TIGER MOTH AEROBATICS

By David Phillips

Preamble
I was recently asked to provide some notes on Tiger Moth Aerobatics to be used as an appendix to a Warbirds aerobatic training syllabus. As I wrote these notes, I was constantly aware of a feeling of: "Well, this is how I do it, but what is the correct or ideal way …?" I have never seen any formal notes on Tiger aerobatics.

The following represents most of what I know about aerobatics in the Tiger. The vast majority of it has been taught or shown to me by others, or has been pinched from Neil Williams's book on the subject. I think it (my brief, not Neil's!) is probably flawed in places, and it certainly is not supposed to be authoritative. My reasons for presenting it here are mostly selfish — I would like to increase my knowledge of the subject. So I am inviting criticism of, and additions to, what I have written below. "Additions" includes alternative ways of skinning the cat.

In particular I would be keen to hear from people who grew up with Tigers, as they probably have clearer and purer recollections of the original way of doing things. Also knowledge of or anecdotes about flick manoeuvres, bunts, inverted spins and inverted flying are most welcome. For example, some flight manuals prohibit bunts and outside loops — but one of Alan Cobham's Tigers did 1500 or so of them in the 1930s.

So, if you have anything to offer on the subject please contact John King and myself via the Contact page on the website. Hopefully what we'll end up with is a forum/discussion via the Cyber Moth, where all and sundry can pick and choose whichever techniques they like best.

Aerobatics — a basic guide

The aim of this brief is to provide a simple and basic guide to aerobatics in the Tiger Moth. To keep it simple, some of the suggestions do not represent textbook or competition style techniques, but rather just an easy way of getting the job done with minimum height or energy loss for someone who is new to either aerobatics or the Tiger Moth. For example, the section on looping will give you a loop that is straight, and (importantly in my view) comfortable to the pilot and passenger, but will be egg shaped rather than perfectly round.

To begin with, some explanations:

1. Top rudder: rudder applied for the purpose of preventing the nose from dropping in relation to the horizon. For example — consider a 360 degree roll to the left from wings

level: an application of top rudder would involve right rudder for the first 180 degrees of roll, and left rudder for the second 180 degrees.

2. Use of rudder: the secondary effect of rudder is roll. Right rudder produces right roll, but only when positive G is applied. If you are flying straight and level and push to minus 1 G, and then apply right rudder, the aircraft will roll left. This is of course due to the negative angle of attack. Logically then rudder with 0 G should produce no secondary roll. This is almost true — but for the Tiger with its dihedral there may still be a slight effect.

This variable G dependent secondary effect is of significance with all rolling manoeuvres, and the stall turn.

As Neil Williams says in his book *Aerobatics* (from which a lot of what follows has been taken): “The misuse of rudder causes nearly all the minor problems in aerobatics …”

Overview

The Tiger Moth is lively and responsive in pitch and yaw (elevator and rudder) but is lethargic in roll (aileron response). Consequently it is good for manoeuvres such as loops, spins, wingovers and stall turns, but requires some finesse with rolling manoeuvres. Even the barrel roll, which can almost be regarded as a crooked loop, takes a moderate degree of skill to complete satisfactorily.

Before practising solo aerobatics in a Tiger, the pilot should be proficient in spin recovery. He or she should also be proficient at recovery from nose high/zero airspeed situations and the frequent consequence of same — the windmill engine restart after the propeller has stopped moving.

Despite its appearance, the Tiger is very robust due to efficient structural design. The highest risk of damage from aerobatics comes from the low speed/nose high situation, and from excessive G loading at high speeds.

Low speed/nose high

The elevators and rudder in particular are very large, and can be damaged if a tail slide of any significance develops. To prevent this, the pilot should try to avoid getting the aircraft “hung up” or stopped in a vertical climb attitude. Avoidance of this can be achieved even at very low speed by firm use of up elevator with full power applied. This will keep at least SOME positive loading on the aircraft until the last moment, which in turn will keep the gravity fed engine running, which will give you some elevator and rudder effectiveness even at zero airspeed. Use these controls to get the nose through or away from the vertical.

