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 Aeroplane, 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. Each tutorial builds up the pilots abilities by using skills described in the previous tutorials and adding to them, so it is important to work through the tutorials in sequence.

While the tutorials are being developed, there will gaps in the series, due to publishing some of the more important tutorials first. Where this occurs, the "building block" approach will be temporarily suspended, and interim versions may contain detail which will subsequently be the subject of a separate tutorial. It is therefore important to check the Club web site periodically to ensure that you have the latest version.

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

2 FLIGHT SIMULATOR REQUIREMENTS

It is assumed that you have installed the latest version of Flight Simulator and are comfortable with its menus and commands. If not, you should first study the Flying Lessons provided with Flight Simulator. These are based on American practice, and unfortunately, if you divert from the intended flight behaviour, (e.g. turning left when asked to turn right), they fail to recognise this and subsequent instructions become meaningless.

It is also assumed that you have a yoke or joystick, and preferably rudder pedals too. If not, you will have to make the equivalent moves using the mouse or appropriate keys. In the early 1990s, Flight Simulator was much less sophisticated than today (as were the computers on which it ran), and it was possible fly quite well by means of the keyboard. Today, to fly well in all the conditions which Flight Simulator can throw at you, it is next to impossible to do so with keyboard and mouse alone.

Rudder pedals become important if you intend to take the hobby seriously. You can fly perfectly well when there is little or no wind using the auto-coordination feature, and rudder pedals are not really necessary. However, with more advanced flying conditions, a strong and turbulent crosswind on final approach for example, rapid and precise control inputs are necessary, making a yoke and rudder pedals essential just to stay on the runway centreline in the air and to steer down it on the ground.

The many add-on features available for Flight Simulator enable the hobby to be expanded almost limitlessly from flying using the basic program to building a complete cockpit mock up with mechanical instruments and

controls. There are hundreds of different Aeroplane created by third party developers, some very sophisticated, and scenery for some parts of the world created from real aerial photographs. These tutorials assume that you have no add-on features, and will fly the Cessna 172SP incorporated within the basic package.

3 THE AEROPLANE COMPONENTS

The basic components of any propeller driven aeroplane are: -

The fuselage	The structure on which all the other components are built into a coherent whole. May be made of high strength magnesium alloys, steel, wood or carbon fibre or a combination of these.
The skin	Covers the structure to reduce wind resistance and provide an environment protected from the elements for all the intricate control linkages, cables and electrical equipment. May be made of high strength magnesium alloys, steel, wood or dope covered fabric. (Dope is a special thin and highly volatile paint which waterproofs the cotton fabric, and also shrinks it so that it fits drum-tight across the structure of the Aeroplane).
The cabin	The essential enclosure for pilot and passengers. Originally (and still frequently) called a cockpit, reflecting the small open enclosure originally created in Aeroplane for the pilot, which had more than a passing resemblance to the places where cock fighting was held in former centuries.
The canopy	Keeps the wind out! Early Aeroplanes had open cockpits, but these are pretty draughty places, and numbingly cold at 100 knots or more in less than tropical climates.

The wings

Without wings there is no Aeroplane – ignoring rockets for now.

Wings are required to generate lift to enable the heavier than air machine to leave the ground. The shape of a wing (known as an aerofoil) is designed so that the air passing over it has to travel further over the upper surface than over the lower.

This results in increased velocity across the upper surface so that the molecules which were next to each other at the leading edge meet again at the trailing edge. This increase in velocity produces a reduced pressure (Bernouilli's Principle for you physicists), and this reduced pressure across the upper surface of the wing produces – LIFT!

You can demonstrate the principle very simply by holding a tablespoon between finger and thumb at the extreme end of the handle, so that it hangs down. Now turn on a tap, and slowly move the bowl of the spoon towards the water flow. The moment water crosses the bowl of the spoon it is pulled sharply further into the water stream, under the influence of LIFT because the water had to travel further over the convex surface of the spoon bowl than it did over the concave surface! I wonder if Archimedes knew this? He knew most things which were then forgotten again.

A helicopter has wings. They rotate, so that lift may be generated without the Aeroplane having to have any forward motion. Helicopters are often called "Rotary wing Aeroplane".

The wings also provide stability in the roll axis (see Exercise 4a)

Empennage

The empennage is the term used for the whole of the aircraft's tail; the tail plane, elevators, tail fin and rudder.

Tail Fin

Provides directional stability in the yaw axis (see Exercise 4a).

Tail Plane

Provides directional stability in the pitch axis (see Exercise 4a).

Engine

Provides a source of energy input to overcome the natural forces which tend to prevent flight, e.g. weight and drag (see exercise 3). Piston engines for aeroplanes are, by modern standards archaic, but they are solid and reliable.

