CIVIL AVIATION AUTHORITY OF NEW ZEALAND
Te Mana Rererangi Tūmatanui o Aotearoa

Basic Concepts

These first seven lessons are provided in this recommended order, please refer to your CFI for the order your organisation uses.

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Contents

BASIC CONCEPTS

Taxiing

The purpose of this briefing is to consider the effects of the environment on the ground handling of the aeroplane. These environmental factors include;

- the surface type,
- slope,
- wind,
- wingtip and propeller clearance,
- other traffic,
- slipstream, jet blast
- seat adjustment,
- windscreen cleanliness,
- inertia and speed judgement,
- blind spots,
- aerodrome layout,
- instrument checks,
- Air Traffic Control (ATC) clearances,
- right of way rules, and
- aerodrome signs and markings.

Taxiing is usually introduced during the first lesson, *Effects of Controls*, but the considerations are usually spread over the lessons leading up to first solo. It is your responsibility to ensure that the student is aware of these considerations before recommending them for first solo. If a student has limited experience or exposure to operating 'machines', a separate taxi lesson may be appropriate.

Taxiing means: manoeuvring the aeroplane on the ground under its own power. This requires concentration and common sense. Your student needs to understand that an aeroplane is less manoeuvrable than a car, wider because of the wingspan, and you cannot reverse an aeroplane.

Objective

Correctly use the aeroplane's controls to manoeuvre the aircraft on the ground at a speed appropriate for the prevailing conditions and situation, following a selected path and stopping at a nominated point.

Considerations

Speed Control

Aeroplane speed is controlled with the hand-operated throttle. Because of inertia, more power will initially be required to get the aeroplane moving, as soon as the desired speed is reached, reduce power as appropriate.

Maintaining taxi speed will be affected by the surface, slope, wind, and power used. Some organisations recommend a minimum power setting while taxiing to minimise spark plug fouling (refer CFI).

Figure 1

To stop, ensure nose wheel is straight, close the throttle fully then apply both main wheel brakes, usually achieved by depressing the tops of both rudder pedals. Slope, surface (wet or dry) and wind all affect the ability to stop. How to apply and release the park brake should also be taught.

Increase power by moving the lever or plunger forward and decrease power by moving it rearwards.

Directional Control

Figure 2

Direction is controlled by nosewheel steering, and is done by pushing the appropriate rudder pedal. This works in the natural sense – push the left rudder pedal and the nose turns to the left, and vice versa. In some aeroplane types they may be augmented by differential braking to tighten the radius of turn if required.

Wind affects directional control, and crosswinds will cause the aeroplane to weathercock into wind as a result of pressure on the vertical tail fin.

Most problems experienced by the student in maintaining directional control are a result of looking just ahead of the aeroplane, rather than at a point in the distance.

Control Positioning

The aeroplane's controls should be held in the appropriate position in relation to wind direction, as stated in the Flight Manual.

The use of full aft elevator in modern nosewheel training aeroplanes is not required while taxiing, but the elevator should be held either in the neutral position or slightly aft to keep the weight off the nosewheel and protect the nosegear. However, this may not be appropriate with high-tail aeroplanes.

Airmanship

Introduce the student to the right of way rules, as they apply while taxiing.

Show the student the aerodrome chart from *AIP New Zealand* Vol 4, pointing out the major features of the aerodrome and where to look for them once in the aeroplane.

Show the student the location of the windsocks and how to interpret them.

Explain to the student that it is important to communicate with the other users of the aerodrome. In order to do this you will be using radio calls to either the traffic or the control tower (as appropriate). You will be giving your position, your intentions and requesting any clearances you may need.

They should listen to the calls you make and the responses you get. Remember to speak slowly and clearly.

Aeroplane Management

Avoid using power against brake.

The pilot's seating position should be adjusted to make sure they can achieve full rudder deflection, and the seat locking should be checked for security. Make sure the student can reach all of the controls and seat height is adjusted so the student can see over the instrument panel. Introduce the appropriate positions for hands and feet while using the controls.

An appropriate period of engine warming should be observed before taxiing (see the Flight Manual).

Brakes should be checked for normal operation soon after the aeroplane begins to move. Close the throttle, depress the brake pedals with the balls of the feet, then slip the feet back down to the bottom of the rudder pedals.

The correct taxi speed is a fast walking pace, about 5 to 10 km/hr.

The use of carburettor heat on the ground should only be used during the run-up procedure and pre-takeoff checks and be on a clear surface, as air from this source is unfiltered.

In winds of more than 5 knots, the aeroplane should always be stopped facing into wind to assist engine cooling.

Taxi on the centreline, but be aware of your own and other aeroplane's wingtips and tailplanes, as well as propeller slipstreams. Be cautious of aeroplanes that may be producing jet blast, and avoid taxiing behind them.

Light aeroplanes may need to taxi right of the centreline to allow opposing direction aeroplanes to pass – aircraft should pass port to port (left to left).

While taxiing, the aeroplane's flight instruments (turn coordination, directional indication, compass and artificial horizon) should be checked for serviceability.

To prevent propeller damage, avoid taxiing over rough surfaces and limit the use of power when over loose gravel. Keep the aeroplane moving; twice as much power may be required to get going again if the aeroplane stops. If the surface looks doubtful, or excessive power (>2000 rpm) is required, stop, shut down and get assistance. Do not try to 'power' out of soft ground.

Human Factors

Adhering to the right-of-way rules, being familiar with and carrying aerodrome charts, and windsock indications will help orientate the student.

Vision will be affected by the cleanliness of the windscreen and side windows, and the cabin pillars. Demonstrate the effect of the blind spots that are created by the cabin structure, and wingtip clearance judgement. Show the student how to move the upper body to see around pillars and to mitigate blind spots.

Make sure all flights carry the *AIP New Zealand* Vol 4 and appropriate charts to aid the student's information processing.

Ground Exercise

The exercise consists of teaching the hand and feet positions and the methods of operating the controls.

Start the aeroplane, apply power to overcome inertia and get the aeroplane moving, test the brakes, maintain an appropriate taxi speed, turn and stop the aeroplane at a designated spot. The student should now practise all these manoeuvres.

Operation of the park brake should be demonstrated and, as appropriate, the effects of slope, surface, wind, and relative positioning to larger aeroplane's slipstreams should also be pointed out.

Introduce aerodrome signs and markings.

Effects of Controls

This lesson is arguably the most important lesson a student will take. A thorough understanding of the primary and secondary effects of control inputs is the basis of all future flying. It is important that the student understands and has the opportunity to practise these effects.

As this is commonly the first formal preflight briefing, a short explanation of the sub-headings should be included, as well as the normal introduction. The *Airmanship* section covers good aviation practice.

This lesson does not aim to teach the student to fly, that will come over the next few lessons. This lesson focuses primarily on each control, how it works, and how it is related to other controls. As a consequence this lesson may seem less coordinated than normal.

Primary flight controls are the elevator, ailerons and rudder. When these are deflected in flight the aeroplane moves about one or more of its three axes. The student needs to know what effect these controls have on the aeroplane's flight path in order to accurately manoeuvre the aeroplane. They also need to see the effect of moving each of these primary flight controls individually, so that any unwanted secondary effect can be countered through coordinated use of the primary flight controls.

Ancillary controls are the throttle, flap and trim. The student needs to know how to operate each of these correctly and what effect their operation will have on the flight of the aeroplane. A clear understanding of the effect of using these controls is important, and then with practise, any adverse effect can be countered.

Objectives

To operate the primary control surfaces and to experience the feel and observe the first aerodynamic effect on the aeroplane in flight.

To operate the primary control surfaces and observe the further (or secondary) aerodynamic effects on the aeroplane in flight.

To operate the ancillary controls and to experience the feel and observe the effect on the aeroplane in flight.

Principles of Flight

Primary Controls

Describe how the aeroplane is controlled on the ground (see *Taxiing* lesson). Speed is controlled by the hand operated throttle and the main wheel-brakes, while direction is controlled by the use of the pedals linked to the steerable nosewheel.

Figure 1

Describe how to hold the aeroplane's controls and explain the concept of dual controls. Identify on your aeroplane which controls are dual, and which are not.

Introduce the terms lift and aerofoil. Describe how lift is produced, with reference to Bernoulli, in the simplest possible terms. For example, if the speed of the airflow is increased the pressure will be reduced and the effectiveness increased, and vice-versa.

Describe the three axes of the aeroplane – lateral, longitudinal and normal (sometimes termed vertical) – and the movement about those axes (use teaching aids).

Figure 2

Drawings, PowerPoints or overheads should be gradually built up and colour coordinated. For example, the lateral axis, the elevator and the word pitch could all be coloured purple.

Describe how deflection of the controls changes the shape and/or angle of attack, affecting lift and producing the first aerodynamic effect. Start with the elevator, as this is the easiest to describe. Then cover the ailerons and the rudder. If the student has difficulty understanding Bernoulli, angle of attack or pressure, state that movement of the controls deflects the airflow and the tail is pushed up or down as applicable (Newton's third law).

The effect of moving the elevator is to pitch the aeroplane. This changes the position of the aeroplane's nose in relation to the horizon – the aeroplane's attitude – and will consequently affect the aeroplane's speed.

The effect of moving the ailerons is to roll the aeroplane. This banks the aeroplane left or right.

The effect of moving the rudder is to yaw the aeroplane. This moves the aeroplane's nose left or right.

Slipstream should be described as the spiral column of air being forced back by the propeller and the primary controls it affects should be pointed out. It should be noted that slipstream is present whenever the propeller is rotating, regardless of the aeroplane's speed. The comparison of standing behind the aeroplane, compared with standing at the wingtip, may help the student visualise the effect of this airflow. This highlights that ailerons are unaffected by slipstream.

Figure 3

Describe the rotational nature of the slipstream and its resultant impact on the tail fin. As the aeroplane spends most of its time in cruise, the manufacturer offsets the tail fin, or the thrust line, to negate the resultant yawing tendency. Therefore, at any power setting other than normal cruise, and at any time the power changes, the aeroplane will want to yaw, and compensating rudder inputs are required.

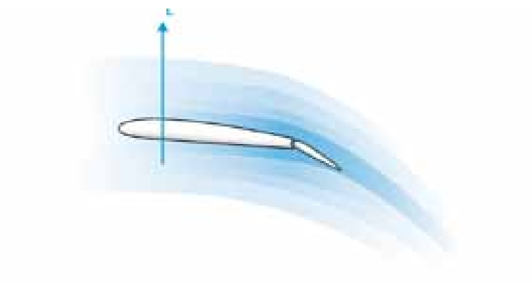
Ancillary Controls

Briefly describe the throttle and its direct connection to the propeller and its effect on the aeroplane's speed. Explain that power is increased by moving the lever (or plunger) forward and decreased by moving the lever rearwards.

Discuss the purpose of trim and how it works. State that most training aeroplanes are fitted with trim tabs to provide sufficient force to hold the primary control surface in the desired position. Emphasise that they are not used to alter the primary control surface's position, they are a pilot aid only. You could also note that trim tabs may be provided on all three primary controls.

Describe where the flaps are located on the aeroplane, how they are operated, how they work (electrically or manually), and the various positions to which they can be selected. It should be noted that flap 'up' means flush with the wings, ie, they do not extend above the wing.

Figure 4



Describe how the flap changes the shape of the wing and the effect that has on lift, drag, L/D ratio, and pitch. Commonly, in high-wing aeroplanes, the nose pitches up with application of flap, and on low-wing aeroplanes the nose pitches down. The reverse occurs in each case when flap is raised, but importantly all aeroplanes will sink when flap is raised. Describe the actual pitch changes the student will observe as a result of using the flap, and the consequent trim changes that will be required.

The structural airspeed limit for flap extension, and the normal operating range, white arc, should be explained.

Inertia

Because an aeroplane has mass (weight) it is subject to inertia. Explain in very basic terms that inertia is the tendency of a body to remain in its current state. If it has stopped on the ground it will take more power to get it moving than to keep it moving. If you want to decrease the speed in flight, the aeroplane will not slow down instantly, but gradually decelerate. This must be taken into account when changing the speed or the direction of the aeroplane.

Airmanship

Knowing who is physically flying the aeroplane is critical. Get the student into the habit of stating "I have control/you have control." The meaning of "follow me through" should be explained, for example, "I want you to place your hands and feet lightly on the controls and feel what I'm doing, but I retain control."

Explain how to use the clock code to report the relative position, height and distance of other aircraft. Aircraft that appear above the horizon are higher, aircraft on the horizon are at the same level, and aircraft below the horizon are lower. Distance is judged from the known size of the object and is prone to perception errors. For example, a Boeing 747 at 10 miles can look like a Cherokee 140 at 2 miles.

The aeroplane is manoeuvred in the air by visual reference to the horizon and ground features. Visual flight rules mean that cloud must be avoided and the ground or water kept in sight at all times. When you get into the air, point out some major features in your local area, as well as the approximate directions of north, south, east and west, and where your aerodrome is located. Over subsequent briefings the various aspects of VFR flight will be discussed. It is vital that you demonstrate compliance with the various VFR requirements.

I'M SAFE

The '**I'M SAFE**' checklist should be introduced for the student to complete before leaving home for their next lesson.

