Principles of Flight

Lift and Weight

- Newton's third law states 'To every action, there is an equal and opposite reaction'. For example, if you lean on a wall, the wall is effectively pushing back with the same force.
- Air is a substance. The faster you move through it, the more air resistance is encountered. We can use a wind tunnel to replicate what happens to objects when they move through air.
- The Bernoulli Principles states that as air flows faster, its pressure must reduce.
- A wing's shape causes the air above the wing to move faster than the air below it. This means that the air above the wing has lower pressure, so the wing is sucked upwards.
- Angling the wing upwards slightly (altering its "angle of attack") causes downwash and creates more lift.

Thrust and Drag

- An aircraft's wings must have air flowing over them in order to generate lift.
- As an aircraft pushes through the air, it experiences drag. If you double and aircraft's speed it encounters 4 times as much drag.
- Drag can be reduced by designing aircraft to have a streamlined shape.
- The force which drives an aircraft forwards is called thrust. This is provided by the aircraft's engine(s).
- In order to stay airbourne, an aircraft must produce enough lift to counteract its weight. To climb, it must produce more lift than weight. To descent, it produces less lift than weight.
- In straight and level flight, lift equals weight and drag equals thrust.

Stability and Control

- An aircraft can move through 3 axes.
    - The *normal* axis runs vertically up and down through the centre of the aircraft. Moving around this axis is called *yawing.*
    - The *lateral* axis runs from through the wings from tip to tip, across the aircraft. Moving around this axis is called *pitching*.
    - The *longitudinal* axis runs along the length of the aircraft, from the nose to the tail. Moving around this axis is called *rolling.*
- Stability is very important. It means that if an aircraft is thrown off its course by turbulence, it will naturally return to where it was.
- When an aircraft pitches unexpectedly, its tail pushes it back level. Rolling is controlled by the wings, and yaw by the fin.
- An aircraft cannot be too stable, and this would make it difficult to change course at all.

- An aircraft's course can be changed by its control surfaces.
    - The ailerons (on the wing's trailing edge, towards the outside) cause an aircraft to roll.
    - The elevators (on the tailplane) cause an aircraft to pitch.
    - The rudder (at the back of the fin) causes an aircraft to yaw.
- The control surfaces are moved using controls in the cockpit. The control column moves the elevators and ailerons. Foot pedals control the rudder.

- Aircraft also have surfaces called Flaps, on the trailing edge of the wing, near to the fuselage. These can be used to vary the amount of lift a wing produces. More lift is needed for takeoff, less for landing.
- Each control surface also has a *trim tab.* This is a small flap on the control surface which can be set to a certain position. When trim tabs on the elevators are set downward, for example, it has the same effect as constantly pulling back on the control column.
- Trim tabs can be useful for correcting an aircraft's stability. If one side is heavier than the other, trim tabs on the ailerons can be used to cancel out this effect.

Stalling

- In normal flight the wing meets oncoming air at a small angle of attack.
- If the pilot increases the angle of attack slightly, the wing produces more lift.
- If the angle of attack is increased above around 15°, the aircraft will *stall*, meaning it loses lift.
- The speed at which an aircraft will stall varies. More weight increases stalling speed. Higher engine power lowers stalling speed. Lowering flaps will reduce stalling speed.
- Most manoeuvres will affect stalling speed in some way.
- An aircraft may stall at any altitude.

Gliding

- Gliders use the pull of gravity to give them speed. As a glider falls, it moves through the air, producing lift and counteracting its fall. Overall, however, a glider is always falling.
- Three forces act on gliders.
    - Drag
    - Weight
    - Lift
- The flatter the angle at which it glides, the further a glider will travel over the ground.
- A glider moving forward at 30kts, into a wind of 30kts will not appear to cover any distance on the ground. A glider moving at 30kts, with a wing of 30kts, will cover the ground at 60kts.

- Rather than flaps, most gliders have air brakes. These are panels which pop out of the wing at 90°, increasing drag. In order to maintain airspeed the pilot then lowers the nose. This technique allows gliders to descend more quickly than they otherwise could.

The Helicopter

- A helicopter's rotor blades are like small wings. As they move through the air, they generate lift.
- To move a helicopter forward, each rotor blade is tilted slightly as it moves around the rear of the rotor disc. This has the effect of pushing some air backwards as well as downwards. This makes the aircraft move forwards.
- The same principle applies to making the helicopter move backwards, left or right.
- Varying the pitch of each blade in this way is known as *cyclic pitch.* It is controlled by the *cyclic pitch control.*
- In order to make a helicopter climb or descend the pilot varies the pitch of all rotor blades together. This is known as *collective pitch.*
- As the rotor disc spins one way, the rest of the helicopter naturally tries the spin the other way. This is called *torque reaction.* This is counteracted by the tail rotor. Varying the thrust of the tail rotor allows a helicopter to yaw.

