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# EE C247B - ME C218 Introduction to MEMS Design Spring 2019

Prof. Clark T.-C. Nguyen

Dept. of Electrical Engineering & Computer Sciences  
University of California at Berkeley  
Berkeley, CA 94720

Lecture Module 15: Gyros, Noise, & MDS

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## Lecture Outline

- Reading: Senturia, Chpt. 14, Chpt. 16, Chpt. 21
- Lecture Topics:
  - ↳ Gyroscopes
  - ↳ Gyro Circuit Modeling
  - ↳ Minimum Detectable Signal (MDS)
    - Noise
    - Angle Random Walk (ARW)

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# Gyroscopes


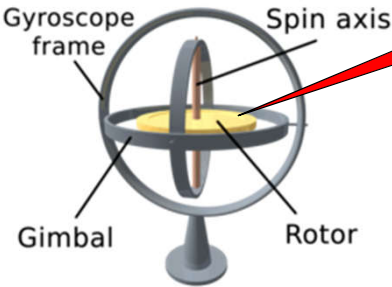
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## Classic Spinning Gyroscope

- A gyroscope measures rotation rate, which then gives orientation → very important, of course, for navigation
- Principle of operation based on conservation of momentum
- Example: classic spinning gyroscope

Rotor will preserve its angular momentum (i.e., will maintain its axis of spin) despite rotation of its gimballed chassis



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### Vibratory Gyroscopes

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- Generate momentum by vibrating structures
- Again, conservation of momentum leads to mechanisms for measuring rotation rate and orientation
- **Example:** vibrating mass in a rotating frame

Mass at rest

Driven into vibration along the y-axis

$C(t)$

y-displaced mass

Capacitance between mass and frame = constant

Rotate 30°

Get an  $x'$  component of motion

$C(t_2) > C(t_1)$

$C(t_1)$

$C(t_2)$

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### Basic Vibratory Gyroscope Operation

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**Principle of Operation**

- Tuning Fork Gyroscope:

Input Rotation

Driven Vibration @  $f_0$

$\vec{\Omega}$

$\vec{v}$

$\vec{a}_c$

Coriolis (Sense) Response

Coriolis Torque

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