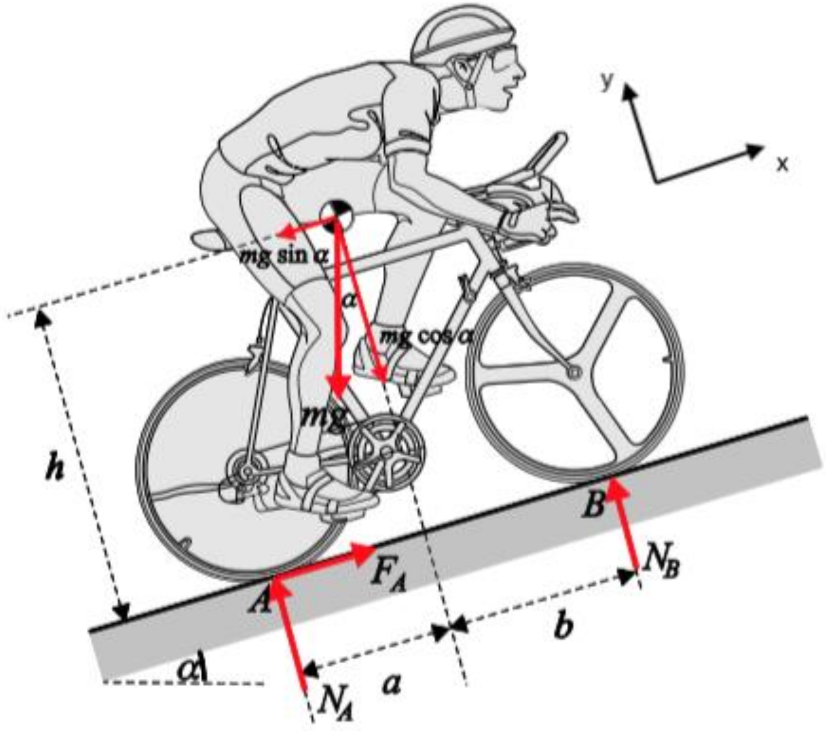
Applied mechanics

Topics

- Notes on stability
- Friction and traction
- Motors and performance
- Using gears