I ***I**llness*

Do not fly when feeling unwell as this will not only degrade the learning experience but affect all phases of flight.

M ***M**edication*

How will the effects of medication be altered by the flight environment, for example, altitude? In addition, why is medication being taken, am I unwell? Do I need to consult an AME?

S ***S****tress*

This takes up valuable space in the short-term memory. Getting into an aeroplane straight after an argument or with other personal worries affects your information processing capabilities.

A ***A****lcohol*

Even in small amounts, alcohol adversely affects brain functioning. Mixed with altitude and the dynamic three-dimensional environment of aviation, it is deadly. Safe periods of abstinence before flight vary with the individual and the amount consumed.

F ***F****atigue*

This affects not only motor skills but also mental skills. Adequate rest is essential for quality information processing and decision making.

E ***E****ating*

A balanced diet and drinking water at regular intervals to prevent dehydration is important. Poor eating habits and/or dehydration can have a detrimental effect on the decision-making process.

In addition, the '**I'M SAFE**' checklist should be prominently displayed in the briefing room for quick reference before flight.

Aeroplane Management

A large-scale photograph of the aeroplane instrument panel and/or cabin layout is a valuable aid.

Give a brief explanation of the purpose of the engine controls. Discuss the sense of movement of these controls.

Throttle

The use of smooth throttle operations should be emphasised. As a guide it should take three seconds to move the throttle from fully CLOSED to fully OPEN, and vice versa. Demonstrate an appropriate grip on the throttle.

Mixture

IN or OUT, UP or DOWN. Explain the type of control and that when the mixture control is pulled fully out the fuel supply is cut off from the engine. This is called Idle Cut Off (ICO) and is normally used to stop the engine (not the ignition key – except where there is a solid state ignition system). This will be demonstrated when you shutdown at the end of the lesson. Discuss how the mixture control is used to alter the fuel/air ratio and then state that for initial training flights the mixture control is set at the full rich position. Leaning the mixture will be covered in later lessons.

Carburettor heat

UP or DOWN, IN or OUT. The purpose of the carburettor heat control should be covered.

Briefly outline the reasons and conditions for carburettor ice forming, the symptoms of its formation, and the cure. In addition, the reason for applying carburettor heat before closing the throttle, and the conditions under which carburettor ice is most likely to form, should be described. Introducing warm air into the carburettor alters the mixture, so is not normally used at high power settings.

Discuss when you would use carburettor heat on the ground, and the precautions you need to take while doing so.

Temperature and pressure gauges

Such as oil, cylinder and fuel, have a normal operating range depicted by a green arc. Red lines indicate operating limits, yellow arcs the cautionary ranges, and often white lines or arcs for other purposes (refer Flight Manual). The importance of monitoring temperatures and pressures for normal readings should be explained. It may sometimes be normal to taxi with oil temperature below the green range (see Flight Manual). On the other hand, it would not be normal to see the oil temperature near the top of the green range after a prolonged descent, even though it's in the green.

Human Factors

Describe the VFR see-and-be-seen principle and the importance of a good lookout.

Discuss the limitations of vision, especially on lookout effectiveness. Stress the need to move the head to see around the cabin structures, so that a thorough lookout can be achieved.

Discuss the limitation of the visual system when attempting to detect small stationary objects and alternatively the ability of peripheral vision to detect movement.

Discuss the effects of information overload in relation to human information processing capabilities and the effect on performance. The short-term memory can hold only 7 items ± 2.

Discuss the effects of stress in relation to human information processing capabilities and the effect on performance. As this is the student's first flight it is a busy and new experience. Future lessons build on those before them and the stress reduces.

The benefits of regular practise and the use of a checklist should be encouraged to help with both of these.

Air Exercise

Describe the method of taxiing the aeroplane under its own power, stopping and turning.

Basic flight training is based on the concept of attitude flying by visual reference. It is important to introduce the student to the concept of attitude, being the relationship between the nose (or instrument panel) and wings, and the horizon. Discuss in simple terms how the primary controls are used.

Primary Effects

Discuss the effect of movement of each of the primary controls in flight, with emphasis on the sense of movement of the control column and rudder pedals – not the sense of movement of the control surfaces themselves. It is what the student sees as a result of control movement that is important, for example, easing back on the control column pitches the nose up.

Emphasise the association between control movement and the natural sense, for example, rotating the control column to the right will cause the aeroplane to roll to the right.

In flight these movements are related to the horizon and confirmed with reference to the instruments. These movements rotate the aeroplane about its axes in a natural sense and always have the same effect relative to the pilot, for example, even when banked rudder will still yaw the nose to the pilot's left or right, but up or down in relation to the horizon.

Further Effects

The emphasis here is on aerodynamic effects, sometimes known as aerodynamic cross coupling. When a control movement is made on its own, movement initially occurs around one axis, followed by an undesired movement about another axis. The main point is that these effects only occur when the control is used on its own.

There is no further or secondary effect of elevator.

When aileron is used on its own, the aeroplane will roll, slip and then yaw towards the lower wing.

When rudder is used on its own, the aeroplane will yaw, skid and then roll in the direction of yaw.

In both cases, if the controls are left alone, the aeroplane will enter a spiralling descent. The initial slip or skid can be demonstrated with a model as it may be difficult to detect in the air, but the secondary effect will be clearly seen. The balance ball will indicate these effects, but you may not wish to draw the student's attention to this instrument yet.

It should be emphasised that these further or undesirable effects of ailerons and rudder can be eliminated through coordination of these controls, and will be dealt with in later lessons. In this lesson, your purpose is to demonstrate these secondary effects, and as a consequence aspects of this lesson are uncoordinated.

Airspeed

Discuss the effect of airspeed on the feel of the controls, the aeroplane response rate, and the amount of movement needed to change the flight path. Commonly, the analogy of holding your hand out the car window and moving it from horizontal to vertical at various speeds is used to describe this effect.

At low airspeeds, typically with a high nose attitude, the controls are easy to move, are less effective and require large movements to bring about a change of flight path. They feel sloppy.

At high airspeeds, typically with a low nose attitude, the controls are harder to move, very effective and require only small movements to bring about a change of flight path. They feel firm.

Slipstream

Figure 5

Describe the effect of slipstream over the elevators and rudder, in relation to high power and idle power settings, at a constant airspeed. At high power the slipstream is increased, and the elevator and rudder are more effective; conversely, at idle power they are less effective. Because the ailerons are situated outside the slipstream their effectiveness does not change with increasing or decreasing slipstream. On some aeroplanes the elevator may be out of the slipstream because of its height, for example the Piper Tomahawk.

Power

With an increase in power the aeroplane will pitch up (for reasons that will be explained in a later lesson) and the nose will yaw to the left. Reducing power will result in a pitch down and yaw to the right. Therefore, whenever the power is changed, the pitch and yaw must be compensated for in order to maintain the attitude.

Trim

Describe the method of trimming, if you are holding the elevator back – trim back, if you are holding the elevator forward – trim forward. Similarly, if the aeroplane is fitted with rudder trim, holding right rudder pressure – move or rotate rudder trim to the right.

Figure 6

Flap

When flap is lowered, lift and drag are increased, which causes the nose to pitch ________. The opposite effect will occur when flap is raised. The change in lift can be felt and the changes in drag can be seen as an airspeed change. Discuss the L/D ratio in context of the initial application of flap on lift compared with the further application and its affect on drag. Any change in pitch will require a change in the trim.

Airborne Sequence

Before Flight

The importance of inspecting the aeroplane before flight should be emphasised and a demonstration of the full aeroplane preflight inspection given.

During the preflight inspection, point out the major features of the aeroplane, the primary controls and movements, both fixed and adjustable trim tabs, and the effect flap has on the shape of the wing. Point out that while full control movement is acceptable on the ground, only small movements are required in normal flight because the primary controls are situated at the extremities (thus providing a large moment arm).

Make sure the student is seated correctly, seat secure, seat belts done up, and point out the limitations imposed on the lookout as a result of the cabin structure.

During the taxi encourage the student to operate the rudder pedals while you hold the control column and operate the throttle. Gradually hand over control of throttle, brakes and control column to the student. Most students will attempt to steer the aeroplane on the ground by rotating the control column – as in a car. They will soon discover that this has no effect on the aeroplane. With a gentle reminder, they will learn to keep the control column neutral and use their feet on the rudder pedals.

Remind the student that a much greater lateral clearance is required than that required for a car.

Point out major ground features and approximate directions of north, south, east and west.

The Exercise

Primary Effects

Before any demonstration, ensure the student is looking in the right place, ie, outside over the nose. If the student is looking at the rudder pedals they are unlikely to see the first effect, much less any further effects.

Figure 7

First explain 'nose attitude' and what you mean by it. The line the horizon makes in relation to the aeroplane's nose will be the primary means the student uses to fly the aeroplane. They must have a sound understanding of aeroplane attitude and how to use it, if they are going to become a pilot.

The primary flight controls and their effects are demonstrated one at a time, with emphasis on the natural sense, to experience the affect themselves. After each demonstration, the student should operate each control one at a time. Ensure that during the rudder movement demonstration and student practise that the wings are held laterally level with aileron. Otherwise the student will see the more obvious roll rather than a pure yaw.

Further Effects

Aileron

The aeroplane should be trimmed to fly so that only the lightest of finger and thumb grips is needed on the control column and the feet are only resting on the rudder pedals. Resist the natural tendency to increase backpressure as aileron is applied, otherwise the yaw will not occur. Secondary effects only occur when the primary controls are used on their own.

Drawing the student's attention to the outside reference point, roll the aeroplane with pure aileron using only the finger and thumb. The slip may be difficult to see, however, the yaw and resultant spiral descent should be apparent.

You should ensure three things – firstly that only moderate angles of bank are used, secondly that the student sees how easy it is to stop the spiral descent by using coordinated control inputs, and thirdly that you demonstrate the further effects in both directions.

The student should get the opportunity to move the controls and experience these further effects, but does not need to master it.

Rudder

Once the aeroplane has been returned to straight and level flight, the further effect of rudder should be demonstrated. Gentle application of rudder is all that is required. Once again the skid is difficult to see but the roll and resultant spiral descent is obvious.

Airspeed

Demonstrate the use of elevator by selecting an attitude and watching its resultant effect on airspeed, then give the student the opportunity to experience it.

To effectively demonstrate the effect of airspeed, maintain a constant power setting and vary the airspeed with attitude.

Nose-high attitude equals low or lower airspeed, nose-low attitude equals high or higher airspeed. At this stage there is no requirement to refer to any specific attitude, for example, level or climbing attitude. During this demonstration the throttle should not be moved but left at a medium power setting, so as to make it quite clear that it is the attitude that directly affects the airspeed. During the high airspeed demonstration, however, the throttle will need to be slightly closed unless the aeroplane has a variable speed propeller and a constant speed unit fitted.

In each case (low and high airspeed) the student should note the feel and response of each primary control. Although any slipstream will affect the feel and response of elevator and rudder in most single engine aeroplanes, the average student on their first lesson will not detect it. It is highly unlikely that the student under these conditions will notice any difference at all regardless of the power setting. Therefore, the student will need to be convinced verbally of what they feel. This is achieved by modulating your voice as each control is moved. For example, low airspeed, elevators light, less effective, BIG movements required; high airspeed, elevators **firm**, VERY effective, small movements required. The benefit of a constant power setting to give a clear demonstration of attitude to control airspeed far outweighs the considerations of control feel and response.

You can demonstrate at the end of this sequence that all three controls work in relation to the pilot and not the horizon by rolling in some bank, pitching the nose up or down and yawing left or right at the same time. The student should then be encouraged to operate all three controls for themselves.

Use the phrase "pitch the nose up", instead of "pull back on the control column."

Slipstream

Although the effect of slipstream is present at all airspeeds with the propeller rotating, it is easiest to demonstrate at a high power setting and low airspeed. Set up the aeroplane for a constant low airspeed with full power on (eg, a climb). Trim. The student should operate all of the controls, noting the feel of effectiveness for each.

The next step is to reduce power to idle to remove the effects of slipstream and set up the same airspeed as before (ie, a glide). Trim. Now the student again operates all controls, noting the changed feel of those within the slipstream – the elevator and rudder, or just the rudder in the case of the Piper Tomahawk.

To effectively demonstrate the effect of slipstream, maintain a constant airspeed and vary the power setting.

Power

To demonstrate the effects of a power increase or decrease, the aeroplane should be trimmed straight and level at an intermediate power setting. Point out that for this demonstration the feet are off the rudder and the hand is resting lightly on the control column before any power change.

It may be better to demonstrate the effects of reducing power first and then trimming for a descent at a low power setting, for example 1500 rpm, which will provide for a greater pitch change when demonstrating the effects of increasing power. Using full power for this gives a very good demonstration, especially as the aeroplane is trimmed for a descent.

The student should experience compensating for the power changes with appropriate pitch and balance application – "keeping the picture the same."

The instructor should trim the aeroplane as required.

Trim

The use of elevator trim to relieve control loads and maintain a constant attitude is demonstrated next. Be aware that the aeroplane is trimmed for an attitude, not an altitude or airspeed. The student should be asked to hold a constant attitude – any attitude will do – you then apply trim to load the control (caution: do not use excessive amounts of trim in case the student suddenly lets go of the control column). When the student can feel that they are pushing or pulling in an effort to maintain the attitude they should move the trim in the appropriate direction to remove the load.

