Dynamics 2

FAR – Rotating Unbalance

(Dynamics of Systems of Bodies)

Rotating Unbalance

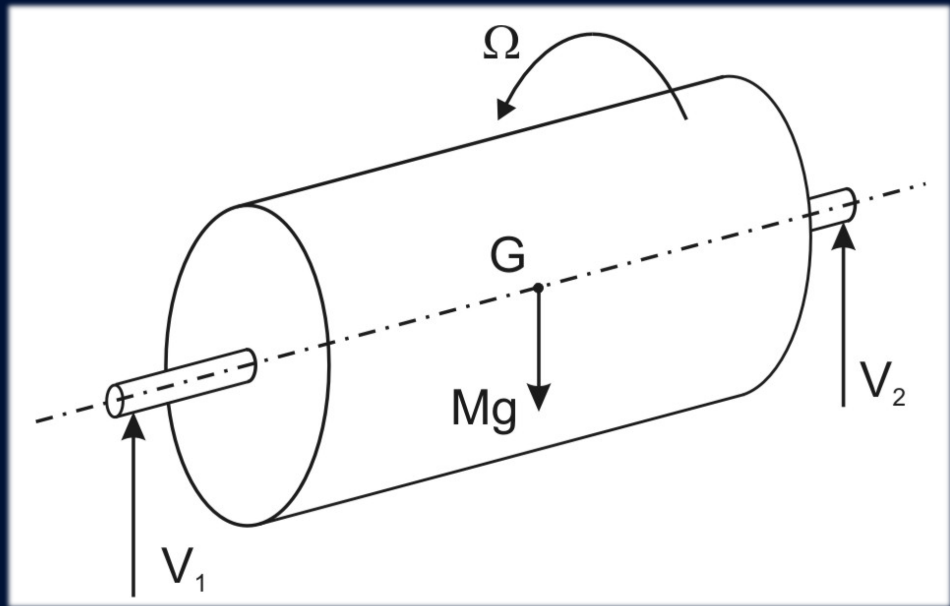
- rotating unbalance applies the force equation - ie GN2
- remember:

  sum of external forces and the body inertia force = 0

- and inertia force acts in opposite direction to a_G
- enormous consequence for rotating machinery

Perfect Rotor

- mathematically perfect at constant Ω
- G lies on centre line between bearings
  - no acceleration so no inertia force
- bearings simply oppose weight

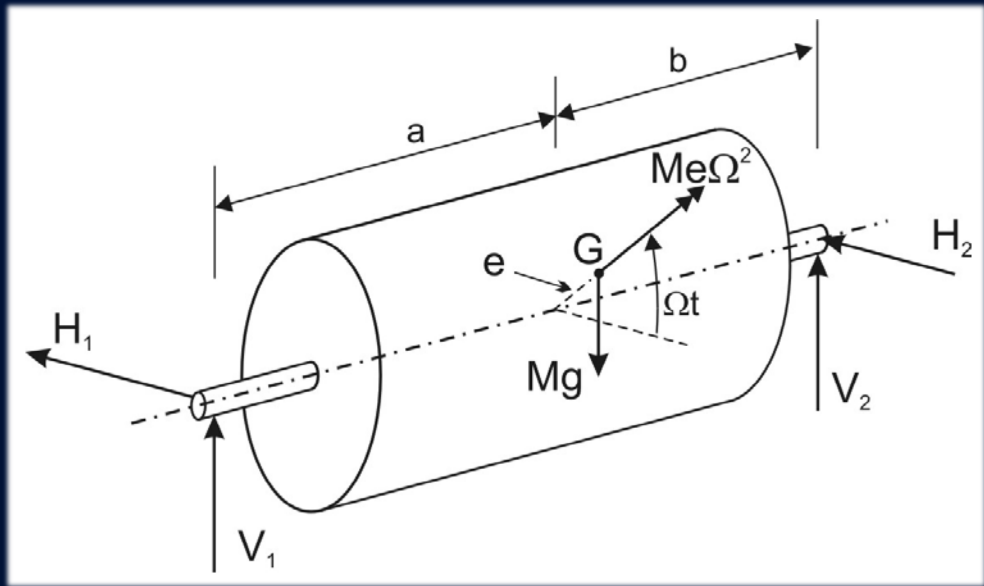


Real Rotor

- real rotors are subject to machining tolerances
  - not mathematically perfect
  - G will not lie on the centre line
- during rotation G will follow a circle of radius e
  - where e is the eccentricity of G
- G will have a centripetal acceleration
  - FBD needs an inertia force acting radially outwards through G
- bearing forces will oscillate

