In the Name of GOD

Guidance and Navigation I: Inertial Sensors

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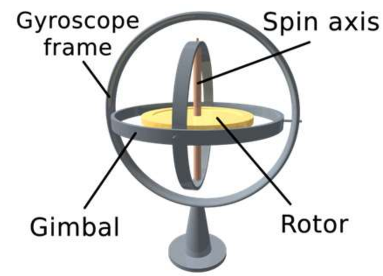
Fundamental principles of gyroscopes

- Gyroscopic inertia: a gyroscopic element tends to maintain the direction of spin axis with respect to the inertial frame



Fundamental principles of gyroscopes

- Angular momentum

$$H = I\omega_s$$

the angular momentum is chosen to be very high

Drift: any undesired deviation of the spin axis

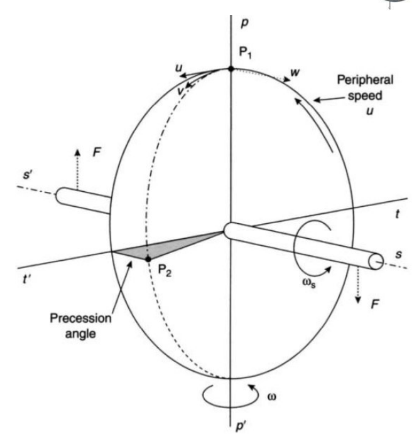
Angular momentum can be increased using a large rotor =>

- Drift ↓ ☺
- Startup time ↑ ☹
- Bandwidth ↓ ☹

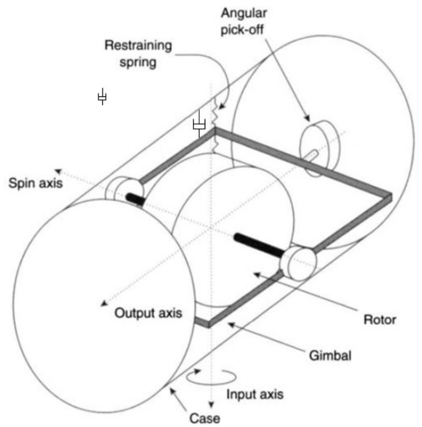
Fundamental principles of gyroscopes

- Precession: If the disc is acted upon by a couple, that is, a torque being about the axis *tt'*, the spin axis of the disc will be forced to turn about the axis *pp'*.
- Law of Gyroscope

$$\mathbf{T} = \boldsymbol{\omega} \times \mathbf{H}$$

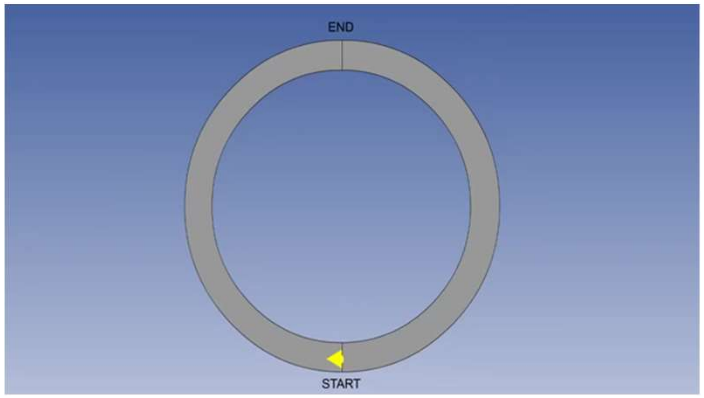


single-axis rate gyroscope

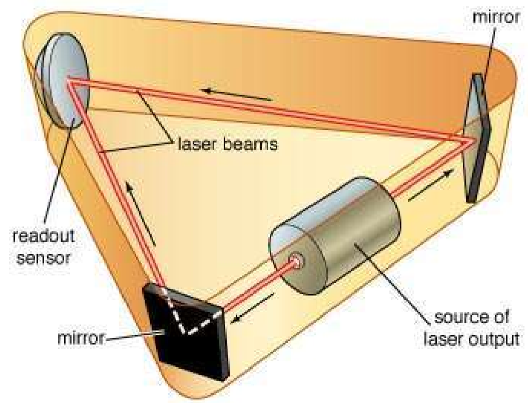


Forced balance?

