

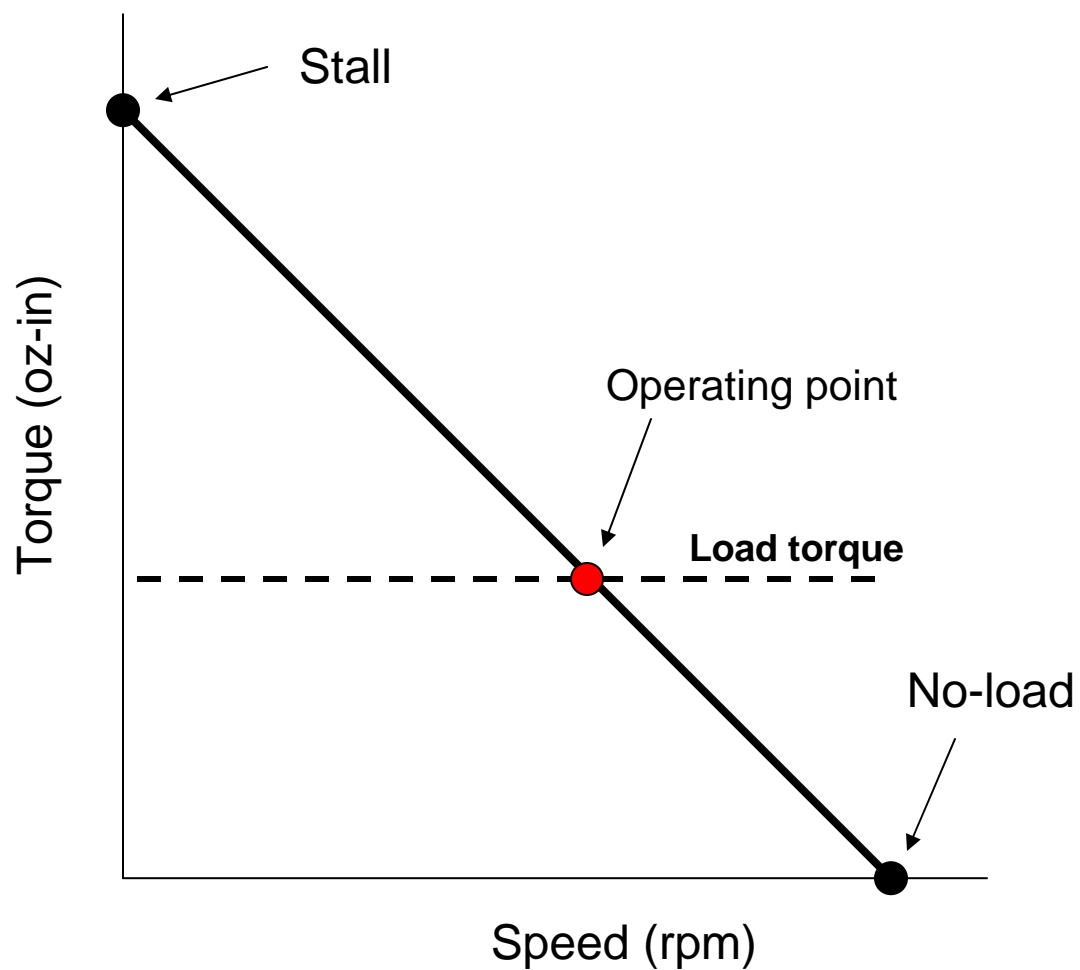
Machine Elements

Transmissions, Bearings, Shafts

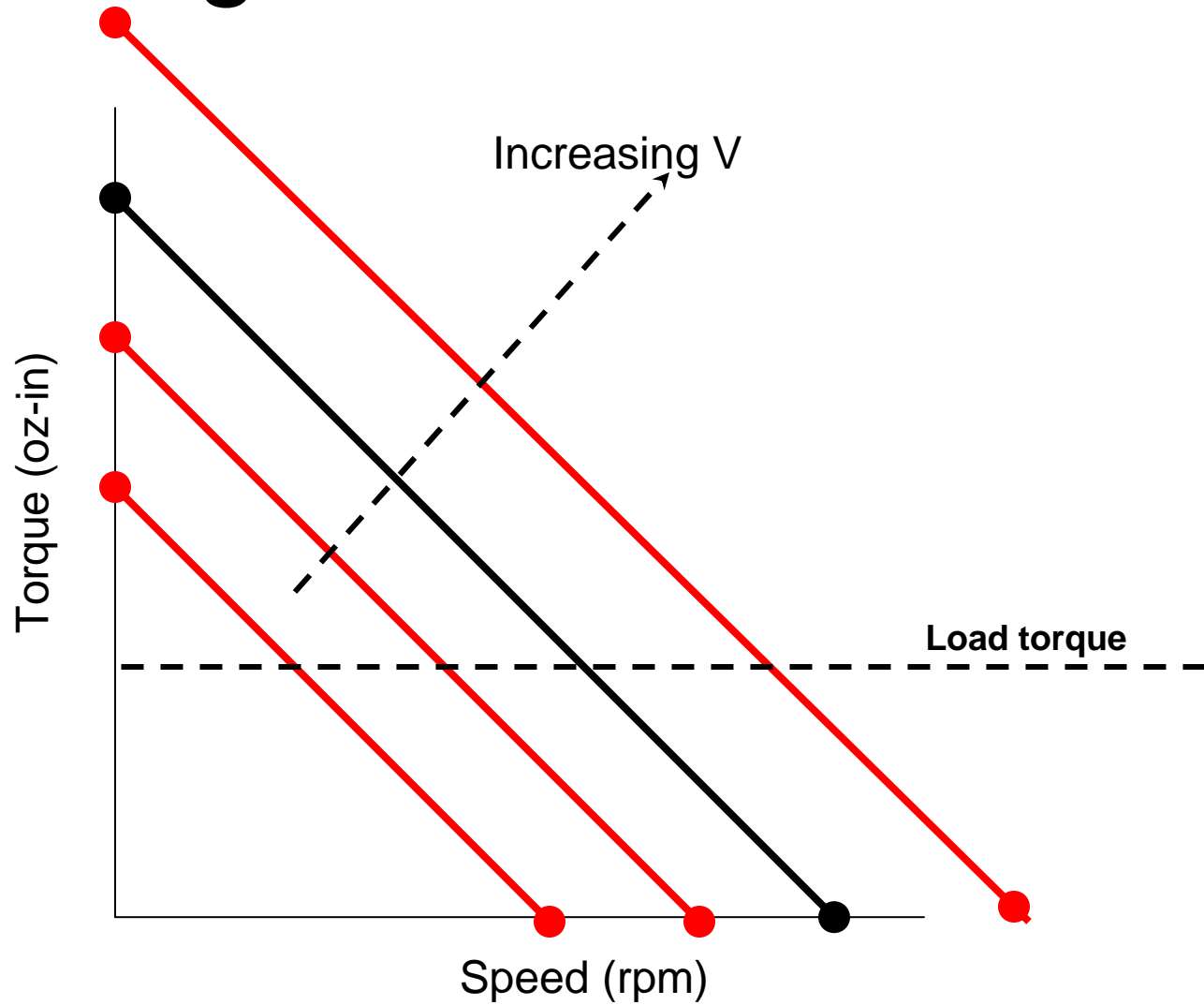
TRANSMISSIONS

**Matching the torque and speed
of the motor to the torque and
speed of the task**

Motor torque-speed curve