Real Rotor

- G at eccentric radius e (generally very small)
  - Inertia force is $Me\Omega^2$ acting radially outwards

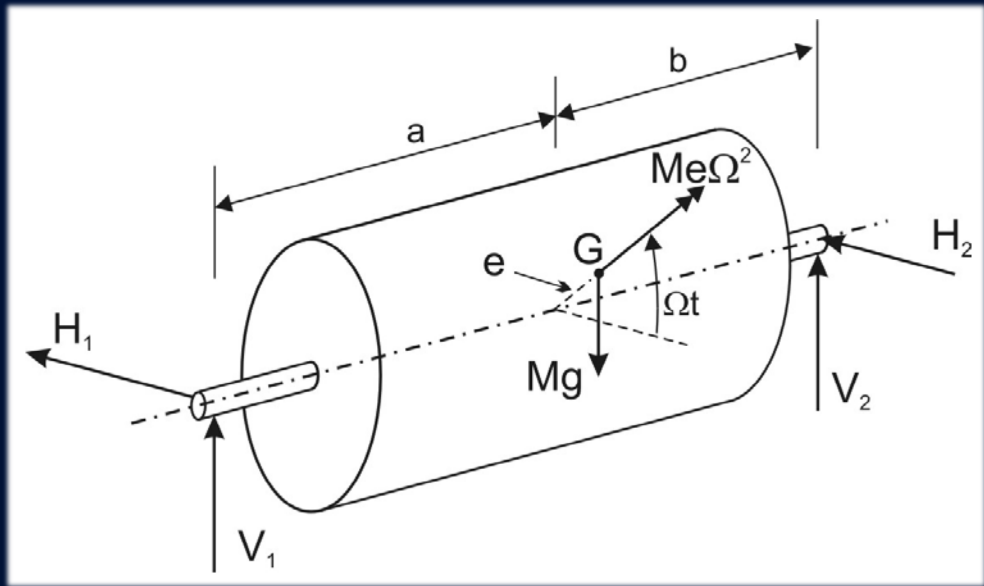


Real Rotor

- G at eccentric radius e (generally very small)
  - Inertia force is $Me\Omega^2$ acting radially outwards
- by $\sum$ forces & moments on FBD
  - define horizontal and vertical bearing forces

$$H_1 = \frac{b}{L} M\, e\,\Omega^2 \cos\Omega t$$

$$V_1 = -\frac{b}{L} M\, e\,\Omega^2 \sin\Omega t$$



Real Rotor

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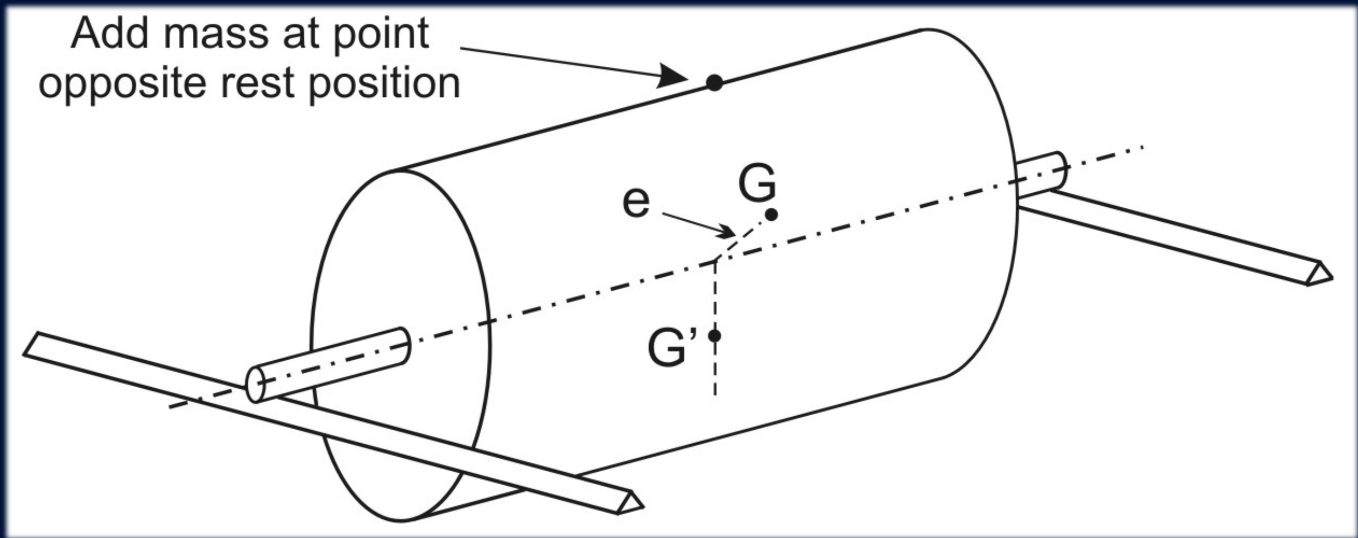
- similarly for H_2 and V_2
- bearing forces are oscillatory
  - proportional to e & Ω^2. This is Rotating Unbalance