Full power will also impart maximum rotational momentum to the propeller, so if the engine does later stop due to lack of gravity feed, the prop is more likely to keep rotating for long enough to re-establish fuel feed and/or a nose down accelerating situation which will allow the prop to windmill and continue turning.

If you push forward on the control column significantly whilst in or close to a vertical climb, the engine will stop instantly, after which you will have little or no control until the nose falls through — in whatever fashion — to a steep nose down attitude. Any time you find yourself approaching zero airspeed with the aircraft in a near vertical attitude AND with the engine at low or zero throughst, it is vital that the controls — elevator and rudder in particular — be held neutral with all your strength. This will minimise the likelihood of damage due to a tail slide with a "controls hard over" situation developing.

High speed
Not a term you hear used much with respect to Tiger Moths — but it can be done. V_{ne} is 160 mph, and anecdotal evidence from a 1950s era ag pilot suggests the terminal dive velocity (full power) is 230 mph. This figure is verified by some Type Record archives unearthed by Keith Trillo.

Any time you exceed even 130 mph during aerobatics in a Tiger you are probably just giving away height and performance for little gain — a necessary evil when doing a roll off the top with its 135 mph entry speed. Another occasion when you may see speeds above 130 is when you are performing a windmill engine start. Be VERY gentle during the ensuing dive recovery. According to Keith's Type Records "Summary of Load Factors", the structure is good for 7.5 G at the stall, but is only good for 1.5 G at 235 mph. (I am surprised it is good for anything other than firewood at this speed!)

An accident report — also unearthed by Keith — regarding wing failure on a Tiger in the Waikato in the late 1950s suggests by interpolation of the Type Record figures that the structure would be good for only 4G at 140 mph. It is very, very easy to exceed 4G at and above this speed as most Tigers will have a strong nose up tendency even with the trim fully forward. Having said that, the only instances of catastrophic structural failure that I have heard of have resulted from either rotten wings (such as in the case above) or mismatched threads on the flying wire fork ends.

Pre flight
Ensure the aircraft is at or below the maximum weight for aerobatics (1770 lbs), and that there are no loose or heavy objects in the baggage locker. Ensure your harness is as tight as you can possibly make it — especially if it is an original Sutton harness. After the first loop the seat cushion will compress and your straps may feel loose again. If possible obtain a very firm seat cushion or a parachute to minimise this effect.

Also, with the Sutton harness, ensure once strapped in that there is no possibility of the top of the control column fouling the piece of string that attaches the harness locking pin to the right-hand shoulder strap. This can happen if the string is too long — forward stick can then catch the string and pull the pin out, especially during a slow roll. This I believe is the reason that the RNZAC's D.M. Allen Memorial Trophy (for aerobatics) has the "Memorial" part in it.

Airborne

Hasell checks as usual. Then set full power and enter a gentle dive and keep accelerating until you reach limiting engine rpm. This will vary according to which version of Gipsy Major engine is fitted, and what the pitch of the propeller is. For most Tigers limit rpm of 2350 or 2400 occurs with full throttle at about 120 mph. Assuming the limit for your particular engine/prop combination is 120 mph, then at any time your speed is equal to or less than this, you can use full throttle and be confident without reference to the rev counter that you are not overspeeding the engine. Above 120, you will have to throttle back to maintain the rpm within limits.

Basic handling exercises

Apply full power and pull the nose up to about 45 degrees above the horizon, and try to hold it there as the aircraft slows. You will end up with the stick fully aft and the nose trying to break left or right with an associated wing drop. With deft use of the rudder only, you will be able to keep the wings level to within about 20 degrees or so for quite a while, with the aircraft tracking more or less in a straight line. There will be considerable buffeting. The key is to prevent any yaw developing, as without yaw a significant wing drop will not occur (on my Tiger anyway!). The objective is to develop a good feel for the Tiger's low speed habits, and rudder use in particular.

Now resume normal level flight and have a good look at the slip needle (top half of the turn and slip indicator) and become comfortable with what it is telling you. In straight and level flight with cruise power, smoothly apply half or two-thirds left and right rudder whilst keeping wings level, to become familiar with how the aircraft feels with significant rudder deflection, and to observe the slip indications. Then try full left and right aileron whilst keeping the rudder central, and note the same.