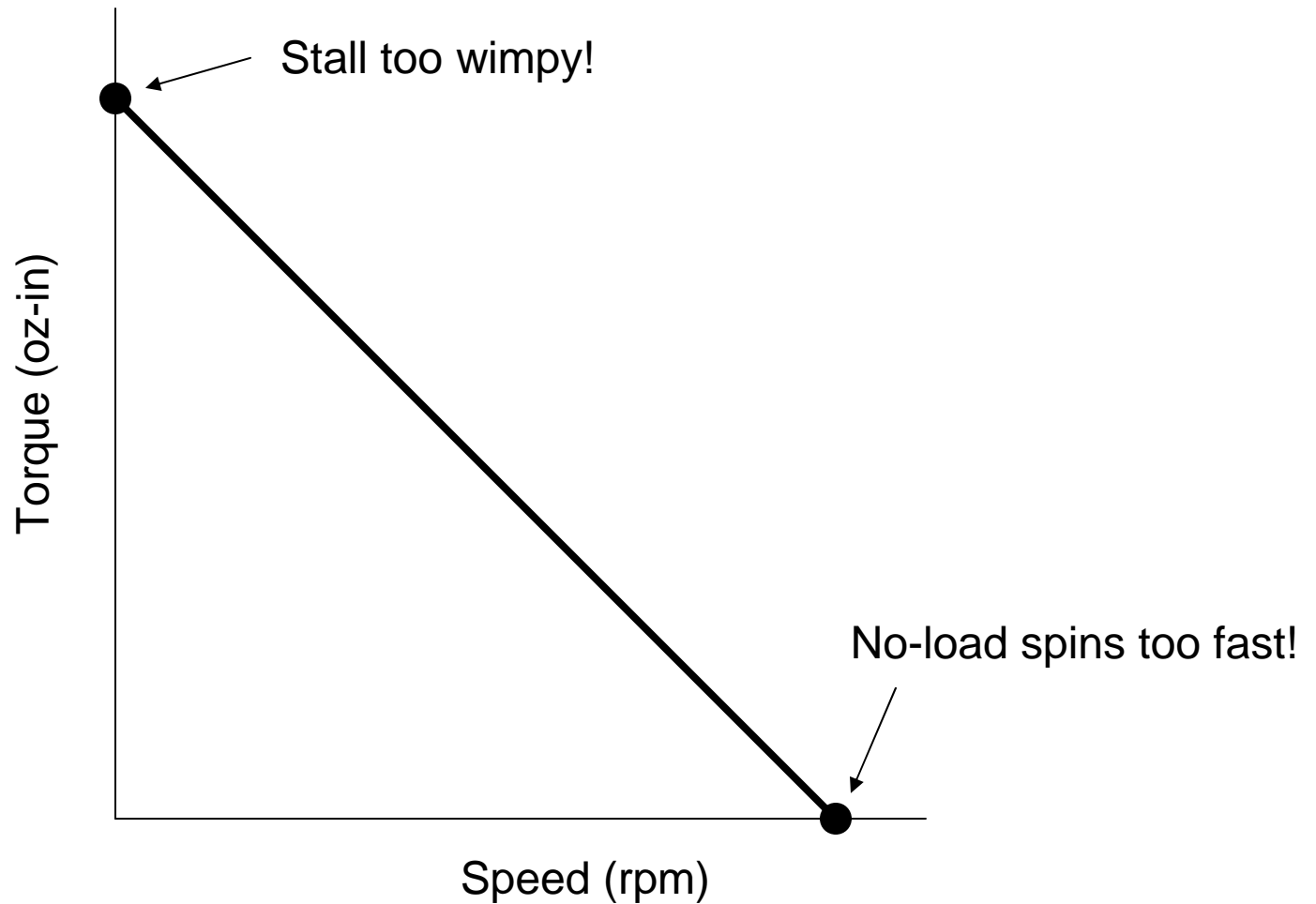
Changes with motor V



Small DC Motors

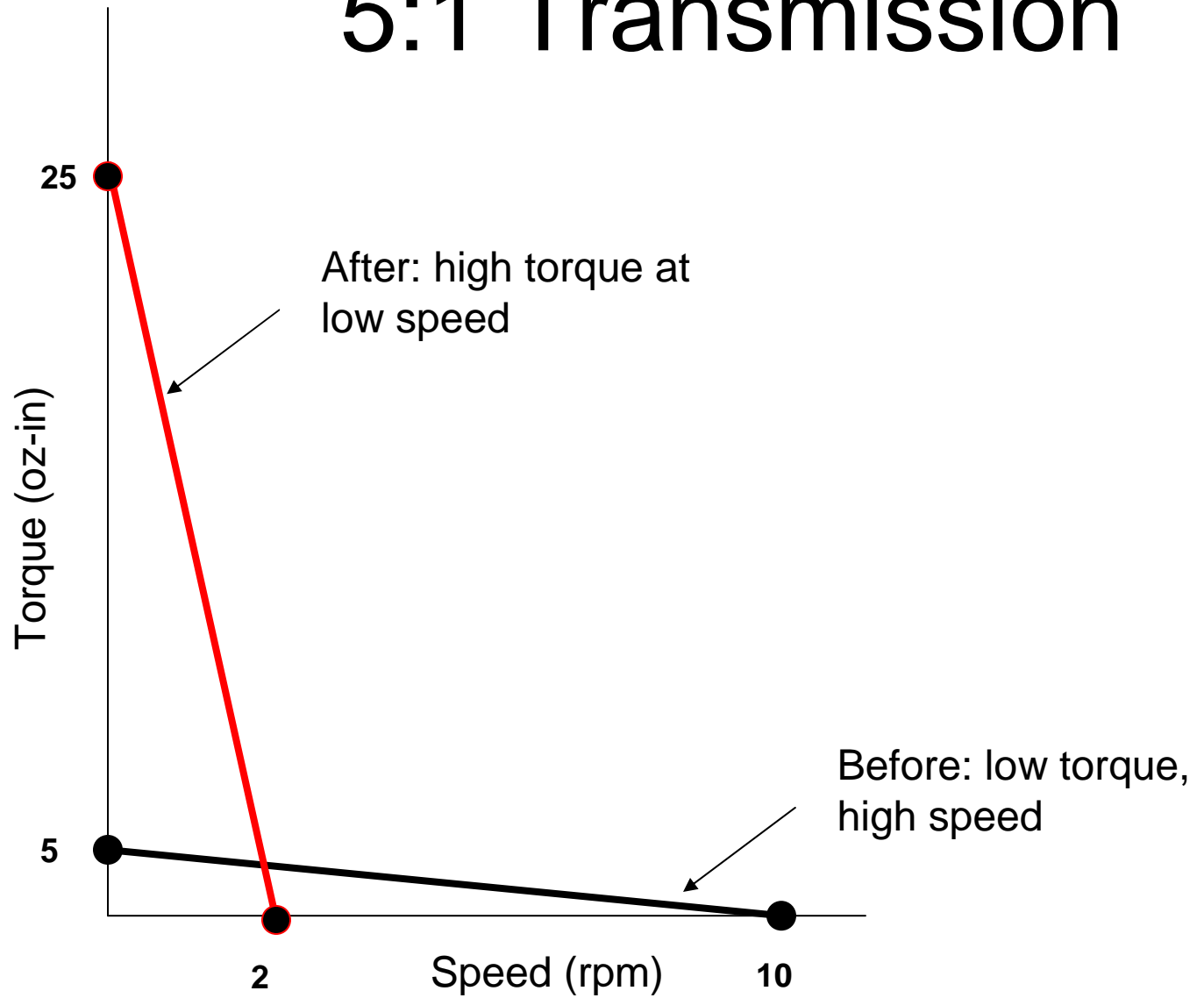
- Plain motors: spin fast, low torque
- Gear motors: spin slow, high torque
- More voltage = more speed and more torque
- Less voltage = slows down, but torque down
