CLIMBING - (Long Brief)

Aim:

To understand the various aerodynamic principles and forces acting on the aircraft in various climb configurations.

Objectives:

By completion of this brief you will be able to recall and recite how the four forces are balanced (resolved) in a climb, as well as name the three main types of climbs and their applications. You will also be able to recall and recite the effects of flap, wind, altitude and temperature on climb performance.

Revision:

What are the four forces and where do they act?

What is mean by equilibrium?

What is the relationship between the four forces in straight and level flight?

Definitions:

Climb - an increase in altitude at a constant airspeed, rate, direction, wings level and the aircraft in balance.

Rate of climb, RoC - altitude gain in time (feet per minute).

Angle of climb, AoC - a function of altitude gain for a given horizontal distance of travel.

Best rate of climb speed (Vy) - the climb speed which corresponds to the greatest altitude gain over time.

Best angle of climb speed (Vx) - the climb speed which corresponds to the greatest altitude gain for a given horizontal distance of travel.

Applications:

Climb after take-off, en-route, terrain obstacle clearance, traffic separation and air traffic control instruction.

Principles:

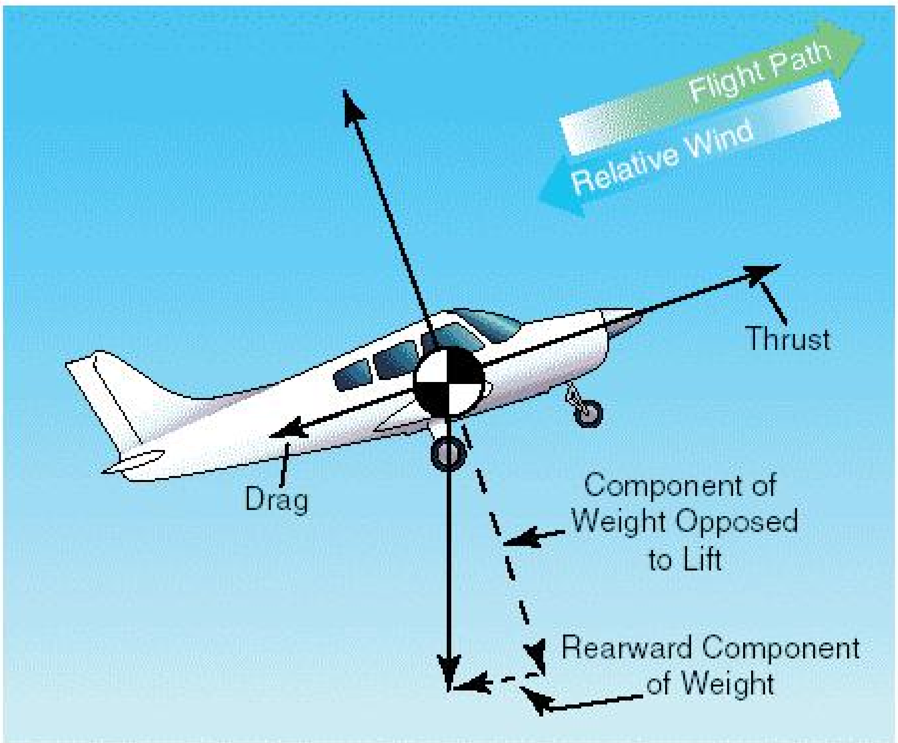
The Forces -

In any steady state of flight, the aircraft is in equilibrium. There is no acceleration or deceleration, and a constant path of motion is maintained. Consider the aircraft in a climb:

During a climb, the aircraft flight path is tilted so that some element of its weight is assisting drag to slow it down.

In straight and level flight, T = D. In a climb, thrust must increase to equal drag *plus* the rearward component of weight (RCW).

T = D + RCW

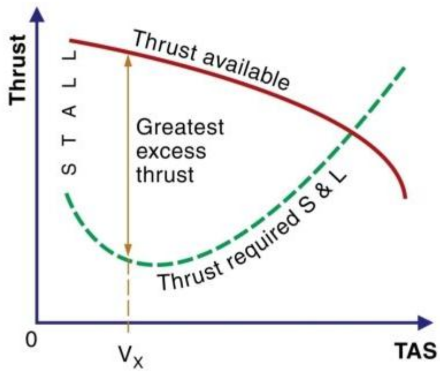


Therefore, in a steady climb, thrust is *greater* than drag.

In order for the forces to be in equilibrium, the resultant from drag and weight must balance the resultant from lift and thrust Due to the inclination of the flight path, this means that **lift is actually less than weight** and thrust is greater than drag. The four forces forces and their resultants in a steady climb are covered in more detail in the RPL theory class /bob Tait book.