Next, try a series of steep turns and reversals — 60 to 80 degrees bank angle — using FULL aileron to enter the initial turn and FULL aileron for the rapid reversals from left to right to left etc. The objective is initially to keep the slip needle more or less centred throughout, and then later to be able to do the same without reference to the slip needle.

The overall aim is to develop a good seat-of-the-pants feel for when the Tiger is in balance, and a feel for how much rudder is required to balance large aileron inputs and turn reversals.

Wingover

This is an excellent manoeuvre to develop coordination and a feel for the aircraft. Apply full power, dive gently to no more than 110 mph, followed by a pull up to approximately 45 degrees above the horizon, followed by a roll to 90–110 degrees angle of bank. Allow the nose to fall through the horizon to approx. 45 degrees nose down, gently rolling to wings level as it does so. Recover from the dive and pull up again to repeat the exercise in the opposite direction.

Minimum indicated airspeed at the top of the manoeuvre may vary from 60 mph down to zero. There should be very little G felt at the top of the manoeuvre, as you "float" over the top. Of course, if you only have 20 mph IAS at the top, you will not be able to pull much G without stalling. The reason the aircraft can still “fly” at 20 mph is that the loading on the aircraft is much less than 1 G at this point.

You know you are “wingovering” properly when the aircraft stays in balance throughout, and when the manoeuvre feels smooth and comfortable throughout … no sudden changes of G loading, no feeling as though you are falling to one side of the cockpit or the other, and no negative G or falling sensation with the resulting instant engine (but not prop) stoppage.

When you are comfortable with the wingover, you can experiment with gentle forward stick inputs at the top of the manoeuvre to determine just exactly how much zero G or slight negative G the engine will tolerate before it cuts out. This will be useful in subsequent manoeuvres — the loop and stall turn in particular — where you might want to make the manoeuvres more rounded or more vertical but without losing power when you do so.

The loop

(For this and all other high speed entry manoeuvres, trim for full power and no less than 90 mph).

From straight and level flight, apply full power and dive gently (approx 20 degrees nose down) to the 115 mph entry speed. Then press the stick smoothly back to achieve a good rate of pitch, ensuring that the aircraft remains in balance (slight left rudder required as the speed drops) and that the wings remain level. As the nose rises well above the horizon, transfer your scan to both wingtips and their adjacent horizons to monitor your progress around the loop.

Keep a slight amount of positive G on over the top of the loop, otherwise the engine will stop; the objective here (initially anyway) is not to make a perfectly round loop but rather to make a perfectly comfortable (probably egg-shaped) one. As you get to within 30 degrees (or so) of inverted, referenced from your wingtips, look towards the front again, looking over the top of the fuel tank — to find the horizon again and to ensure that the wings are level. As you accelerate down the back side of the loop, increase the G loading so as to bottom out at the same speed and altitude as at entry. Slight right rudder may be required as the aircraft accelerates. Continue with the back pressure until the nose is 20 degrees or so above the horizon to conserve energy, and level out when the speed is back at approx 90 mph. Remain at full throttle throughout.

The stall turn

It is important to ensure that the engine does not stop due to fuel starvation during this manoeuvre, as good rudder authority is essential. So don’t pull up beyond the vertical, or push once the vertical is attained, as either of these sins will result in fuel starvation and engine stoppage — with the possible consequence of propeller stoppage.

Additionally, it requires significantly more skill to stall turn to the left than to the right, due to the effect of slipstream from the engine.

For these reasons I suggest that during the early stages, and until familiarity is gained, that all stall turns are done to the right, and from a pitch attitude of slightly less than vertical. And ALWAYS have sufficient altitude available for a windmill start. My first Tiger Moth ended up in a paddock twice as a consequence of ignoring these rules. (No, I don't have a learning disability — the second time I was watching from the ground!)

The stall turn can be completed from level flight at cruise power, but using the same entry parameters as for the loop — 115 mph — will allow more time to achieve and assess the vertical climb. This is important. As with the loop, remain in balance and keep the wings level. Failure to do so will result in ending up pointed to the left or right of vertical, and the turn at the top will be more difficult if it is opposite to the bias you have allowed to creep in.