- If spin too fast, bearings fail
- If too much current, coil heats up and melts

Motor complaints



Solution: A transmission → gets you on a new T-S curve

5:1 Transmission



$$T_2 = n \cdot T_1 \quad v_2 = (1/n) \cdot v_1$$

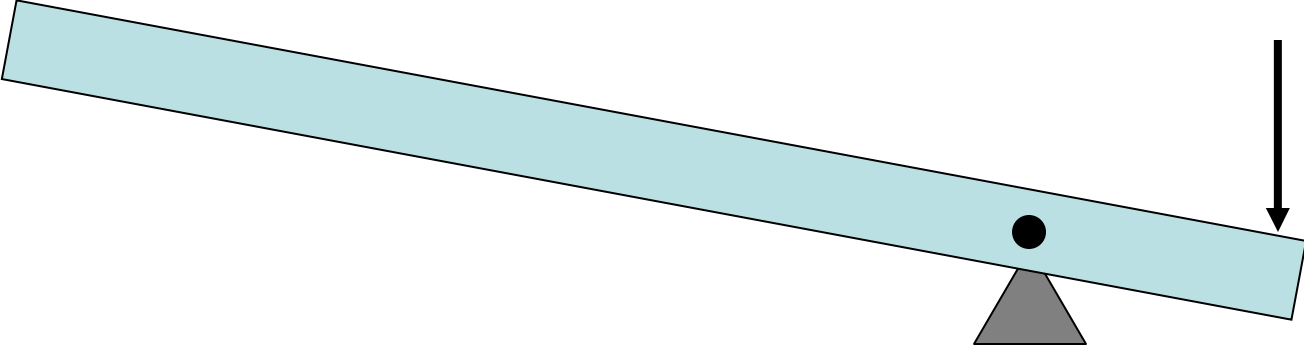
Same power!