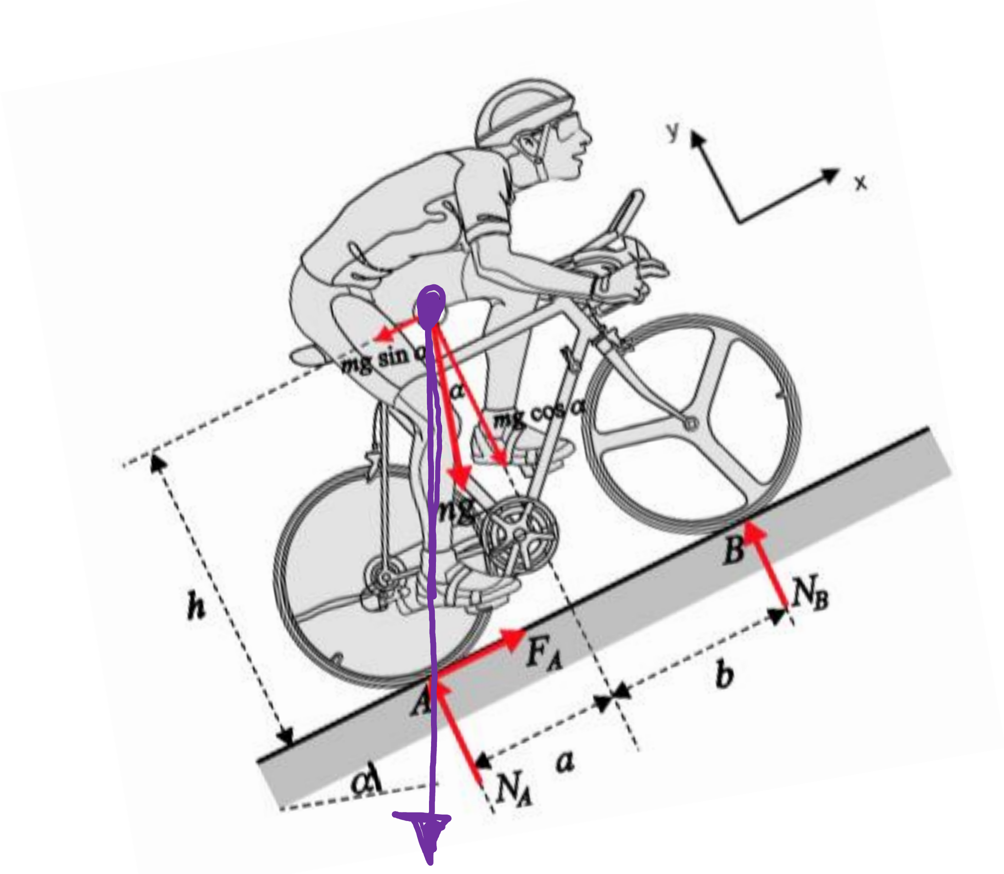
Stability

- We saw in the George Street Challenge that the cyclist (or robot) will tip over when the normal force on the front wheel goes to zero



Geometric stability

- For this problem, that occurs when the gravity vector passes through the ground contact point of the rear wheel



