LONG BRIEF

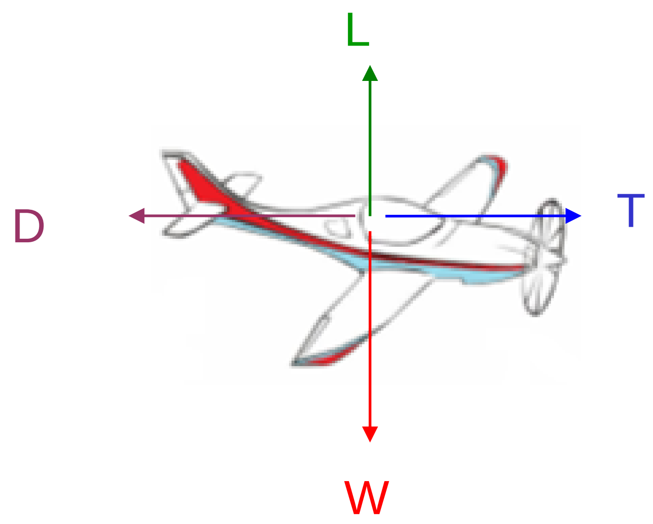
FLYING STRAIGHT, LEVEL & IN BALANCE

Exercises 6(1) and 6(2)

CONTENTS

FORCES IN STRAIGHT & LEVEL FLIGHT

In straight and level flight, the lift of the aircraft (L) acts at 90° to the wing. This is opposed by weight (W) which acts vertically downwards towards the earth. Thrust (T) acts in the direction of flight and is opposed by drag (D) which acts in the opposite direction of flight.



If all forces remain equal, the aircraft will maintain the same altitude and speed.

STABILITY

Stability in general refers to the way in which an aircraft is designed to return to a datum attitude following a disturbance. The ideal is for an aircraft to be stable enough to make it docile to fly but still controllable.

If an aircraft is too stable it will be heavy and cumbersome to control. Not stable enough and it will be impossible to control.

Aircraft designers work to achieve a fine balance between stability and controllability.

The reason for the aircraft diverting from its original position may be due to a gust of wind, slight turbulence, or even pilot input. The aircraft is designed to deal with diversions from each of the three axes of movement.

There are two types of aircraft stability – static stability and dynamic stability

Static stability refers to the aircraft initial tendency towards regaining an attitude.

Dynamic stability refers to the overall tendency following dampening or oscillations.

Lets look at both types in turn and then the ways in which aircraft designers achieve stability...

Exercise 6(1), (2): Straight, Level & Balanced Flight

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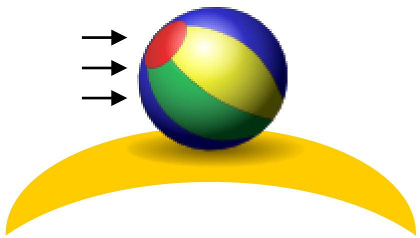
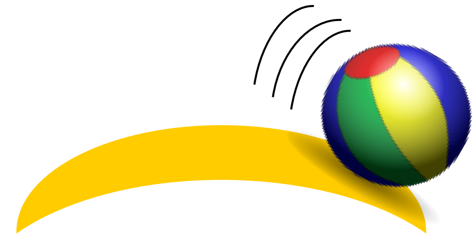
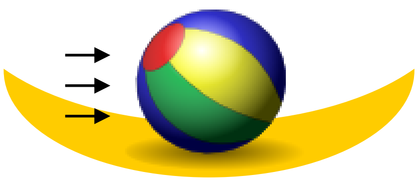
STATIC STABILITY



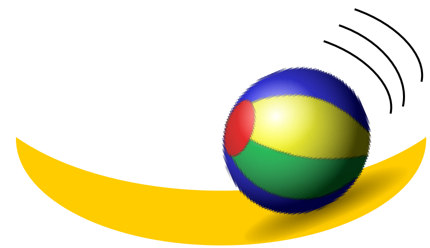
If we imagine a ball at the top of a hill... If the ball is pushed sideways, it will continue to depart from its original position as it rolls down the hill



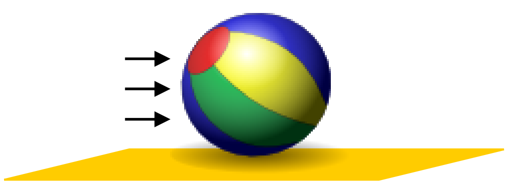
This is NEGATIVE static stability



If we imagine the same ball at the bottom of a concave slope.. If the all is pushed sideways it will eventually return to its starting point