To trim the aeroplane the student should be encouraged to gradually relax their grip on the control column as they neutralise the control forces and, looking outside at the attitude, observe any change. If a change is observed, the desired attitude should be re-selected with the primary flight controls, then pause while equilibrium is re-established, and then re-trim and start the checking process again. As already pointed out, the student at this stage, cannot feel subtle control pressures. However, the changing attitude should be relatively easy to detect. The aim is to be able to fly the aeroplane at a constant attitude, using only a finger and thumb grip, and this will not be achieved in one lesson.

Flap

Point out the white arc on the airspeed indicator.

To demonstrate the effect of flap, an attitude should be selected for a suitable speed within the white arc. Trimmed for straight and level, flap is selected, the pitch change for the aeroplane type noted and the aeroplane re-trimmed. This will not necessarily require the application of full flap to occur. The student can operate the flap, but be aware that observing the pitch change is the more important aspect. From trimmed level flight demonstrate the effect of raising the flap, and the re-trimming required. Also note the changes in lift and drag, and the sink encountered with changes in airspeed.

After Flight

After landing, allow the student to revise taxiing and to move the mixture control to ICO on shut down.

The operation of the aeroplane's heater/demister and fresh-air vents can be demonstrated.

After the debrief (see below) tell the student the next lesson will be *Straight and Level*, and that you will be using the controls you learnt about today to fly straight and level. They may want to do some further reading on this.

Debrief

Comments are given here as a guide to the novice instructor on how to complete the debrief while gaining the experience needed to expand their teaching.

The debrief is an opportunity to revise the exercise, and for both you and the student to reflect on whether the objectives have been met.

Did the student operate the aeroplane's primary controls and experience the first aerodynamic effects? Did they observe the further effects on the aeroplane in flight? Did they operate and experience the ancillary controls and their effects?

If you require verbal confirmation from the student that the objective has been achieved, questions should be phrased to test understanding. Do not ask if the student observed the secondary effects of the primary controls. Preferably, ask the student to describe the further effect of one, or each, of the primary controls.

It is important at this early level to allay any fears or false expectations by reinforcing the fact that there is much to learn. Competence at this stage is not as important as understanding – every lesson will build on the last and give the student every opportunity to improve.

BASIC CONCEPTS

Straight and Level

This lesson should start with you asking the student what they did in the last lesson, what do they remember, and determining if they have remembered correctly.

We must be able to fly the aeroplane in a straight line, on a constant heading and at a constant altitude. Maintaining a constant altitude requires a constant attitude and a constant heading requires the aeroplane to be wings level and in balance.

This is the first exercise in coordination for the student, and it is very important that they understand, and can then demonstrate, how the controls they learnt about in the previous *Effect of Controls* lesson are used to achieve and maintain a constant heading, constant altitude, constant airspeed, and in balance.

It is also an important lesson because it shows the interrelation of a number of variables, such as power, airspeed, pitch and yaw.

The lesson should initially cover configuring straight and level flight at a constant airspeed and then maintaining it. It is followed by regaining straight and level after a disturbance and finally straight and level at different airspeeds and power settings.

It is critical that the student understands that straight and level is achieved by referencing the aeroplane's attitude with the horizon, and then checked by reference to the aeroplane's instruments. Use a moveable 'windscreen view' to show the correct attitude for straight and level flight.

Figure 1

Objectives

To establish and maintain straight and level flight, at a constant airspeed, constant altitude, in a constant direction, and in balance.

To regain straight and level flight.

To maintain straight and level flight at selected airspeeds or power settings.

Principles of Flight

In VFR flight, flying straight and level should only be accomplished with reference to the horizon. Define the horizon for the student and explain how the horizon can be identified if it is not visible, for example with hills or weather in the way.

The Four Forces

The four forces acting on the aeroplane should be explained.

Weight

Acts straight down through the centre of gravity.

Lift

Is produced by the wings and acts upwards through the centre of pressure.

Thrust

Is provided by the engine through the propeller.

Drag

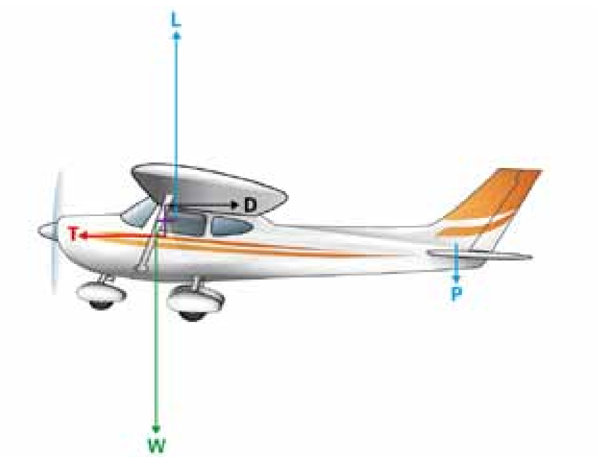
Is the resistance to motion felt by all bodies within the atmosphere.

Equilibrium requires a constant airspeed and constant direction (the combination of these is velocity). A constant direction is maintained by the wings being level and the aeroplane in balance.

Equilibrium is achieved when lift = weight and thrust = drag.

Describe how the arrangement of these forces forms couples. Lift acts through its centre of pressure and is slightly behind the centre of gravity, where weight acts (small moment arm), creating a nose-down pitching couple. The comparative size of the lift and weight forces to thrust and drag forces should be discussed. For general aviation aeroplanes the lift/drag ratio is said to be about 10:1. Your diagram should reflect this ratio approximately – a picture is worth a thousand words.

Figure 2



The ideal arrangement is for the thrust line to be well below the drag line. This provides a large moment arm to compensate for the smaller forces of thrust and drag, and creates a nose-up couple that balances the nose-down couple of lift and weight.

In the previous lesson *Effect of Controls*, the student saw the pitch change when power was increased and decreased. The arrangement of these couples is the reason for the pitch changes. A decrease in power will pitch the nose down into a descent, without pilot input, and an increase in power will pitch the nose up.

In practice, getting the thrust and drag lines separated far enough to balance the lift/weight couple is not possible. Therefore, the tailplane is set at an angle of attack that will provide a down force on the tailplane in level flight, which combined with the large moment arm, balances the forces.

Any further imbalance between the couples, as a result of weight or airspeed changes for example, are compensated for by the elevator.

Lift

Lift is generated by air flowing faster over the top surface of the wing, compared with air flowing under the wing. Air is made to flow faster by shaping the top surface – called camber.

The formula for lift is:

$$L = C_L \, \tfrac{1}{2} \, \rho \, V^2 \, S$$

Where,

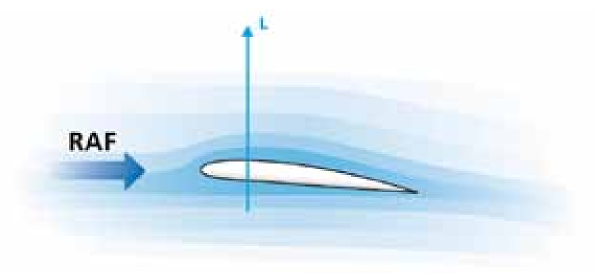
- **C_L** is the co-efficient of lift (angle of attack)
- **½** is a constant
- **ρ** (rho) is the density of the air
- **V** is the airspeed, and
- **S** is the surface area of the wing.

The two elements the pilot can easily control are airspeed and angle of attack, so in essence;

L = angle of attack x airspeed

Angle of attack (**α**) is the angle between the relative airflow and the chordline of the aeroplane's wing.

Figure 3



The most efficient angle of attack is approximately 4 degrees, but as no angle-of-attack indicator is fitted to light aeroplanes, the airspeed is used as a guide to the aeroplane's angle of attack.

In order to keep lift constant, any change in the angle of attack must be matched by a change in the airspeed. For example if airspeed increases, less angle of attack is required to maintain a constant lift. A decrease in airspeed will require an increase in the angle of attack to maintain constant lift and consequently altitude.

Performance

Introduce the concept of

Power + Attitude = Performance

Power is set by reference to rpm – use the organisation's recommended rpm setting for training flights, in the example below we have used 2200 rpm.

The attitude will depend on the aeroplane type, in this example we will use four fingers below the horizon.

In this case the performance we want is a constant altitude, direction and airspeed – straight and level.

Power +	Attitude =	Performance
(2200)	(four fingers)	(straight and level)

Airmanship

Discuss the lateral boundaries of the training area and the importance of managing the flight to remain within them.

Revise 'I have control – you have control.'

Aeroplane Management

Stress the importance of smooth but positive control movements.

Operation of the mixture control has been explained in the previous lesson. During initial training, as a result of regular altitude and power changes, the mixture is normally left in the full rich position.

Revise why carburettor heat is set to HOT at power settings below ______ (commonly the green arc or 1900–2000 rpm).

Human Factors

Review the visual limitations discussed in the last lesson and how blind spots effect a good lookout.

There is a lot of information for the student to absorb in the early lessons, so reassure the student that there will be plenty of time to master these skills.

Air Exercise

Identify the horizon, and what attitude is required relative to the horizon, with the appropriate power setting, to establish and maintain straight and level flight.

Power +	Attitude =	Performance
(2200)	(four fingers)	(straight and level)

With the use of the 'windscreen view' show the attitude in the correct position as well as in the too low and too high positions.

Establish Straight and Level

Establishing straight and level flight is achieved by using the mnemonic **PAT**.

P ***P****ower*

Set the power for selected (normal) straight and level performance.

A ***A****ttitude*

The attitude for straight and level is made up of three elements.

Elevator	Set the nose attitude – for level (eg, four fingers)
Aileron	Wings are level relative to the horizon – for straight
Rudder	In balance – for straight

If a constant direction is not being maintained on the reference point (and the DI should confirm this) either the wings are not level, or the aeroplane is out of balance, or both.

Balance is confirmed with the balance ball indicator. The method used to achieve balance is 'stand on the ball'. If the ball is out to the left, increased pressure on the left rudder pedal is required. This is a pressure increase, more than a movement and 'stand' implies continued pressure. Once the ball has been centred, reducing pressure will allow it to move out again.

The aeroplane is kept in balance to not only keep the aeroplane flying straight, but also for best efficiency by keeping the drag to a minimum and achieving the best airspeed.

If the correct level attitude has been selected the airspeed will be about ______ knots. If the correct power setting is maintained the aeroplane will maintain altitude, and if the wings are level and balance maintained the aeroplane cannot turn. Therefore, the objective to fly at a constant airspeed, constant altitude, constant direction, and in balance is achieved.

T ***Trim***
Take the time to teach this thoroughly, make sure the student relieves all of the control pressures so that their hands can come off the controls and the aeroplane remains level.

Maintaining Straight and Level

Maintaining straight and level is achieved by using the mnemonic **LAI**.

L ***Lookout***
In a scan loop ahead, look out to the left and scan 20 degrees for 2 seconds from left to right, passing over the nose of the aeroplane.

A ***Attitude***
Ensure the attitude is correct relative to the horizon and, more importantly, constant.

I ***Instruments***
Used to confirm accurate flight – not set it. From right to left the instruments are scanned, and this brings the scan back to the left side of the aeroplane and the process starts again.

During the instrument scan, only those instruments important to the phase of flight are read. In this case the altimeter will probably be scanned on every sweep, with oil pressure and temperature scanned every 10th sweep.

Regaining Straight and Level

1. Check the airspeed, and the power setting – set the correct power setting. If the airspeed is decreasing, increase power, if the airspeed is increasing, decrease power.
2. Check the nose attitude – set the attitude for straight and level
3. Check the wings are level and the ball is in the middle – level the wings, centre the ball
4. Reset the power after making any changes to the attitude
5. Check **PAT** (power, attitude, trim)

For small altitude adjustments of less than 150 feet, the attitude is altered with elevator, and when the desired altitude is regained the correct level attitude is set, held and trimmed. For bigger altitude adjustments power is usually altered.

Straight and Level at Different Airspeeds and Power Settings

Power + Attitude = Performance

It should be emphasised that every time power or airspeed is altered, a change in rudder pressure will be required to maintain balance. Therefore, during those phases of flight where power or airspeed are changing, rudder will need to be applied to maintain balance. In addition, when rudder is being used to centre the ball, the wings must be held laterally level with aileron.

List the various power, airspeed and attitude required to maintain straight and level flight. An example is shown below.

Power	2200	1800	2500
Airspeed	80–90 knots	60 knots	110 knots
Attitude	Normal	High	Low

As can be seen, a high power setting means a higher airspeed, requiring a lower nose attitude. Conversely a low power setting means a low airspeed, requiring a higher nose attitude.

Airborne Sequence

On the Ground

Show the student the preflight inspection again, and have them follow you through, pointing out what they would be looking for.

- Make sure the student's seat is properly adjusted.
- Talk the student through the engine start up.
- Revise taxiing.
- Talk the student through the checks.

The Exercise

Have the student follow you through with the takeoff, and once safely airborne hand over control to the student, showing them the climb attitude and reference point you want them to hold.

On the way out to the training area teach the horizon concepts and point out the local landmarks.

Establish the aeroplane in straight and level.

