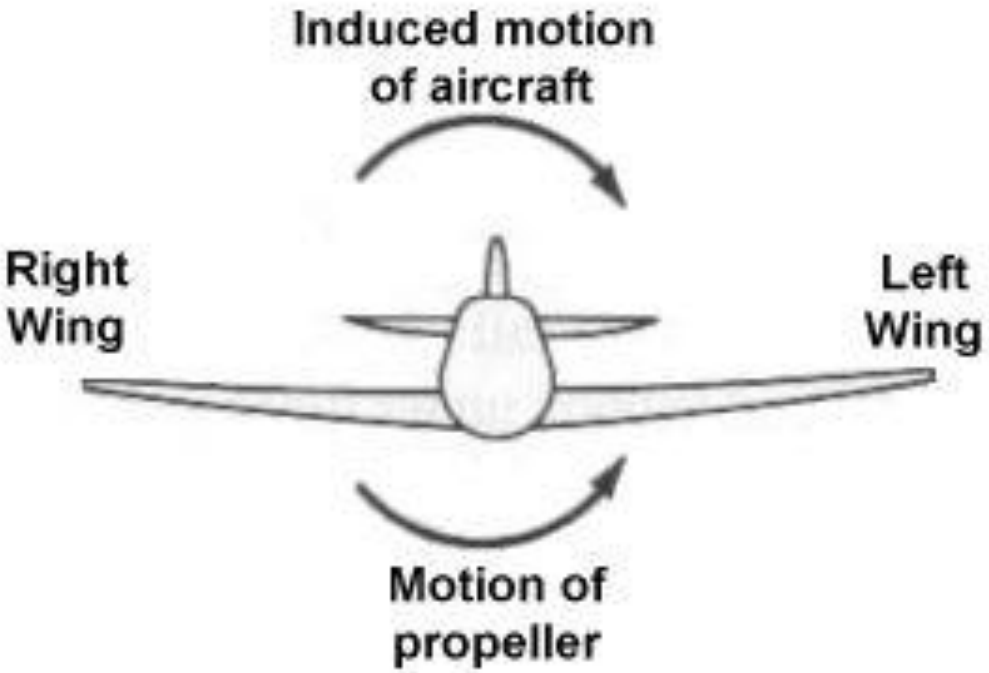
Prop effects

(Why we need right thrust)

- Torque reaction
- Spiraling Slipstream
- Asymmetric Loading of the Propeller (P-Factor)
- Gyroscopic Precession