This is POSITIVE static stability



If we imagine the same ball on a flat surface and we push it sideways, it will maintain its new position

This is NEUTRAL static stability

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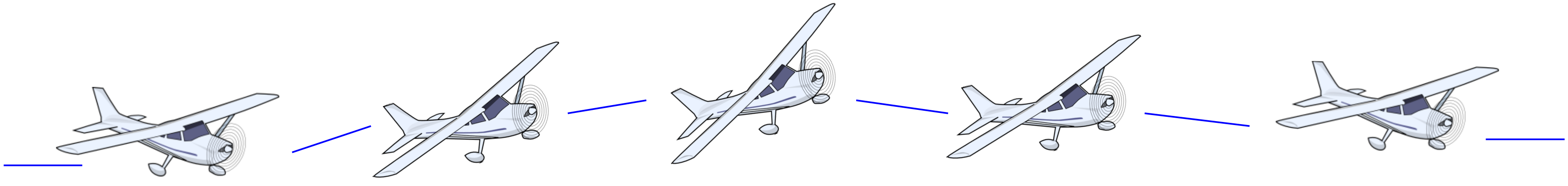
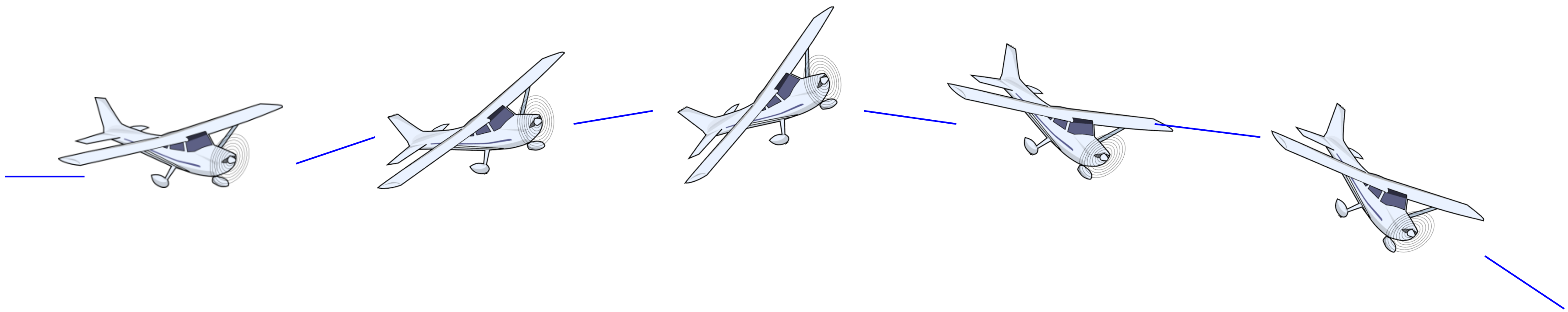
DYNAMIC STABILITY

Dynamic stability refers to the way in which an aircraft attempts to return (or not) to its starting position.



The aircraft above shows POSITIVE dynamic stability it returned to its starting point with minimal oscillations.



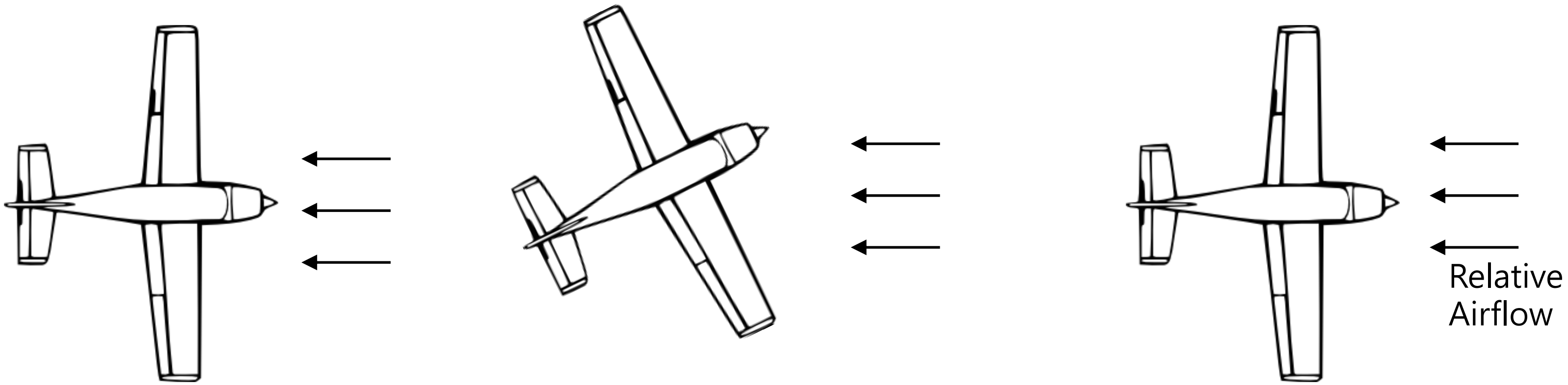
The aircraft above shows NEGATIVE dynamic stability it is unlikely to return to its starting point.