Point out the horizon to the student – let them note the attitude when level. Demonstrate an attitude that is too high and an attitude that is too low.

Configure the aeroplane, using **PAT**, in straight and level flight at normal cruising power. Once the student has recognised the attitude, and noted that the wings are level and the aeroplane is in balance, hand over control.

Talk the student through establishing straight and level using **PAT** and maintaining straight and level using **LAI**.

Make minor deviations away from straight and level and talk them through regaining it.

Show the student the effect of a marked imbalance. They should be able to 'feel' that the aeroplane is out of balance. Then show a slight imbalance. This is much harder for them to 'feel' or detect, and that is why the balance ball is used to correct slight imbalances. Show them how to correct for an imbalance.

You should then give the student some practise at regaining straight and level by disturbing the aeroplane in roll, pitch, trim and power.

Demonstrate the lookout technique, outside and inside.

Once the student is comfortable with regaining straight and level, demonstrate the different power settings, and corresponding airspeed and attitudes, required for straight and level flight. Finish by letting them practise returning to straight and level flight by changing the power, adjusting the attitude and remaining in balance.

On the return to the aerodrome, point out the local landmarks again, and show them the descending attitude, ready for the next lesson.

After Flight

Debrief the student.

Next lesson will be *Climbing and Descending*, they may want to do further reading on this, and ask them to think about the attitudes for climbing and descending they saw in this lesson.

CIVIL AVIATION AUTHORITY OF NEW ZEALAND
Te Mana Rererangi Tūmatanui o Aotearoa

BASIC CONCEPTS

Climbing and Descending

This lesson builds on the coordination skills learnt in the previous lesson, *Straight and Level*. Check with the student what the important elements of the last lesson were. Have they remembered the attitudes you looked at last time, and that all the controls need to be moved in a coordinated way?

There are a large number of power changes made during this air exercise and it is important the student reviews and practises the coordination of elevator and rudder adjustments with changes in power.

There are generally four types of climb: best angle, best rate, cruise and recommended (for visibility and engine cooling). There are also generally three types of descent: glide, powered and cruise.

It is recommended you teach the best rate climb and the glide, with a demonstration of the others as time permits.

The last lesson was *Straight and Level*, now we must learn how to climb and descend to and from straight and level flight, so that we can move towards the circuit lessons.

Objectives

To enter the climb and the descent from straight and level flight.

To maintain a climb and a descent at a constant speed, constant rate, in a constant direction and in balance.

To level off at specific altitudes.

Principles of Flight

Climbing

To maintain a constant speed and direction the aeroplane must be in equilibrium, as discussed in the *Straight and Level* lesson. We demonstrate the relationships between the four forces in the climb to show that the aeroplane is still in a state of equilibrium when climbing.

There is no requirement to prove anything in a preflight briefing. Statements illustrated with diagrams are sufficient to support the air exercise.

There is a common misconception that in the climb the lift is increased, since if lift must equal weight in level flight, it might appear logical that lift should be increased to climb, but it is not so. Drawing the forces to show that lift is not increased in the climb – but is slightly reduced – should illustrate that the aeroplane is in equilibrium during the climb.

The most important concept the student should grasp, in simple terms, is that in order for an aeroplane to climb thrust must be equal to drag plus the rearward component of weight ($T = D + RCW$). The rate at which the aeroplane will climb, depends on how much more power is available, lots of additional power available will mean a high rate of climb.

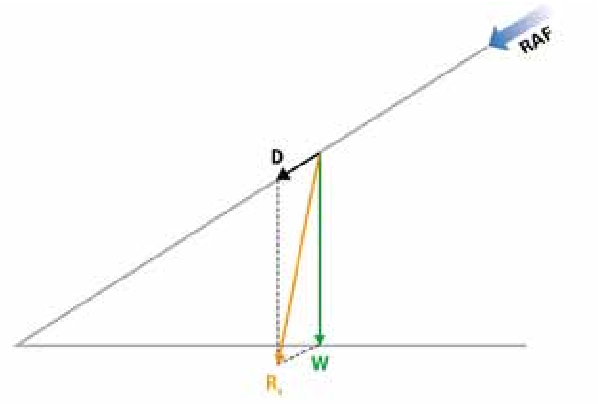
The Forces Acting on the Aeroplane in a Climb

From the previous lesson the student will know that there are four forces acting on the aeroplane, lift, drag, thrust and weight, and that in straight and level the aeroplane was in equilibrium. The same is true of the climb – the forces are in equilibrium. They will also know about relative airflow.

Explain that for simplicity your diagram will show the forces acting through just one point, and that the climb angle has been exaggerated for clarity.

Start by showing weight and drag and their resultant – R1.

Figure 1

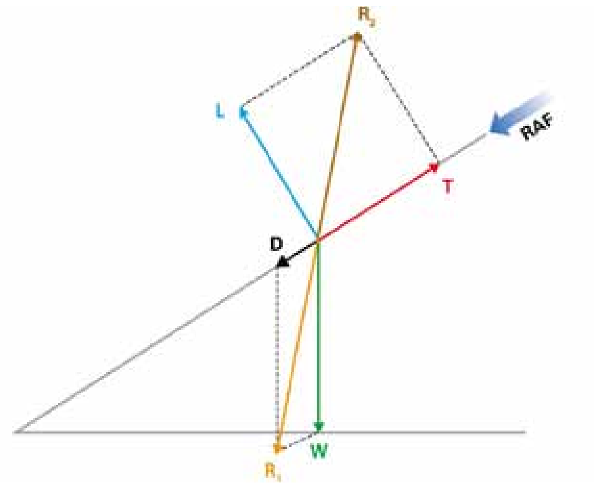


Make the statement: "Since the aeroplane is in equilibrium there must be a force equal and opposite to this resultant – R1"

Then, draw a line from the central point, equal and opposite to R1 and label this R2.

Resolve R2 into its two components, lift and thrust.

Figure 2



The relationship of the four forces is next explained, as was done in straight and level. Starting with thrust (T) and drag (D).

In straight and level flight thrust equals drag (T = D).

In a climb, thrust must increase to equal drag plus the rearward component of weight (T = D + RCW).

It should be clear to the student from your diagram, that in a steady climb, "thrust is ______ than drag."

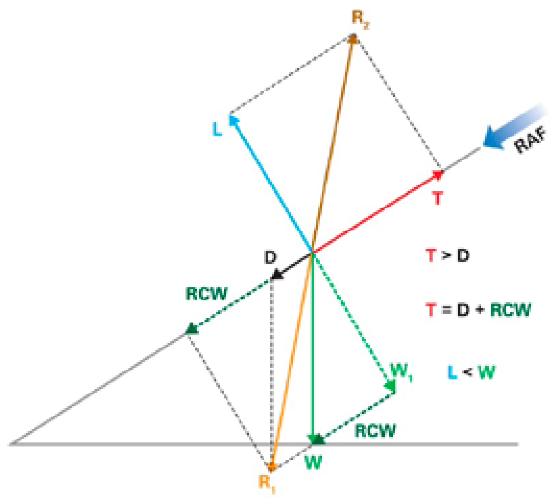
Why then, does the aeroplane not accelerate?

To resolve this question, break weight (W) down into its two components, with the rearward component of weight (RCW) added to the drag vector.

Thrust is equal to the drag plus the ______.

You may wish to finish off the parallelograms to tidy up your resolution of vectors. The end result looks like this:

Figure 3



Finish off by asking the student what force controls the climb. And is there a limit to that force? How might that limit the climb?

Climb Performance

Having discussed the forces in the climb, the various factors affecting the climb performance are discussed.

Power

You have just established that the more power available, the better the climb performance.

Altitude

Engine performance (power) decreases with altitude, so there will be a limit to how high the aeroplane can climb.

In addition, anything that opposes thrust is detrimental to climb performance.

Weight

The greater the weight, the greater will be the RCW (rearward component of weight). Therefore, weight reduces the rate of climb and the angle.

Flap

Increases lift and drag and alters the Lift/Drag ratio. Since drag opposes thrust, any increase in drag will reduce the rate and angle of climb.

Wind

Affects only the climb angle and the distance travelled over the ground (the range) to reach a specific altitude.

Table 1

The various configurations for the four types of climb in your training aeroplane are:

Performance =	Power	+	Attitude
Best rate climb	full power	no flap	________ knots
Best angle climb	full power	no flap	________ knots
Cruise climb	________ rpm	no flap	________ knots
Recommended climb	________ rpm	no flap	________ knots

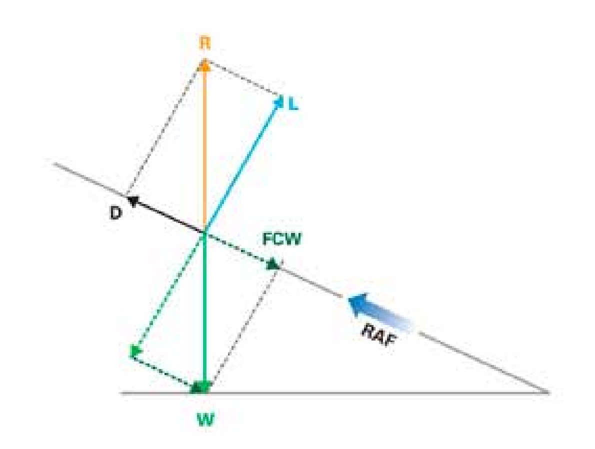
Let the student know that you will be using the best rate climb for this lesson and you will demonstrate the others. They may experience these climbs at this stage but their application will become clearer in later lessons.

Descending

Equilibrium is required for a steady descent. If, while in level flight, the power is removed there will be no force balancing the drag. In order to maintain flying speed the nose must be lowered.

With the nose lowered and weight still acting down towards the centre of the earth, there is now a forward component of weight (FCW) that balances drag. State that for equilibrium there must be a force equal and opposite to weight. This force R is made up of lift and drag. Therefore, the aeroplane is in equilibrium.

Figure 4



Point out that the relative airflow is now coming up the slope to meet the aeroplane and therefore the angle of attack is still approximately 4 degrees.

Power

Power controls the rate of descent (RoD), the more power used, the less the RoD. Power also reduces the descent angle and increases the distance travelled over the ground, increasing the range from a given altitude.

Lift/Drag ratio

The ratio of lift to drag is a measure of the efficiency of the wing, for example, the higher the lift to drag ratio the further the aeroplane will glide (its range). Another way to think of it is the L/D ratio determines the steepness of the glide, or descent angle.

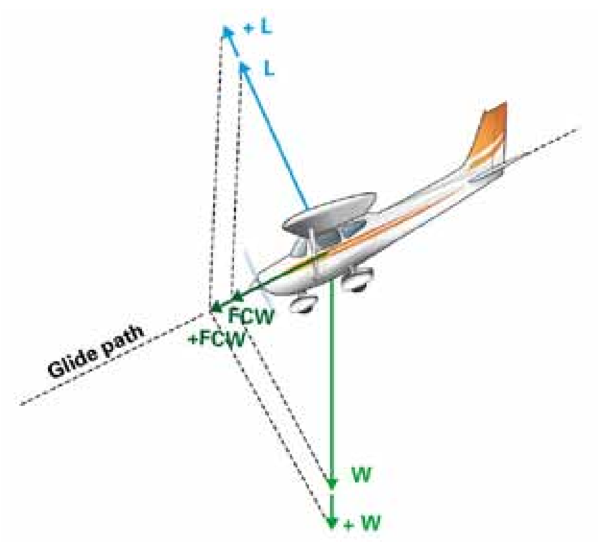
If you then change this ratio by increasing the drag (by extending flap or flying at an incorrect airspeed) a greater forward component of weight is required to balance the drag – steepening the flight path.

Weight

A change in weight does **not** affect the descent angle. With an aeroplane flying at its best L/D ratio, an increase in weight will increase the FCW, increasing the speed down the slope, and therefore the rate of descent, but not the descent angle.

Show this by increasing the length of the weight vector in your diagram. The FCW increases the airspeed down the slope, and the increased airspeed leads to an increase in lift and drag (with the L/D ratio remaining unchanged), and all the forces remain in equilibrium.

Figure 5



Flap

The increased drag produced by the flap requires an increased FCW to maintain equilibrium and thereby steepens the descent, increases the RoD, and reduces the range.

Wind

Affects only the descent angle and the range from a given altitude.

Table 2

The various configurations for the three types of descent in your training aeroplane should be stated, for example:

Performance	=	Power	+	Attitude
Glide		propeller windmilling	no flap	______ knots or ______ ft/min RoD
Powered		1500 rpm (guide only)	flap as required	______ knots or ______ ft/min RoD
Cruise		______ rpm (within green range)	no flap	______ knots or ______ ft/min RoD

Teach the glide first, then the others can be taught as a variation of the glide.

Airmanship

Situational awareness should be briefly described as a three-dimensional assessment of what has been, what is, and what will be. Explain that this skill takes time to develop, but should be practised at every opportunity.

Introduce the concept of threat and error management in simple and practical terms, as applicable to climbing and descending.

The met minima requirements for VFR flight outside controlled airspace, below 3000 feet amsl or within 1000 feet of the ground should be revised – refer to the *NZ Airspace* poster and *Met Minima* card.