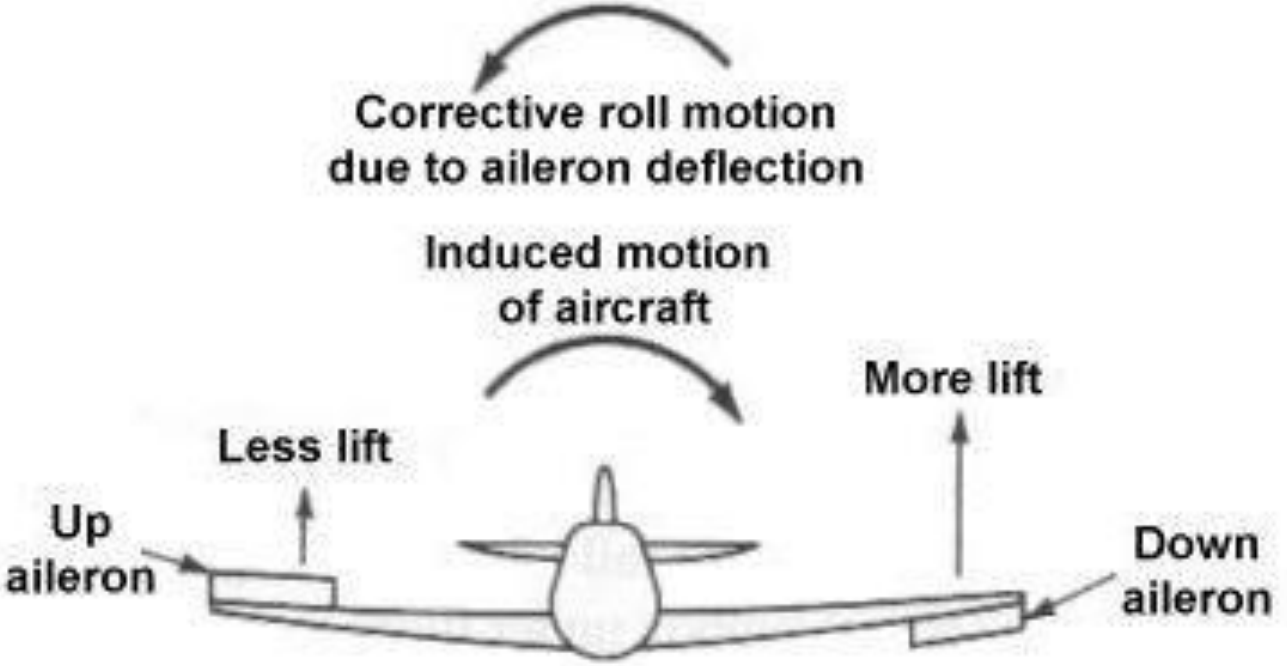
Propeller torque effect

Influence of engine torque on aircraft movement



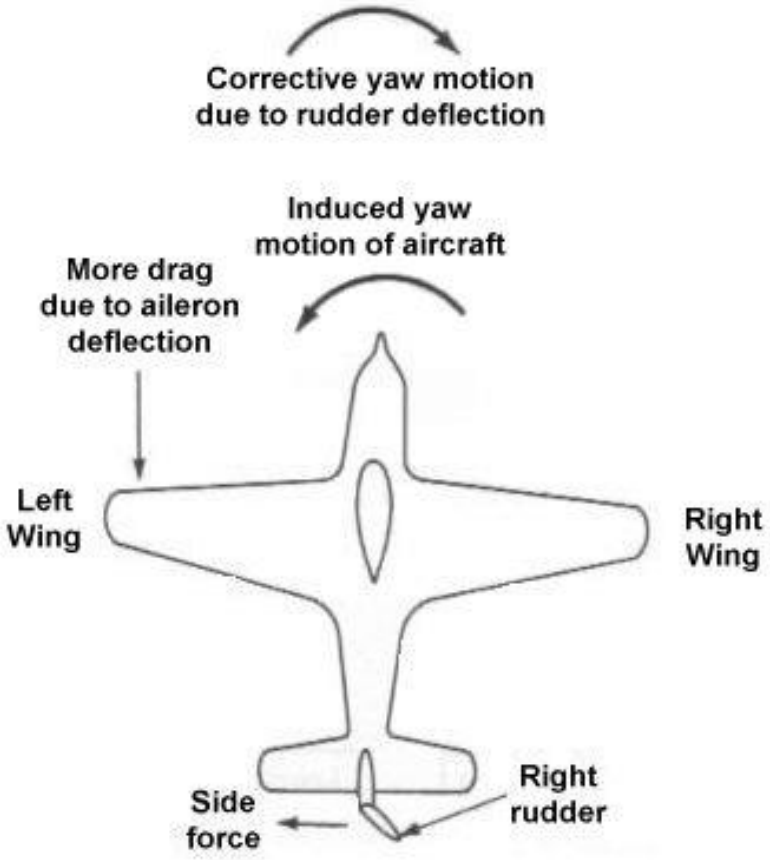
the propeller turning clockwise (when viewed from the cockpit), imparts a tendency for the aircraft to rotate counterclockwise

To counter the aircraft roll left, the pilot applies right aileron



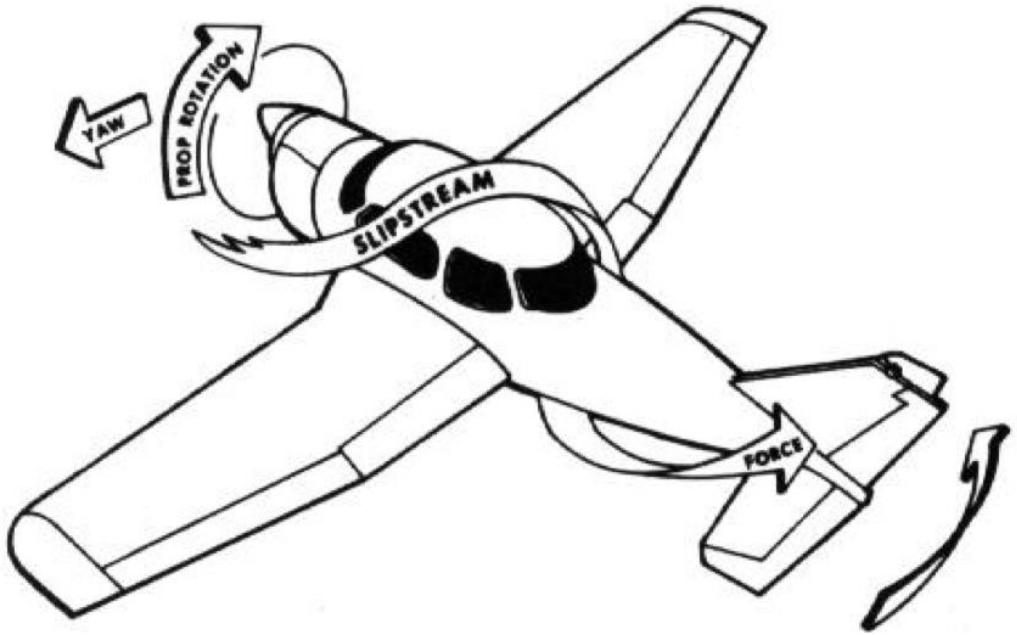
The downward aileron deflection on the left increases the airfoil camber, which will typically increase the profile drag. Conversely, the upward aileron deflection on the right will decrease the camber and profile drag. The profile drag imbalance adds to the adverse yaw.

