Back to our favorite cyclist...get your computers out

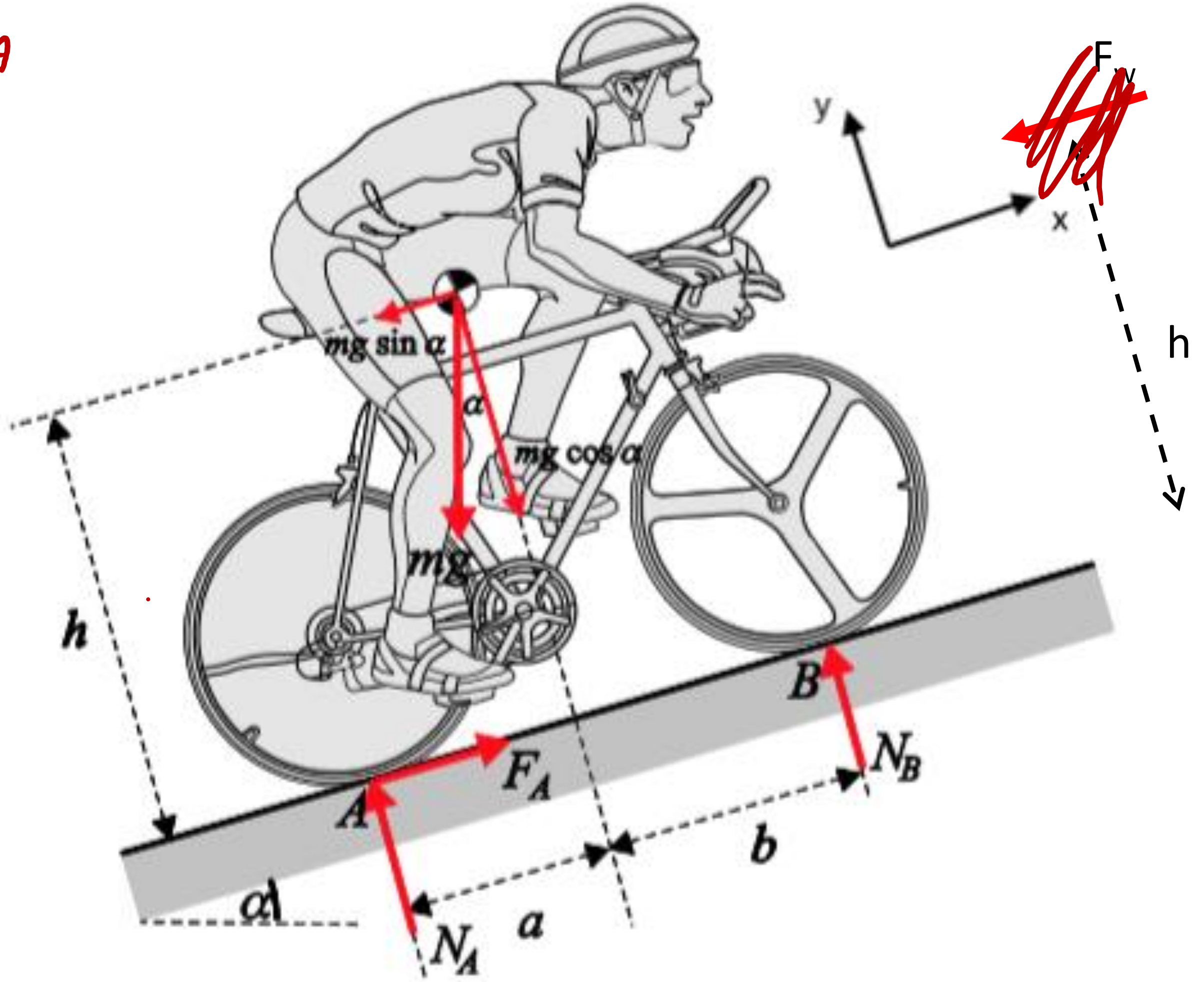
1) Find expression for F_A

$F_A = mg \sin\alpha$

