Inertial Sensors
Motion Sensing

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Lecture - Outline

- Accelerometers and Gyroscopes
- Acceleration sensing
- Angular velocity sensing

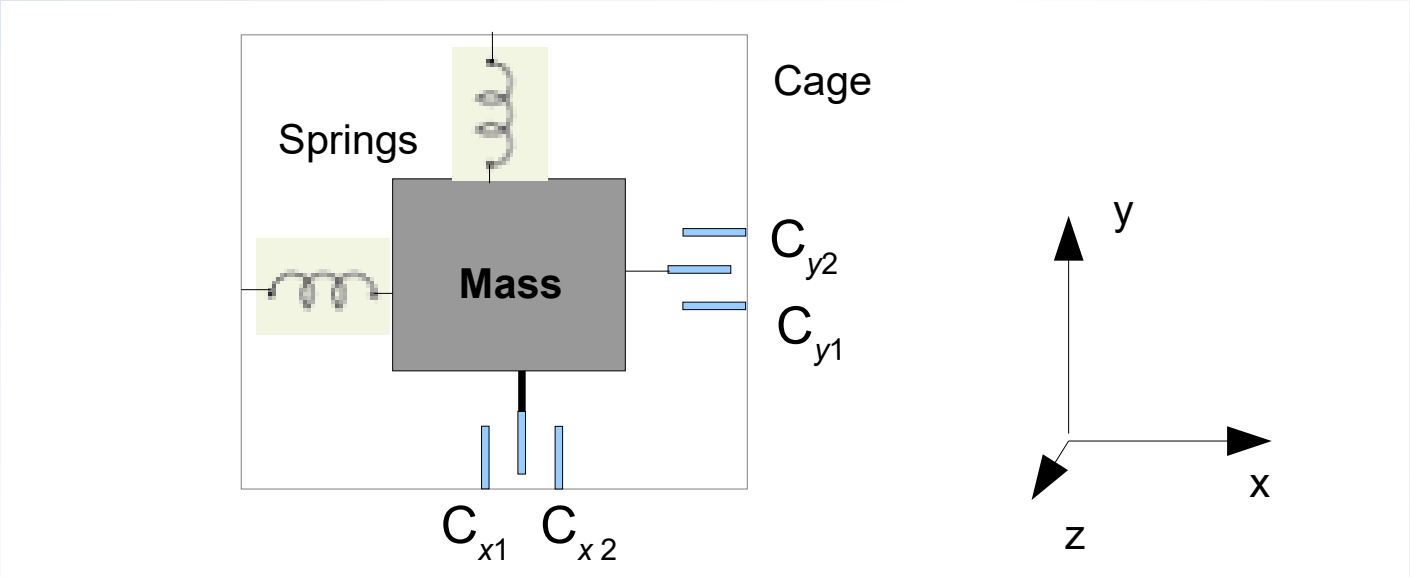
Accelerometers and Gyroscopes

- Inertial motion
- Do not depend on connection to a reference frame
  - “Tetherless”
- Suitable for ambulatory measurement

Accelerometers

- Measurement of acceleration
  - Force and mass: F=ma
- Acceleration due to gravity is always present on Earth
- Need to separate acceleration due to motion from gravity

