DEFINITIONS

Aerofoil
An aerofoil is a device designed to produce more lift (or thrust) than drag when air flows over it.

Angle of Attack
This is the angle between the chord line of the aerofoil and the relative airflow. This angle is independent of the pitch angle of the blades.

Camber
This is the maximum distance between the chord line and the mean camber line.

Mean Camber Line
This is a curved line that passes mid-way between the upper and lower surface of an aerofoil.

Span
The distance from the rotor centreline to the blade tip when the rotor blade is horizontal.

Chord line
This is an imaginary straight line that passes through the leading edge and trailing edge of an aerofoil.

Chord
The length of the chord line between the leading and trailing edge of an aerofoil.

Aspect Ratio
The span divided by the chord.

Twist (Washout)
The decrease in pitch angle from the root of the blade to the tip.

Feathering Axis
A line between the root end and the tip of a blade around which the blade rotates to alter its pitch angle.

Centre of Gravity (C of G)
A point within an object through which all the forces of gravity are considered to act. If an object was suspended from this point, it would be in balance. For a rotor blade, the C of G should ideally be on the feathering axis.

Centre of Pressure (C of P)
This is the point on the chord line where the sum of all the aerodynamic forces are considered to act. This point moves toward the leading edge of an aerofoil when the angle of attack is increased. The movement of the C of P is less with a symmetrical aerofoil than it is with a non-symmetrical one. For a rotor blade, the C of P should ideally be on the feathering axis.

Advancing Blade
The blade moving in the same direction as the helicopter. In forward flight in an American helicopter, the advancing blade is on the right side of the helicopter.

Retreating Blade
The blade moving in the opposite direction as the helicopter. In forward flight in an American helicopter, the retreating blade is on the left side of the helicopter.
**Pitch Angle**
This is the angle between the chord line of the blade and the reference plane of the rotor hub or the plane of rotation of the rotor. This is a mechanical angle, not an aerodynamic angle, which is set by the amount of collective and/or cyclic pitch that is applied.

**Angle of attack**
This is the angle between the chord line of the blade and the relative airflow. This angle is independent of the pitch angle. Depending on the flight regime and the position of the blade in relation to the direction of flight, it may be less than, the same as, or greater than the pitch angle.

**Relative Airflow (RAF)**
This is the direction of the airflow in relation to the aerofoil. It is created by the movement of the aerofoil through the air, the movement of air over the aerofoil or a combination of both. It is the resultant of the rotational airflow and the induced airflow.

It can also refer to the airflow in relation to the rotor disc.

**Relative Air Speed**
Relative airspeed is the sum of the velocity of the air and the velocity of the object it is approaching.

**Induced Flow**
In relation to a rotor blade, it is the component of the relative airflow that is at right angles to the plane of rotation.

In relation to the rotor disc, it is the total mass of air induced to flow by the action of the rotor, most of the induced flow passes through the rotor but some may miss it altogether.

**Induced Angle** (Inflow Angle)
The induced angle is the angle between the plane of rotation and the relative air flow approaching the rotor blade. Some publications refer to this as the 'inflow angle'

**Total Reaction**
A single vector representing the sum of all the aerodynamic forces acting on an aerofoil.

**Lift**
Lift is the force derived from an aerofoil and it acts at right angles to the relative airflow.

The amount of lift an aerofoil produces is determined by the following formulae :-

Lift = CL ½ p V^2 S

Where :-

CL = Co-efficient of lift (The efficiency of the aerofoil in producing lift). This changes with the shape of the aerofoil, its surface friction (smoothness and cleanliness) and its angle of attack.

p = Air density

V^2 = Velocity squared

S = Surface area of the aerofoil.

In some publications the vertical component of Total Rotor Thrust (TRT) is called lift, and the horizontal component is called thrust, however, in order to avoid confusion with other uses of the terms lift and thrust, I will refer to the vertical component of TRT as 'Vtrt' and the horizontal component of TRT as 'Htrt' throughout this course.

The vertical component of Total Rotor Thrust (TRT) opposes the weight of the helicopter and the horizontal component of TRT pulls the helicopter through the air.
**Drag**
The retarding force acting in line with the relative airflow.

\[ \text{Drag} = CD \frac{1}{2} p V^2 S \]

Where:

- \( CD \) = Co-efficient of drag (The efficiency of the aerofoil in minimising drag). This changes with the shape of the aerofoil, its surface friction (smoothness and cleanliness) and its angle of attack.
- \( p \) = Air density
- \( V^2 \) = Velocity squared
- \( S \) = Surface area of the aerofoil

**Form Drag**
This is the drag due to the shape and size of the object.

**Skin Friction**
This is the amount of drag created by the retardation of the boundary layer of air in contact with the surface of the aerofoil.

**Profile Drag**
This is a combination of Form Drag and Skin Friction. In the case of a rotor blade, it is the drag created by the movement of the rotor blade through the air without creating lift - i.e. at an angle of attack that does not produce either positive or negative lift.

**Induced Drag**
This is the drag created by the production of lift.

**Parasite Drag**
This is the drag of non-lift producing elements of the aircraft - i.e. fuselage, rotor head, undercarriage etc.

**Lift/Drag Ratio**
Whenever an aerofoil is producing lift, it is also producing drag. The amount of lift produced compared to the amount of drag produced is the lift/drag ratio and is an indication of the efficiency of the airfoil.

**Stall**
The condition under which the airflow separates from the aerofoil, resulting in a massive increase in drag and an almost total loss of lift. An aerofoil usually stalls at an angle of attack around 16 degrees.