Adverse yaw is corrected with right rudder



Spiraling Slipstream

- Propeller rotation causes a spiraling motion of the airflow behind it
- The slipstream rolls around the aircraft striking the vertical stabilizer from the left causing left yaw.
- Effect is greatest at high RPM and low air speed.

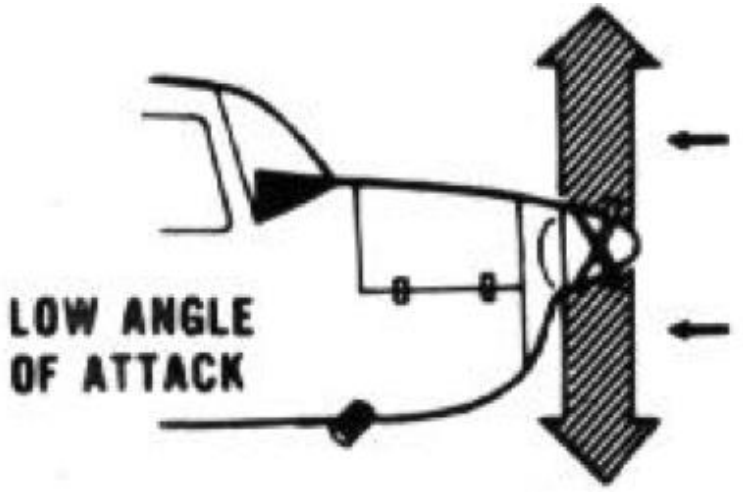


P-Factor

Asymmetric Loading of the Propeller

Causes:

- For an aircraft in straight and level flight, the propeller disc is perpendicular to the relative wind.



- Each of the propeller blades will contact the air at the same angle and speed

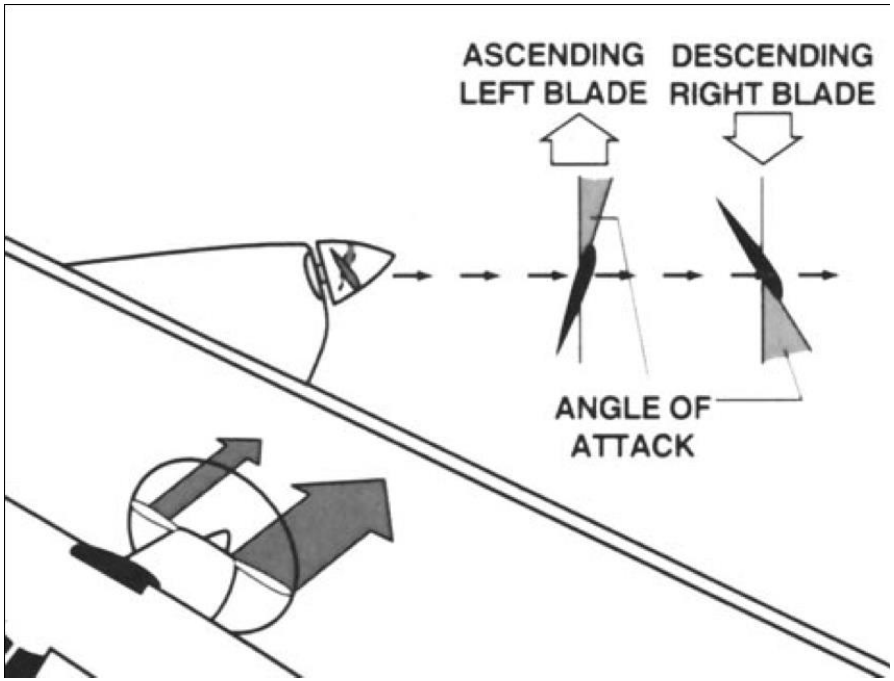
- The thrust produced is evenly centered across the propeller.

P-Factor

Asymmetric Loading of the Propeller

At a high angle of attack:

- The descending blade (right side) has a greater pitch angle than the ascending blade
- More thrust is produced on the right side of the prop

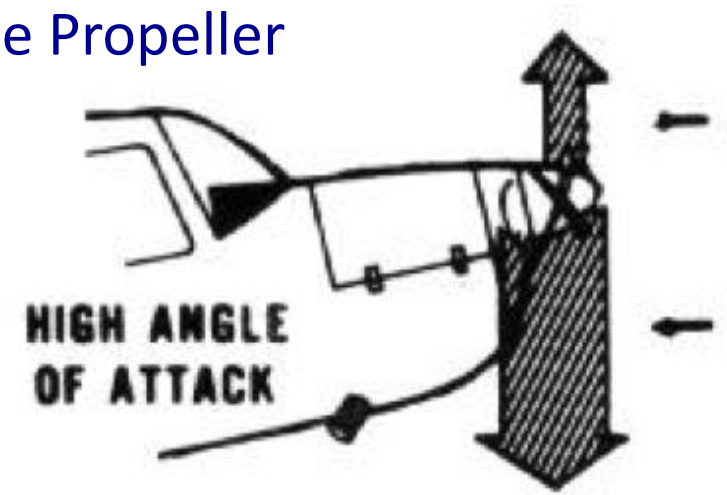


- This creates a left yaw
- Effect is greatest at high RPM, high angle of attack and low air speed
- Opposite effect in a descent

P-Factor

Asymmetric Loading of the Propeller

- At an increased angle of attack the airflow will meet the propeller disc at an increased angle.