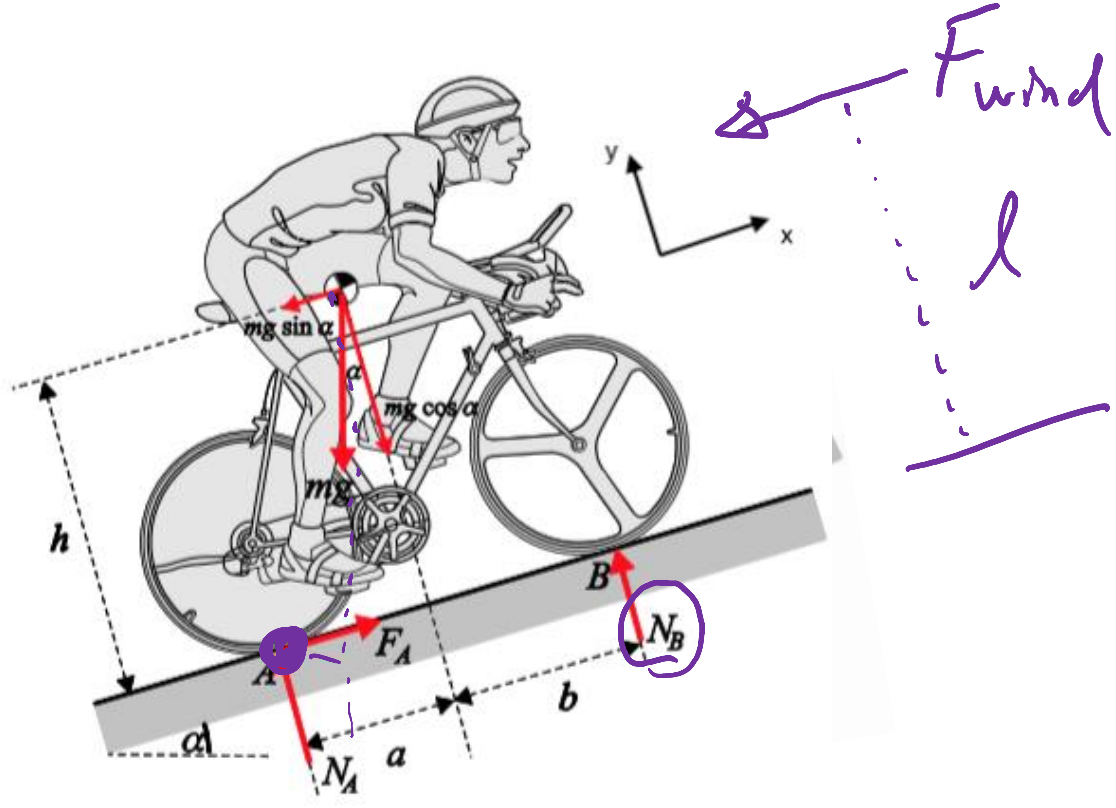
Word of Warning

$$\boxed{h\,mg\sin\alpha - a\,mg\cos\alpha = -\ell F_{wind}}$$

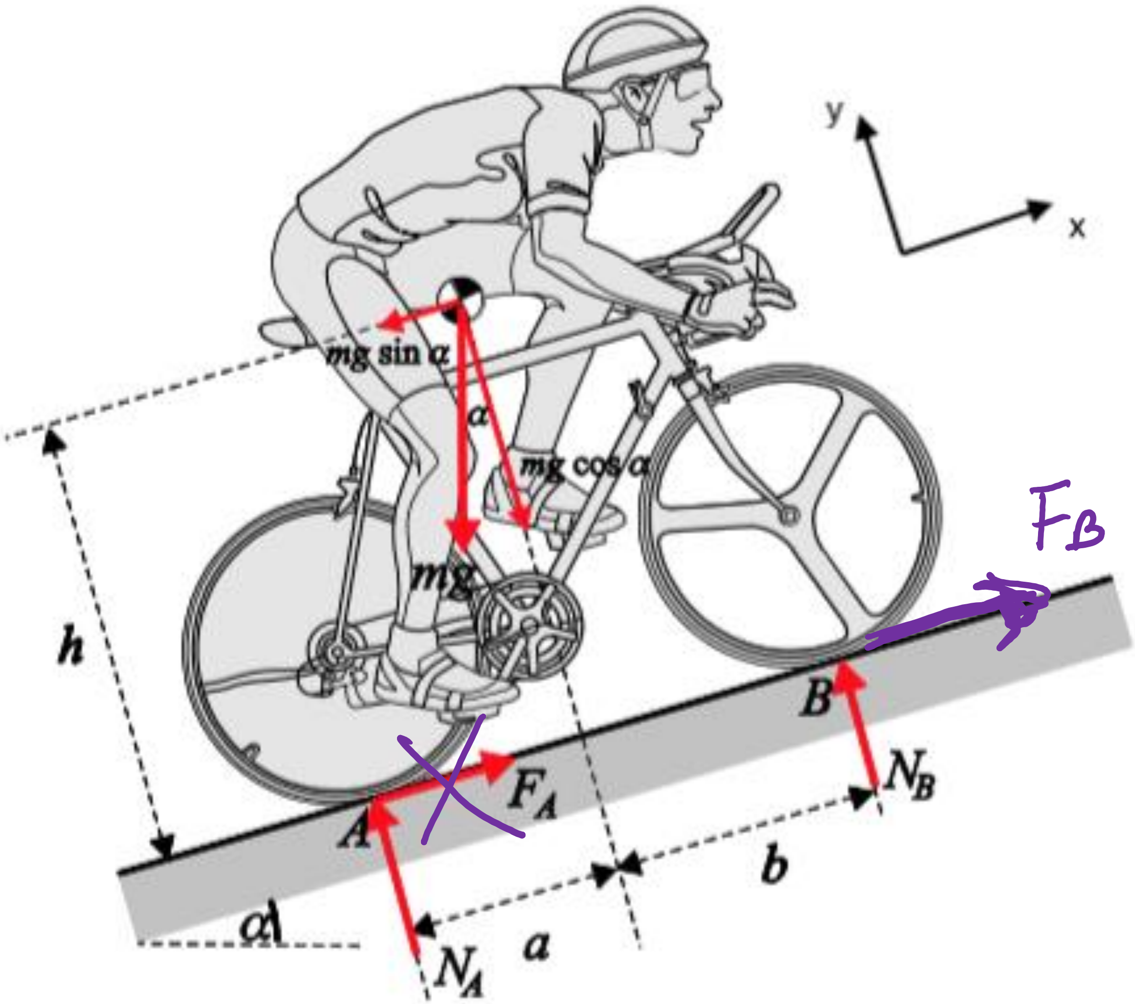
- But be careful if other, external forces are added!