$$T_2 = n * T_1 \quad v_2 = \frac{1}{n} v_1$$

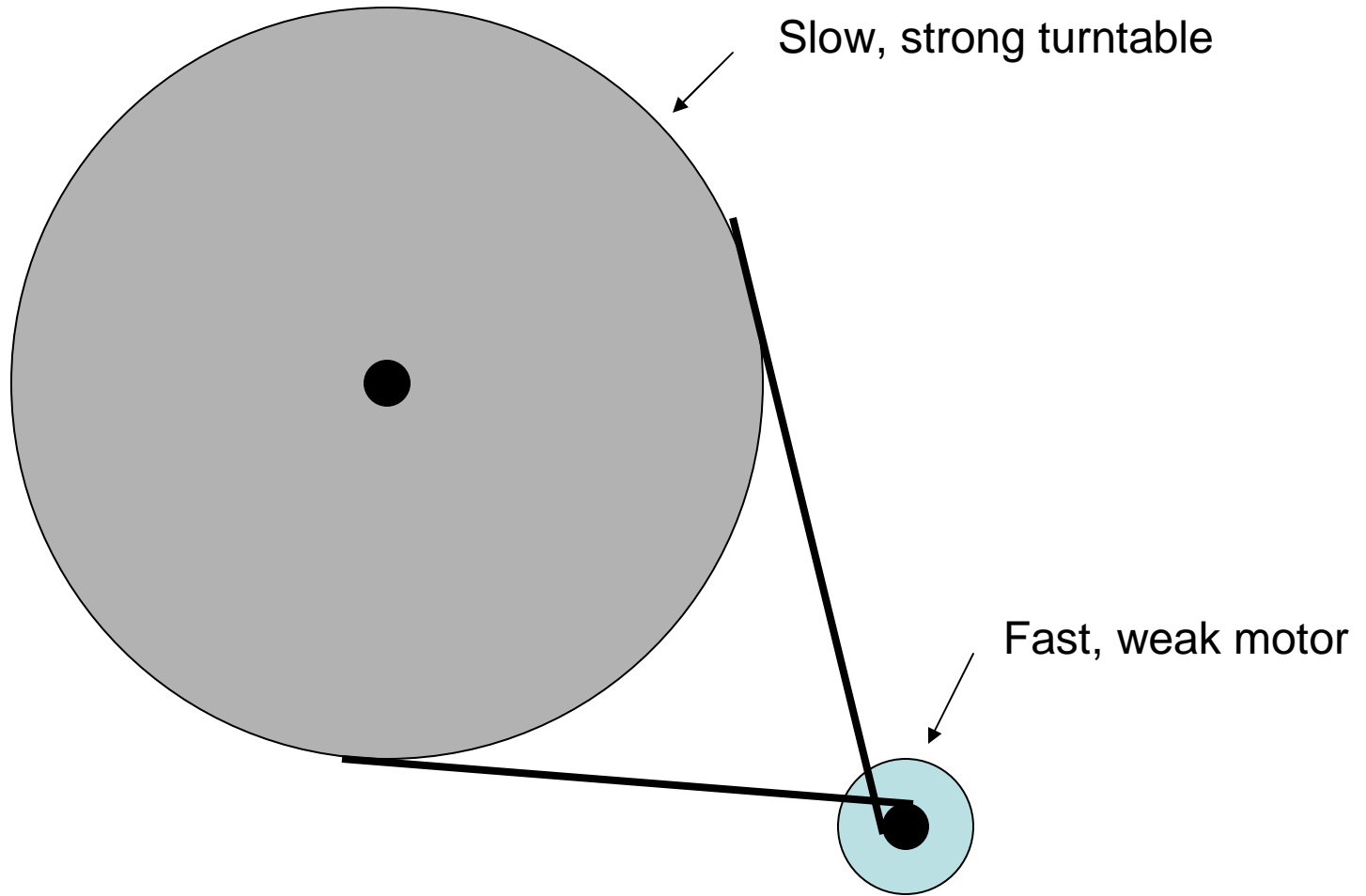
$$P = T * v$$

$$P_1 = T_1 * v_1$$

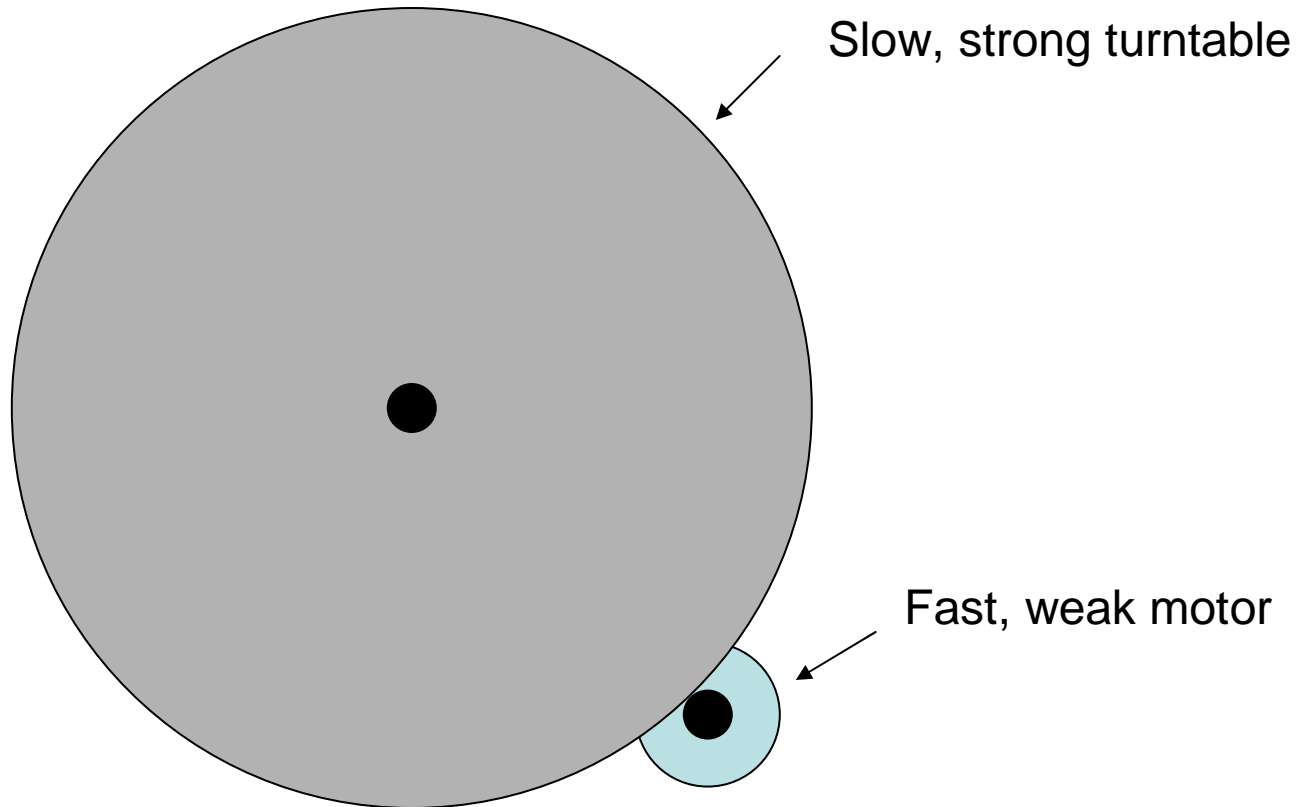
$$P_2 = T_2 * v_2 = [nT_1] * \left[\frac{1}{n} v_1 \right] = P_1$$



Belt Drive



Rim Drive



BEARINGS and SHAFTS

**Getting things to spin by
transmitting rotary power**

BEARINGS

**A BEARING REDUCES
DEGREES-OF-FREEDOM**

SPECIFICATIONS