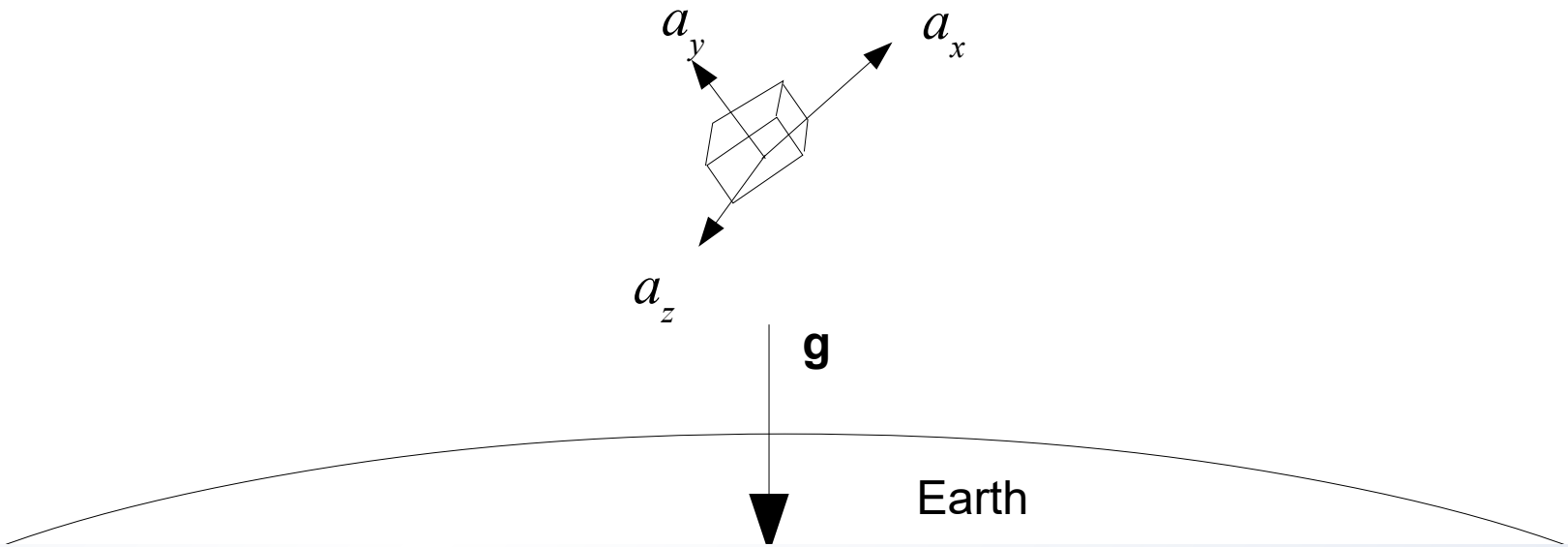
Measurement of Acceleration



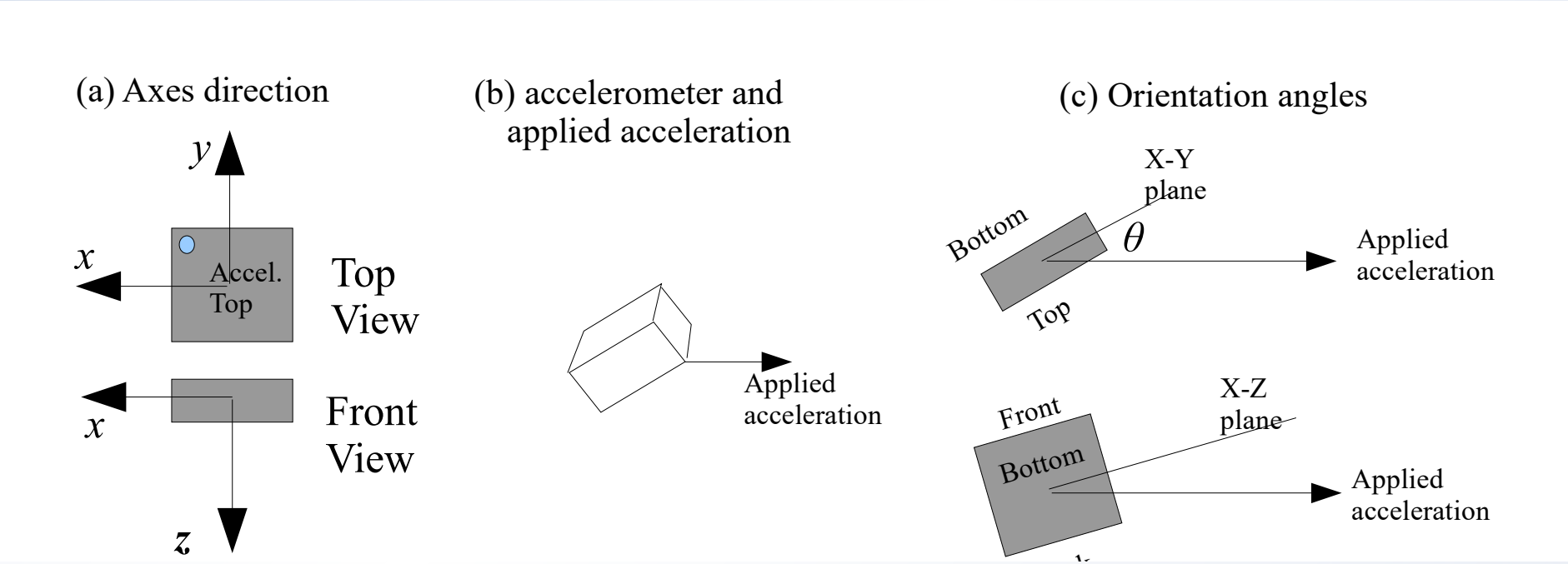
Principle of Equivalence

- From the point of view of a mass:
  - Acceleration due to gravity is indistinguishable from acceleration due to motion