Discuss minimum height requirements. For example, 500 feet agl minimum over unpopulated areas, 1000 feet agl minimum over built-up areas but not less than that required to glide clear of the populated area. Stipulate any club or organisation minimum safe heights.

Discuss the restrictions on lookout in relation to high and low nose attitudes. Explain that there are at least two methods for ensuring the area ahead is clear, lowering the nose every 500 feet or making gentle S-turns. While climbing out to the training area you will use gentle S-turns.

As the exercise does not involve prolonged climbs or descents – usually no more than 500 feet – there is no need to use either method, but a good lookout must be maintained, particularly before starting the climb or descent.

Revise situational awareness in relation to aeroplane positioning, lateral and vertical limits of the training area, and VFR met minima requirements within the training area.

The **I'M SAFE** checklist may be revised, but emphasis should be placed on this checklist being completed before the student leaves home.

Aeroplane Management

Throttle

The student has informed you of the power setting that will give the best climb performance. You need to point out that not all aeroplanes can climb on full power continuously.

If the organisation or aeroplane has an rpm limit for the prolonged climb, it should have been explained in the desired configuration above, if not then explain it here.

The detrimental effects of a prolonged glide should be discussed, for example, plug fouling and excessive cylinder-head cooling. This should lead to a discussion on the advantages of a powered descent.

Mixture
The use of full rich mixture, to aid engine cooling and prevent detonation, at power settings above 75% (below 5000 feet) should be explained.

During training it is common practice to use full rich mixture in the descent (discuss mixture control in prolonged descent from altitude).

Carburettor heat
Is not normally used at climb power settings because of the detrimental effect of carburettor heat on engine performance, and therefore climb performance.

In the descent, hot air is selected before reducing power because of the difficulty in recognising the symptoms of carburettor ice at low power settings and the increased likelihood of carburettor icing.

Temperature and pressure gauges
In the climb it is normal to see an increase in oil and cylinder head temperatures with a decrease in oil (and fuel) pressure. In the descent it is normal to see a decrease in oil and cylinder-head temperatures and an increase in oil (and fuel) pressure.

The normal readings for this aeroplane in the climb and descent should be discussed. In addition, how to prevent these readings reaching their limits in an air-cooled engine should be discussed. For example, lowering the nose attitude to climb at a higher airspeed or, if necessary, levelling off for a short period, or during descent increasing power every 1000 feet to warm the engine oil and clear the spark plugs of carbon deposits, or the use of a powered descent.

Human Factors

Discuss the effects of trapped gases in the middle ear and sinus in relation to their expansion with increasing and decreasing altitude. In general, a comfortable rate of descent for a fit person is 500 feet per minute. Discuss and demonstrate the ‘valsalva manoeuvre’.

Discuss the dangers of diving and flying.

Discuss the effects of altitude on vision with regard to empty sky myopia (short-sightedness) or focal resting lengths, reinforcing the need for a clean windscreen and systematic scan technique. Also discuss the effect of the background on object detection.

As a result of high power settings, noise levels will be increased and it is appropriate to discuss the effects of exposure to noise as well as how to prevent hearing damage.

Air Exercise

The air exercise concentrates on improving the coordination skills learnt in the previous lessons, by entering and maintaining the climb and descent, while maintaining the aeroplane in balance, and regaining straight and level. It is particularly important to reinforce the need to balance power changes with rudder.

Introduce some basic radio calls.

Climbing

Discuss the nose attitude position in relation to the horizon for the selected climb configuration.

Entry to the climb is taught as **PAT**, reinforcing the concept that climb performance depends on power. Since increasing power smoothly (stop the resulting yaw with rudder) will cause the nose to pitch up, power and attitude should be considered a coordinated movement, and no engine over-speed should occur.

Power + Attitude = Performance

P Power
Check mixture rich, smoothly increase power (while stopping the yaw with rudder) to full power or maximum continuous; keep straight using the reference point.

A Attitude
With elevator, select and hold the attitude for the nominated climb, maintaining wings level with aileron and balance with rudder.

T Trim
Remove excessive loads by trimming back. Once performance has been confirmed, trim accurately to maintain a constant attitude.

If the correct climb attitude is selected the airspeed will be ______ knots (exactly). If both the attitude and the power setting are correct, the resulting performance is a steady rate of climb of ______ ft/min (500–700 approx). If the wings are held level and balance maintained, the aeroplane cannot turn. Therefore, the objective of entering and maintaining the climb has been achieved.

Maintaining the climb incorporates the **LAI** scan, with those instruments pertinent to the climb being scanned most frequently for accurate flight.

If the airspeed is not correct then the attitude is incorrect, and performance will be affected. Emphasise that the airspeed is altered by reference to attitude, and that due to inertia once a change has been made, a smaller change in the opposite direction will be required, to hold the new attitude. These corrections are commonly stated as "change – check – hold – trim".

To regain straight and level from a climb, the mnemonic **APT** is used.

A Attitude
Anticipate the required altitude by approximately 10 percent of the rate of climb, ie, a climb of 500 feet per minute will require an anticipation of 50 feet.

With the elevator, select and hold the level attitude. The airspeed will increase only gradually, because the aeroplane must overcome inertia. To assist this process, climb power is maintained until a suitable airspeed has been achieved. As the airspeed increases the aeroplane's nose will want to pitch up, requiring subtly increasing forward pressure on the control column to maintain the correct attitude. The wings should be kept level in relation to the horizon, and rudder adjusted to keep straight on the reference point.

P Power
Through ______ knots, decrease power to ______ rpm. The resultant pitch change and yaw must be compensated for, remember to use smooth throttle movements.

T Trim
Accurate trim cannot be achieved until equilibrium has been established. However, obvious control loads may be reduced immediately, then followed by accurate trimming.

Once the instruments confirm level flight is being maintained, the aeroplane can be accurately trimmed to maintain the selected **attitude** and reference point.

Descending

Discuss the nose attitude position in relation to the horizon for the descent.

Entry to the descent is taught as **PAT**.
Power + Attitude = Performance

P Power
Check the mixture is RICH, carburettor heat HOT, smoothly close the throttle and keep straight using the reference point.

A Attitude
With the power reduction the nose will want to pitch down, with elevator, hold the level attitude until the nominated descent airspeed is almost reached (allowing for inertia), and then select and hold the attitude for the nominated descent. Maintain wings level with aileron and balance with rudder.

T Trim
Remove excessive load by trimming (usually backwards) and once the performance is achieved, trim accurately to maintain a constant attitude.

With the correct descent attitude selected the airspeed will be ______ knots exactly. If the attitude is correct, and the power is set correctly, the resulting performance is a steady rate of descent of ______ ft/min (approx 500). If the wings are held level and balance maintained, the aeroplane cannot turn. Therefore the objective of entering and maintaining the descent has been achieved.

Maintaining the descent incorporates the **LAI** scan, with those instruments pertinent to the descent being scanned most frequently for accurate flight.

If the airspeed is not correct then the attitude is incorrect. Emphasise that the airspeed is altered by reference to attitude and that, due to inertia, once a change has been made a smaller change in the opposite direction will be required to hold the new attitude. "Change – check – hold – trim."

To regain straight and level from the descent the mnemonic **PAT** is used. Because of inertia, power leads the sequence to arrest the descent.

P ***P**ower*

Anticipate the required altitude by approximately 10 percent of the rate of descent, ie, a descent of 500 feet per minute will require an anticipation of 50 feet.

Carburettor heat COLD, smoothly increase power to cruise power (balancing with rudder).

As airspeed increases, rpm may increase slightly, requiring another throttle adjustment.

The power change will cause the nose to yaw, if not corrected with rudder, and to pitch up. The pitch-up tendency encourages a coordinated movement because the next step is:

A ***A**ttitude*

With the elevator, select and hold the level attitude. Maintain wings level with aileron, and balance with rudder.

T ***T**rim*

Remove obvious loads, and when straight and level has been confirmed through **LAI**, trim accurately to hold the correct **attitude**.

Airborne Sequence

On the Ground

Ask the student to carry out the preflight inspection, while you observe.

Ask the student to taxi, and point out the obstructions and possible threats as they go. Depending on the level of comfort of the student at this stage of their training, you may like to introduce the checklists to them and get them to follow you through, or do the checks as you call them out.

The Exercise

Depending on their level of comfort, you may either want to let the student complete the takeoff, while you follow them through, or talk them through the experience.

On the way out to the training area demonstrate the climbing attitude relevant to the horizon and the corresponding speed. Ask the student to point out the landmarks they were shown in the last lesson.

Review straight and level with emphasis on a specific altitude.

From straight and level nominate a reference point and altitude to climb to – considering cloud and overlying airspace restrictions. Demonstrate the climb and the level off to resume straight and level at a specific altitude. Anticipation of the altitude is required.

The student should now practise the entry to the climb, maintaining the climb and the level out until proficient. Then have the student establish the aeroplane in another climb and demonstrate different climb attitudes and corresponding speeds, noting rate of climb effect, and the effect of flap, especially flap retraction in a climb, in preparation for the go around in the circuit lessons. Once it had been demonstrated, encourage the student to make the flap selections and note the effect it has on the attitude, airspeed, rate of climb and trim.

Have the student establish in straight and level on a reference point. Nominate a reference point and altitude to descend to – considering minimum height restrictions. Remind the student that you will be using the glide, with the throttle closed. Demonstrate the glide and the level off to resume straight and level at a specific altitude. Anticipation of the altitude is required.

The student should now practise the entry to the descent, maintaining the descent and the level out. Once the student has completed the sequence, have the student establish the aeroplane in another descent and demonstrate the effect of power and flap. Once it had been demonstrated, encourage the student to make the flap selections and note the effect it has on the attitude, airspeed, rate of descent and trim.

Practise the climb and descent as required, so that the student is comfortable with the entry, maintenance and exit, and coordinates rudder with power changes.

On the way back to the aerodrome demonstrate the cruise descent, including the selection of power and rate of descent appropriate for the conditions, and remind the student that there will be time to practise this on every flight.

After Flight

The next lesson will be turning. Ask the student to read any notes they have on turns and to remember the attitudes they saw in this lesson.

Ask the student what they learnt about power changes and rudder use.

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Medium, Climbing and Descending Turns

A medium turn is defined as a turn using up to 30 degrees angle of bank.

Climbing and descending turns are combined with medium turns within this briefing, but your organisation may prefer to present a separate briefing, consult with your CFI.

The turning lesson builds on the previous lessons. The student will improve their attitude control and learn to smoothly and accurately coordinate aileron and rudder. During the roll-out the student will need to allow for aeroplane inertia and use smooth control inputs to regain the original reference point and height.

During this lesson the student will have the opportunity to practise straight and level, climbing, and descending. This is the stage at which the lookout technique is taught specifically, with the emphasis on the 20 degree per 2 second visual scan technique.

Define the medium turn and explain angle of bank. Explain that if you wanted to change direction, you wouldn't normally complete an entire circle. However, in order to reduce the chance of disorientation we complete a 360 degree turn and regain straight and level on the original reference point.

Objectives

To change direction through 360 degrees at a constant rate – using 30 degrees angle of bank – while maintaining a constant altitude and keeping the aeroplane in balance.

To complete a medium turn while climbing and while descending.

Principles of Flight

Start with a diagram of the aeroplane flying into the board (so that the student is correctly orientated) and revise how lift equals weight in straight and level flight.

Lift Vector

It is very important that the student understands that in order to turn the aeroplane an acceleration towards the centre of the turn must be provided. This is done by banking the aeroplane with aileron. Breaking lift down into its two components shows that it is the horizontal component of lift (centripetal force) that provides this acceleration towards the centre of the turn.

With the lift vector inclined, the vertical component of lift no longer supports the aeroplane's weight. To maintain a constant altitude or height, the total lift vector must be increased so that the vertical component now equals the weight. The appropriate amount of backpressure on the control column achieves this.

Figure 1a

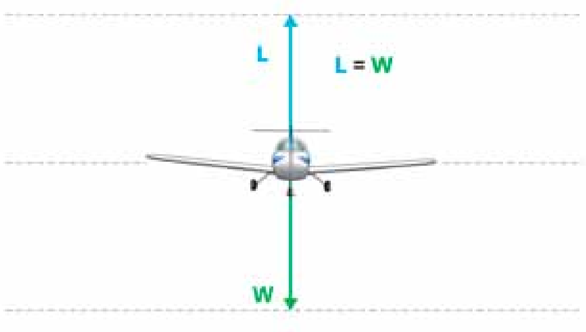
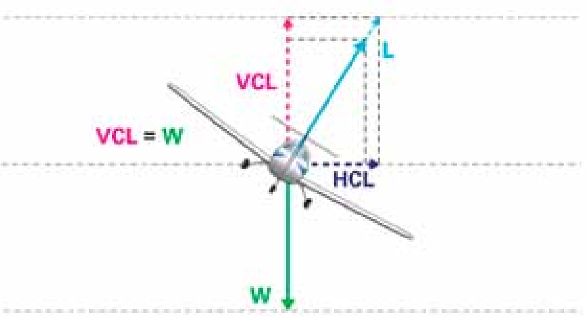


Figure 1b

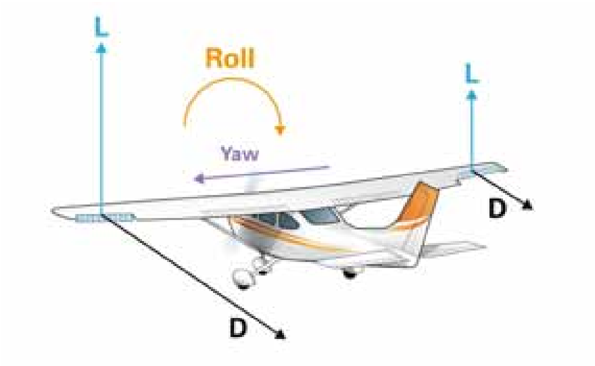


Of the options available for increasing lift, changing the angle of attack is the most practical. Any increase in lift will produce a corresponding increase in drag, and therefore, a reduction in airspeed. In the medium level turn, the lift and drag increases are very slight and the decrease in airspeed is minor – only subtle elevator application may be necessary.