Rotor Balancing

- unbalanced rotors cause excessive noise, wear and fatigue failure
  - balancing is standard practice
- two approaches
  - Static
  - Dynamic

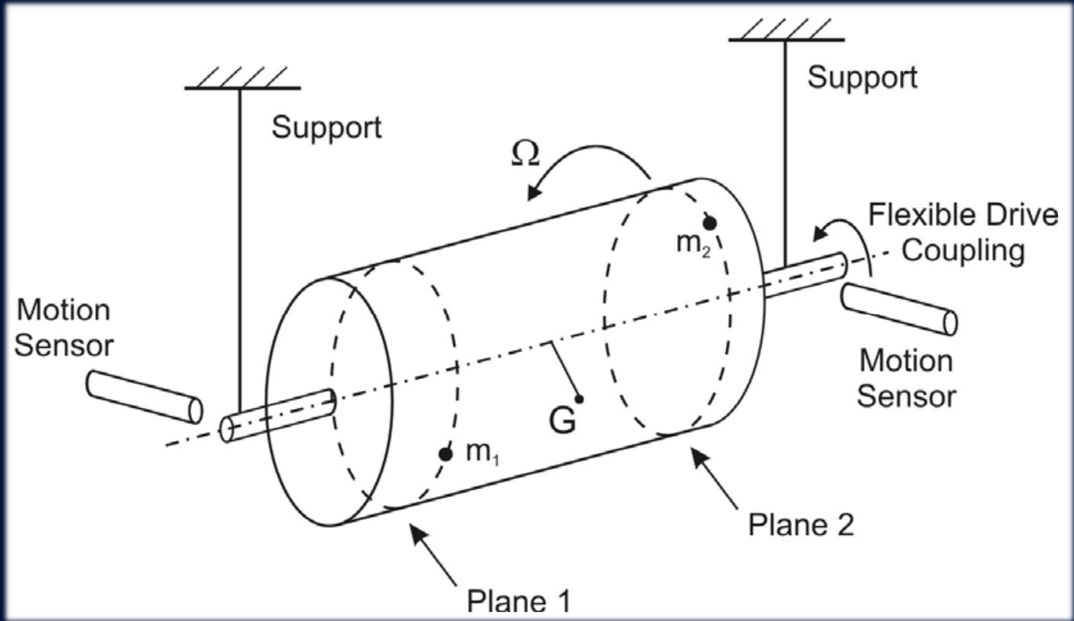
Static Balancing

- rotor is placed in a low-friction support
- mass added until no obvious pendulum action
  - G on bearing centre line
- unreliable except for thin rotors (as single plane)