- A mass in a gravitational field experiences a force in the same way as if the mass is moving with acceleration

Tilt measurement



Accelerometer axes



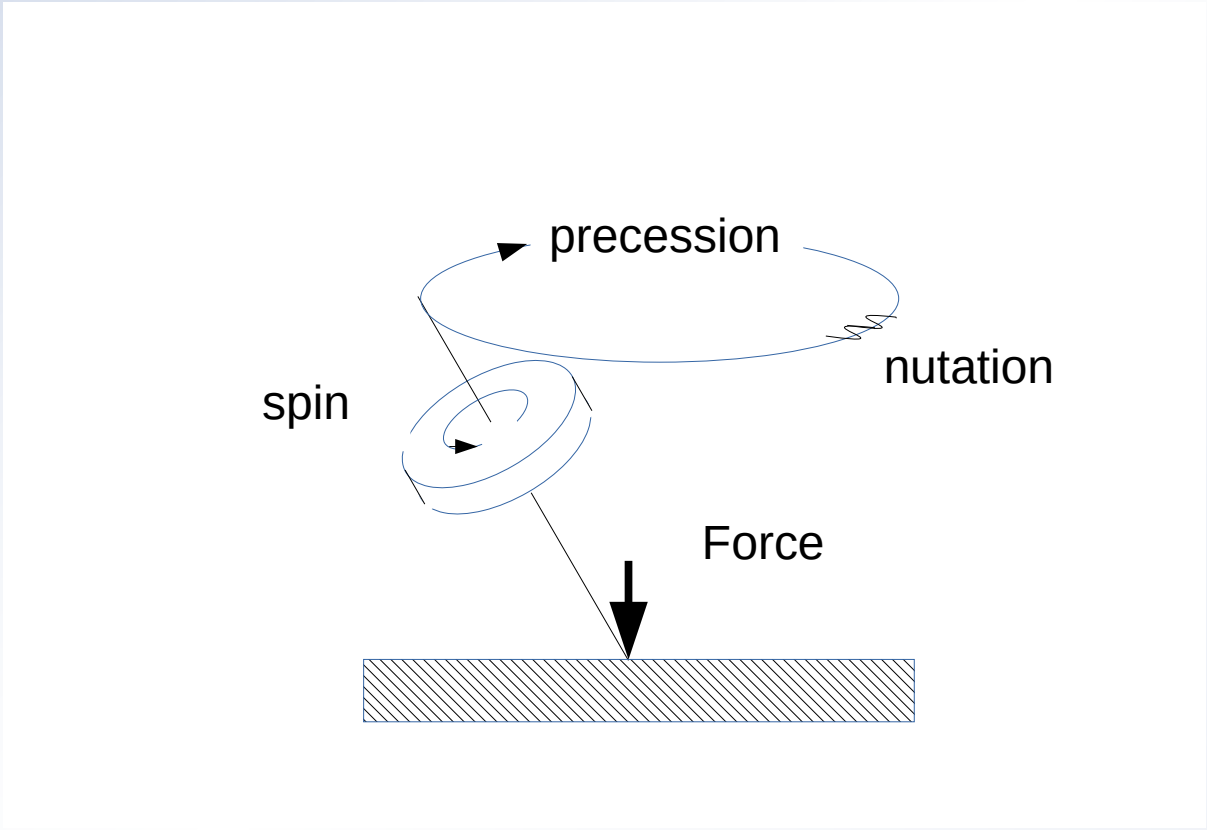
Tilt sensing with multi-axis accelerometer