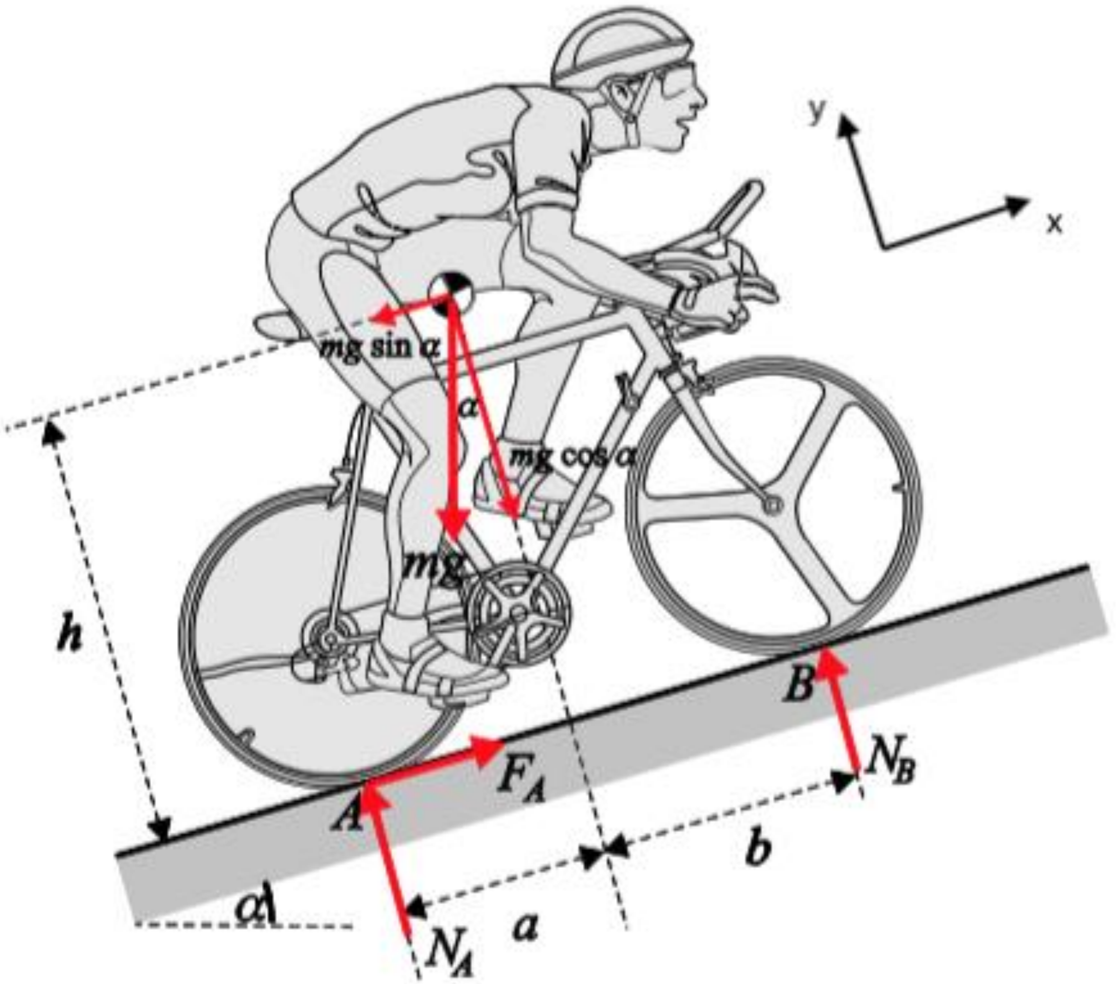
$\Sigma F_x = 0$

$\Sigma F_y = 0$

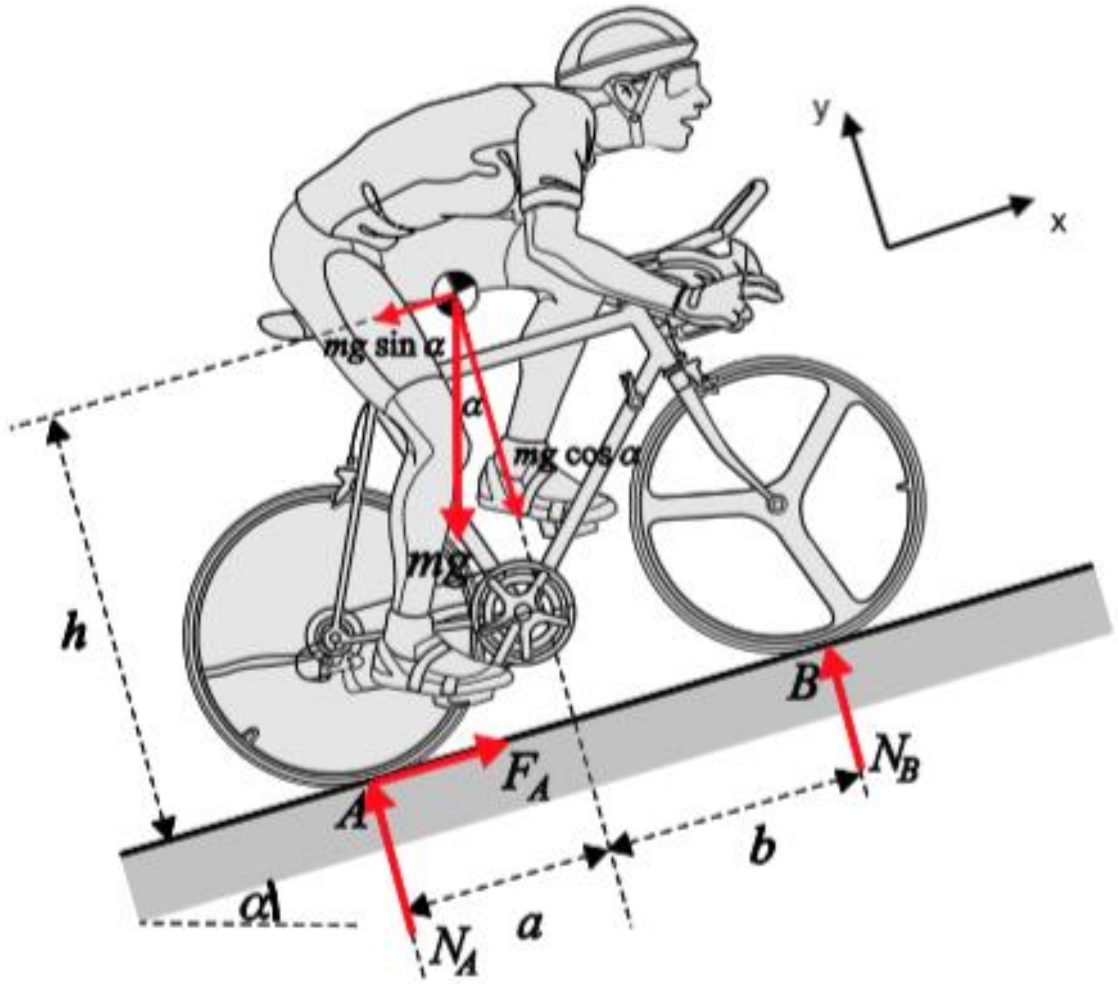
$\Sigma M = 0$



$$\Sigma F_y = 0 = N_A + N_B - mg\cos\alpha$$



$$\sum M_A = 0 = -mg\cos\alpha \cdot a + mg\cos\alpha \cdot h + N_B \cdot (a+b)$$