- Ability to constrain motion
- Friction
- Load
- Lifetime
- Fabrication/Mounting
- Cost

TO SLIDE OR TO ROLL?

Rolling elements: Low friction, complex, expensive

Sliding elements: Simple, high friction





Angular contact roller bearing

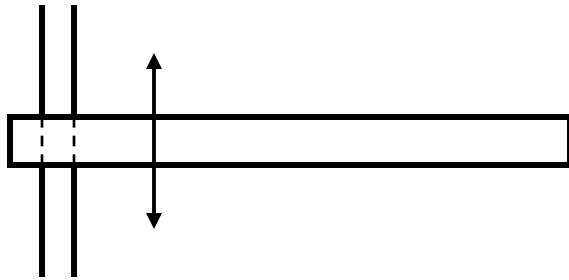


Tapered Roller Bearing

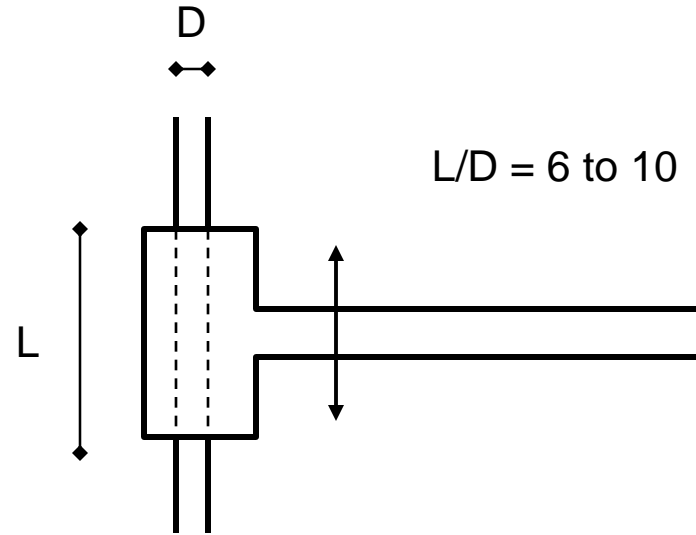


Rulon bearings

Sliding bearings (prismatic joints)