Rear seat references: when your flight path is exactly vertical, the top surface of the bottom wing tip area will appear to be at or very slightly over 90 degrees to the horizon (taking into account the positive incidence of the wing (rigging angle) and the curvature of the aerofoil. It may be easier to reference from the top of the cockpit door which should be just short of vertical, although due to your line of sight you cannot view this directly against the horizon.

From the front seat, the spear at the flying wires intersection makes a good reference, at or slightly over the vertical. The top of the cockpit door may also be used.

As with the loop, pull up smoothly to the vertical using the same references and remaining in balance, and ensure you are not one wing low. When you get to the vertical (or as close to it as you want) STOP all movement in pitch. Ensure that the top surfaces of the lower wings REMAIN at (close to) 90 degrees to the horizon. If you allow even a small pitch rate to continue, the aircraft will roll as it yaws over the top of the manoeuvre and your exit will not be 180 degrees out from your entry.

This roll is caused by the secondary effect of rudder due to the slight positive angle of attack resulting from the pitch rate. This is a very common error, often caused by the pilot being in a hurry to get out of the vertical due to the rapidly decreasing air speed indication.

Resist this temptation. For an ideal stall turn there should be a well defined vertical track AFTER you have stabilised in the vertical, and BEFORE you start the turn.

Stall turn RIGHT (with the engine): ideally we should wait until the aircraft comes to a stop before applying full right rudder. With practice this point (zero airspeed) can be sensed without looking inside the cockpit. The vibration changes subtly and there is a sense of the prop cavitating. If you are reluctant to wait this long, then the point at which the airspeed decreases through 40 mph is a good reference. Apply full right rudder, and the aircraft should pivot on its axis and the nose should cut through the same piece of the horizon the right wingtip was previously on, with the left wingtip doing likewise soon thereafter. As you go over the top of the turn, keep the wings vertical with the ailerons.

Once the nose is below the horizon, the yawing momentum will tend to swing the nose to the right beyond the vertical down line, and this should be opposed with coarse left rudder to stop the aircraft exactly at the vertical.

Leave full power on throughout. As the speed increases, and after you have established a vertical track downwards, gently ease out of the dive and raise the nose above the horizon as per the exit from the loop to conserve energy.

When comfortable with the basic workings of this manoeuvre, focus on getting the aircraft exactly vertical to begin with.

Stall turn LEFT (against the engine): this can easily turn into an equal competition between the left-yawing force of the rudder and the right-yawing force of the slipstream. We can help the rudder slightly in this competition by using it slightly earlier, and by reducing power somewhat at the same time. Decelerating through 50 mph in the vertical, briskly apply half left rudder, and as the nose starts to yaw reduce power by about half. As the nose continues to yaw, feed in more left rudder and progressively further reduce power.

The idea is to get the nose moving left and to keep it moving; once it has gone past 45 degrees or so gravity helps significantly and slipstream becomes less relevant. Again use coarse (right this time) rudder to prevent the overswing on the vertical down line, and smoothly re-introduce full power before pulling out.

If you use too much rudder too early on the vertical up line, the yawing force produced will be opposed and balanced by the stabilising force of the airflow (ie NOT engine produced slipstream) acting on the fin and rear fuselage. This will result in a stable (non yawing) upward sideslip. Yawing momentum is lost, and the aircraft may well become "hung up" with the nose 15 or 20 degrees left of the vertical.

Gravity eventually prevails. If the pitch attitude is less than 90 degrees, the aircraft will tend to pitch forward (negative G) starving the engine. If the aircraft was sliding backwards immediately prior to this, the chances of propeller stoppage are high. For this reason, it is more important to have the aircraft tracking exactly vertically to begin with.

To summarise: the stall turn right is relatively simple as the rudder and slipstream act together to yaw the aircraft through 180 degrees. This powerful yawing combination allows an acceptable stall turn from as low as 70 degrees nose up — 20-odd degrees before the vertical. The stall turn left, however, relies to a large degree on gravity to pull the nose around. If the attitude is significantly short of the vertical, then the aircraft will simply pitch forward in a very messy manoeuvre.

The name “stall turn” is actually inappropriate as the aircraft should not stall; the angle of attack should remain at zero and never get anywhere near the 15 degrees stalling angle. The American term “hammerhead” more accurately describes the manoeuvre.

