The vector diagram.

This is used to explain how a helicopter flies and how the rotors react to changes in pitch and air speed.

The standard diagram assumes the aircraft(a/c) is in a still air hover. This is to say the a/c is not moving relative to the ground and there is no air flow(wind/forward speed) over the disc.

As mentioned we have two axis which our four basic principles operate on. These are named Plane of Rotation (X axis) and Axis of Rotation (y axis)

AoR

PoR
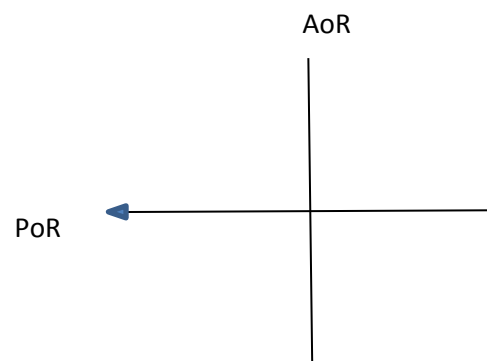
We then have our rotor blade. This is traditionally drawn off centre so as to keep the diagram uncluttered. However we assume the rotors Centre of Pressure is acting at the origin. Extending from the blade is out Chord line.
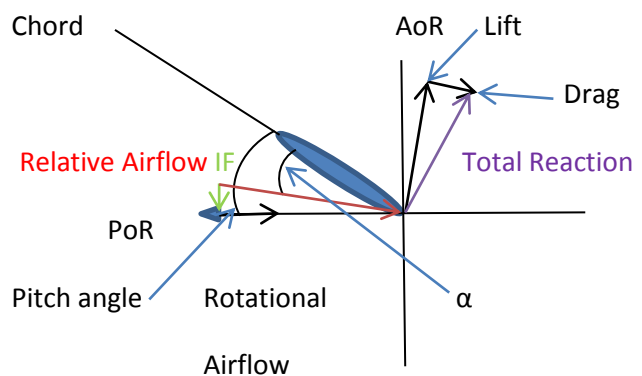
Chord   AoR

PoR
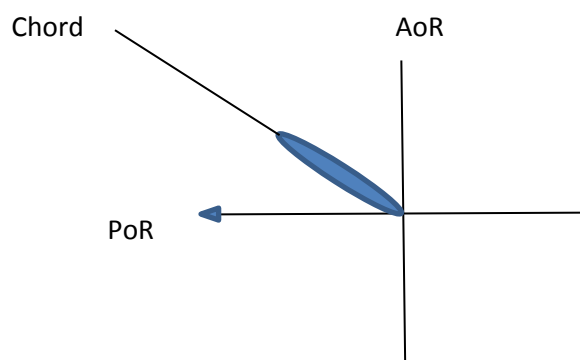
We can now draw on the Rotational Airflow and the IF. Rotational airflow acts along the PoR and IF along AoR. IF is fairly small and Rotational Airflow large in comparison.

Chord   AoR

                          IF

              PoR

   Rotational
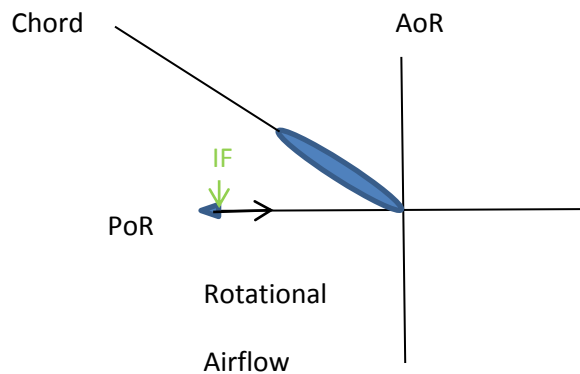
                    Airflow

From these we can deduce the Relative Airflow. This is the airflow the blade sees. We can then take two angles. The first is the pitch angle of the blade and the second is Alpha (α) or AoA.

Chord   AoR

Relative Airflow IF

              PoR

Pitch angle   Rotational   α
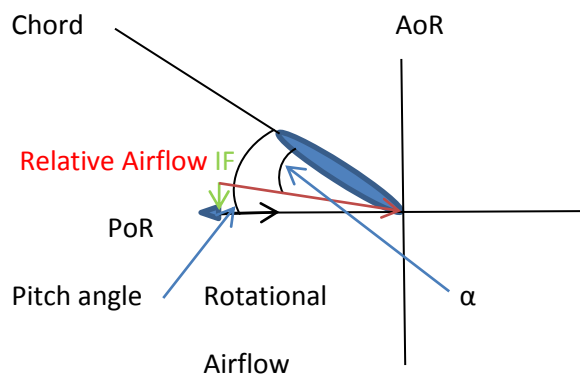
                    Airflow

So now we have our blade being acted upon by the relative airflow at a given angle of α. The blade then produces Lift at 90 deg to Relative Airflow and drag 90 deg to Lift. We then combine the two to give us Total Reaction.

Chord   AoR   Lift

                                                      Drag

Relative Airflow IF   Total Reaction

              PoR

Pitch angle   Rotational   α

                    Airflow

Nearly there. Ok, we can separate the Total Reaction into its constituent vectors on the X and Y axis and these give us the Rotor Drag and Total Rotor Thrust(TRT). These two forces are countered by Thrust (or in a helicopter Torque(Tq)) and Weight and when these are balanced we are in a steady state. For the purpose of this example we said we were in a hover, so if nothing changes we will remain hovering.
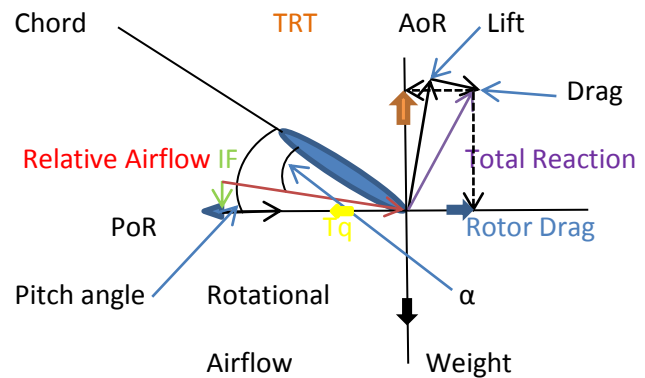
There simple. I'm sorry about the cluttered nature of the diagrams. This would normally be drawn on a large white board but I think it works OK?

Tom