The CIX VFR Club	Flight Training Notes	Exercise 6
For Simulation Purposes only. Not to be used for real World flight	STRAIGHT and LEVEL FLIGHT	Issue 1.2 31/07/12

1 INTRODUCTION

This series of tutorials for the CIX VFR Club are based on real world flight training. Each document focuses on a small part only of the necessary skills required to fly a light aircraft, and by echoing real world training, you will be a better Flight Simulator pilot and get more enjoyment out of the hobby as a result.

These tutorials are written specifically for the Flight Simulator Default Cessna 172. Some details will be different for other aircraft.

You should read Exercise 5 before continuing with this tutorial.

2 OBJECT

The object of this lesson is to teach the student to fly at a constant speed, altitude and direction.

3 FORCES IN EQUILIBRIUM – OR NOT

When an aircraft is flying at a constant speed, height and direction, the forces acting on it are in equilibrium, i.e. lift equals mass (or weight) thrust equals drag (See Fig. 1).

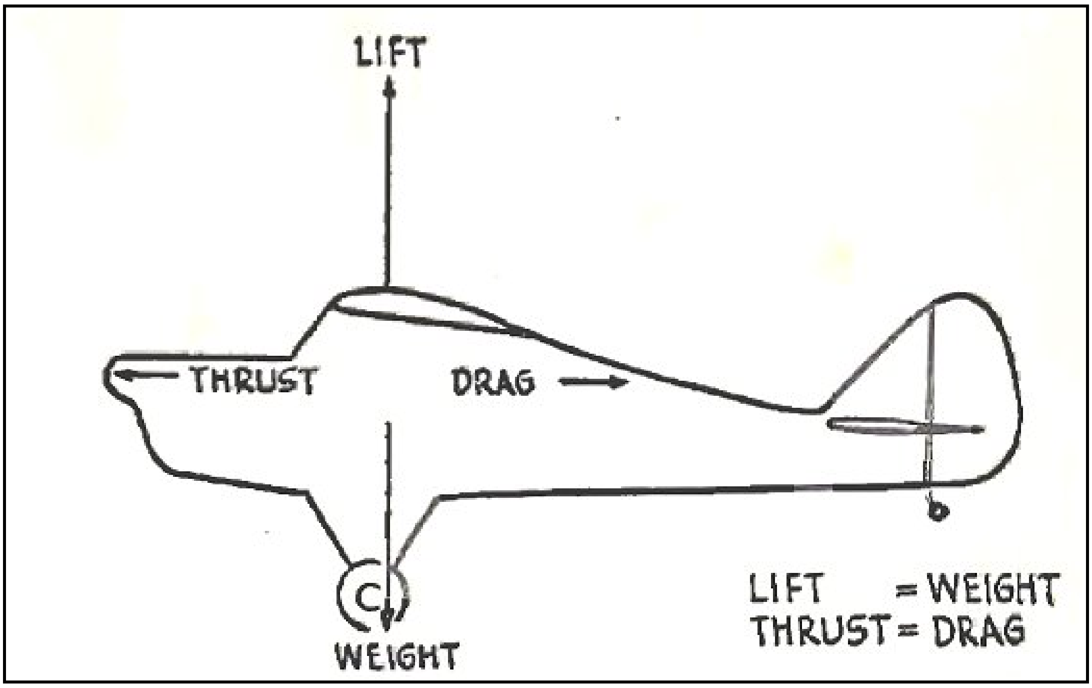

Fig. 1 The Aircraft in Straight & level Flight

A change in any one of these forces will bring about a change in the others. For example, if power is increased, the thrust will be greater than the drag and the aircraft will accelerate. The increase in speed of the air over the wings will generate more lift, which will now be greater than the weight, so the aircraft will begin to climb.

Changes in throttle setting have an effect on the directional stability of the aircraft as well as changing the thrust, because the slipstream adds a yaw effect. The rotation of the propeller causes the slipstream to travel back along and around the fuselage in a helical path. It flows unhindered under the rear fuselage, but on the top it hits the causing a swing. The direction of swing depends upon the direction of rotation of the propeller. American built engines mainly rotate clockwise, as seen from the cockpit, and the yaw effect is to the left. British built engines mainly rotate anti-clockwise as seen from the cockpit and the yaw effect is to the right.