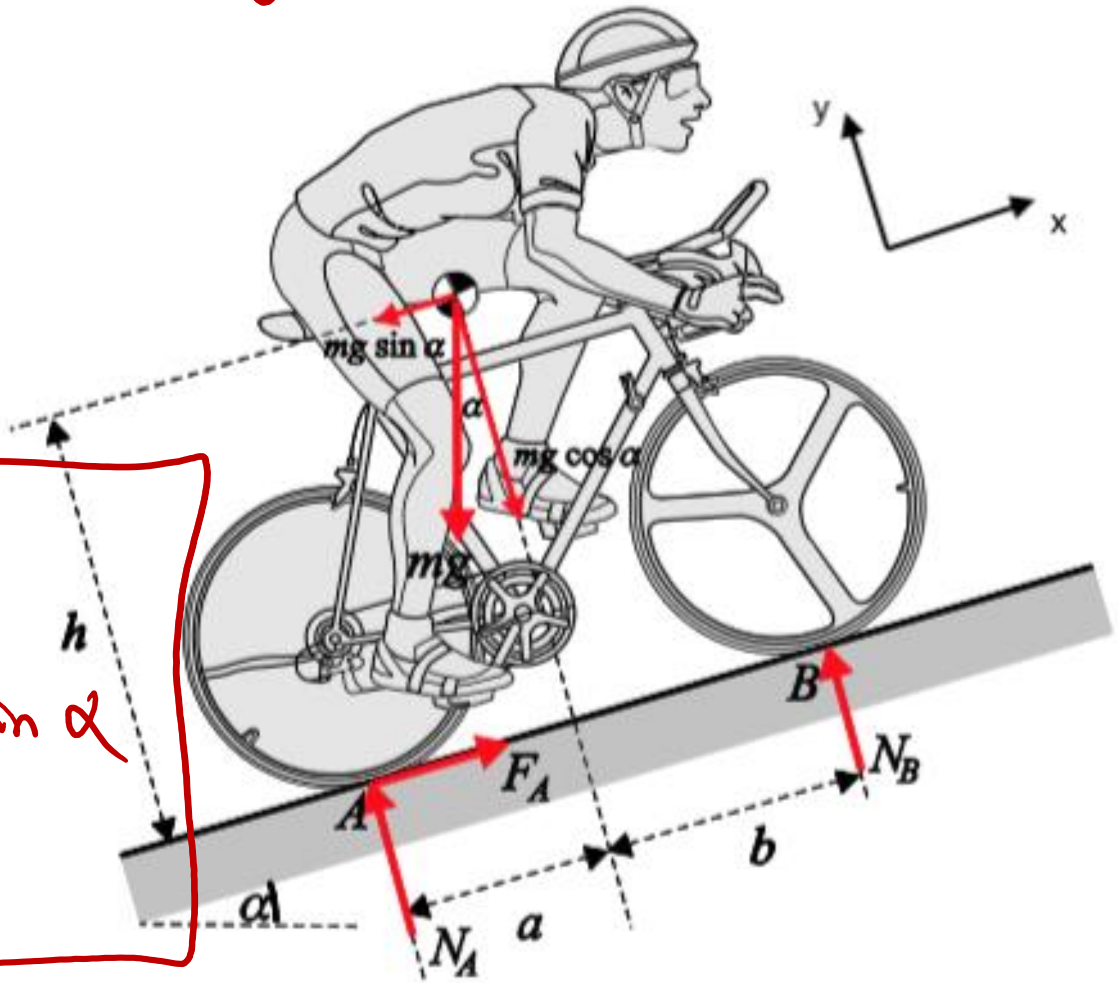


$$\Sigma M_B = 0 = mg\cos\alpha \cdot b - N_A(a+b) + mg\sin\alpha \cdot h$$

$$N_A = \frac{mgb\cos\alpha + mgh\sin\alpha}{a+b}$$

$$F_A = \mu N_A$$

$$\boxed{F_A = \frac{mg(b\cos\alpha + h\sin\alpha)\mu}{(a+b)} = mg\sin\alpha}$$

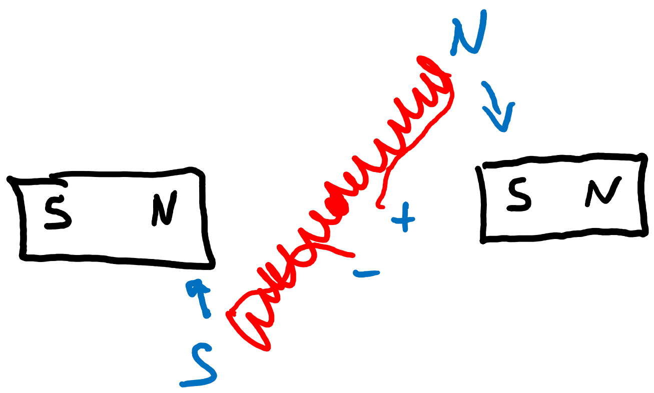


What if we wanted to use a motor?

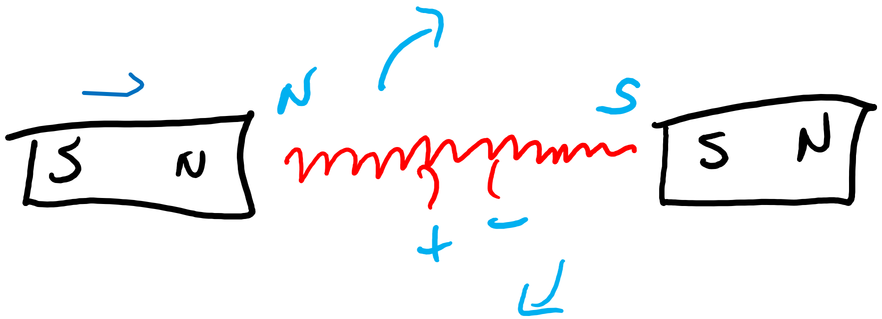
- How are motors rated? What do we need to know about a motor?

What if we wanted to use a motor?

- How are motors rated? What do we need to know about a motor?
  - Torque
  - Speed
  - Power



S
N
S
N
+
-
S
N



S
N
N
S
S
N
+
-

Motor characteristics

- The torque is proportional to the current going through the motor

$$\tau = K_T \cdot I$$

- We know that voltage is what drives current.