**Dissymmetry of Lift**
This is the un-equal lift produced by each rotor blade as its relative airspeed is increased as it becomes the advancing blade and decreased as it becomes the retreating blade (lift varies at the square of the speed). It is automatically corrected by blade flapping.

**Flapping to Equality**
Whenever dissymmetry of lift occurs, the blades flap automatically to eliminate this dissymmetry and equalise the lift; the advancing blade decreases its angle of attack as it flaps up whilst the retreating blade increases its angle of attack as it flaps down.

The blades continue to flap until their lift is equal; when this occurs, the blades stop flapping, hence the term 'Flapping to Equality'.
**Rotor Drag**
The portion of drag on a rotor blade that is in line with the plane of rotation of the rotor disc. It is rotor drag that must be overcome by engine torque.

**Rotor Driving Force**
The force that causes the rotor blade to move in the direction of rotation. It can come from engine power, aerodynamic forces, or from a combination of both. If the rotor driving force is not equal to the rotor drag, the R/RPM must be increasing or decreasing.

**Rotor Thrust**
The vertical component of the lift of a rotor blade. The sum total of the rotor thrust on all of the blades becomes the Total Rotor Thrust (TRT) of the rotor system.

**Total Rotor Thrust**
The force created by a rotor at right angles to the plane of rotation of the rotor disc. This force acts through the rotor head and is broken up into a vertical component that opposes the weight of the helicopter and a horizontal component that pulls the helicopter through the air.

**Axis of Rotation** (Control axis)
This is the axis around which the blades rotate. It is a line through the rotor head at right angles (perpendicular) to the plane of rotation (tip path plane). It is not always in line with the rotor mast.

**Coning Angle**
The angle between the feathering axis of the blade and the plane of rotation. This varies with R/RPM (centrifugal force) and rotor thrust.

**Coriolis effect**
The tendency for a rotating body to increase its RPM when its C of G moves closer to its axis of rotation. A rotor blade moves forward on its drag hinge when it flaps up (the C of G moves inboard) and the R/RPM increases when the coning angle increases (all the blades flap up).

**Disc Area**
The area contained within the tip path plane. The size of this area is affected by the coning angle and therefore varies in flight.

**Disc Loading**
The gross weight of the helicopter divided by the disc area. As the disc area varies in flight with changes in TRT, R/RPM, etc, so does the disc loading, even at a constant weight.

**Thrust**
In an aeroplane, thrust is the force from the propeller or the jet engine that drives the aircraft through the air. In a helicopter, the horizontal component of total rotor thrust that is providing the force to pull the helicopter through the air, is often referred to as thrust.

In order to avoid confusion with other uses of the terms lift and thrust, I will refer to the horizontal component of TRT as 'Htrt' and the vertical component of TRT as 'Vtrt' throughout this course.

**Tip Path**
The path described by the tips of the rotor blades.

**Tip Path Plane**
The plane (disc) within the tip path. It is parallel to the plane of rotation.
**Plane of Rotation**
This is the plane that is parallel to the tip path plane and passes through the rotor hub.

**Velocity**
A combination of speed and direction.

**Rotor Heads**
- **Fully articulated**
  The rotor head has hinges and bearings that allow the blades to feather, flap and drag independently of each other.

- **Semi Rigid**
  The blades are free to feather individually but the rotor head 'teeters' to allow the rotor to flap as an assembly.

- **Rigid**
  The blades rotate in the feathering plane but movement in the flapping and dragging plane is achieved by bending of the blades.

**Feathering**
The rotation of the blade around the feathering axis (changes in pitch angle) due to cyclic and collective control inputs

**Lead-Lag** (Dragging or Hunting)
The horizontal movement of the blade or blades. Also called hunting.

**Hunting**
See lead-lag.

**Flapping**
The movement of the blade in a vertical plane.

**Hinge Offset**
The distance between the flapping hinge and the centre of the rotor hub.

**Gyroscopic Precession**
The characteristic of a rotating body to delay its reaction by 90° after an external force is applied.

**Phase Lag**
The angular difference between the control input and the subsequent reaction (gyroscopic precession). It is normally 90°, but on helicopters with a large diameter rotor head, it may be one or two degrees less due to the offset of the flapping hinges, bearing friction, etc - i.e. if you had a 10 metre diam rotor head with flapping hinges at the perimeter and blades that were only 10cm long, the blades would not take 90° to react to a control movement.

**Advance Angle**
This is the number of degrees the manufacturer sets the control input in advance of the desired reaction point to compensate for the phase lag in order to ensure the rotor disc reacts in the same sense as the cyclic movement - i.e. forward cyclic causes the rotor disc to tilt forward.

If the manufacturer did not build in an advance angle, the pilot would have to move the cyclic in a direction that was 90° to the direction in which he wanted the helicopter to move – i.e. right cyclic to make the helicopter move forward.
**Hooke's Joint Effect**
The movement of the blades in the lead lag plane to maintain an even spacing of the blades regardless of the tilt of the tip path plane or axis of rotation.

**Ground Effect**
The increase in rotor thrust due to the proximity of the ground reducing the induced velocity.

**Ground Resonance**
A destructive force created by an imbalance of the main rotor causing the helicopter to rock from side to side on its landing gear.

**Harmonic Vibration**
See ‘Sympathetic Resonance’.

**Sympathetic Resonance**
A resonance or vibration that is set up when two components are rotating at an RPM where they react with one another to create a vibration that is usually destructive to one or both components.

**Pitching**
The movement of the aircraft around its lateral axis.

**Rolling**
The movement of the aircraft around its longitudinal axis.

**Yawing**
The movement of the aircraft around its vertical axis.