Rolling manoeuvres
Quite a challenge in the Tiger, as the ailerons are not powerful and can be easily overpowered by the secondary effect of rudder at low speeds.

Aileron roll
Because the roll rate is so slow, it is necessary to get the nose well above the horizon before starting, otherwise you will end up with a very nose low exit. However, it is also necessary not to get the nose too far above the horizon, otherwise you will get too slow which in turn will markedly lower the roll rate — and you will again end up with a very nose low exit. Unfortunately these two requirements overlap, and the only antidote is more speed on entry.

Dive to 115 mph with full power, then pull the nose up to 25 or 30 degrees above the horizon. STOP the pitch rate, ie remove any elevator input, then apply full aileron and just a touch of rudder to balance. The objective from here on is to achieve a maximum rate of roll with a minimum of nose dropping below the horizon. Return the rudder to central by the 45 degree point, and as you go past 90 degrees start easing the stick forward as much as you dare without stopping the engine. Note: in my experience the engine is slightly more tolerant of 0 or slight negative G whilst in the horizontal (rolling, pushing etc) than in the vertical (ie stall turn entry).

The goal here is not to hold the nose on or above the horizon as with the slow roll, but rather just to limit the amount by which it falls. In this way hopefully we can keep the engine running throughout. Once you go past the inverted position you can ease off on the forward stick and start introducing top rudder (ie if rolling right, then right rudder and vice versa). Top rudder will further limit the nose drop and will substantially improve the roll rate through the last 90 degrees to wings level again.

This is not a Tiger friendly manoeuvre, and don’t be surprised to see very nose low exit attitudes, especially if you keep some back pressure on the stick throughout.

Barrel roll
Perhaps best thought of as a “crooked loop” in a Tiger. The main challenges here are to:

1. get the nose sufficiently (very) high during the first part of the roll;
2. sustain a reasonable roll rate across the top of the manoeuvre when airspeed is very low; and
3. avoid burying the nose during the third quarter of the roll.

There are two gates: the aircraft should be wings level (momentarily) as the flight path (not the nose — the flight path!) of the aircraft cuts the horizon pulling up at the start of the roll, and wings level (inverted) when the flight path cuts the horizon half way through the roll. This translates to a normal level attitude at the start and (approximately) the point at which the horizon appears under the bottom of the fuel tank when inverted. If you wait until the nose cuts the horizon inverted, you will already be going downhill rapidly and will probably lose a lot of height

Barrel roll right: start as for a loop by diving at full power to 115 mph, simultaneously turning 45 degrees left away from the desired roll axis. On reaching 115, pull up and commence a gentle roll to the right, balancing with rudder. As the flight path pitches upwards through the horizon the wings should be passing through level. Initially we want to get a lot of pitching done without too much rolling, as we want to get the nose at least 45 degrees above the horizon by the time we get to 90 degrees of roll. After passing 90 degrees of roll, any back pressure on the stick will pull the nose down and sacrifice height, so release most of this pressure and allow the aircraft to float inverted over the top at close to zero G. The speed will be dropping, so after the 90 degree point you will probably need to increase aileron deflection to the maximum to keep a reasonable roll rate going.

Roll rate can be enhanced at the low speed achieved at this point by applying rudder in the same direction, although this will work only with more than zero G applied. This in turn requires more back pressure on the stick whilst inverted, which in turn leads to burying the nose — so it is a trade-off between roll rate required and the resulting lower attitude.

After passing the inverted, the nose will drop and the aircraft will start to accelerate again, and the roll rate can be managed again by ailerons only. Our priority now is to complete the roll without the nose dropping too far. As the wings go past the 135 degree point (5/8ths of the way through the roll), start applying top rudder to prevent the nose from dropping too far. This will also increase the rate of roll, especially during the last 90 degrees of roll, so it may be necessary to reduce the aileron input slightly.

Upon reaching wings level, pull the nose up again to 90 mph to conserve energy. To picture the geometry of the manoeuvre, imagine yourself flying along in the middle of a giant baked beans can that is lying on its side. You make a diving 45 degree turn away from the centre axis of the can, and then pull up and make a corkscrew roll in the opposite direction — around the axis — with your wheels just brushing the interior surface of the can. When you reach wings level again, pull up to the centre axis again.