Basic Navigation

Basic Navigation

- Good navigation is all about knowing where you are on a map, knowing where you want to go, and choosing the best route to follow in order to get there. It combines map reading with using a compass.
- There are three types of North.
    - Grid North – This is just the top edge of whatever map you're looking at.
    - Magnetic North – This is the Northern pole of the Earth's magnetic field. It is actually somewhere in Canada, and moves around slowly.
    - True North – This is where all the Earth's lines of longitude meet, at the top, and is also the actual North Pole.
- In the northern hemisphere you can find North by using the pole star, which can be found by looking for the plough or 'big dipper' constellation.

The Compass

- A compass is a precision instrument and requires careful handling. Try not to drop it, and keep it away from electrical items.
- Compasses will be affected by nearby ferrous metals.
- Setting the map
    - Turn the compass capsule until the GMA (*Grid magnetic angle* - the angle between grid north and magnetic north, currently around 3°) is set against the direction arrow.
    - Place the compass on the map so that the long edge of it matches the North-South gridlines, and the direction of travel arrow points to the top of the map.
    - Turn the map and the compass together until the compass needle's red end is within the orientating arrow (the large arrow on the capsule).
- When translating between compass readings and bearings on a map, you need to account for grid-magnetic variation. When changing from a grid bearing to a magnetic one, *add* the GMA. When changing from magnetic to grid, subtract the GMA (Grid-to-mag: add. Mag-to-grid: get rid).

Practical Navigation

- It is often important to measure the distance you have travelled. Distance = time x speed.
- Use Naismith's rule to work out how long a journey will take. Assume a walking speed of 4km/h, plus half an hour for every 200m of climbing or descent. Your speed will also be affected by uneven terrain or heavy loads.
- Count your paces to get an idea of distance.

- There are several methods you can use o make navigation easier.
    - *Handrailing.* Follow linear terrain (power lines, valleys etc) that leads to where you're going.
    - *Aiming Off.* Aim for an easy to spot feature that is near where you want to be.
    - *Contouring.* Follow the contours of the land.
    - *Attack Points.* Pick an easily identifiable feature to aim for.

Weather

- When out on an expedition you must be prepared for whatever weather conditions may arise. Good equipment and careful planning will allow you to carry on whatever the weather.
- The Earth's atmosphere is constantly moving. This is caused by the sun heating the Earth's surface. The surface then heats the air above it, causing it to rise until it cools as begins to fall.
- The UK's weather is governed by several large, moving air masses.

Name	**Characteristics**	**Summer**	**Winter**
Polar Maritime	Cold, damp air from the North Atlantic	Cool winds, heavy showers, thunder in mountains.	Heavy showers in west with snow in mountains. Clear skies at night in the east giving frost.
Arctic Maritime	Cold, damp air from the North Pole	Very cold with frequent heavy showers	Very cold strong north, north-easterly winds. Heavy snow showers in north
Polar Continental	Cold, dry air from Russia and Siberia	Warm and dry, cloud free. East coast tends to be cool and showery with coastal fog in the north	Sleet and snow showers in the north. Cold strong east winds
Tropical Continental	Warm, dry air from Northern Africa	Very hot and dry, hazy with occasional thunder storms.	Doesn't occur in winter.
Tropical Maritime	Warm, damp air from the mid Atlantic	Warm south-west winds. Low stratus cloud over west coast	Stratus cloud, hill fog and drizzle, clearing in the north-west. Warm with prolonged rainfall in westerly mountains
Returning Polar Maritime	Slightly cold, damp air that originates in Canada, and travels across the North Atlantic	Warm with squally showers and storms inland	Stratus cloud. Showers in the western mountains

- Areas of high or low air pressure are the cause of variation in our weather. To visualise these, meteorologists use lines drawn on maps known as isobars, which connect areas of the same pressure, rather like contours on a map.

- At around 90 degrees to isobars, there are sometimes areas known as fronts, where a cold air mass meets a warm one. Where these happen, air forms a spiralling motion as the cold, denser air falls below the warm, lighter air.
- An anticyclone is a region of high pressure, with light winds circulating in a clockwise direction (in the northern hemisphere) round the centre of high pressure. In general they are stable slow moving systems, consisting of warm dry air, bringing long periods of fine clear weather.
- Clouds are named according to both their shape and height. There are three main types of cloud:
    - *Cirrus* - Thread-like clouds found only at high levels and composed of ice crystals.
    - *Cumulus* - A lumpy or heaped cloud.
    - *Stratus* – A featureless layer of cloud.
- The basic names of clouds may be combined, and the prefixes *cirro-* or *alto-* added to identify the height at which the cloud is occurring.
- The words *cumulus* and *stratus* on their own identify clouds whose base is below 2000m. *Cumulus* may be combined with *nimbus* (Latin for rain), to give *cumulonimbus* - a heaped rain cloud.
- A layer cloud from which rain is falling is called *nimbostratus.*