Engine (cont…)	The slow revving long stroke big cylindered aeroplane engine is more durable and suffers less wear than the buzzy-bee high r.p.m. over square mini-cylindered modern car engines which are only required to run for 80,000 miles or so (around 3,000 hours running at most) before they are scrapped. Typical aeroplane engines have a statutory life between overhauls of 2,000-2,500 hours, (they must be overhauled by law after that) but can be overhauled almost indefinitely as all wearing parts are renewable. To improve reliability even further, the ignition system uses a magneto to generate the high voltage for the spark plugs. A magneto does not rely any other electrical circuit to function other than the connections to the spark plugs. In the event of electrical failure in the aeroplane, the engine will continue to run. The ignition system is also duplicated – 2 plugs per cylinder, 2 magnetos, dual wiring. Not only is this a safety feature, it improves ignition efficiency (both plugs spark on the firing stroke) and therefore power output.
Propellor*	Comprises several blades (from 2 to as many as 8 on BIG engines). Each blade is an aerofoil section, so it provides "lift" in the same way as a wing does. The lift however is horizontal in direction, and so is called thrust. Many propellors have variable pitch (i.e. angle of attack – see Exercise 4b) which allows them to produce varying thrust at constant speed. This is more efficient that a fixed pitch propeller and also reduces stress on the engine.
Wheels	Or skids, skis or floats – allow maneuvering on the ground or water, or snow. For ease of maneuverability, a three wheel configuration has been adopted for all aeroplanes since the earliest years of aviation. The 3rd, steerable wheel was for 40 years or more at the rear of the aeroplane, but improved ground handling and stability was obtained by having the steerable wheel under the nose, particularly on hard surfaced runways, and that is the configuration almost universally employed today.

*For the purposes of these training notes, we can ignore other aeroplane propulsion systems.

4 EXTERNAL CONTROLS

The help system in Flight Simulator provides a good description of cockpit controls and systems, and it is unnecessary to repeat it in this document. Equally importantly, the help system describes the computer controls used

within Flight Simulator itself to achieve the results obtained in a real aeroplane.

As installed FS shows a small "tool tip" when you hover the mouse pointer over an instrument, lever or switch. Known in Flight Simulator as "Cockpit Tips", you can switch these on or off as you wish. This is done from within the Aircraft menu section.

The aeroplane in flight is capable of manoeuvring any or all of three axes; the roll axis, the yaw axis and the pitch axis. These are described fully in Exercise 3, Section 2.1. The flying control surfaces are designed to change the way the aeroplane behaves in each of these three axes.

Ailerons	These are attached to the trailing edge of each wing, normally at the outer end. In more sophisticated aeroplanes the ailerons are slightly twisted along their long axis, so that their effect is constant. The Ailerons control the aeroplane in the Roll axis. The force produced by the ailerons is proportional to the distance from the aeroplane's Centre of Gravity (C of G) and the degree of deflection, so if the distance from the C of G is greater, then the deflection must be less to achieve the same force.
Elevators	These are moving surfaces attached to the rear of the tail plane. The Elevators control the aeroplane in the Pitch axis. Some aeroplanes have a tail plane which rotates in its entirety, known as an "all flying tail" or "stabilator". Some tailplanes are attached to the top of the rudder (known as a "T-tail" configuration), e.g. the piper PA38 Tomahawk, and some have the tailplane attached to the rear part of the fuselage.
Rudder	This is attached to the tail fin. The Rudder controls the Aeroplane in the Yaw axis. The rudder moves about a vertical hinge on the trailing edge of the tail fin in response to movement of the rudder pedals.
Elevator Trim Tab	This control is not always fitted, depending on the design of the aeroplane. Its purpose is to move the elevators using aerodynamic forces so that the elevators may be set where required without having to hold the yoke in a constant position, which would be very tiring on a long flight. By correctly using this control, via the "trim wheel" the aeroplane can be flown "hands off" for significant periods. The Trim tab is a small area of the tailplane fixed at the rear, usually on one side only, rather like a miniature aileron.

Flaps Similar to ailerons, these are attached to the trailing edge of each wing, normally inboard of the ailerons. Hinged at the wing, the rearward end is lowered into the airflow to: -

1) to increase drag, thus giving a steeper approach without increasing the airspeed, and
2) to increase lift particularly at low speed.

The first stage of flaps is usually 10°, with typical increments of 10o to a maximum of 30° or 40°. The Cessna 172SP in FS9 and FSX, has a maximum flap angle of 30°.

Slats Leading edge slats are fitted to some aircraft, notably, among light aircraft, the De Havilland Tiger Moth. When deployed, they allow the wing to operate at a higher angle of attack. A higher coefficient of lift is produced so the aircraft can fly at slower speeds, or take off and land in shorter distances.

Spoilers Spoilers are plates on the top surface of a wing which can be extended upward into the airflow and *spoil* it. Spoilers greatly reduce lift but increase drag only moderately. Few powered light aircraft are fitted with spoilers, but gliders often are.

Air Brakes Air brakes are plates on the top surface of a wing which can be extended upward into the airflow in a similar manner to spoilers. Air brakes are designed to increase drag while making little change to lift. Many airliners have controls which are in effect a combination of spoilers and air brakes. Few powered light aircraft are fitted with Air Brakes, but gliders often are.