Adverse Yaw

From the *Effects of Controls* lesson, the student knows that ailerons are used to bank an aeroplane, and this is achieved by changing the shape (camber) of the wing, which in turn changes the lift on that wing. In order to bank right, for example, the left (or up-going) wing has more lift and the right (or down going) wing has less lift.

Figure 2



One of the side-effects of increasing lift is a corresponding increase in drag. So even though there is more lift on the up-going wing, and the aeroplane rolls, there is also more drag on that wing, and that produces a yaw, away from the direction of the turn – termed adverse yaw.

To overcome this effect and to achieve balanced flight, rudder pressure is applied in the direction of turn, while the ailerons are being moved. Once the required bank angle is achieved, and the ailerons centralised, the rudder pressure can be reduced to maintain balance.

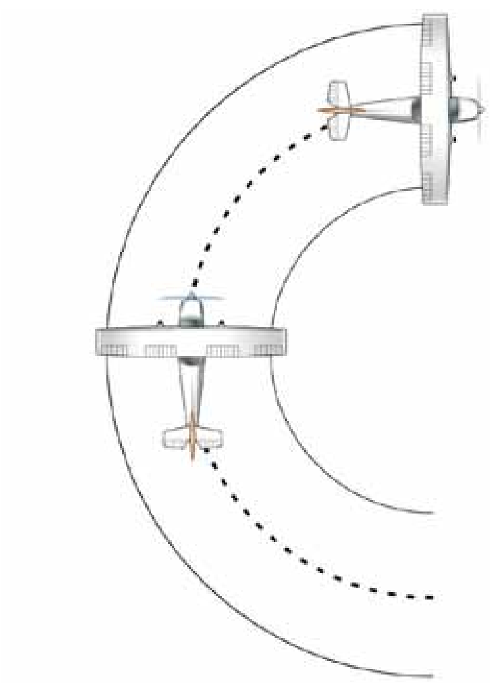
The amount of rudder required to overcome adverse yaw is dependent on the rate of roll, for example, during a rapid roll more rudder will be needed than at lower rates. The benefits of differential and frise ailerons may be discussed.

During descending turns, while at low airspeeds, the ailerons will need to be deflected further to achieve the same roll rate as at higher airspeeds. The increased deflection increases the drag, and requires more rudder to overcome the adverse yaw.

Overbanking

Overbanking is the tendency of an aeroplane to want to continue the roll into the turn, or increase the bank angle of its own accord.

Figure 3



In a level turn, the outside wingtip travels further, and therefore faster, than the inside wingtip. This increase in airspeed results in an increase in lift, which produces a tendency to roll into the turn. Even though this effect is minimal in small training aeroplanes, there will be a tendency for the aeroplane to increase its angle of bank if uncorrected.

For the purpose of this briefing, the increased tendency to overbank in both medium level turns and in climbing turns is caused by the outer wing travelling faster than the inner wing, thereby producing more lift and causing the aeroplane to increase the bank angle. Emphasis must be placed on negating these tendencies by maintaining the required angle of bank with aileron, commonly referred to as **holding off bank**.

In descending turns, the inner wing travels down a steeper descent path and hence meets the relative airflow at a greater angle of attack than the outer wing. The effect is to reduce, neutralise or even reverse the tendency for the bank to increase.

This can be expanded on in a separate briefing if needed.

Performance

As covered in the *Climbing and Descending* lesson, excess power determines the rate of climb. When a turn is combined with the climb, the tilting of the lift force and the increase in drag decreases the excess power, and reduces the rate of climb. Therefore, where a requirement to turn and climb exists, and performance is consequently reduced, the angle of bank is commonly limited to 20 degrees, with 15 degrees used for this exercise.

There are no significantly detrimental effects on performance when descending at angles of bank of up to 30 degrees.

Airmanship

Introduce the 20 degree per 2 second visual scan technique. The lookout starts at the tail – by looking over the shoulder opposite to the direction of turn – and continues forward through the nose of the aeroplane, in the direction of the turn, to finish looking at the tail again. Discuss the restrictions imposed on a good lookout by the airframe, and therefore the appropriate head movements required to minimise blind spots.

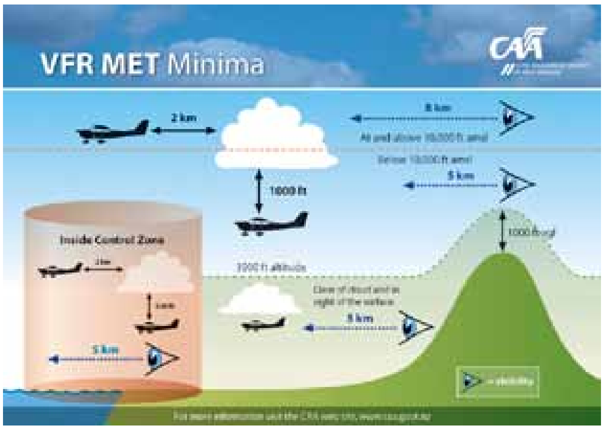
Developing the student's situational awareness is very important, and at this stage the lookout, and listen out, are particularly important.

Discuss situational awareness in relation to;

- completing 360 degree turns
- monitoring the aeroplane's position in the training area
- the minimum and maximum altitudes to be used
- the current weather

Introduce the VFR requirements within controlled airspace (5–2–1), you may like to provide them with a *VFR Met Minima* Card.

Figure 4



Aeroplane Management

There are no new engine handling considerations for this exercise, so revise the use of smooth but positive throttle movements.

Revise why carburettor heat may need to be used.

Human Factors

Turns are practised through 360 degrees to minimise disorientation. Choose an easily identifiable reference point.

For some students, the sensations of the turn may be uncomfortable at first. They may also tend to lean out of the turn. Let them know that this is a natural human tendency, as the body tries to realign itself with the perceived vertical, and that it will stop with exposure and practise. Students may also feel a slight increase in their weight, G, this is the opposite reaction to the acceleration toward the centre of the turn (centripetal force) – called centrifugal force.

Air Exercise

The first exercise will be a demonstration of adverse yaw, emphasising the appropriate use of rudder.

Discuss entering, maintaining and exiting the medium level turn, at a bank angle of 30 degrees.

The climbing turn is commonly demonstrated at 15 degrees angle of bank and the descending turn at 30 degrees angle of bank.

The markings on the artificial horizon should be explained – at least up to the 30-degree bank angle mark.

Figure 5

Entry

With a reference altitude, prominent reference point chosen, and the heading noted, emphasise and complete a thorough lookout.

Once the lookout is complete, roll the aeroplane smoothly into the turn with aileron and apply sufficient rudder in the same direction to maintain balance. Increase backpressure on the control column as required to maintain the altitude. Emphasise that the increase in backpressure is very slight, for example, if the aeroplane was being flown with the finger and thumb in level flight, only one more finger would be required to maintain the turn.

To maintain a constant airspeed when entering both the climbing and descending turn, relax backpressure as required.

In the Turn

At 30 degrees angle of bank – which should be recognised by reference to the attitude and confirmed by instruments – a slight check of aileron will be required and rudder pressure reduced to maintain balance.

Maintaining the turn involves using the **LAI** scan.

L ***L**ookout*

In a scan, look out to the left (port) and scan 20 degrees for 2 seconds from left to right, passing over the nose of the aeroplane. Emphasise looking into the turn.

A ***A**ttitude*

Ensure the attitude for 30 degrees angle of bank and level flight is correct relative to the horizon and, more importantly, constant. When the outside scan is complete, scan inside.

I ***I**nstruments*

Are scanned to confirm accurate flight (height – bank – ball).

Angle of bank is controlled with aileron – altitude with elevator.

During the turn, scan only those instruments relevant to the manoeuvre and do not trim the aeroplane.

Exit

Lookout into the turn for traffic and the upcoming reference point. Allow for inertia by anticipating the roll out so that the wings will be level when the reference point is reached. Common practice is to use half the bank angle as a guide, for example, in a 30 degree bank, start the roll out 15 degrees before the reference point. This helps establish a smooth roll out, making it easier to coordinate.

Approximately 15 degrees before the reference point is reached, start to smoothly roll wings level with aileron, balance with rudder in the same direction, and relax the backpressure to re-establish the level attitude and maintain a constant altitude. Check **PAT**.

Airborne Sequence

Before Flight

The student should be able to taxi by this point. Introduce the instrument check during the taxi, and continue (or begin) to involve the student in the checklists.

You may want to introduce some basic radio work. For example have the student call ready for takeoff, and respond to the clearance (if one is required).

The Exercise

On the way out to the training area revise the different climbing attitudes and their performance.

The student should be capable of climbing to a suitable altitude and levelling off. A short amount of straight and level practise can be done while you talk about adverse yaw. Since it is best to demonstrate adverse yaw at low speed, ask the student to slow the aeroplane down while maintaining straight and level. Take control and demonstrate adverse yaw. There is no need for the student to practise this.

Start with level 30 degree turns.

Emphasise the lookout, before and during the turn, by moving your upper body to demonstrate that more than just head movement is required to overcome blind spots.

Rather than patter the entry as "roll in with aileron, balance with rudder", it may be better to patter the actual control movements; for example, "roll in with right aileron, balance with right rudder." You will be able to move to "balanced entry" and "balanced exit" as the student progresses.

Once the student has completed satisfactory medium level turns, both left and right from straight and level, ask the student to enter a climb or descent and demonstrate the attitudes for climbing turns and descending turns. Then the student should enter the climb/descent while turning.

Finish the lesson with the student consolidating what they have learnt. Ask the student to climb/descend to an altitude and turn to roll out on a feature, so they can practise coordinating entering the climb/descent while turning and completing the climb/descent while levelling off. The student should complete the manoeuvres at a different altitude and heading from where they started.

On the way back from the training area more practise at the different descents and descending turns can be completed. The student may like to use the flap again to become a little more familiar with it.

The student may well be comfortable enough to fly the aeroplane in the circuit, under your direction. Discuss how you will be joining the circuit, and any radio call you need to make.

After Flight

Depending on the CFI's lesson sequence, the next lesson may be *Slow Flight*, where the student will need to fly straight and level and turn at a slower speed than they have yet seen. Ask them what sort of attitude they would expect to see if they were flying slower than normal.

Encourage them to do some pre-reading before the next lesson.

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BASIC CONCEPTS

Slow Flight

There are a number of situations when the aeroplane must be flown at or near its minimum airspeed, for example, during takeoff, landing, a go around, or missed approach and in the stalling lessons.

This lesson is not for operational slow flight, but aims to improve the students' awareness of the characteristics of flight at slow airspeeds and provides practise in maintaining balanced flight at those airspeeds. It is another important coordination exercise, reinforces the lessons learnt during *Straight and Level* at varying airspeeds, and is good preparation for the stalling lessons and for the takeoff and landing phase of circuit training.

Objectives

To slow the aeroplane and maintain straight and level at low airspeed (1.2V_S).

To maintain straight and level at low airspeed in various configurations.

To maintain a constant altitude while turning at low airspeed.

To return to normal operating airspeeds.

Principles of Flight

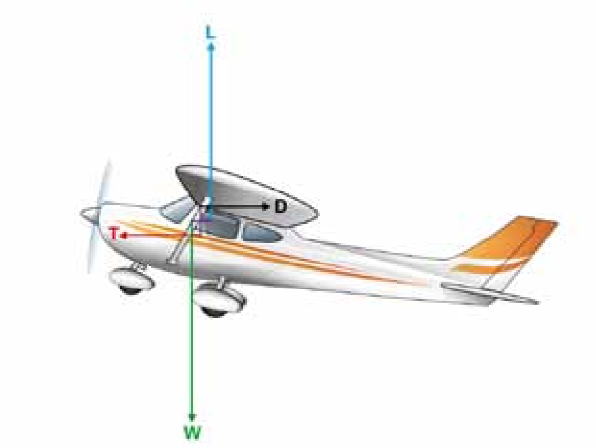
In normal cruise the angle of attack was approximately 4 degrees and the airspeed ______ knots.

From the *Straight and Level* lesson, lift is primarily controlled by varying either angle of attack or airspeed. As lift must equal weight to maintain level flight, as the airspeed decreases the angle of attack must increase.

Power + Attitude = Performance

In order to fly level at lower than normal airspeed, a higher than normal nose attitude is required, and once at that attitude, a small increase in power is needed to maintain the desired altitude.