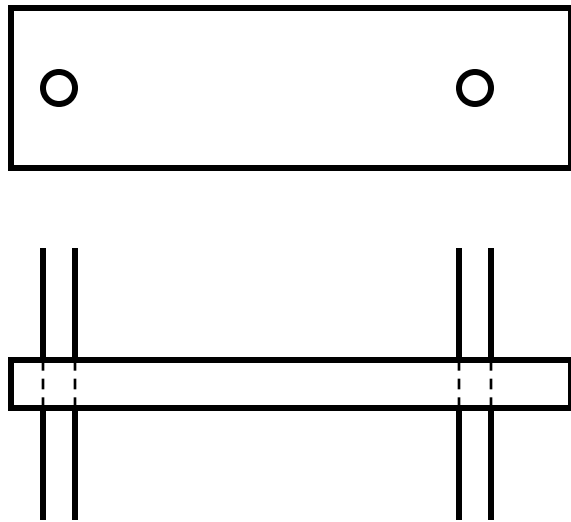


BIND

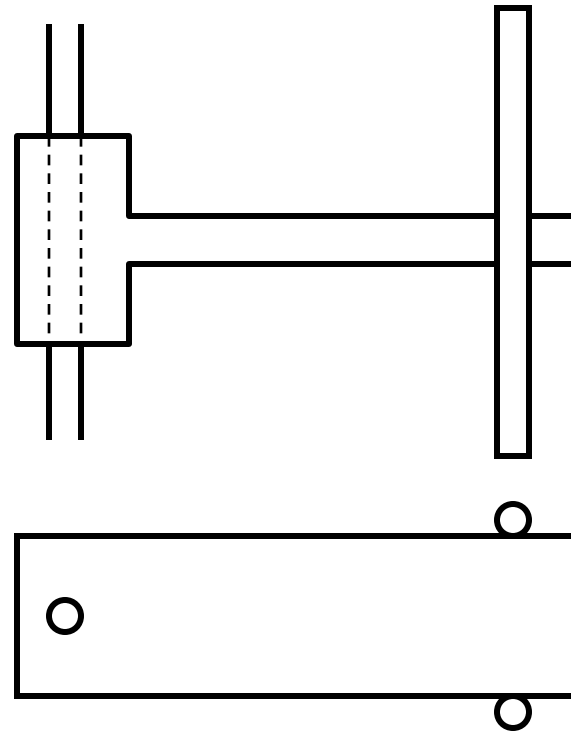


NO BIND

More sliding joints



BIND



NO BIND



KH Linear bushing



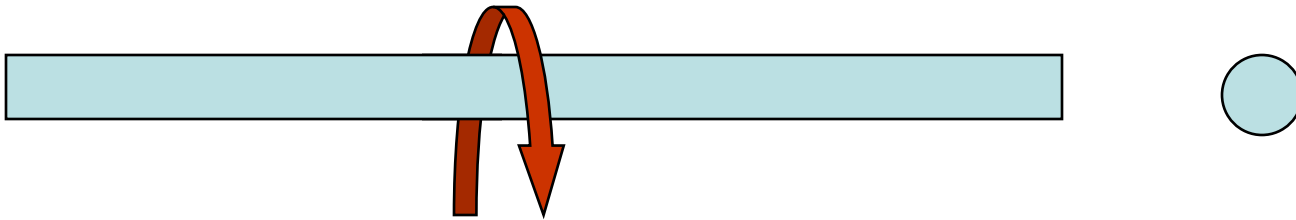
alibaba.com linear bearings



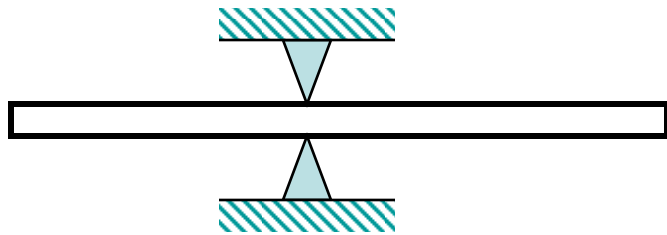
Danahermotion.com



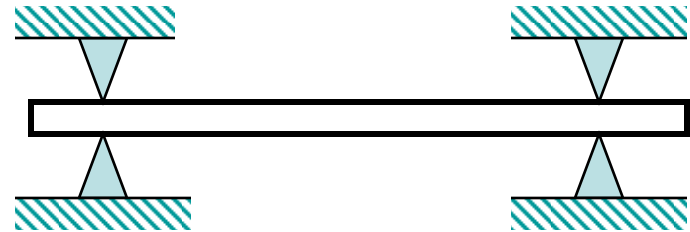
Shaft



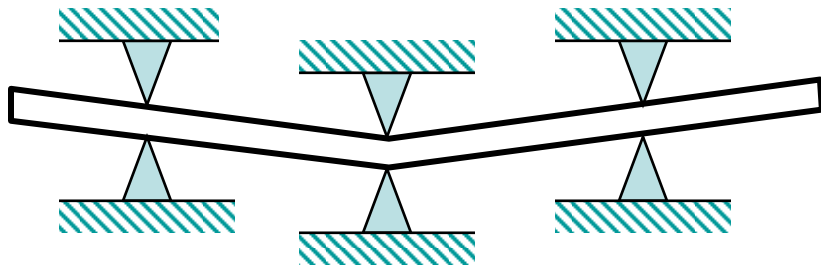
SUPPORTING SHAFTS



NO!