Motor characteristics

- The torque is proportional to the current going through the motor

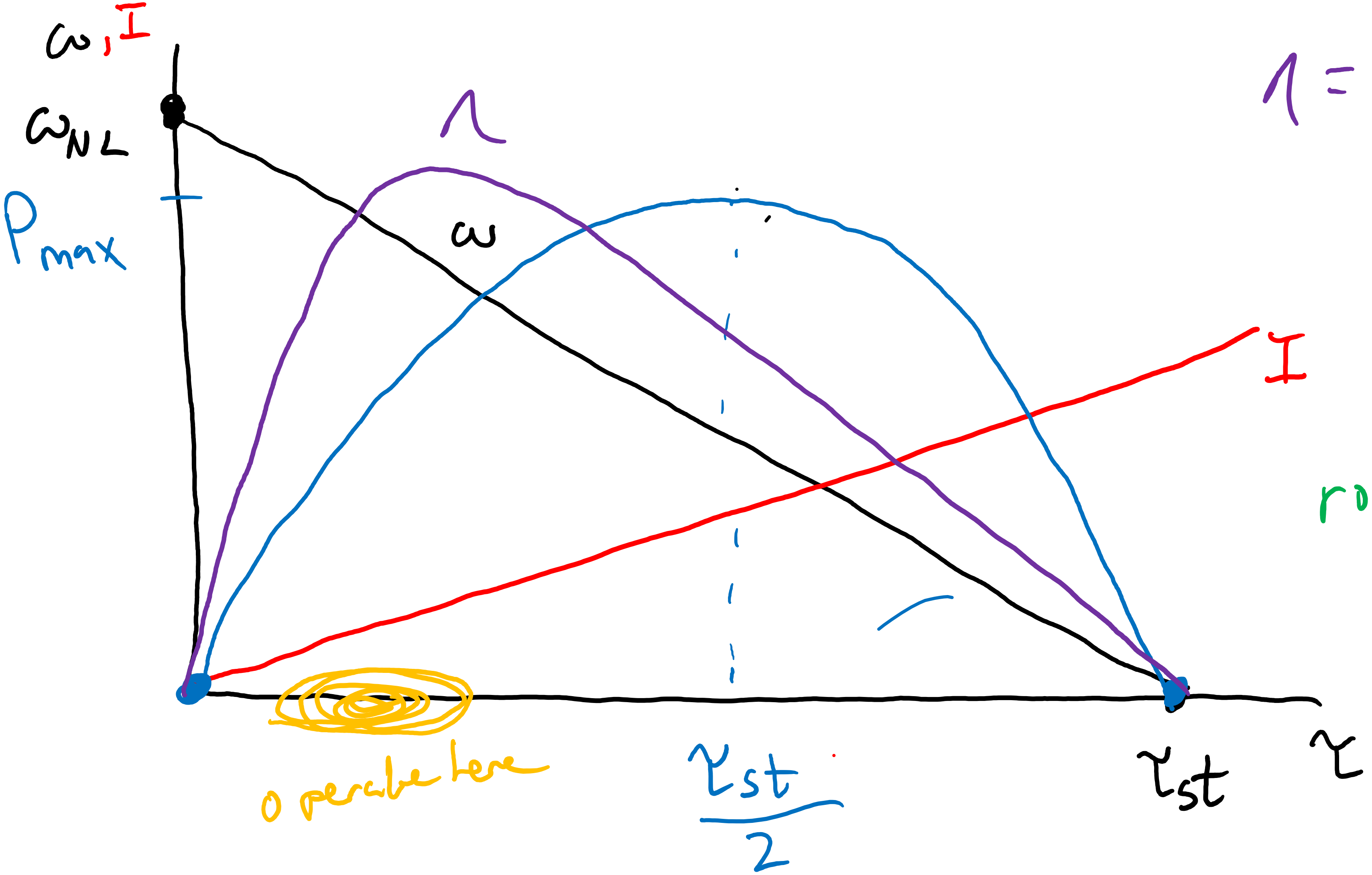
$$\tau = K_T \cdot I$$

- We know that voltage is what drives current.
- But as the motor spins, “back-EMF” works against that applied voltage.