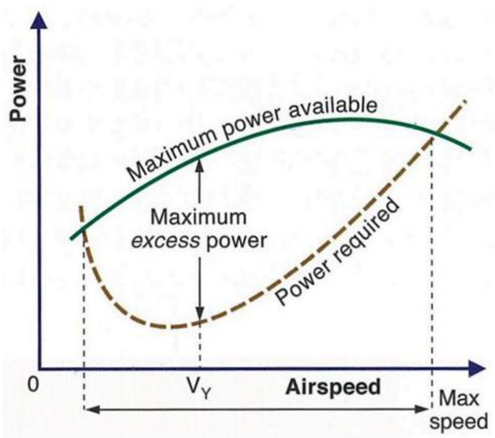
Best Angle of Climb (BAoC) (Vx)

The more thrust we have available to us in excess of drag, the steeper we can make our climb by raising the nose and accepting a larger RCW. **We will achieve our best Angle of climb by climbing at speed Vx, (60kts in the C172 and PA 38) which provides the greatest amount of thrust to drag.** Vx is used for obstacle clearance as it provides the greatest vertical height gain in the shortest horizontal distance.



Best Rate of Climb (BRoC) (Vy)

This is when we achieve the greatest vertical height gain in the shortest time. Vy is 75kts in the C172or 70kts PA 38. Best Rate of climb is achieved at a speed corresponding to maximum excess *power*.

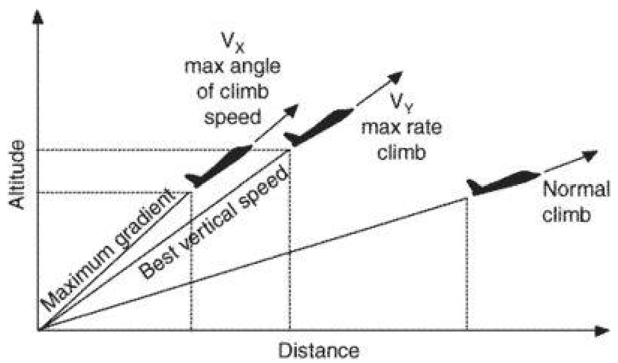


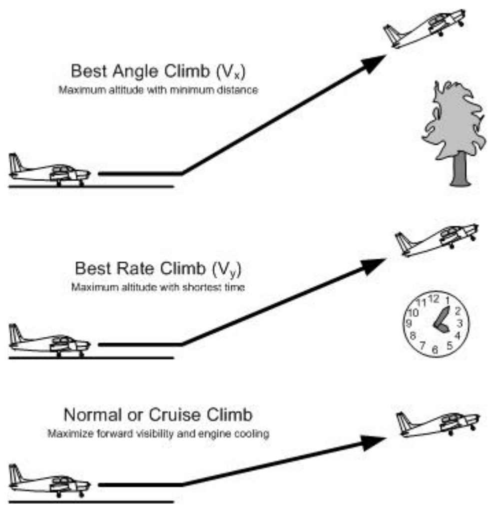
The difference between *thrust* and *power* is subtle but important. Whereas Thrust is a pure force, Power is a *rate* of doing work - and work in this case is climbing.

The power available to our aircraft is dependent on the amount of work our propeller can do in a given amount of time, and is deduced from both the thrust available AND the drag forces on the propeller relating to airspeed of the aircraft.

Normal (cruise) climb - 80 - 85kts

This type of climb is used for changes of level en-route where we will still like to maintain a good ground speed. It also provides better engine cooling and forward visibility.





Considerations:

The effect of flap

Flap increases lift but also increases drag. This means that more power and thrust is required to remain straight and level and there is less excess available. This then deteriorates our RoC and AoC.

Effect of altitude and temperature

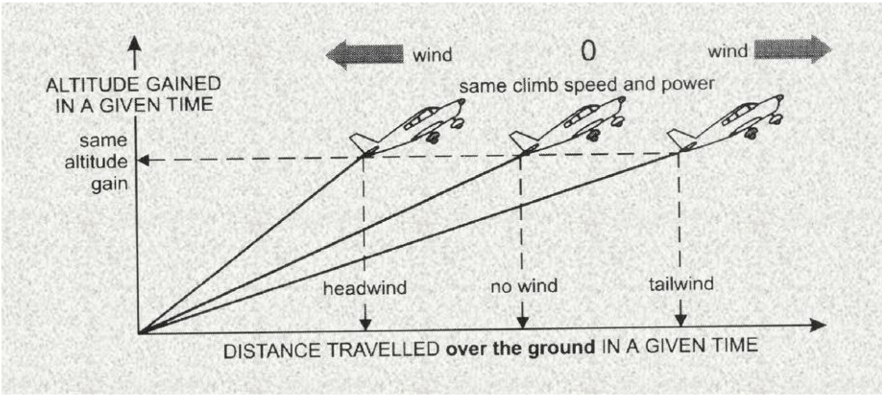
With an increase in altitude or temperature, air density decreases and in turn so does our engine performance. It follows that RoC and AoC will both be reduced.