$$\Sigma M_{A} = (a+b)\cdot N_B = 0$$

$$+h\,mg\sin\alpha$$
$$-a\,mg\cos\alpha$$
$$+\ell\cdot F_{wind} = 0$$



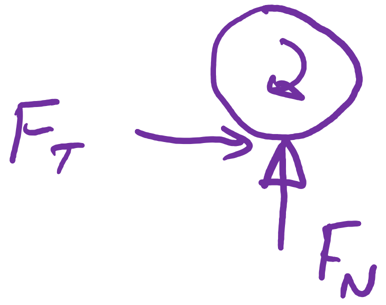
How does the analysis change for FWD?



Friction

- The friction factor, μ, relates the *maximum* traction force to the normal force:

$$F_T \leq \mu \cdot F_N$$

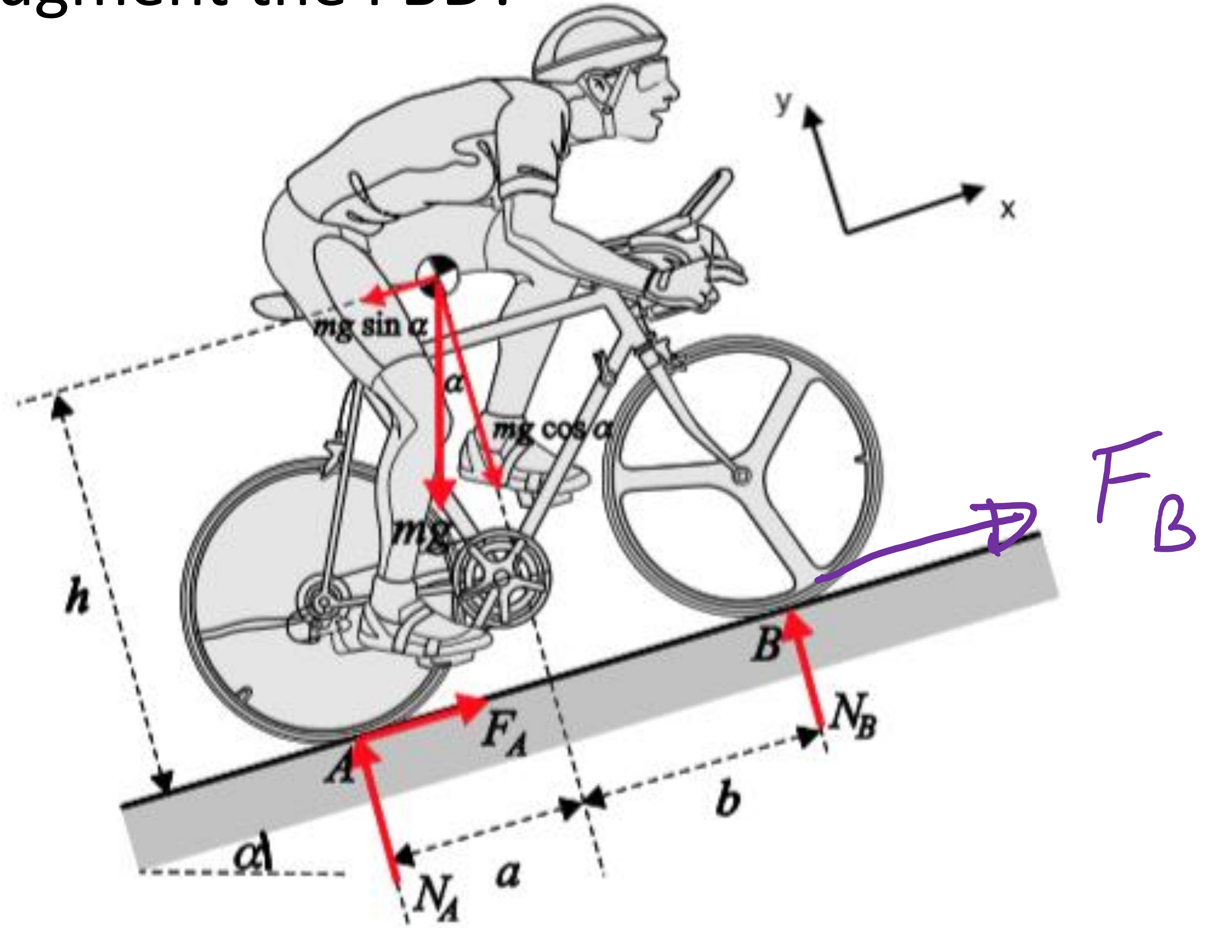


- That doesn't mean it *has* to be equal, but we can use that condition to determine when we lose traction. The "worst case scenario."

$F_T = \mu F_N$ @ slipping

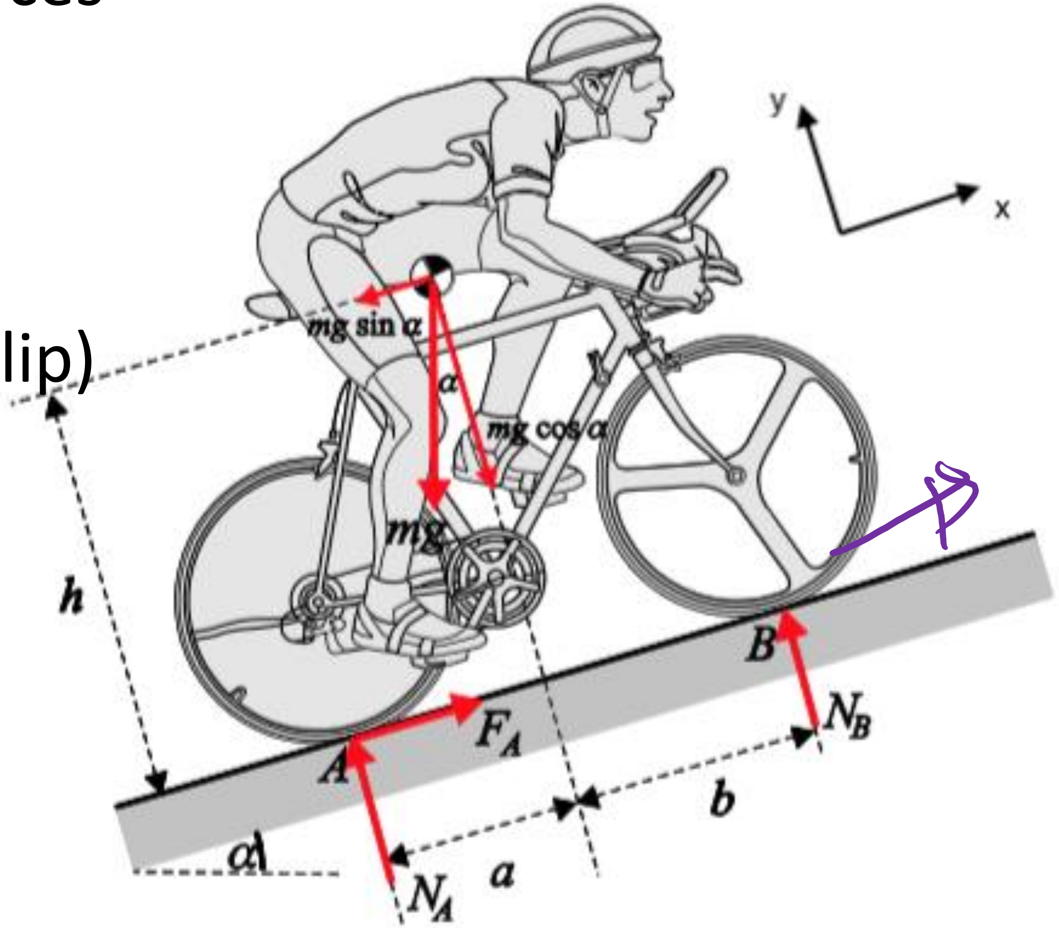
Let’s work a 4WD problem

- How would you augment the FBD?