Motor characteristics

$$P = \omega \cdot \tau$$

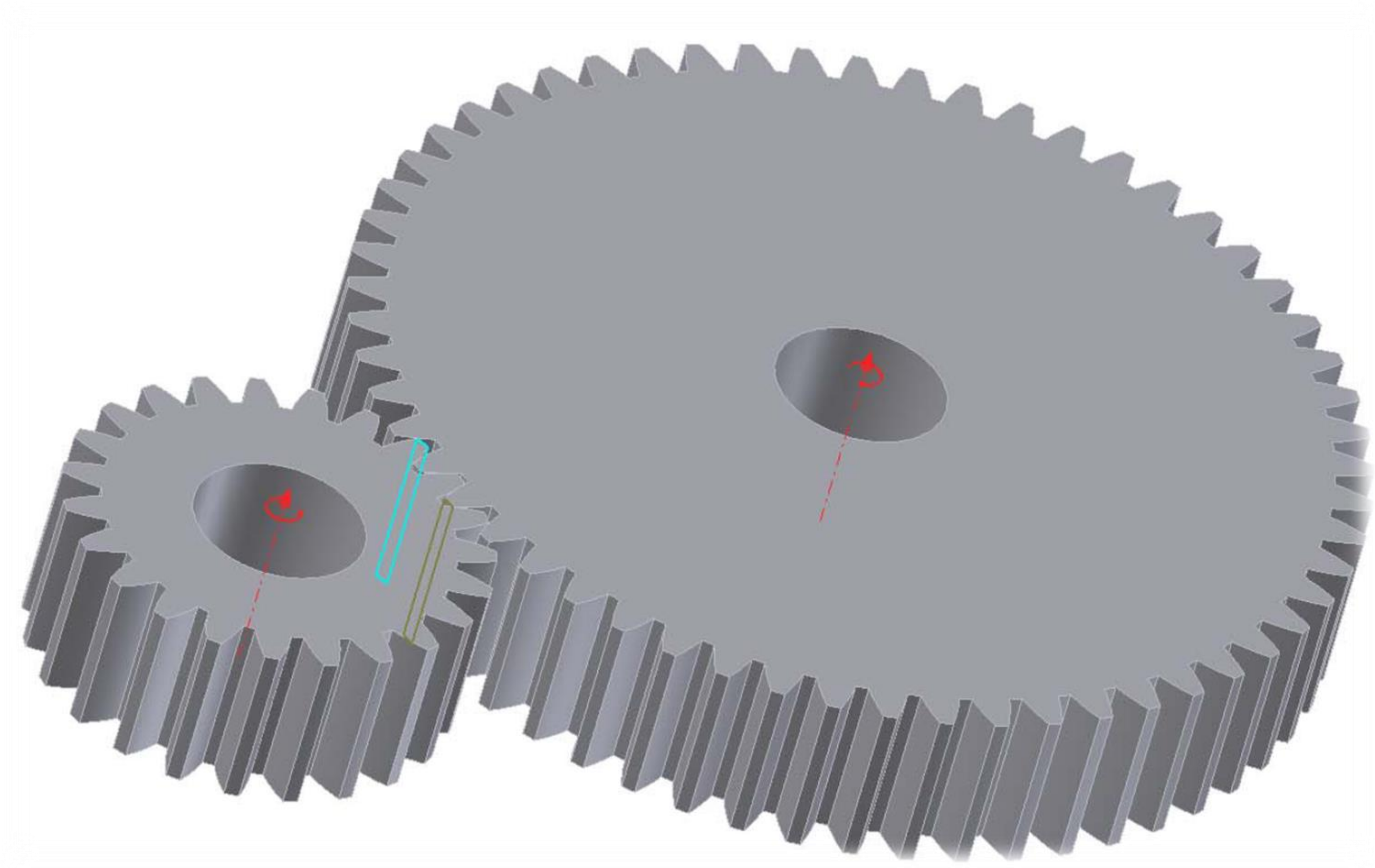
$$\eta = \frac{P_{mech}}{P_{elec}} = \frac{\omega \cdot \tau}{V \cdot I}$$



robots like ω↓ τ↑

Motor characteristics

Gears to the rescue!



Gears

- We can define the gear ratio, e, as the ratio of teeth, N, on the driving gear to teeth on the driven gear.

$$e = \frac{N_{driving}}{N_{driven}}$$

- That means that it is also the ratio of the speed of the output shaft to the input

$$e = \frac{N_{driving}}{N_{driven}} = \frac{\omega_{out}}{\omega_{in}}$$

- But what about torque?

Gears and torque

- Power out equals the power in times the efficiency, which is always less than 1