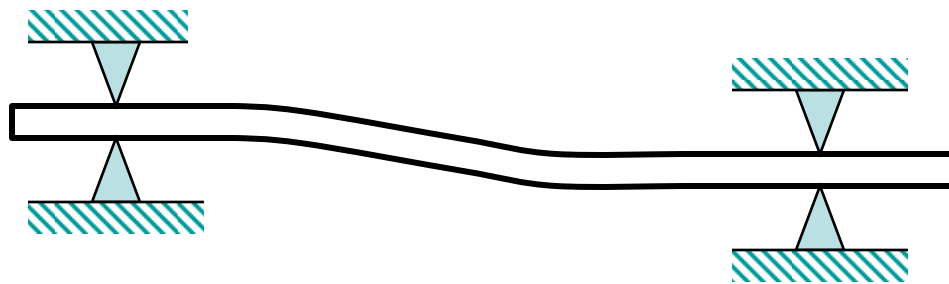


YES!

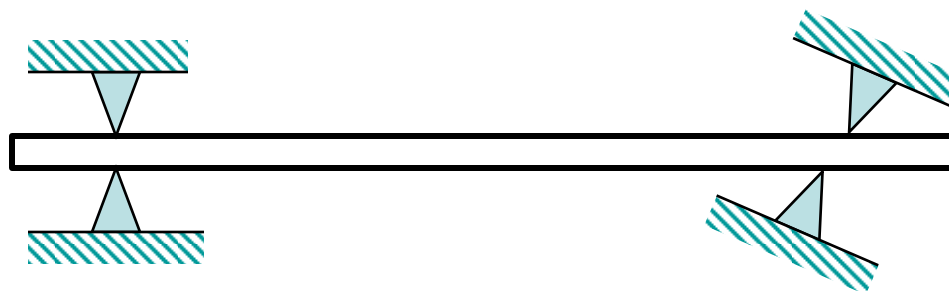


NO!

Bearing misalignment

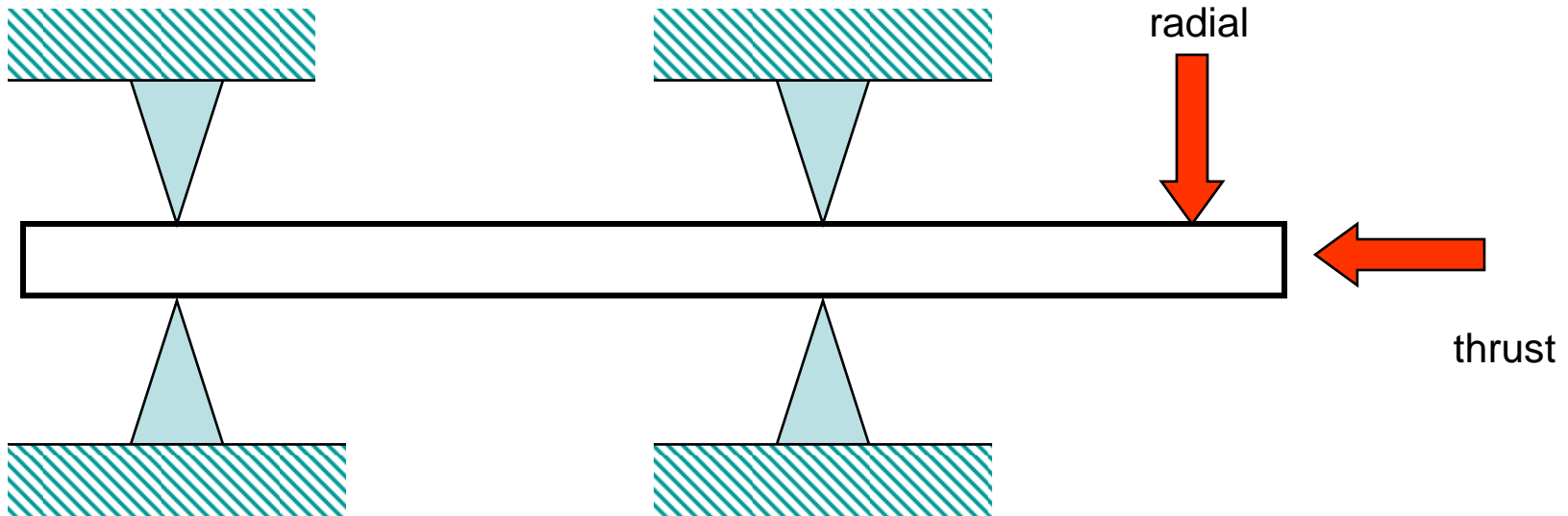


OFFSET

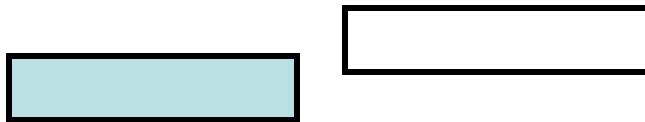
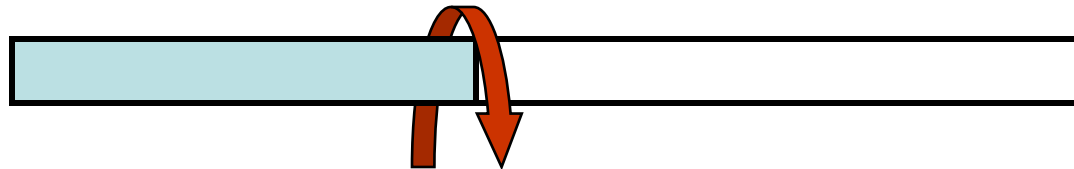