- The propeller blades moving down and forward will have a greater relative wind velocity and therefore will produce greater thrust.
- The propeller blades moving up and will have a decreased relative wind velocity and therefore decreased thrust.
- This asymmetry displaces the center of thrust

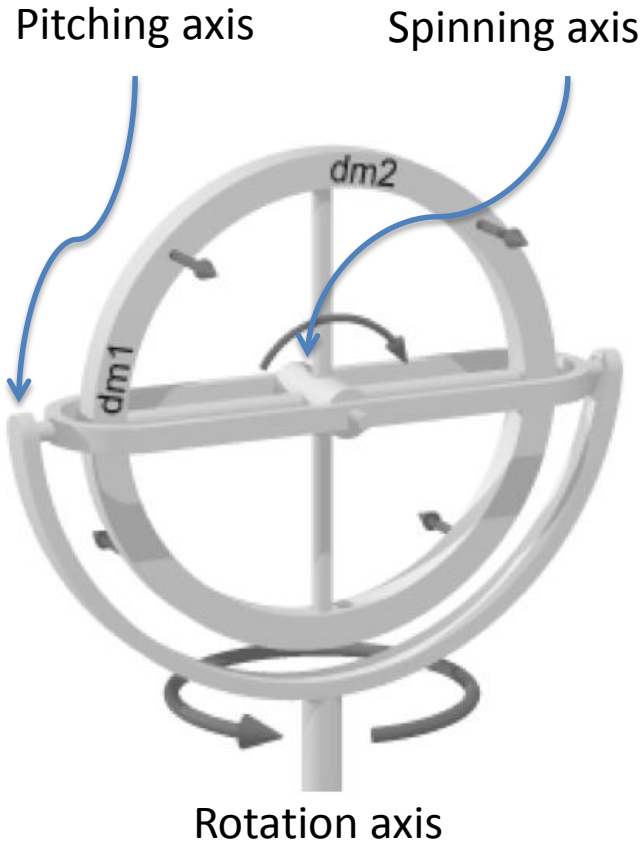
P-Factor

Asymmetric Loading of the Propeller

- Relocation of the propeller's center of thrust when the aircraft is at a high angle of attack
- Exerts a yawing moment on the aircraft
- Left yawing tendency when upright.
- Right yawing tendency when inverted.

Gyroscopic Precession

Why does a gyroscope behave the way it does?



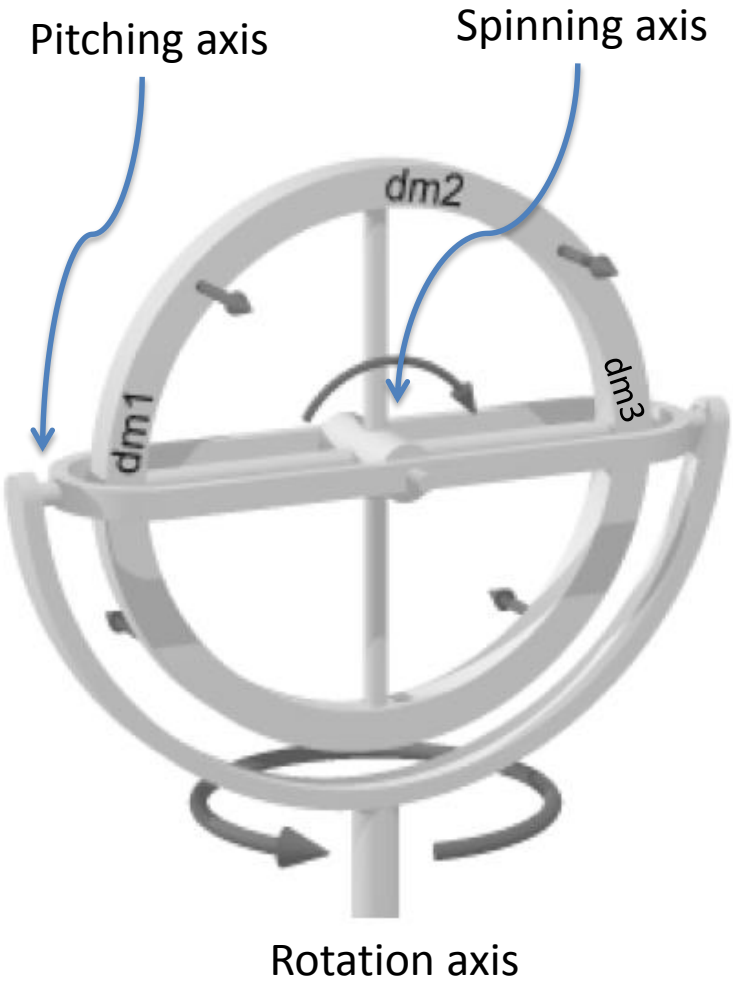
Rotation of a spinning mass produces a torque at 90 degrees to the plane of the two axes