Exercise 6(1), (2): Straight, Level & Balanced Flight

LONG BRIEF

STABILITY

Directional stability refers to stability in motion around the normal / directional axis (yawing). The vertical stabiliser (fin) of the aircraft is designed to assist.



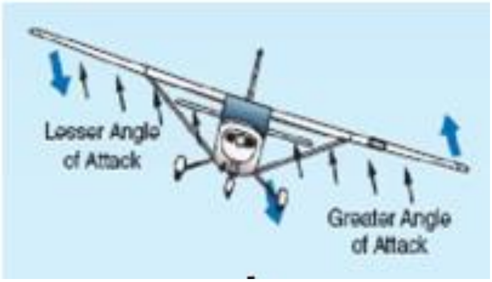
If the aircraft is disturbed (uninvited yaw) the fin is presented to the airflow at a different angle of attack which has the tendency of returning the aircraft to its original starting position.

Exercise 6(1), (2): Straight, Level & Balanced Flight

LONG BRIEF

STABILITY

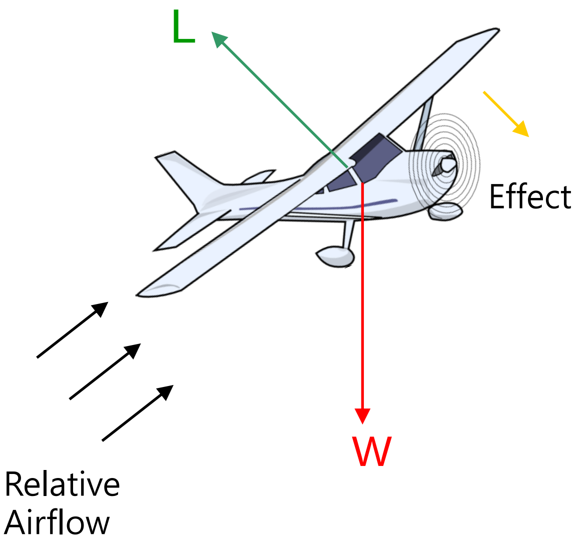
Lateral stability refers to stability in motion around the lateral axis (rolling). A number of different features are used to assist wing dihedral, wing sweepback, high keel surfaces and a low centre of gravity, and high wing configurations.



If a wing with dihedral encounters a disturbance in roll it will also sideslip which presents the lower wing to the airflow at a greater angle of attack. This means that the lower wing creates more lift and has the tendency to roll back to the wings level position.

Sweepback works by the lower wing after the sideslip creating more lift than the upper wing because the lower wing has a greater area presented to the airflow. This will tend to return the aircraft to the wings-level position

STABILITY



Aircraft which have a high keel (high fin, T-tail etc) and a low centre of gravity will mean that there is a restoring force after a disturbance in roll.

The same effect occurs when an aircraft has high wings as the wings above the centre of gravity form part of the keel surface.

THE LIFT FORMULA

There are many mathematical formulas associated with flying. Some are important to understand but do not worry if maths is not your subject! We will explore the formula section by section so that you gain a good basic understanding of the concepts involved.

The formula for lift is:

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

So what is C_L?

This means the "coefficient of lift" which sounds very confusing! This encompasses a range of things but the easiest way to understand it for now is that it refers to the angle of attack of the aircraft.

So what is $\frac{1}{2} \rho$?