Cuban 8 (also called horizontal 8)

Commence as for a loop, but STOP the nose from pitching when you are 5/8ths of the way through, ie when you are inverted diving at 45 degrees. Reference this 45 degree nose down attitude from the lower wingtip(s) against the horizon. Now look through the centre section struts and the front windscreen to a reference point on the ground, and HOLD it there for a couple of seconds to allow some acceleration (which gives more aileron effectiveness).

Holding this sight picture briefly will ensure you have STOPPED any pitch rate (some forward stick required) which is important to prevent barrelling of the subsequent roll.

Now roll to upright using full aileron and NO rudder. When you are at the 90 degree point you can use top rudder (which will now assist roll) to help keep the nose fixed where you want it. Upon reaching wings level, maintain the 45 degree nose down attitude until you again reach looping speed (115mph) and repeat the exercise to complete the figure 8. If you are not remaining straight with respect to your ground reference points it is very likely due to unwanted elevator input during any part of the roll, or due to rudder input during the first quarter (from inverted to 90 degrees angle of bank) of the roll.

Slow roll

Prior to starting out with this manoeuvre it is a good idea to first just get comfortable — if that is possible — with being upside down in level flight in a Tiger. Finding a hard seat cushion will help a lot here, as if you have done any positive G manoeuvres on a soft cushion it will compress and your straps will be loose. The sensation of subsequently falling into them as you roll upside down is most unpleasant.

During pre flight it is worth experimenting with how to get full aileron travel; this is more important if you are tall as your knees can prevent you from getting full travel, especially with right aileron. It may be necessary to try to “hide” your knees, and perhaps hold the very top of the stick to get more freedom of movement.

The major challenges are to keep the nose from dropping below the horizon and to co-ordinate rudder and aileron use to maintain a constant rate of roll. Significant deflections of top rudder are required; this will oppose the roll for the first and third quarters, and help it for the second and last quarters.

Consider initially doing this manoeuvre with the elevator trim fully forward, to help keep the nose up whilst inverted. Pushing is a much less natural control input than pulling, and if you are having to use a lot of forward stick force it will be difficult to be precise with the ailerons.

It will be slightly easier to roll right with the engine.

Having achieved an entry speed of 115, pull up to 15 degrees above the horizon and apply full aileron with a touch of rudder to balance. As the roll progresses through 45 degrees, gently begin to reverse the rudder to hold the nose up. After you pass 90 degrees this top rudder will increase the rate of roll, so slightly decrease aileron deflection and start easing the stick forward to keep the nose above the horizon. As soon as the engine cuts, retard the throttle to idle.

Passing through the wings level inverted position, the nose should still be above the horizon. You will now need to smoothly reverse the rudder so that it remains top, but do this carefully and minimally as it is now opposing the roll at a time when speed is low and decreasing. You will need full aileron for this phase. Approaching the 270 degree point you will need a significant amount of top rudder to keep the nose up whilst the speed is steadily decreasing. Do not use so much that the roll stops, and if necessary allow the nose to drop slightly.

For the last quarter, the aircraft will be quite slow, and you may well need neutral or opposite aileron (against the direction of roll) to counter the powerful rolling effect of the top rudder. Open the throttle slightly as you pass the 270 degree point, and as soon as the engine responds smoothly advance to full throttle.

As Neil Williams says: “The rudder should be used to delay/minimise the nose drop, not to stop it completely.” If you use a lot of rudder, you will simply end up sideslipping, which is a very effective method of reducing speed and energy. The roll should start with the nose about 15 degrees above the horizon, but do not expect to keep it there, especially after engine stoppage; expect to exit with the nose no lower than 10 degrees below the horizon. Also (Williams), the nose will wander slightly to the left and right during the roll, but should end up on the same heading as upon entry.

The first objective should be just to complete the roll with the nose not dropping too far beneath the horizon, and remaining on an approximately straight track. Once this has been achieved, you can experiment with varying the aileron to keep a constant rate of roll throughout. This will involve less than full deflection to begin with, full deflection by the 90 degree point, backing off until inverted, then full deflection to the 270 point, and then backing off to neutral or even opposite aileron to counter the powerful rudder.