Inertia: catching a ball

- A body in motion…
- The ball exerts a force on the glove as it loses it’s inertia

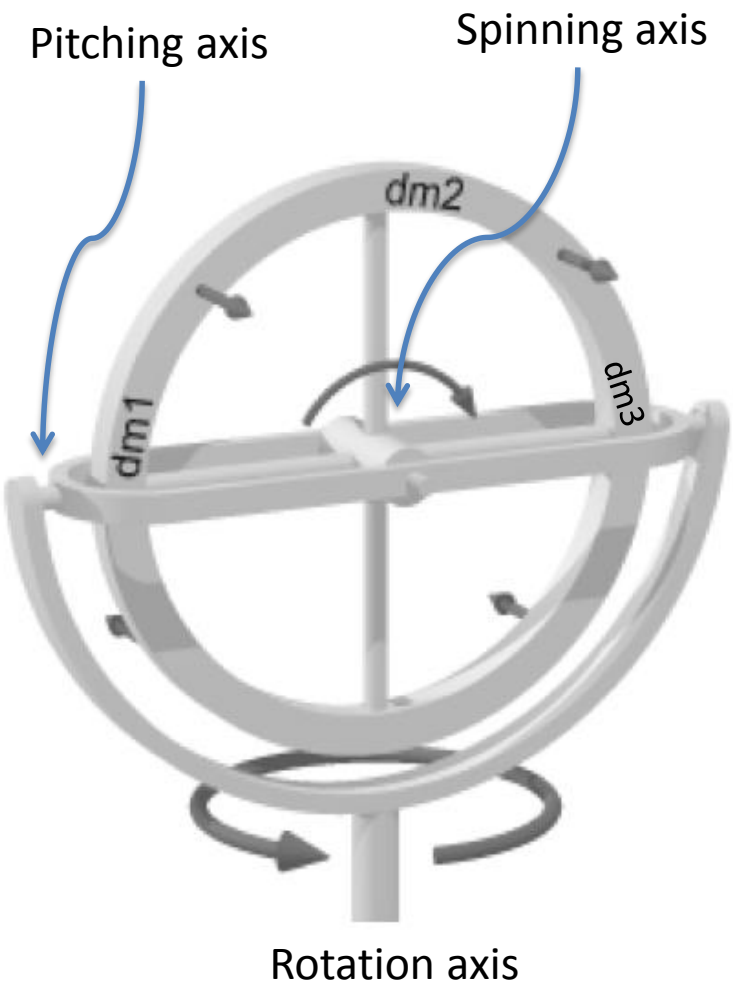
Gyroscopic Precession

- First, only consider turning about the rotation axis
- The point dm1 has inertia (more correctly moment of inertia) coming out of the picture
- The point dm2 has no inertia with respect to the rotation axis



Gyroscopic Precession

- Now add rotation on the spinning axis
- As the point on the wheel moves from dm1 to dm2 it must lose it's inertia exerting a force as shown on the upper left arrow
- This force creates a torque or the pitching axis