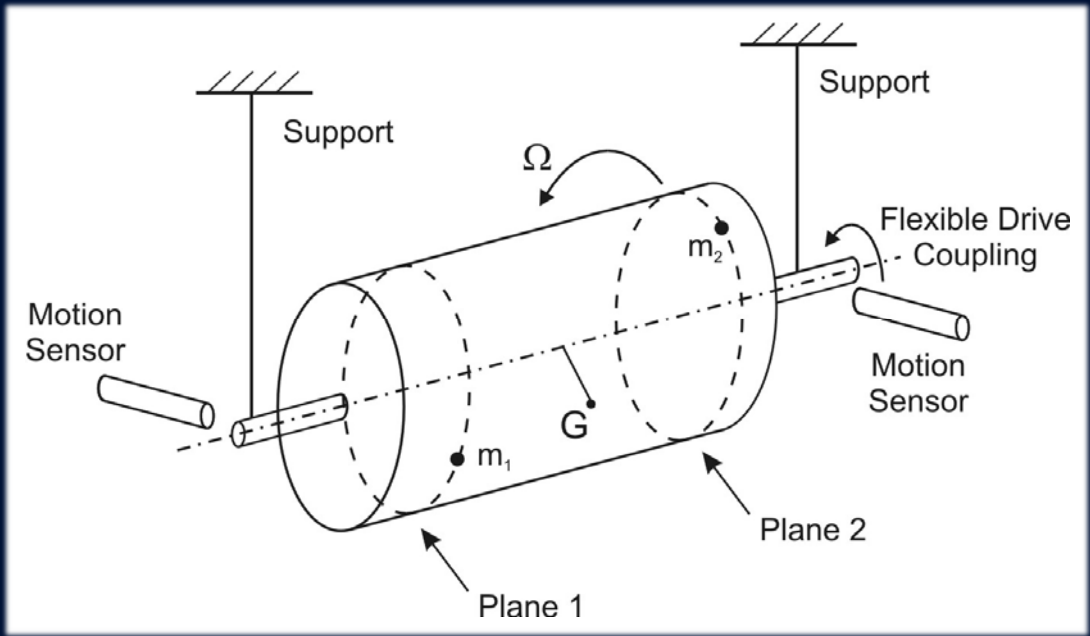
Dynamic Balancing

- rotor mounted in balancing machine
  - run at high speed through a flexible coupling
- bearings very flexible in the horizontal plane
  - transducers detect the unbalance vibration



Dynamic Balancing

- two balancing planes chosen
  - machine computes the mass to be added at specific angular locations in each plane
- reliable
  - zero deformation
  - not for large rotors



Dynamic Balancing

- two balancing planes chosen
  - machine computes the mass to be added at specific angular locations in each plane
- reliable
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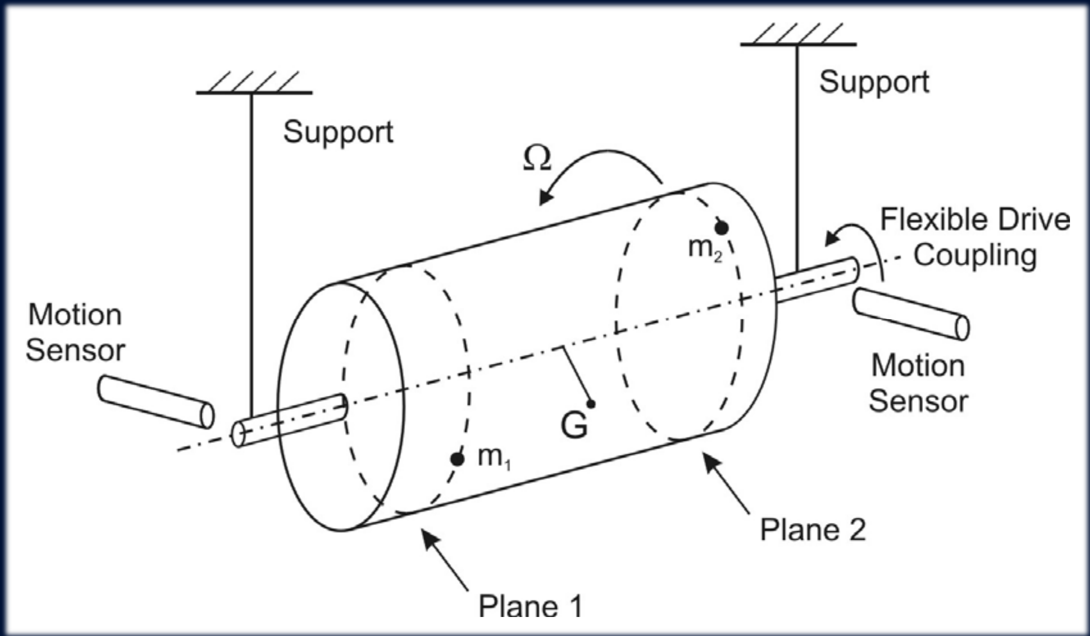
  - not for large rotors
- Kwik-Fit
  - tyre balancing



Dynamic Balancing – Car Tyre

Summary

- causes and effects of rotating unbalance
- static balancing
- dynamic balancing