To overcome the slipstream effect, aircraft designers

1) Fit a spring to pull the rudder bar in the desired direction
2) Attach a small metal “trim tab” to the trailing edge of the rudder, which is set on the ground by bending in the direction necessary to hold the rudder at a slight angle.
3) Offset the tailfin at a slight angle.
4) Install the engine out of line with the fuselage so that the thrust axis is to one side of the aircraft centreline

Each of these methods imparts a turning force on the aircraft to counteract the slipstream effect. Unfortunately, with the exception of method (4), all of these arrangements only work perfectly at cruising speed, and changes of throttle upset the balance of the system. More sophisticated aircraft are fitted with a rudder trim control which provides the best solution.

Good straight and level flying is essential for accurate cross-county flights and the ability to fly in a straight line at a pre-determined height and airspeed takes some time to master.

4 ATTITUDE FLYING

Directional control is maintained by either small movements of rudder alone, to correct small errors, (1 or 2 degrees), or a combined use of aileron (banking) and rudder to correct larger errors.

Controlling airspeed often proves difficult for the student at first, and he/she tends to over control, going from “too slow'' to “ too fast'' in a series of prolonged pitching movements which are caused by not waiting for the airspeed to settle before making any further adjustment.

The generally accepted best way to fly straight and level in light aircraft is to maintain the correct pitch attitude. This means in practice, placing the horizon in a position relative to the top of the coaming appropriate for the cruising airspeed required, and this position must be learned for each aircraft type flown. At any given throttle setting, positioning the horizon a known height above the coaming will result in the same airspeed every time.

Changes to airspeed are made by raising or lowering the nose with the elevators, which changes the angle of attack. Climbing or descending is controlled with power. If the speed is increased by lowering the nose, then a descent will commence unless power is added. Conversely, if the nose is raised, the aeroplane will climb unless the power is decreased.

The aeroplane differs from other vehicles in that there is an optimum speed which requires the least amount of power to maintain level flight. If an attempt is made to reduce this speed by holding the nose higher the aeroplane will begin to descend and more power will be required to maintain altitude.

In fact the lowest speed requires full throttle because of the very rapid increase in drag, “profile drag”, which is generated at high angles of attack with a larger area of the wing presented to frontal airflow. High drag needs high thrust for the forces to be balanced. At the opposite end of the aircraft’s performance envelope, full speed demands full throttle because of the very high “induced drag” produced by the resistance of the high airflow.

The adjustment of attitude and power to achieve a given performance has given rise to two of aviation’s hundreds of little epithets:

To achieve a required performance, (cruising speed, climb rate, descent rate) both power and pitch (nose) attitude must be adjusted.

Power plus Attitude equals Performance

The order in which adjustments are made is always (with one exception) to set the required power, then adjust the attitude to achieve the performance required, then trim the aircraft to maintain that performance.

Power, Attitude, Trim (PAT)

The only time that the order in which adjustments are made is changed is when levelling out at the top of a climb. If power is reduced from climb power to cruise power before the nose has been lowered to cruising attitude, and the airspeed allowed to build up to cruising speed then the climb stops abruptly and the aircraft will fail to reach the desired altitude. So you lower the nose first, allow airspeed to build up to cruise speed, set “cruise power” and then trim the aircraft to maintain it.

Attitude, Power, Trim (APT)

5 BALANCED FLIGHT

For maximum efficiency, and thus minimum fuel use, the aircraft must be flown “in balance”. This means ensuring that the aircraft is flying with the wind striking the wings exactly at right angles to their span. This is achieved by use of rudder, whilst observing the balance ball in the turn and slip instrument. The ball should be kept in a central position in the cruise. Because of the designed-in turning force to counteract the slipstream effect at cruise speed as outlined above, constant application of rudder to maintain the slip ball in the centre should not be necessary in cruising flight.

If it is found that some rudder input is required, then the pilot may be flying at less than or more than the optimum cruising speed. (Alternatively the compensatory arrangement may need adjusting, but this will not be so in Flight Simulator, as it is "hard coded" in the aerodynamics of the flight model.