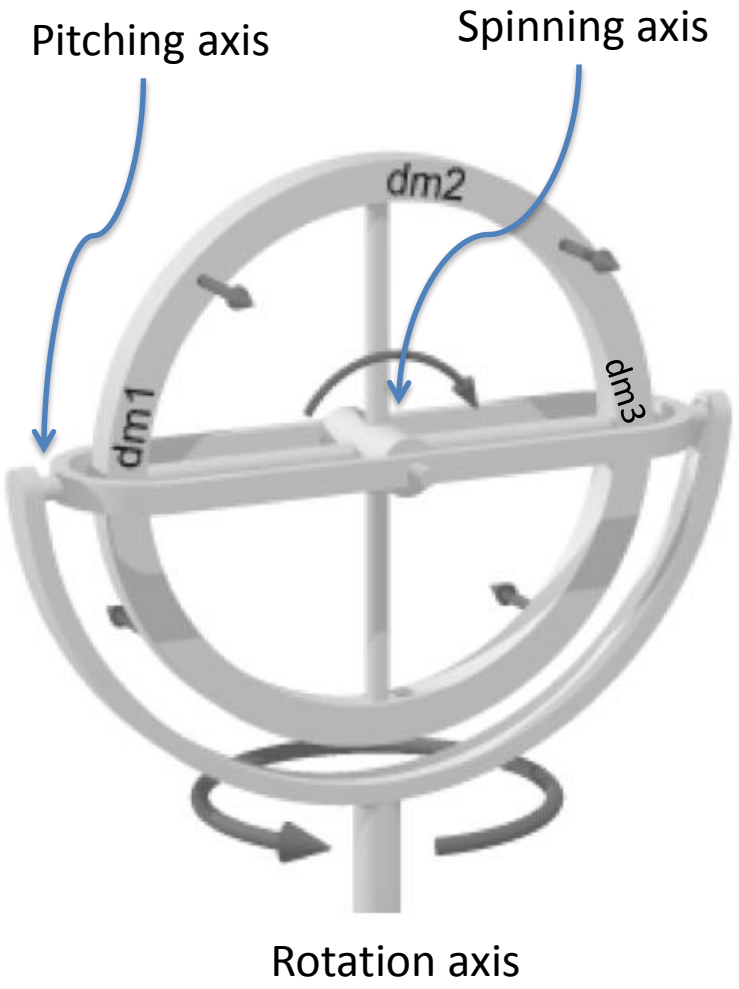


Inertia: throwing a ball

- A force is required to get the ball moving
- The ball is pushes back with an equal and opposite force

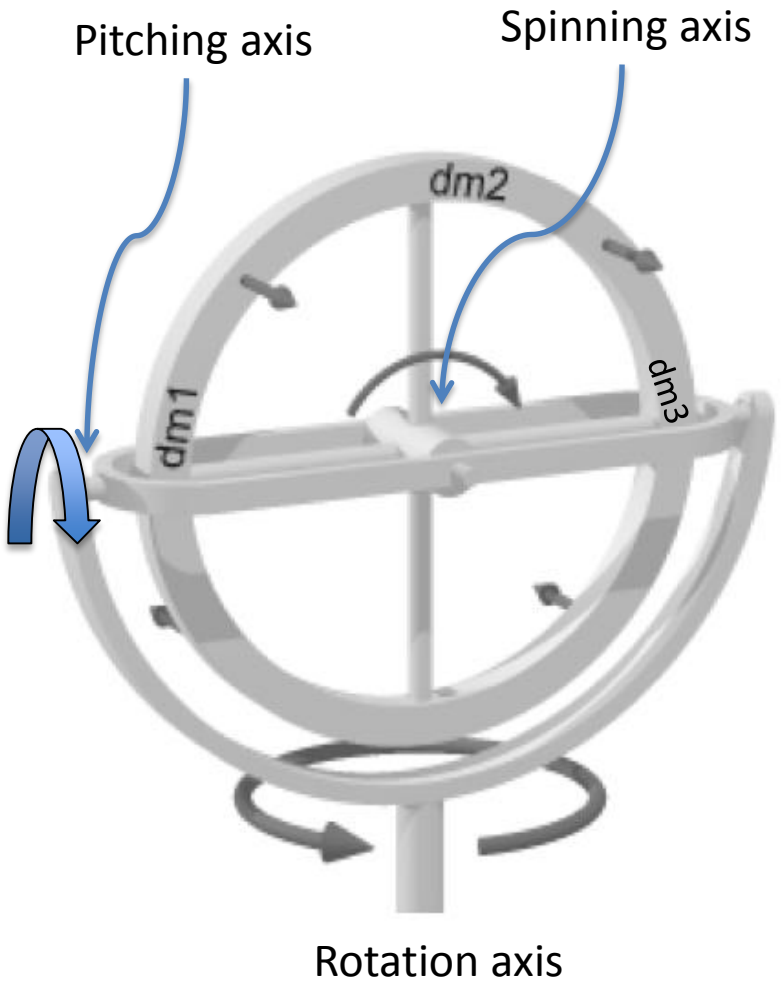
Gyroscopic Precession

- As the point moves from dm2 to dm3 a force is exerted by the wheel in the direction shown by the upper right arrow to regain inertia.
- The same is true for the lower portion creating a force in the direction as shown.



Gyroscopic Precession

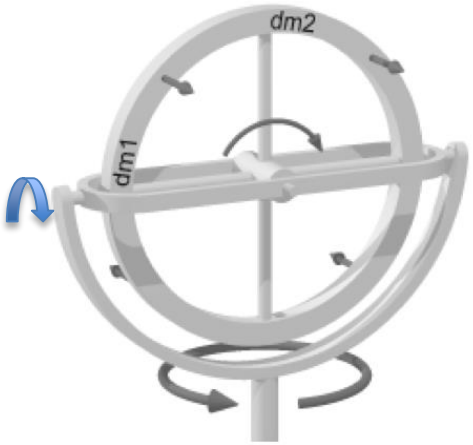
- The combined forces create a torque on the pitching axis as shown with the blue arrow
- If the wheel was a spinning propeller as you sit in the cockpit, the plane is turning left and the induced torque caused by gyroscopic precession causes the plane to pitch up