Roll off the top
With full power dive steeply to 135 mph. Passing approximately 120 mph you will need to throttle back somewhat to keep the engine from overspeeding. Upon reaching entry speed, pull up smoothly (do NOT jerk the stick back) into a fairly tight loop. As the speed decreases through 120 mph re establish full power. Use the same visual references as for a loop. As the aircraft reaches the level inverted attitude (bottom of the fuel tank on the horizon) ease the stick forward to hold this attitude, and hopefully the engine will keep running for a second or two.

Then complete the second half of a slow roll. If/when the engine stops, close the throttle.

Your airspeed will be low, so it is necessary to get FULL aileron in ASAP and get the aircraft rolling. Keep the rudder locked neutral initially. You will soon need top rudder to keep the nose on or above the horizon, but be cautious with this as it will be opposing aileron input until you reach the 90 degree point. If the engine has stopped due to negative G, open the throttle slightly passing the 90 degree point, and when the engine responds, open the throttle fully. It is easier to roll to the right with the engine, but make sure you are applying FULL aileron and that the top of your right (stick) hand is not restricted by your right knee.

Like the stall turn to the left, practice of the roll of the top may well result in a stopped propeller. Review the windmill start procedure and adjust your entry height accordingly.

Spinning
Conventional in all respects. Entry from level flight can be achieved by slowing the aircraft with throttle closed to 45 mph (ie just above the stall), and then smoothly applying full left or right rudder. As the yaw begins, bring the stick smoothly and firmly all the way back to the aft stop, and keep it there. The nose will drop smoothly to a steep nose down attitude and the aircraft will stabilise in a comfortable and stable spin within three-quarters of a turn.

The best outside reference is straight ahead between the centre section struts (under the fuel tank), as looking for the horizon above the wing will involve lifting your head significantly — probably not a good idea during a spin.

Recovery involves applying FULL opposite rudder and then moving the stick smoothly and centrally forward, usually to about half way between neutral and full forward. Centralise the rudder smoothly as soon as the rotation stops, and recover from the ensuing dive. As the nose approaches the horizon, increase thrust to cruise power.

The rate of turn (spin) will accelerate briefly as the nose drops during the recovery — same physics as for the spinning ice skater who pulls in her arms. The spin should stop within one turn, and recovery can be even quicker with more aggressive use of forward stick

Flick roll
This manoeuvre is pretty hard on a Tiger, so is not recommended. However, you can do an accelerated spin entry from 65–70 mph without doing too much harm. It is a convenient way of initiating a roll over and pull through.

From level flight and 60 mph, open the throttle fully. Accelerating through 65 mph, pull the nose up firmly whilst smoothly applying full right rudder. The aircraft will smoothly and gently flick to the right. Approaching the inverted, centralise the rudder and release the back pressure momentarily. As the aircraft unstalls it will stop rolling — hopefully exactly in the inverted attitude — and you can then simply complete the second half of a loop to recover. If the spin continues, CLOSE THE THROTTLE and recover.

The flick roll can be continued level through 360 degrees, but you will have to apply opposite rudder and stick forward a good 40 to 60 degrees short of wings level to stop the roll at the very low speed you will find yourself at. It is very hard (for me anyway) to stop this roll with any sort of precision as the aircraft is very slow on exit.

Reducing power may also help to stop the (partly torque induced) rotation to the right. The aircraft will recover much more cleanly from a roll to the left (against the engine) and there is no need to reduce power — however significantly more violence will be required to get the aircraft rolling that way in the first place.

More energy can be saved, and a quicker roll rate achieved, by easing the stick forward significantly after the flick has started, maintaining full rudder deflection. The real answer to the lack of energy when exiting the roll is to start with more of it in the first place. Williams recommends 2 x the stall speed (90 mph) less 5 mph for safety = 85 mph for a flick roll. But you can feel the aircraft working when it flicks at this speed, and you will probably be reluctant to continue unless the aircraft is Government property.