ANGULAR

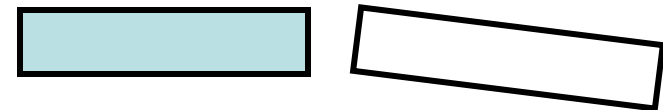
Bearing load



JOINING SHAFTS

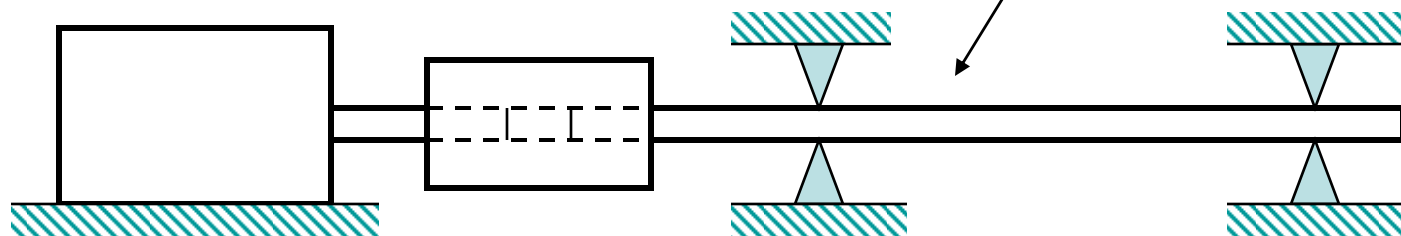
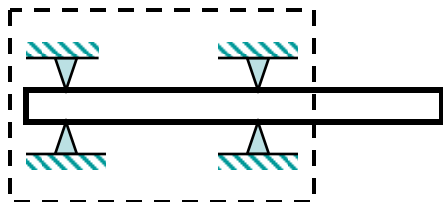
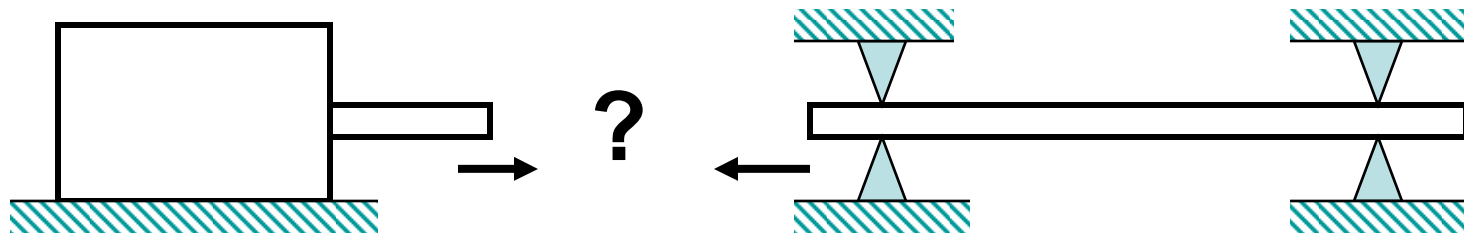


Offset misalignment



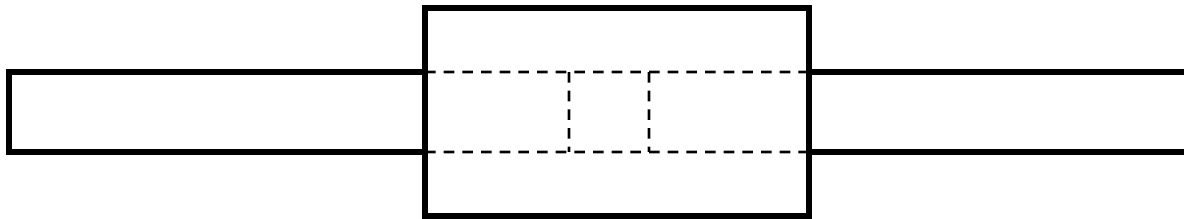
Angular misalignment

A classic binding problem

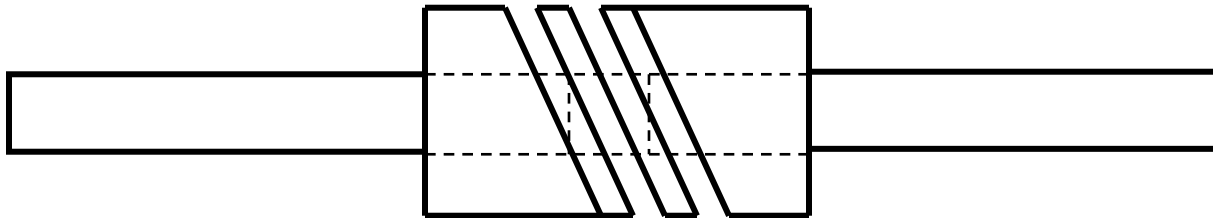


one shaft, 4 supports
= binding!

Coupling methods

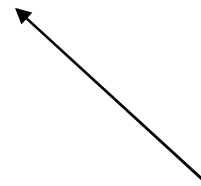
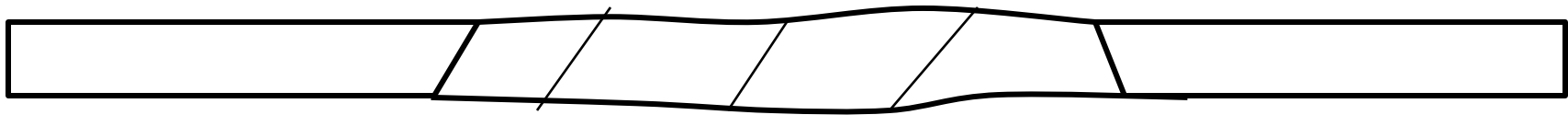


rigid coupler,
press-fit or glue or
set-screws



flexible coupler

Or, just tape 'em together



electrical tape or fiber reinforced tape