Figure 1



Revise control effectiveness at slow speeds and the effects of slipstream. The controls will be sluggish and not as responsive as they would be at a higher speed and the reduced slipstream will require balancing with rudder.

Revise the effect of low airspeeds on control input and response. As was seen in the turning lesson a slower speed produces more adverse yaw.

Airmanship

Revise the 20 degree visual scan technique as introduced in the *Medium, Climbing and Descending Turns* lesson. Take into account the high nose attitude.

HASELL checks are carried out before stalling and aerobatics, and are introduced in this lesson.

H ***Height (not altitude)***
Not less than 2500 feet above ground level.

Some organisations stipulate a height greater than 2500 feet agl, consult with your CFI.

A ***Airframe***
State the configuration to be used.

S ***Security***
No loose articles, harnesses secure.

There should be no loose articles in the cockpit at any time because of the potential for jammed controls. Explain that harness security is a good aviation practice consideration.

E ***Engine***
Temperatures and pressures normal, mixture RICH, fuel sufficient and on fullest tank. Fuel pumps operated in accordance with operator procedures.

This is a routine systems scan to ensure everything is normal, before and during the exercise.

L ***Location***
Not over a populated area and clear of known traffic areas, including airfields.

L ***Lookout***
Carry out a minimum of one 180-degree, or two 90-degree, clearing turns, to ensure other traffic will not result in conflict.

Aeroplane Management

The use of smooth but positive throttle and control movements should be stressed. Even though more positive movement of the controls will be required there is no need to be aggressive with the controls.

Revise why carburettor heat may need to be used.

Be aware that operating at low airspeeds may raise engine operating temperatures.

Consider the position of the aeroplane three dimensionally within the training area.

Consider the warning symptoms of the approaching stall and be constantly aware of the aeroplane's configuration and flight phase.

Human Factors

There is a high level of concentration needed in this exercise, and is therefore quite a demanding lesson.

The high nose attitudes will be unfamiliar to the student.

Air Exercise

Straight and Level at Low Airspeed

Using the flight manual, or by conducting a stall, determine $1.2V_S$

A reference altitude is nominated and a reference point selected.

Power + Attitude = Performance

P ***P****ower*
Is reduced (carburettor heat may be required) to approximately ______ rpm.

The resultant pitch change and yaw must be compensated for. Ensure smooth throttle movements are used.

A ***A****ttitude*
With the elevator, adjust the attitude to maintain level flight.

The airspeed will decrease gradually. As the airspeed decreases the aeroplane's nose will want to pitch down, requiring subtly increasing back pressure on the control column to maintain the altitude. The wings should be kept level in relation to the horizon, and rudder adjusted to keep straight on the reference point.

Remind the student that during those phases of flight where power and/or airspeed are changing, a change in rudder pressure will be required to maintain balance.

T ***T****rim*
Promptly and accurately.

Maintain straight and level flight at the nominated airspeed, adjust power as necessary to maintain height and apply the mnemonic **LAI**.

L ***L****ookout*
In a scan loop, look out to the left (port) and scan 20 degrees for 2 seconds from left to right, passing over the nose of the aircraft.

A ***A****ttitude*
Ensure the attitude is correct and, more importantly, constant. When the outside scan is complete, scan inside.

I ***I****nstruments*
The instruments are scanned to confirm accurate flight.

If a constant altitude is not being maintained, use power as required and adjust attitude to maintain the nominated airspeed.

Power + Attitude = Performance.

If the correct level attitude has been selected the airspeed will be ______ knots (as nominated).

If the correct power setting is maintained the aeroplane will maintain level flight, and if the wings are level and balance maintained the aeroplane will remain straight.

Turning at Low Airspeed

Lift will need to be increased in the turn and this will produce an increase in drag. Power will need to be increased to combat the drag and maintain the nominated airspeed.

Revise adverse yaw from the *Medium, Climbing and Descending Turns* lesson. Adverse yaw is countered with rudder applied in the direction of the roll, maintain balance.

At low airspeeds the ailerons will need to be deflected further to achieve the same roll rate as at higher airspeeds. This will significantly increase the induced drag and require more rudder to negate the adverse yaw.

Returning to Normal Cruise

To regain normal cruise, the mnemonic **PAT** is used. Because of inertia, power leads the sequence to arrest any descent resulting from lowering the attitude.

***P* *P*ower**

Carburettor heat COLD (if applicable), and smoothly increase power to full power.

Correct the resultant yaw with rudder and the pitch up with elevator while:

***A* *A*ttitude**

Gradually lowering the nose and holding the level attitude. Maintain wings level with aileron, and balance with rudder (as airspeed increases).

***T* *T*rim**

Remove obvious loads. When flaps have been raised (if applicable) and normal cruise airspeed achieved, set cruise power, and confirm straight and level is maintained.

LAI – trim accurately to hold the correct attitude.

Airborne Sequence

On the Ground

Ask the student to do the preflight inspection, and then to come to you afterwards if they have any questions.

Introduce more radio work, and ask the student to call and complete the checklists.

The Exercise

The student should be able to complete the takeoff by themselves.

On the way out to the training area, there is opportunity to practise climbing and turning.

The student then enters straight and level from the climb and is talked through the **HASELL** checks.

Demonstrate the entry to slow flight at the nominated airspeed and in the nominated configuration – with and without flap. The student should practise after each demonstration.

Demonstrate turning (at up to 20 degrees angle of bank) including reversing the turn direction, followed by student practise.

Allow the student to regain normal cruise, while talking them though the process.

Establish the aeroplane in the approach configuration in a descent at 1.2V_S. Then establish the aeroplane in a climb, thereby simulating the go around.

On the way back to the aerodrome, discuss some more radio calls, and talk them through rejoining the circuit.

After Flight

The next lesson will be *Basic Stalling*, ask the student to read up on this.

Provide the student with a copy of the checklists and ask them to start learning the correct responses for the checklist items. Inform them that you will expect them to know the checklists from memory before they do their first solo flight, and the first step to memorising them is to learn the correct responses.

Basic Stalling

The *Slow Flight* lesson has introduced the student to the practice of flying close to the stall, here you are furthering their knowledge by showing how the aeroplane behaves when there is not enough lift produced by the wings to balance its weight.

Many new terms and concepts will be introduced to the student during this briefing, and these should be kept as simple as possible.

When an aeroplane stalls, it is not like a car – the engine does not stop. The stall is a breakdown of the smooth airflow over the wing into a turbulent one, resulting in a decrease in lift. The lift will no longer fully support the aeroplane's weight, and the aeroplane sinks.

For the basic stall we keep the aeroplane's configuration as simple as possible, power will be at idle, flap will be up, and if the undercarriage can be raised it is.

There are three reasons the student needs to know about stalling. The first is so they can avoid the inadvertent stall. The stall does not just happen – there are many warning signs of its approach, and the student should be familiar with these.

To prevent the inadvertent stall a pilot needs to be able to recognise the symptoms of an approaching stall, experience it, and then learn the correct recovery technique.

The second reason for being familiar with the stall was highlighted in the last lesson, *Slow Flight*. There are a number of times an aeroplane will be operated at a speed close to its stall speed.

The most common of these, and the third reason, is the approach and landing phase of the flight. Every landing is a controlled approach to the stall.

Objectives

To control the aeroplane to the point of stall, recognise the symptoms of the approaching stall, experience the stall itself, and recover with minimum height loss.

To control the aeroplane to the point of stall, recognise the symptoms of the approaching stall, and recover at stall onset with minimum height loss.

Principles of Flight

The basic stall is conducted in a power-idle clean configuration, ie, flap up.

The cause of this breakdown of smooth airflow is the result of the wing being at too high an angle of attack to the airflow.

The model aeroplane may be used to show that aeroplanes do not fly at an angle of attack of 90 degrees to the relative airflow. Therefore, somewhere between straight and level and 90 degrees, a limit is reached at which the air can no longer flow smoothly over the aerofoil.

For the average aerofoil used on general aviation aeroplanes, this limit is reached at an angle of attack of about 15 degrees. It should be emphasised that no matter what speed the aeroplane is flying at, when this angle is exceeded the aeroplane will stall because of the breakdown of the smooth airflow.

One way to do this would be, from straight and level, to close the throttle to idle and attempt to continue flying level.

In straight and level flight the angle of attack was about 4 degrees and the airspeed about ______ knots.

As experienced in *Effects of Controls*, lift is primarily controlled through angle of attack and airspeed, and lift must equal the aeroplane's weight to maintain level flight, then, as the airspeed decreases, the angle of attack must be increased to maintain lift equal to weight.

L = angle of attack x airspeed

As the angle of attack increases, the airflow finds it more and more difficult to follow the contoured upper surface of the wing (aerofoil) smoothly, and the point at which the airflow breaks away from the wing, the separation point, moves forward from the trailing edge. At the same time, the point through which lift acts, the centre of pressure (C of P), also moves forward along the chord line; this movement is unstable because it reduces the moment of the lift/weight couple.

Figure 1a

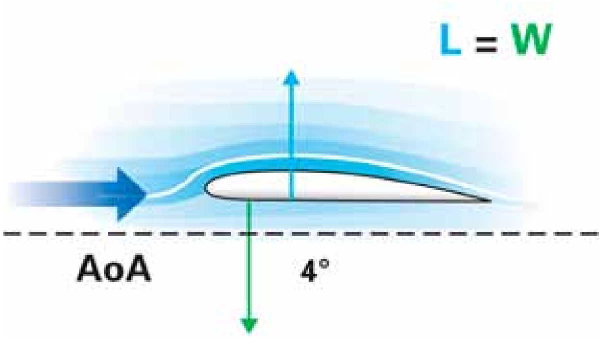


Figure 1b

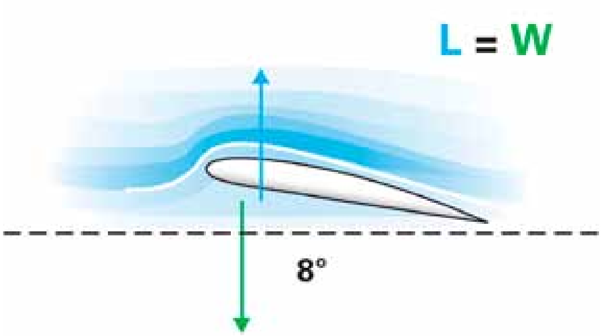
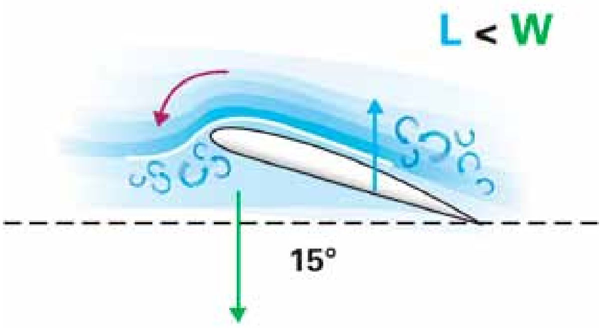
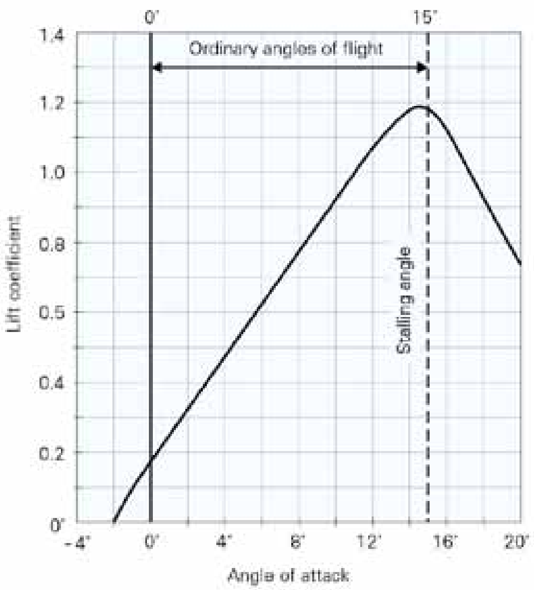


Figure 1c



Eventually, the stalling (or critical) angle of attack is reached, and the inability of the air to flow smoothly over the top surface of the wing results in a decrease in lift and a large increase in drag. This may be illustrated by the C_L against angle of attack graph.

Figure 2



The result is that the aeroplane sinks. At the same time, the C of P moves rapidly rearward. The rearward movement of the centre of pressure increases the moment provided by the lift/weight couple, causing the nose to pitch down – a stable movement.

The factors affecting the stalling speed are discussed in *Advanced Stalling*, the emphasis of this briefing is on the cause of the stall – exceeding the critical angle.

Airmanship

Passengers should not be carried during this exercise.

Situational awareness considers not only the position of the aeroplane three dimensionally within the training area, but also the warning symptoms of the approaching stall, and awareness of the flight phase – power set at idle, but attempting to maintain level flight.

Revise the **HASELL** checklist, incorporating those elements particular to stalling. This check is completed before the first stall.

H ***H**eight (not altitude)*

Sufficient to recover by not less than 2500 feet above ground level.

The altitude loss should be no more than 300 feet and the recovery height should provide an appropriate environment for practise.

Some organisations stipulate recovery by a height higher than 2500 feet agl, consult with your CFI.