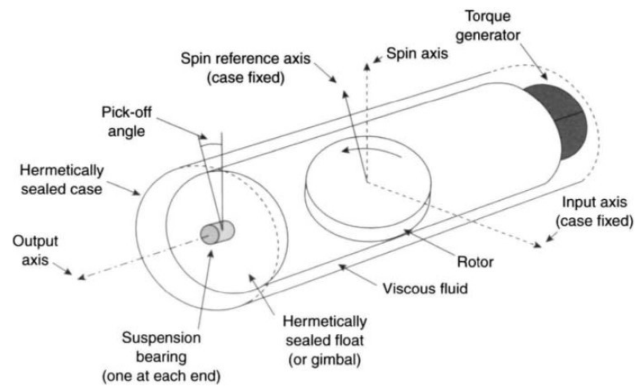
Fiber Optic Gyroscope (FOG)



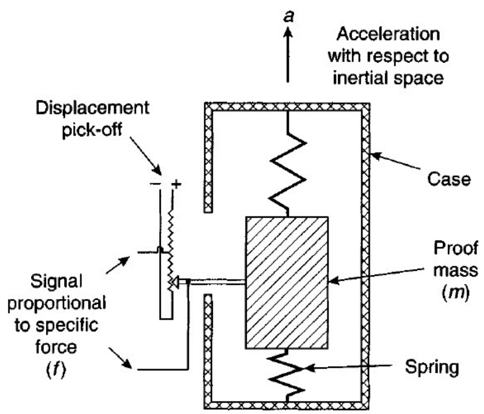
Ring Laser Gyro (RLG)



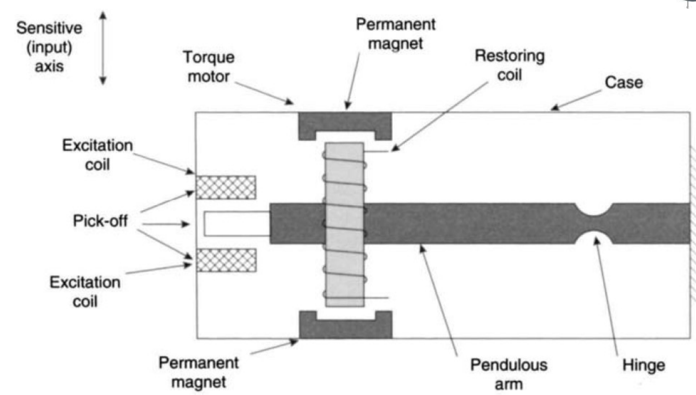
Rate-integrating gyroscope



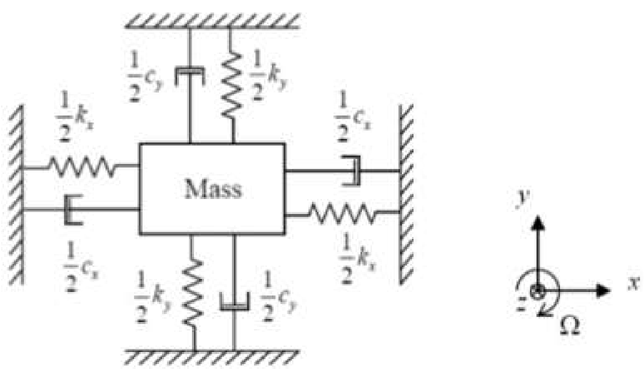
Spring-mass accelerometer



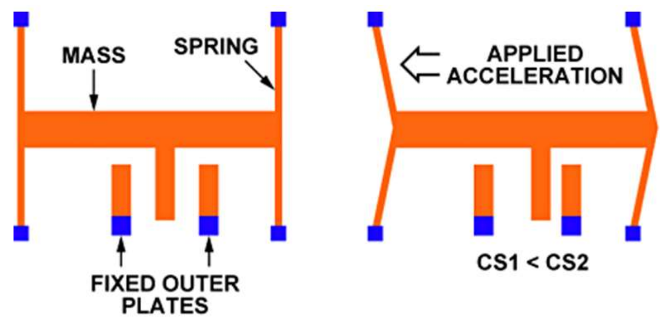
Force-feedback pendulous accelerometer



MEMS Gyroscope



MEMS Accelerometer



Errors of a gyroscopic

- Fixed bias (◦/h): the sensor output which is present even in the absence of an applied input rotation
- Acceleration/g-dependent bias (◦/h/g): Biases which are proportional to the magnitude of the applied acceleration (as a result of mass unbalance in the rotor suspension)
- g^2-dependent bias (◦/h/g^2): Biases which are proportional to the product of acceleration along orthogonal pairs of axes
- Scale-factor errors (ppm): Errors in the ratio relating the change in the output signal to a change in the input rate which is to be measured and compensated.
- Cross-coupling errors (ppm): sensitivity to turn rates about other axes (due to non-orthogonality of the sensor axes)

Rate Table

Tilt and Index Table

- Accelerations less than g can be exerted to the accelerometer using a tilt table

Centrifuge Turn Table

- A centrifuge turn table is used to calibrate an accelerometer.
- The accelerometer is installed in a given distance from the axis of rotation.
- $a=r\omega^2$
- The output is measured in different turn rates and …