This is "half rho" which refers to air density (or how thick the air is – cold air is "thicker" than warm air. As pilots, we cannot do a huge amount about this variable other than to climb or descend by a significant amount.

So what is V^2?

This refers to the speed of the aircraft.

So what is S?

This refers to the surface area of the wing of the aircraft. In a Cessna 152 we can change how big the aircraft is by selecting flap. This is not the case in all aircraft.

THE LIFT FORMULA

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

A basic understanding of this formula can help us understand how the aircraft reacts to certain changes we might make…

In straight and level flight, we need the lift that the aircraft is producing to stay the same (to oppose the weight which is also staying the same).

This formula shows that if we increase the speed of the aircraft (V^2) something else MUST decrease so that the lift remains constant. We cannot easily change the air density ($\tfrac{1}{2} \rho$) and so we need to either reduce the surface area of the wing (S) by reducing the amount of flap selected, or we need to reduce the angle of attack (C_L) by lowering the nose of the aircraft.

Or to summarise – if I wish to fly at a faster speed, I must lower the nose attitude of the aircraft (or raise flap) or the lift will increase and the aircraft will gain altitude.

THE FREDA CHECK

Every 10 – 15 minutes it is vital for the pilot to confirm that the aircraft is in a fit state to continue the flight. This check is known as the "FREDA" check and we shall explore the components of the check here.

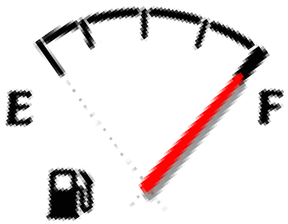
F	Fuel
R	Radios
E	Engine
D	Directional Indicator
A	Altimeter

"FREDA" is a mnemonic – a way of using a word to help us to remember something more complex. Each of the letters relate to something else. We will have a look at each of these individually now.

THE FREDA CHECK

F – FUEL

Just like in a car, the engine requires fuel in order for it to continue to run. The main difference in an aircraft is that there are no petrol stations handy! The pilot must monitor the fuel state of the aircraft throughout flight and plan in sufficient reserves to allow an approach and landing at an airfield to refuel when required.



Unlike a car, the gauges in aircraft are notoriously unreliable (legally the only requirement is for them to be accurate when empty!) and so it is important to know not only how much fuel was in the aircraft when the engine was started but also to know the fuel consumption per hour of the aircraft.

In a Cessna 152 the standard fuel capacity is 93 litres. The aircraft burns approximately 23 litres per hour. If the tanks were full at the beginning of the flight and the aircraft has been running for 90 minutes, the fuel state should be 48 litres. It is generally wise to land with at least one hour of fuel in the tanks.

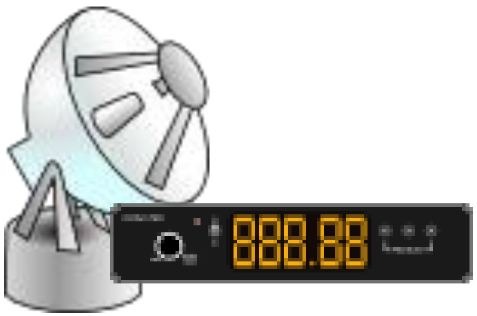
In some circumstances the "F" in FREDA may also be used as a reminder to lean the mixture.

In some aircraft it is important to know which fuel tank is being used and that the tanks are balanced in content but in the Cessna 152 the tanks both feed to the engine at the same time and so this is not required.

THE FREDA CHECK

R - RADIOS

Ensure that the aircraft communications are set to the correct radio frequency and that the volume is at a sufficient level to be able to hear if Air Traffic Control are attempting to make contact. If there are standby frequencies available, setting them can ease pilot workload in the future.



It is also wise at this point to ensure that any navigational receivers are set as required for the flight being undertaken. These "nav aids" will be looked at in detail later on in your PPL or LAPL training.

The transponder of the aircraft is also a type of radio. It transmits a signal to anyone within range with a radar screen and can give them information regarding your aircrafts position and altitude. Unless you have been given a specific code to set on the transponder, you should ensure that it is set to "7000" and that it is selected to give information about altitude as well as position (Mode C). The number on the transponder is known as a "squawk" and 7000 is used for conspicuity – to make a general aviation aircraft conspicuous on a radar screen.

THE FREDA CHECK

E-ENGINE

Time to monitor the aircraft engine parameters to ensure that it is running correctly. There are a number of items to check.