A ***A**irframe*

The entry configuration is revised: idle power, flap up.

S ***S**ecurity*

No loose articles, harnesses secure.

The basic stall in the modern light aeroplane is very gentle, but it is good aviation practice to secure loose articles, to stop them moving around the cabin, and check harness security.

E ***E**ngine*

Temperatures and pressures normal, mixture RICH, fuel sufficient and on fullest tank.

Commonly the electric fuel pump is switched ON to guard against an airlock (refer CFI). In addition the carburettor heat may be cycled to ensure ice has not formed.

L ***L**ocation*

Not over a populated area and clear of known traffic areas, including airfields.

Stalling is not carried out over populated areas because large power changes are made throughout the exercise and may disturb people on the ground.

This exercise is not carried out near other aircraft.

L ***L**ookout*

Carry out a minimum of one 180-degree, or two 90-degree, clearing turns, to ensure other traffic will not result in conflict.

During the last part of the turn, start looking for a suitable reference point on which to roll out and use for the stall entry.

Introduce the **HELL** checks (a subset of **HASELL**) which are carried out between each subsequent stall.

H ***H**eight (not altitude)*

Regained or sufficient to recover by not less than 2500 feet above ground level.

E ***E**ngine*

Temperatures and pressures normal.

L ***L**ocation*

Not over a populated area and clear of known traffic areas, including airfields.

L ***L**ookout*

One 90-degree clearing turn.

Common practice is to make these turns in the one direction (usually left) so that the exercise is carried out in a box over the same ground features. This general practice can be altered to allow for wind direction and strength (drift), the training area boundaries, and other traffic.

Aeroplane Management

As large power changes will be made, it is appropriate to revise the requirement for smooth but positive throttle movements and the correct use of carburettor heat.

All preflight inspections should include a search for loose articles. Discreetly ensure a sick bag is available.

Human Factors

The regular turns and steeper than normal nose attitudes could lead to a level of disorientation – make sure the student has time between stalls to orientate themselves.

When you teach the stall you will need to gauge the student's level of apprehension and provide appropriate reassurance in a calm professional manner. As the student gains more practise and exposure to stalling their comfort levels will increase, and they should become relaxed about stalling the aeroplane – but never complacent!

The effects of stress are reduced by overlearning the procedure, to produce an initial automatic response, and by experiencing the sensations of the stall, to desensitise the pilot. Tell the student that if they feel uncomfortable at any point, they should say so, the aeroplane can then be flown level, until they feel comfortable to continue.

Air Exercise

Entry

HASELL checks are completed and a reference point on which to keep the aeroplane straight is nominated, confirm with the DI. Nominating a reference altitude is a function of the **HASELL/ HELL** checks.

Because of the high nose attitude at the stall, choose either a high reference point or have the student sight one along the side of the engine cowling.

From level flight, carburettor heat is selected HOT and the throttle smoothly closed. As the nose will want to yaw and pitch down, keep straight with rudder and hold the altitude with increasing backpressure on the control column.

Through ______ knots, or when the aural stall warning is heard, select carburettor heat COLD, as full power will shortly be reapplied.

Stall Warning Symptoms

Decreasing Airspeed

The first true symptom is a decreasing airspeed. Low airspeed and a high nose attitude are not always present in the approach to the stall, for example, the high-speed stall as a result of pulling out of a dive too sharply. Therefore, although it is desirable to inform the student that a high nose attitude and low airspeed are indicators of an approaching stall for most phases of flight, they will not always be present.

Less Effective Controls

The next symptom is less effective controls as a result of the lowering airspeed – as they will have experienced in the *Slow Flight* lesson. The student should also recognise the progressively increasing stick forces as the stall is approached.

Stall Warning Device

Reduced control effectiveness is usually followed by the stall-warning device. However, this is not a true symptom, as the device is mechanical and may not work. The type and operation of the stall-warning device fitted to the aeroplane should be described.

Buffet

The last generally noted symptom is the buffet. This is caused by the turbulent airflow from the wings striking the empennage. The effects of buffet are least noticeable in high-wing/low-tailplane aeroplane types, such as Cessnas. This is because the airflow breaking off the high wing combined with the high nose attitude, results in most of the turbulent airflow missing the empennage. Whereas in the low-wing/high-tailplane arrangement, for example the Piper Tomahawk, the turbulent airflow directly strikes the empennage and is very apparent.

At this point, as a result of the low airspeed, elevator effectiveness has been reduced to the point where no further increase in angle of attack can be achieved, even though the control column is held well (or fully) back. This results in the aeroplane sinking and the change in relative airflow causes the critical angle to be exceeded.

The aeroplane stalls, altitude decreases and (generally) the nose pitches down. It is important the student be able to correctly identify when the aeroplane has stalled.

Recovery

The recovery is broken down into two distinct parts: unstalling the aeroplane, and minimising the altitude loss.

To unstall the aeroplane, the angle of attack must be reduced. Even though the aeroplane's nose may have pitched down at the stall, the angle of attack is still high because the aeroplane is sinking. Since increasing the backpressure (or pulling back) increased the angle of attack, decrease the backpressure (or check forward). The 'check forward' with the elevator is a smooth but positive control movement – not a push.

In addition, no aileron should be used; ailerons must be held centralised, for reasons that will be discussed in the next briefing – *Advanced Stalling*. However, the correct use of aileron must be stated right from the beginning in order to get the sequence right first time and every subsequent time.

You should be attempting to introduce stalling in its simplest and most basic form. Therefore, every effort should be made to avoid the wing-drop. If the aeroplane has a known tendency to wing-drop in the basic configuration it may be necessary to explain this tendency and the result, as well as the reason for not using aileron in the recovery (refer CFI).

If an explanation is required, keep it as simple as possible at this level. For example, "For various reasons one wing may stall before the other and this will produce a roll; ignore the roll (no aileron, aileron central, aileron neutral) and simply check forward."

Your choice of terms – check forward, relax backpressure, ailerons neutral, no aileron, or ailerons central – should match your airborne patter.

It should be made clear that reducing the angle of attack is all that is needed to unstall the aeroplane. The aeroplane will enter a descent, and the student can now regain straight and level from the descent (**PAT**). The altitude loss will be about 300 feet using this method, and will be the first recovery method the student practises.

However, **to minimise the altitude loss** –

Power + Attitude = Performance

For the least loss of altitude, the maximum amount of power is required (hence carburettor heat COLD during the entry) so smoothly but positively apply full power (prevent yaw – keep straight) and raise the nose smoothly to the horizon. There is no need to hold the nose down, as excessive altitude will be lost, similarly increasing backpressure too rapidly, or jerking, may cause a secondary stall.

Nose-on-the-horizon is used as the reference attitude. Of the attitudes the student is familiar with the level attitude is too low and the aeroplane will continue to sink, resulting in unnecessary altitude loss. Alternatively, the climb attitude is too high, as the pitch-up created by full power combined with inertia may result in a secondary stall. In addition, the student should be discouraged from thinking that pulling back will make the aeroplane stop sinking – that's how the stall was entered.

A compromise attitude is required to arrest the sink and allow the aeroplane to accelerate to the nominated climb speed. The simplest attitude to use is to put the top of the nose cowling just on the horizon. For some light aeroplanes this attitude is the same or similar to the climb attitude, but at least the student has not been encouraged to try to climb by simply pointing the aeroplane upwards.

The expected altitude loss should be stated, for example, not more than 100 feet.

The aeroplane should be held in the nose-on-the-horizon attitude until the nominated climb speed is reached and then the climb attitude selected.

Common practice is to use the recommended or normal climb speed, for example 70 knots. However, you may nominate speed for best angle of climb or for best rate of climb (refer CFI).

Straight and level flight should be regained at the starting altitude and the reference point or heading regained if necessary.

Recovery at Onset

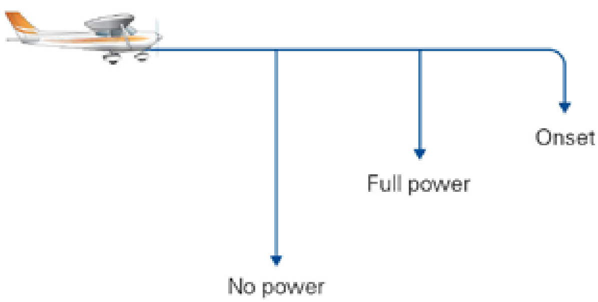
All stalling exercises should finish with a recovery at the incipient stage, more commonly referred to as the onset. This is to emphasise that, under normal conditions of flight, the stall is avoided.

The second objective of this exercise is to recover at onset, which means at the stall warning or buffet.

The stall itself is simply the stall and is sometimes referred to as fully developed, meaning that the stall has occurred. A fully developed stall does not imply a wing-drop.

The expected altitude loss from a recovery at onset (depending on which symptom is first detected) should be stated, for example, less than 50 feet. With practise and improved situational awareness, this altitude loss can be reduced to zero – as the aeroplane is not permitted to stall.

Figure 3



Airborne Sequence

On the Ground

Make sure the preflight inspection identifies any loose objects and they are secured.

Encourage the student to take on more of the radio work, and to start their study for the radiotelephony exam.

Run through the checklists with the student, checking that they are learning the responses.

The Exercise

On the way out to the training area there is opportunity to practise climbing, straight and level and turning.

Demonstration

When setting the aeroplane up and choosing a reference point choose one into or with the wind to reduce any problems the student might have with drift perception.

Start with a demonstration of the basic stall and recovery, rather than the recovery at onset. Although the student is being taught to avoid the stall, they still need to experience what it is they are trying to avoid. During the demonstration the student should be advised to observe the high nose attitude, and asked to identify the actual stall so both instructor and student know they recognise the same thing.

In line with the objective of recognising the symptoms that warn of an approaching stall, the next step is to carefully demonstrate the symptoms.

One method of doing this effectively is to slow down the entry so that the patter can be synchronised to each of the symptoms as they appear. This is achieved by informing the student that in order to give them a good long look at each of the symptoms, no attempt will be made to maintain a constant altitude during this entry.

As this is not the entry you want the student to use, and to avoid distractions, no follow-through takes place.

The entry is pattered as "reference point, reference altitude, carburettor heat HOT, reduce power, keep straight and wings level." Remind the student to look outside at the reference point to keep the wings level with aileron and straight with rudder – just a glance at the balance ball is all that is required.

From this point on, you can adjust the amount of backpressure to synchronise your patter to match the symptoms. For example, with practise you will be able to synchronise the words "and the stall warning sounds like [pause] that."

The aeroplane can be held in the stall to demonstrate the buffet and the sink if required.

At the stall, the nose-down pitch is observed and the normal recovery carried out by you without patter.

If the sink was discussed in the air exercise, this can be demonstrated only from a level entry. It is difficult to detect and may register as a RoD on the VSI, even though the elevator is held well or fully back, before the nose pitches down. The decision to include this demonstration depends on whether or not it was discussed in the air exercise, the aeroplane type, and ultimately the CFI.

Once the symptoms have been carefully demonstrated there is no need to rattle them off during every stall entry. Your patter can now be directed at the recovery.

Patter and Follow Though

The entry and recovery without power is pattered with the student following through. In addition, the student is given the opportunity to carry out the entry and recovery without power because this is the simplest recovery, and because checking forward centrally, when the nose is pitching down is not a natural reaction – but must be made through a conscious decision.

With the aeroplane in a glide descent the student can be asked to put the aeroplane into either straight and level flight (**PAT**) or directly into a climb (refer CFI) and the altitude loss noted.

Minimising the altitude loss is covered next. This requires the application of full power earlier than the previous student practise, and smoothly raising the nose to the horizon until the nominated climb speed is reached while stopping yaw with rudder.

If the benefits of power in reducing the altitude loss are to be seen clearly, you must ensure that during the demonstrations accurate altitude holding is maintained throughout the entry.

Talk Through

From this point the student is talked through and can practise. Remember, for this lesson, the correct recovery sequence of events is more important than speed or coordination of execution.

At the end of the airborne sequence, a recovery at onset should be carried out by the student. Common practice is to nominate a symptom at which the recovery will be initiated, for example, 60 knots, stall warning, or buffet (if the latter is easily detected).

If the student has practised slow flight and can recognise the symptoms leading up to the stall, they should be able to fly the aeroplane slowly and avoid an inadvertent stall.

This is an appropriate time to demonstrate a stall with power and flap (see *Advanced Stalling* lesson). It has been recommended in this text that this manoeuvre be taught after the circuit lessons, but refer to your CFI for the point at which your organisation teaches this manoeuvre. If the Advanced Stalling lesson is to be delayed until after the circuits, the student will benefit from seeing a stall with power and flap demonstrated before they undertake circuit training. It is important the student understands the recovery technique still requires a reduction in the angle of attack by checking forward

On the way back to the aerodrome they can practise more straight and level, particularly concentrating on prompt and accurate trimming. As well as turning and descending, the student should be talked through the circuit and as much of the approach as you think they are capable of.

After Flight

Debrief the student and remind them that there will be lots of opportunity to practise stalling, but the primary objective is to be able to recognise the stall and avoid the inadvertent stall.

Next lesson may be *Advanced Stalling*. Refer to the CFI.

Encourage the student to continue learning the checklists.

CIVIL AVIATION AUTHORITY
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