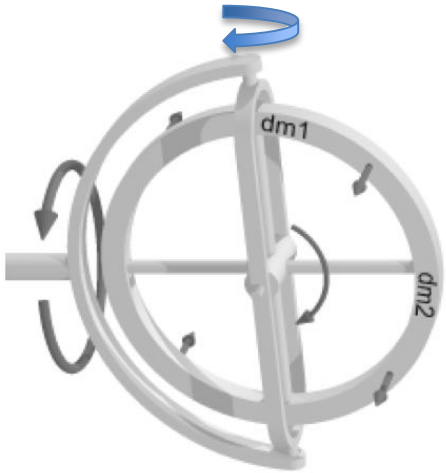


Gyroscopic Precession

In summation

- During straight, level flight there is no effect

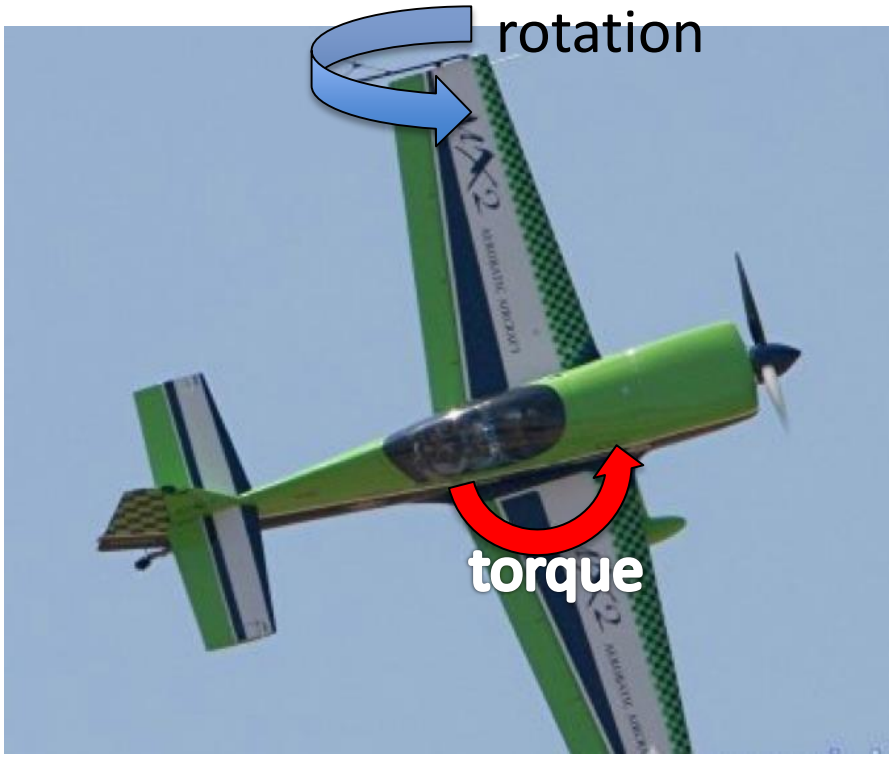




- yawing left pitches up
- Conversely, yawing right pitches down

- Pitching up yaws right
- Conversely, Pitching down yaws left

Applications of Gyroscopic Precession



Knife edge spin:

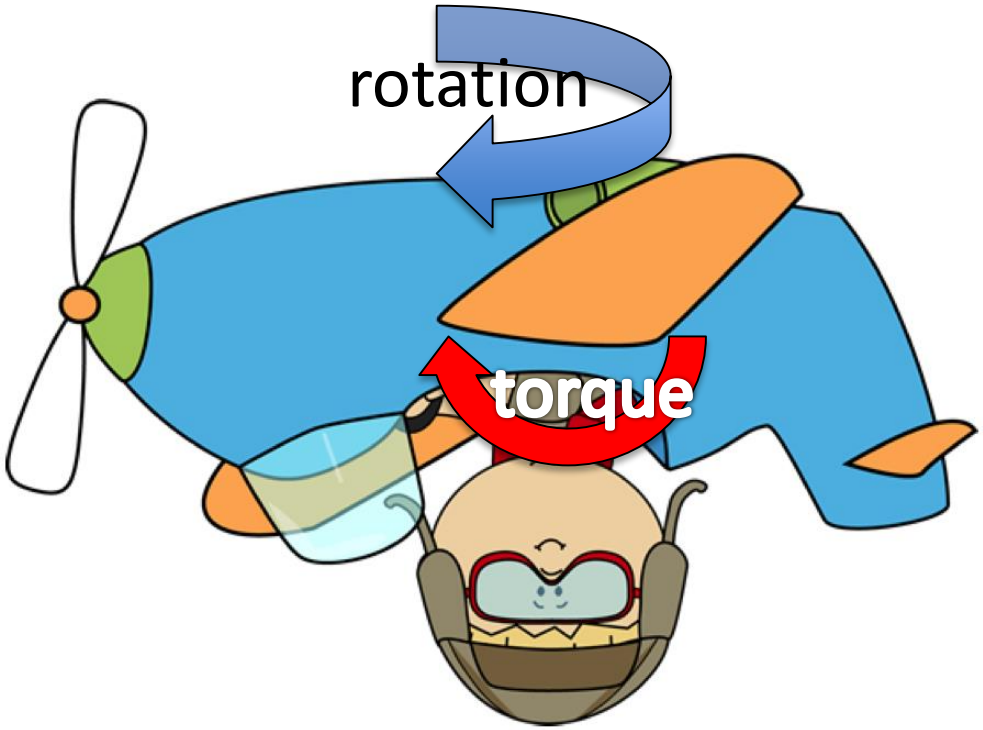
- Rotating about the wing axis in a downward pitch direction imparts a torque in the direction of left yaw.
- The left torque helps keep the nose up