Falling leaf
This manoeuvre consists of a consecutive series of incipient spins. From straight and level flight, close the throttle and wait for the aircraft to stall. As the stall occurs apply full rudder, and the nose and wing will drop. As soon as the wing drops apply full opposite rudder; the yaw should stop within 45 degrees or so, the nose will rise slightly (since the stick should still be fully aft), and then the other wing will drop. Immediately apply full opposite rudder etc etc…and keep repeating the cycle for as long as you want. Recovery occurs instantly when you push the stick forward, since you already have (for 99.9 percent of the time anyway) anti-spin rudder applied. Decide in advance upon an exact height to begin recovery, as it is easy to become tied into the cycle and to attempt recovery with rudder only. You MUST push the stick forward to break the cycle.

In Neil Williams's book the technique includes releasing the back pressure with each rudder reversal to momentarily unstall the aircraft. This probably does result in the true falling leaf, with more pitching and more leaflike behaviour. However, if you are a nanosecond slow with your timing — or maybe even if you aren't — the speed will tend to increase between cycles and the result can be quite a violent flicking reversal.

Keeping the stick fully aft throughout will keep the speed back and the manoeuvre gentle and predictable.

In-flight engine start (or windmill air start)
The need for this procedure is most likely to stem from running out of speed with the nose above 60 degrees or so of pitch. It is more likely to happen if the engine is at idle either due to throttling back, or due to fuel starvation as a consequence of negative G, for example after falling out of a stall turn to the left (against the engine torque etc).

For practice purposes we first need to stop the engine. Start from a minimum height of 3000 feet, preferably above an area suitable for a forced landing if the worst comes to the worst. Throttle back to idle and pull the nose above the horizon, select ONE set of magneto switches to off, and immediately open the throttle fully (same as for engine shutdown on the ground). Hold the aircraft at or close to stall speed and wait for the propeller to stop.

With the prop stopped, establish a glide at 60 mph, and check:
Fuel selector: ON,
Throttle: set 1/3 open.
Magneto switches (the ones that were turned OFF!) back ON.

Smoothly and without delay, lower the nose to at least 70 degrees nose down, and preferably to the vertical. Do not reduce the dive angle until the propeller starts turning, and then GENTLY ease out from the dive; if you were trimmed for cruising speed before starting this exercise, you will find yourself "pushing" during the recovery to stop the nose from pitching up too rapidly with the consequent excessive G. What speed the prop starts turning at, and how long you need to remain in the dive, depends on a number of factors including: pitch of prop, how tight the engine is, which compression the engine stopped on (weak or strong one?) and length of time the turning force is applied to the prop, ie you might have to dive for three times as long with a 45 deg dive as you would for a vertical dive. Continue the dive until the propeller is rotating; I have seen it go through one compression and then stop again.

Be very careful easing out of the dive. You will do the aircraft far less harm by overspeeding the airframe slightly due to a relaxed pullout, than you will by doing an aggressive pullout at high speed. Having said that, on a well run in engine the prop will start turning before 120 mph indicated, so completing the start and recovering from the dive should be easily possible without exceeding V_{ne} of 160 mph.

Finally

Many of the manoeuvres described above can be completed at slower speeds; I have used 115 mph for many as a simple one size fits all — easier to remember etc. However, the slow roll entry is often quoted as 110 mph and it can be done slower. A light Tiger will loop from 100 mph, and the stall turn can be done from straight and level cruise — you just have less time to establish an exactly vertical climb.

Finally finally, to quote Jim Rankin: "Between manoeuvres, any time you are flying at a speed greater than the full throttle straight and level speed of your aircraft, you are giving away energy." It follows from this that the best way to conserve energy between manoeuvres is to fly at your best rate of climb speed. Continuous aerobatics in a Tiger means continuous height loss, so I suggest whilst practising technique, finish each manoeuvre with a 65 mph climb, and maintain this until you are ready for the next manoeuvre. You will save a lot of time and energy this way.

If you are practising for the Tiger Moth Club aerobatics competition, however, you will need to have a level flight segment before and after each manoeuvre, and ideally you should not climb or descend between manoeuvres. Height is sacrificed to preserve geometry.

Limitations

Engine: maximum rpm:	2400 Gipsy Major 1C
	2350 Gypsy 1 & 1F
minimum oil press:	30 psi
maximum oil press:	60 psi

Airframe: +6G, -3G (more than you will ever need, positive or negative!)