- Tilt of the sensor with respect to the direction of acceleration
- Used in mobile devices, games, etc.

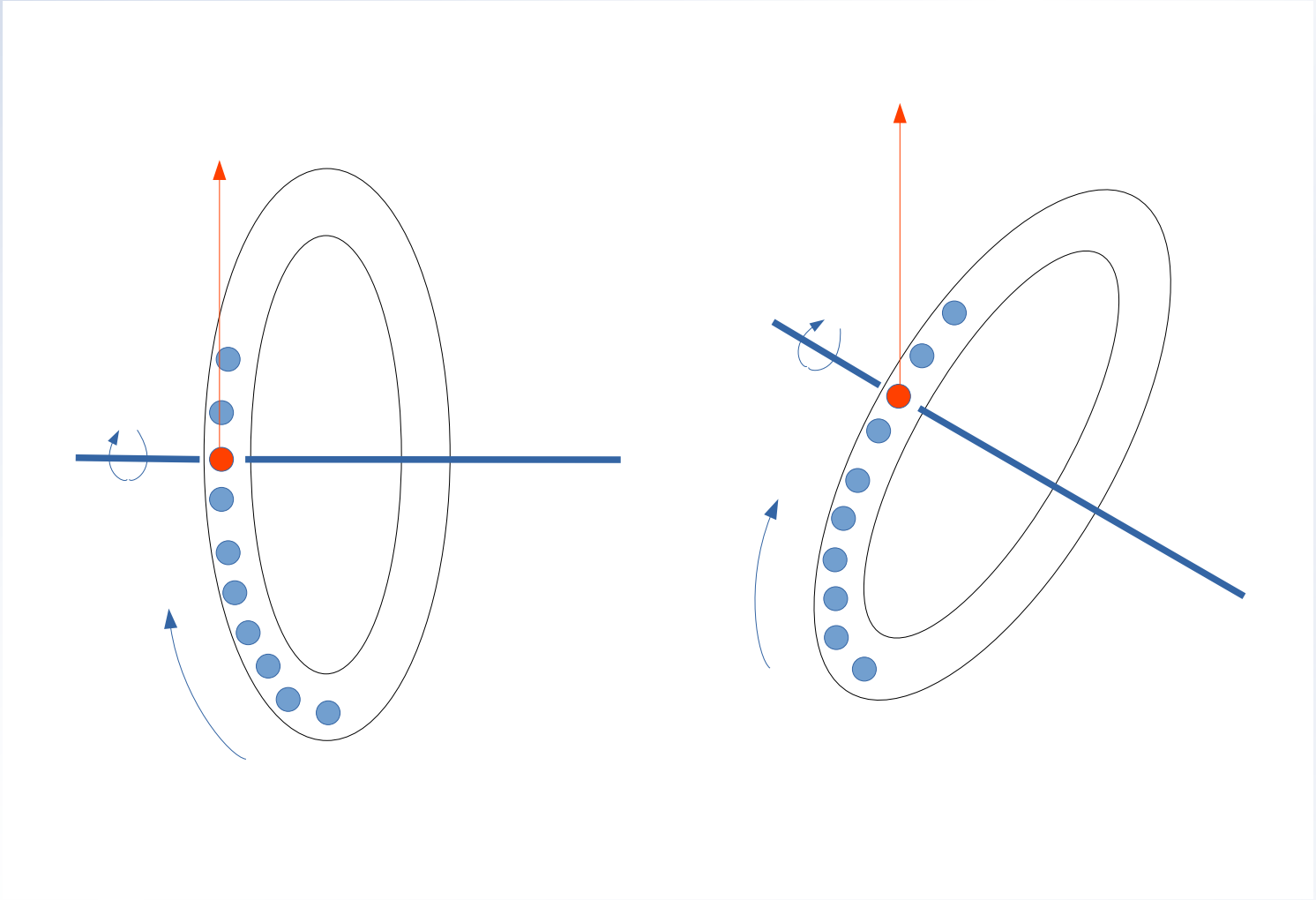
Gyroscope

- Spinning mass
- Spin, Precession, Nutation
- Gyroscopic moment
  - Moving particles in the rim of wheel
- Tilt wheel
  - Resisting force

Gyroscope



Gyroscope Principle



Disc gyroscope

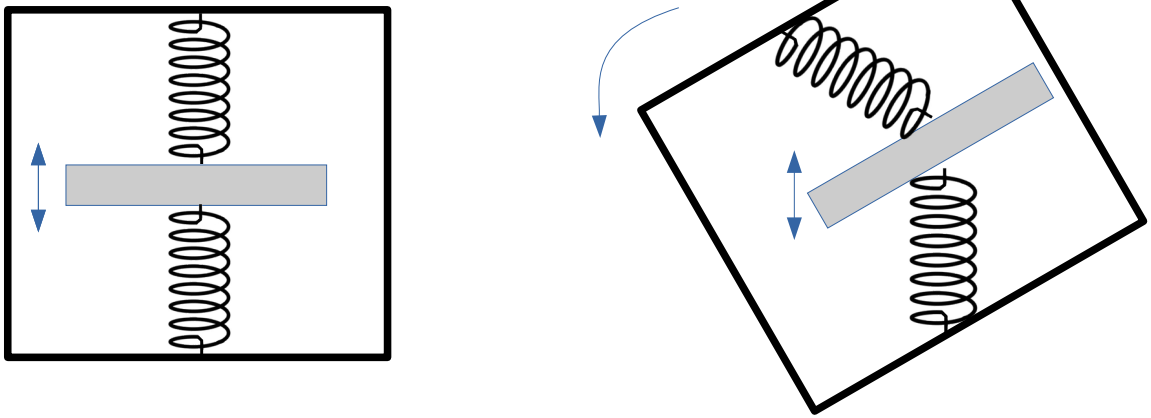
$$mgr = \omega_s \omega_p I_s$$

- Mass, m
- Radius of disc, r
- Spin angular vel
- Precession angular vel
- Spin moment of inertia

Example

- Disc of mass: m=5kg
- Spin=12 rps
- Radius of spin gyration, r = 70mm
- Precession=0.5 rps
- Spin : ω_s=2(3.14159)(12)=75.4 radians/s
- Precession: ω_p=2(3.14159)(0.5)=3.14159 rad/s
- Moment of inertia:I_s=(m)(r^2)=0.0245 kg.m
- Gyroscopic force=$\omega_s \omega_p I_s$=5.8 Nm

Vibrating gyroscopes



Vibrating gyroscope – Coriolis force

- Force, F
- Angular Velocity of rotation/precession
- Linear velocity of oscillation
- Mass, m

$$F = -2\,\omega_p\,v_{osc}\,m$$

End of Lecture