Applications of Gyroscopic Precession

Upright flat spin:

- Rotating (yawing) left (with right aileron to keep wings level) imparts a torque in the direction of up pitch.
- This helps to keep the nose up.

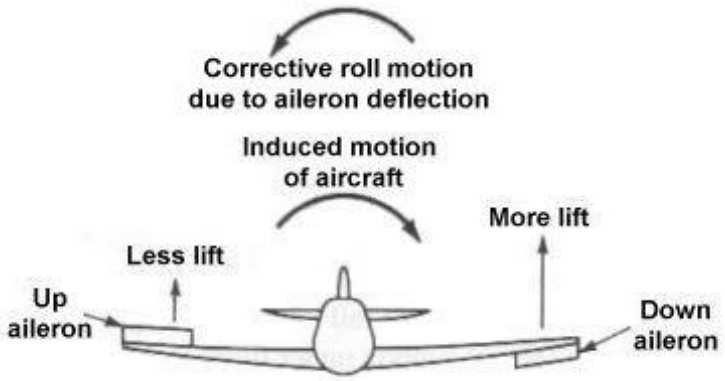
Applications of Gyroscopic Precession



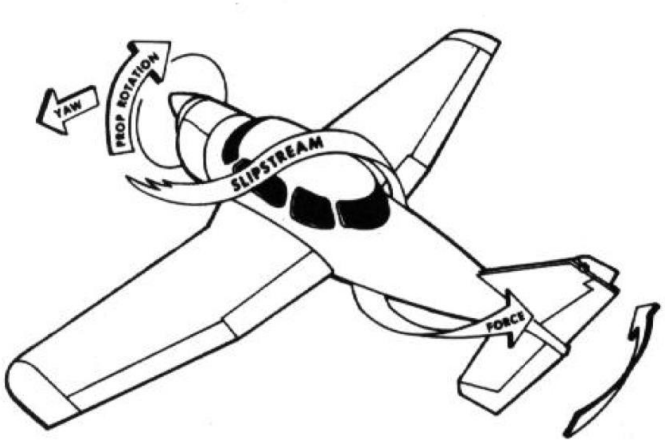
inverted flat spin:

- Rotating (yawing) right (with right aileron to keep wings level) imparts a torque in the direction of down pitch.
- This helps to keep the nose up

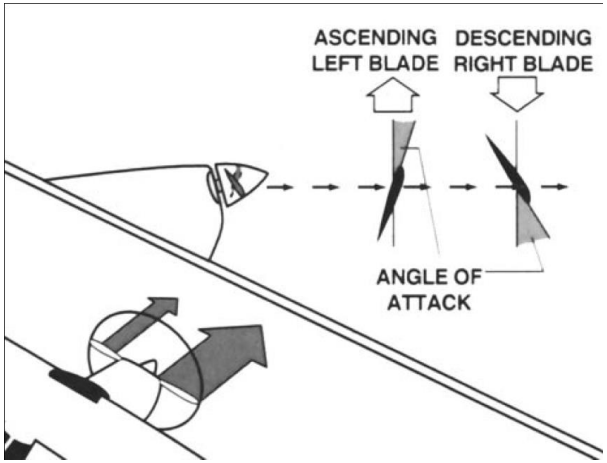
Summary



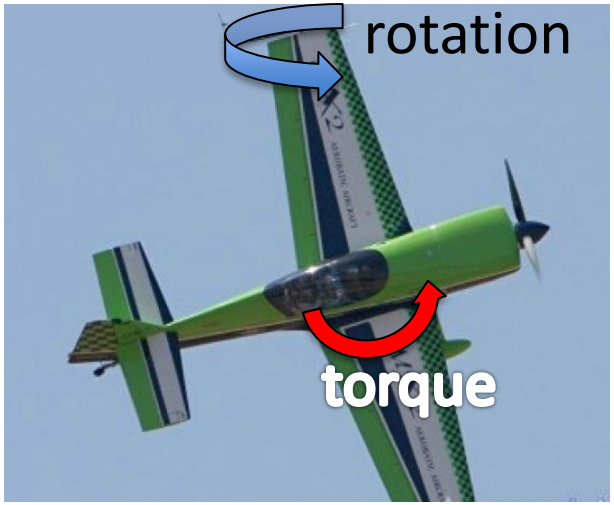
Torque reaction



Spiraling slipstream



P-Factor



Gyroscopic precession