Do a carburettor check just as you were taught in exercise 4(2). Select the carburettor heat to "hot" and note the drop on the rpm gauge. If the rpm does not drop, rises, or the engine runs roughly, carburettor ice is present and the heat should be continued until the engine runs smoothly again. The rpm should return to where it started once the carburettor heat is selected to "cold".

Check that the engine temperature and pressure gauges are indicating in the green arcs. If they are outside the green sections, the aircraft should be landed at an airfield as soon as possible.

Check that the suction gauge and the ammeter are indicating correctly. If there is an issue it is usually best to return to base as soon as possible. If the ammeter is discharging, for example, the aircraft engine is not charging the battery and so there may be issues with using the radios or the flaps.

Exercise 6(1), (2): Straight, Level & Balanced Flight

THE FREDA CHECK

D – DIRECTIONAL INDICATOR

The directional indicator (DI) is a gyroscopic instrument used to discern the direction of the aircraft. It needs to be aligned to the magnetic compass.

The DI, however, works on the basis that the earth is not rotating and, over time, it will become mis-aligned with the compass.

Make sure that the aircraft is being flown in straight, level, balanced flight at a constant speed. This will ensure that the compass maintains position and the compass heading read.

Use the adjustment knob on the DI to align the reading with that read from the magnetic compass. It is usually best then to confirm that the correct heading has been set. This is a bit of a fiddly job to begin with but will get easier with practice.

THE FREDA CHECK

A - ALTIMETER

The altimeter will give the pilot information about the aircraft height or altitude but only if it is set correctly to the appropriate pressure datum.

Check that the subscale of the altimeter is set to the correct pressure setting (usually the last one given to you by Air Traffic Control).

Later in the course in the meteorology lectures, you will learn the importance of the correct altimeter setting for the safety of the aircraft. In the Aircraft General Knowledge lectures you will learn the various ways in which the altimeter is used.

Use the adjustment knob on the DI to align the reading with that read from the magnetic compass. It is usually best then to confirm that the correct heading has been set. This is a bit of a fiddly job to begin with but will get easier with practice.

THREAT & ERROR MANAGEMENT

We shall now examine some of the threats that may occur during the cruise phase of flight and errors that may be made by the pilot. We will also examine how these can be reduced to a minimum.

Symbols used throughout this section are as shown below.

The threat being discussed.

The error being discussed.

The management of the threat and/or error that mean it is reduced to the lowest possible risk.

Exercise 6(1), (2): Straight, Level & Balanced Flight

LONG BRIEF

THREAT & ERROR MANAGEMENT

Flight in uncontrolled airspace means that traffic is not separated by air traffic control.

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By learning and applying an effective lookout technique, the pilot can minimise the risk from other aircraft in flight. A scanning pattern that covers a wide arc around the aircraft at the same level but also above and below the aircraft will be vital in all flights.

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A pilot who fails to monitor the temperature and pressure of the engine, and their fuel usage could lead to an engine failure.

If the pilot carries out cruise checks (the FREDA check) every 10 – 15 minutes this will ensure that the engine parameters and fuel state are monitored closely and the risks are reduced to a minimum.

Exercise 6(1), (2): Straight, Level & Balanced Flight

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THREAT & ERROR MANAGEMENT

The pilot of the aircraft may get disorientated and enter controlled airspace in error.

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If the pilot confirms altimeter settings regularly and maintains good situational awareness, the likelihood of disorientation is minimised.

Can you think of any other issues that may occur during straight and level flight?

Exercise 6(1), (2): Straight, Level & Balanced Flight

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SUMMARY

There are four main forces in flight – lift, weight, drag and thrust.

An aircraft in straight and level flight will have balanced forces of lift and weight.

At a constant speed, drag and thrust will also be in balance.

There are two main types of aircraft stability – static and dynamic

Most training aircraft are designed to be as stable as possible without making it too "heavy" to fly.

Stability in in the longitudinal plane (pitch) is provided by the tailplane. Stability in the lateral plane (roll) is provided by dihedral, sweepback or high wing configuration. Stability in the directional plane (yaw) is provided by the vertical stabiliser / fin.

The FREDA check is used every 10 – 15 minutes in flight to monitor the way in which the aircraft engine is working and also to monitor that the instruments and radios are being used in the correct way.

You should now attempt the Progress Check for this exercise.