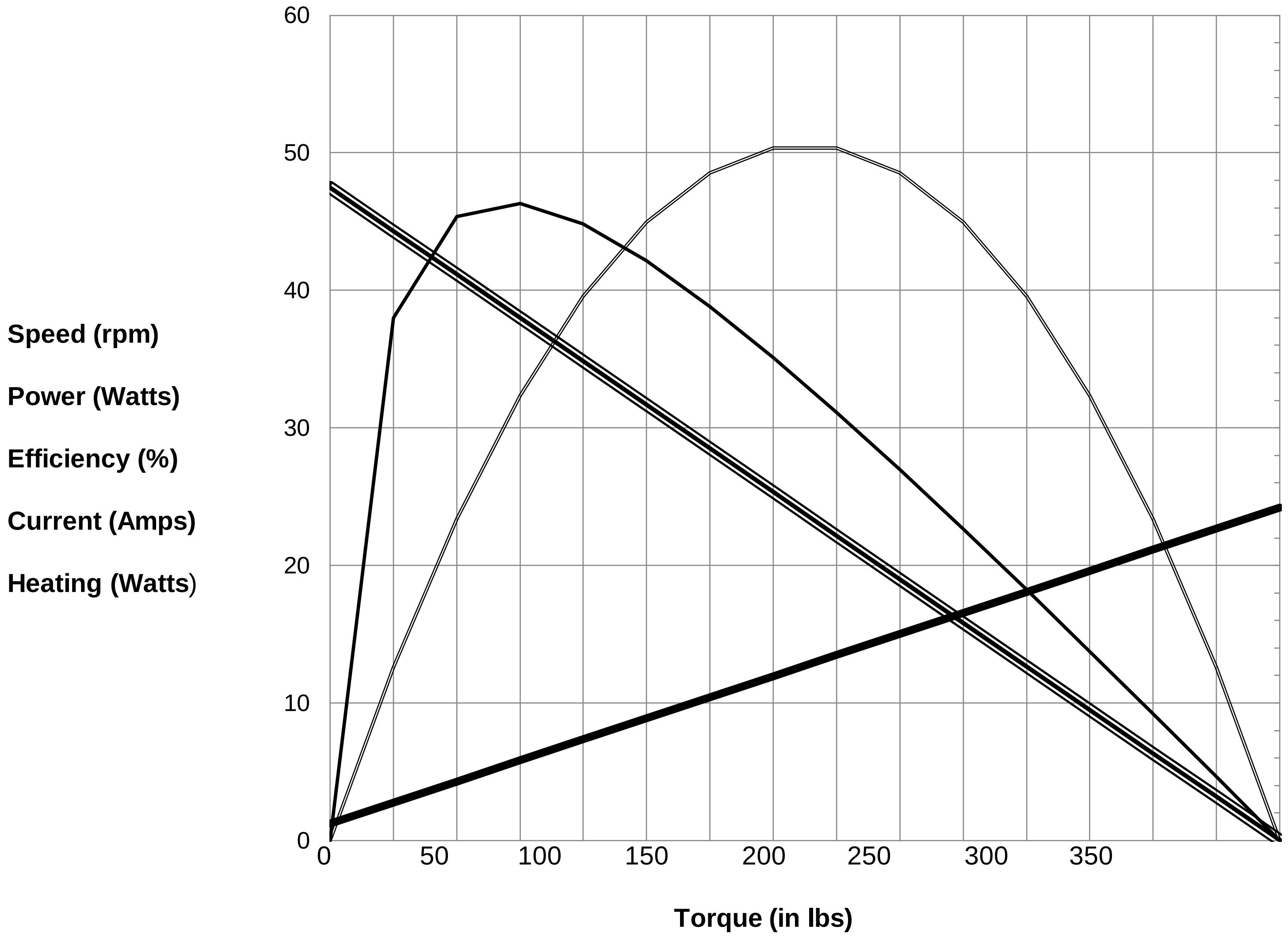
$$P_{out} = P_{in} \cdot \eta_{gear}$$

- By substituting speed and torque for power, we get,

$$\omega_{out} \cdot \tau_{out} = \omega_{in} \cdot \tau_{in} \cdot \eta$$

- Which is rearranged to

$$\frac{\tau_{out}}{\tau_{in}} = \frac{\omega_{in}}{\omega_{out}} \cdot \eta = \frac{1}{e} \cdot \eta$$



Speed (rpm)
Power (Watts)
Efficiency (%)
Current (Amps)
Heating (Watts)
60
50
40
30
20
10
0
0
50
100
150
200
250
300
350
Torque (in lbs)