Effect of slipstream

In a climb we have a slow forward speed and a high power setting which provides the greatest slipstream effect (i.e. yaw due to airflow striking the side of the vertical tailplane). Constant right rudder deflection is likely required.

Effect of wind

Wind has no effect on RoC as rate depends on power and time only. However, since AoC depends on horizontal distance covered, a headwind will reduce horizontal distance covered and thus increase our AoC (our climb will be steeper), while a tailwind will increase horizontal distance covered and thus decrease our AoC (our climb will be shallower).

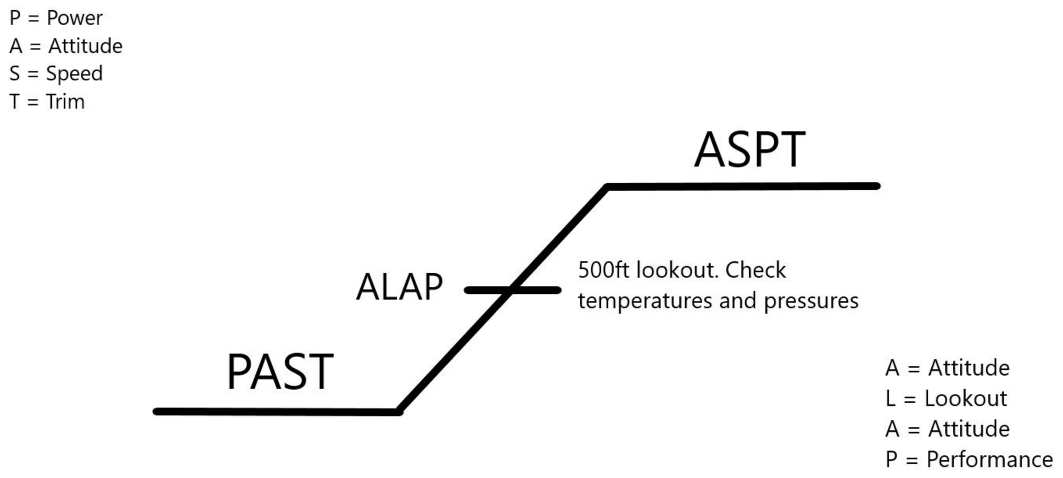


High nose attitude/Low airspeed

Due to the high nose attitude in the climb, our forward visibility is reduced. Every 500ft we should either low the nose or alter heading to check for any threats. Climbs also typically involve high power settings at low forward airspeed. As the engine is air cooled, there is a risk of over-heating and therefore we must exercise extra vigilance in monitoring oil temperature and pressure.

Application

Below is the sequence used to enter and level off from a climb.



Entry into climb: Lookout, Reference Point/Heading, Mixture Rich (if applicable)

Power - Set climb power (full power in a light training aircraft)

Attitude - Set climb attitude

Speed - Allow speed to decrease to applicable climb speed

Trim - Adjust trim as required to maintain climb attitude

Power, Attitude, Speed, Trim (P.A.S.T)

Maintaining: Lower the nose every 500ft for lookout, check T's and P's.

Attitude - Check attitude

Lookout - Conduct lookout for other traffic

Attitude - Re-check attitude

Performance - Check performance instruments (confirm correct airspeed, altitude, rate of climb, heading)

Attitude, Lookout, Attitude, Performance (A.L.A.P)

Level-off from a climb to straight and level: Anticipate level-off by 10% of RoC.

Attitude - Set straight and level attitude

Speed - Allow speed to increase *before* making reducing power

Power - Reduce power to desired cruise setting

Trim - Adjust trim as required to maintain straight and level attitude

Attitude, Speed, Power, Trim (A.S.P.T)

It is important that when leveling-off from a climb, we allow our airspeed to increase before reducing power, to reduce the amount of time spent accelerating to cruise speed. If we reduced our power too quickly, the Angle of Attack (AoA) necessary for level flight will constantly change as the aircraft's speed slowly builds up. If we kept power on until we approached normal cruising speed and then set the trim, we would only need to do so once, giving us time to focus on other things sooner.

Airmanship

- Lookout, lower nose every 500'
- Monitor engine instruments
- Handover / Takeover Procedure
- Smooth control handling
- Power + Attitude = Performance
- Do not chase airspeeds - set our attitude and focus most of our attention outside.