in ground effect.

Basic Concepts

There are many reasons a helicopter pilot may need to hover out of ground effect. In some cases, he will be hovering fairly close to the ground, but need to stay a little higher than 1/2 rotor diameter in altitude. A common reason might be obstacles that prevent a landing such as tall grass, shrubs, etc.

In other cases, he may be coming to a stop hundreds or thousands of feet above the ground. Electronic News Gathering (ENG) helicopters do this all the time when on station filming a breaking news story. So will helicopters involved in external lift operations.

Performance Charts

Every helicopter Pilot Operating Handbook (POH) has both In Ground Effect (IGE) and Out Of Ground Effect (OGE) hover charts. This allows the pilot to predict whether the helicopter will be capable of hovering OGE or not. If the performance chart indicates that the helicopter is not capable of OGE hovering at the particular density altitude and weight, the pilot will either have to plan to use an IGE hover, or will have to make some other change to enable OGE hover, such as reducing the weight of the aircraft, or waiting until the temperature is lower.

Ring Vortex State

Ring Vortex State (or Settling with Power) is never a problem when hovering IGE, but is always a possibility when attempting to hover OGE. If the pilot zeroes his airspeed and attempts to hover out of ground effect but does not have adequate performance, the aircraft will start to settle into the rotor downwash. If the pilot allows this to reach around 300 feet/minute or so, the aircraft can enter the ring vortex state. Depending on how high above the ground the helicopter is, the pilot may or may not have enough altitude to recover. Thus one of the things a pilot should do when attempting to hover OGE is to assure himself that he has adequate power to maintain the hover. Generally he would do this by checking the POH before the flight, or examine the power gauges as he comes to an out of ground effect hover.

Holding Position

In a low IGE hover, a pilot generally holds position by just looking at the ground in front of or next to the helicopter. If the helicopter starts to drift, the pilot makes control inputs to maintain a zero ground speed.

When hovering OGE hundreds or thousands of feet in the air, this is a more difficult task because it is not as apparent when the helicopter makes small movements over the ground.

Besides just looking at the ground far below the helicopter, the pilot can line up objects to determine if he is moving. For instance, if he sees a tree in front of a building, and the tree is in front of a particular window, movement of the helicopter will cause the tree to move against the building so that it no longer appears in front of that particular window. A control input to move it back will help to restore the helicopter position. With two or more well picked pairs of objects, the pilot can hold position fairly accurately. In addition, he can use parts of the helicopter such as the landing gear against the backdrop of the ground to help hold position. If he moves his head, hover, that picture will change and he needs to account for that.