6 FLIGHT PRACTICE

6.1 Establishing Cruise Speed

1) At the required altitude place the nose of the aircraft in the approximate attitude in relation to the horizon for straight and level flight.
2) Hold the attitude in this position and set cruise rpm.
3) (c) Allow the speed to settle and move the elevator trimmer until no pressure is required on the yoke.
4) Adjust the airspeed with small changes of attitude, and retrim.
5) Remove any tendency to climb or descend with power, readjusting attitude as necessary and retrim as required.
6) Keep the wings level to prevent the aeroplane from turning off course.
7) With the wings level prevent the aircraft from yawing by use of rudder (Check the balance ball is in the centre).
8) Should the aeroplane swing off course, bank the aircraft slightly (turn the yoke) in the direction necessary to bring it back on course. This movement should be co-ordinated with a little rudder in the same direction to prevent slip.

6.2 Changing Speed

1) From cruising speed open the throttle one hundred r.p.m. above cruise power and notice the nose tends to rise and the aircraft climb.
2) Prevent the climb by forward pressure on the yoke and retrim. Note that the airspeed has increased.
3) Now reduce power below cruising r.p.m. Notice the nose drops and the aircraft loses height.
4) Prevent loss of height by backpressure on the yoke and retrim. . Note that the airspeed has decreased.
5) Progressively reduce the speed further by moving the stick back.

6) Increase the power to prevent loss of height until the aeroplane just maintains height at a low airspeed (around 50 knots in the Cessna 172). Note that full power is necessary to maintain height.

Fig. 1 Straight and Level Flight at Cruising Airspeed

The “power plus attitude equals performance” rule means that, in straight and level flight a given power setting will always result in the same airspeed in still air conditions, so long as the attitude is also adjusted to maintain level flight.

The higher the power setting, the more nose down the pitch attitude must be, and vice versa. It follows that whenever the power is changed, the aircraft must be re-trimmed at the new pitch attitude in order to maintain level flight.

6.3 Instruments

The 6 primary flight instruments are grouped together in all modern aircraft. These are (From top left to bottom right in Fig. 2 below): -

Airspeed Indicator, Attitude Indicator, Altimeter, Turn Indicator, Direction Indicator and Vertical Speed Indicator.

Fig. 2 The Primary Flight Instruments

The following instruments should be monitored whilst maintaining straight and level flight: -

6.3.1 Airspeed Indicator

This instrument takes a few moments to settle at a new airspeed because of the' time required by the aircraft itself to change speed due to inertia. This 1ag is appreciable and can cause inexperienced pilots to "chase" the airspeed.

6.3.2 Attitude Indicator

The A.I. is not used greatly in visual flight, but is a vital instrument in instrument flight. It indicates roll (banking) and pitch.

6.3.3 Altimeter

On all but a calm day thermal currents may cause height to vary although the airspeed and r.p.m. are correct and the pilot must compensate for these variations. If there is a sudden small gain in height the nose should be lowered and height lost by increasing the speed at that power setting. Similarly a small loss in height can be regained by raising the nose slightly, but an increase in power may also be necessary in this case.

6.4 Turn Indicator

The wings of the small model aeroplane will bank in the same direction as the bank of the full size aircraft ALWAYS. (In cloud, one can get the sensation of turning one way whereas the aircraft is actually turning in the other direction. This effect, being a function of the inner ear balance mechanism, is not yet reproduced in Flight Simulator!

The balance ball is incorporated in the Turn Indicator. If the ball is moved away from centre then the aircraft is either “slipping” (falling into a turn), or “skidding” out of the turn, much as a car would skid on ice. In cruising flight the ball should be held central with rudder at all times.

6.4.1 Direction Indicator

The direction indicator is a gyroscopic instrument which indicates the aircraft’s magnetic heading. Its indication is more stable than the magnetic compass, but it must be synchronised with the magnetic compass before it can provide meaningful information.

6.4.2 Vertical Speed Indicator

The slightest movement of the aircraft up or down is indicated and this becomes apparent as soon as the yoke is moved back or forward. The

V.S.I. will give an indication of up or down movement (in feet per minute) long before the altimeter registers a change in height.

6.4.3 Tachometer (Engine r.p.m.)

A change in airspeed will alter the r.p.m. at the same throttle setting. If the aircraft is set to descend at a given power setting, it will increase in speed. The propeller will also increase in speed (r.p.m.) as the load on it decreases.

A climb will produce the reverse effect. For this reason always re-check the r.p.m. once the airspeed has settled.

Tachometer showing Cruise r.p.m.