Approach

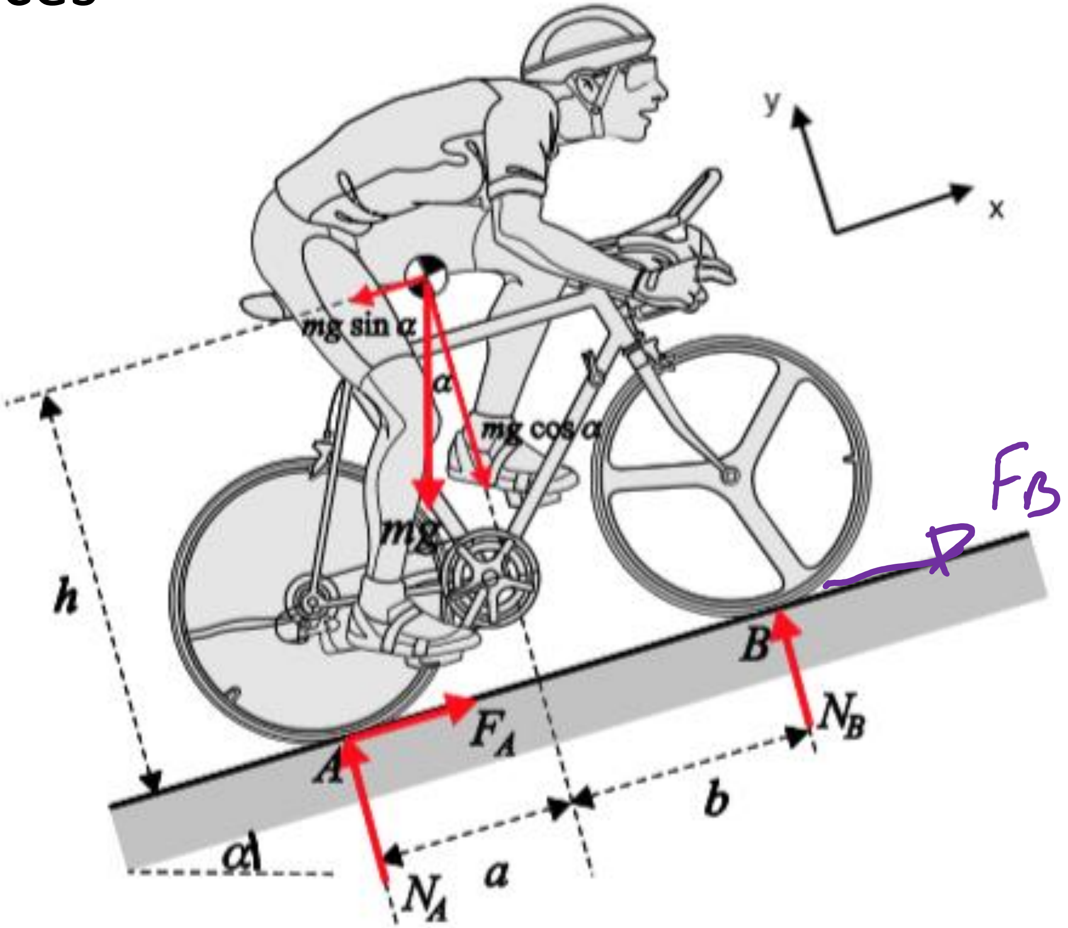
- Find expression(s) for the normal forces (EoE in y and/or moments)
- Find expression for propulsion force (EoE in x)
- Assume limiting case (just starts to slip)
- Substitute limiting case



Approach

- Find expression(s) for the normal forces (EoE in y)

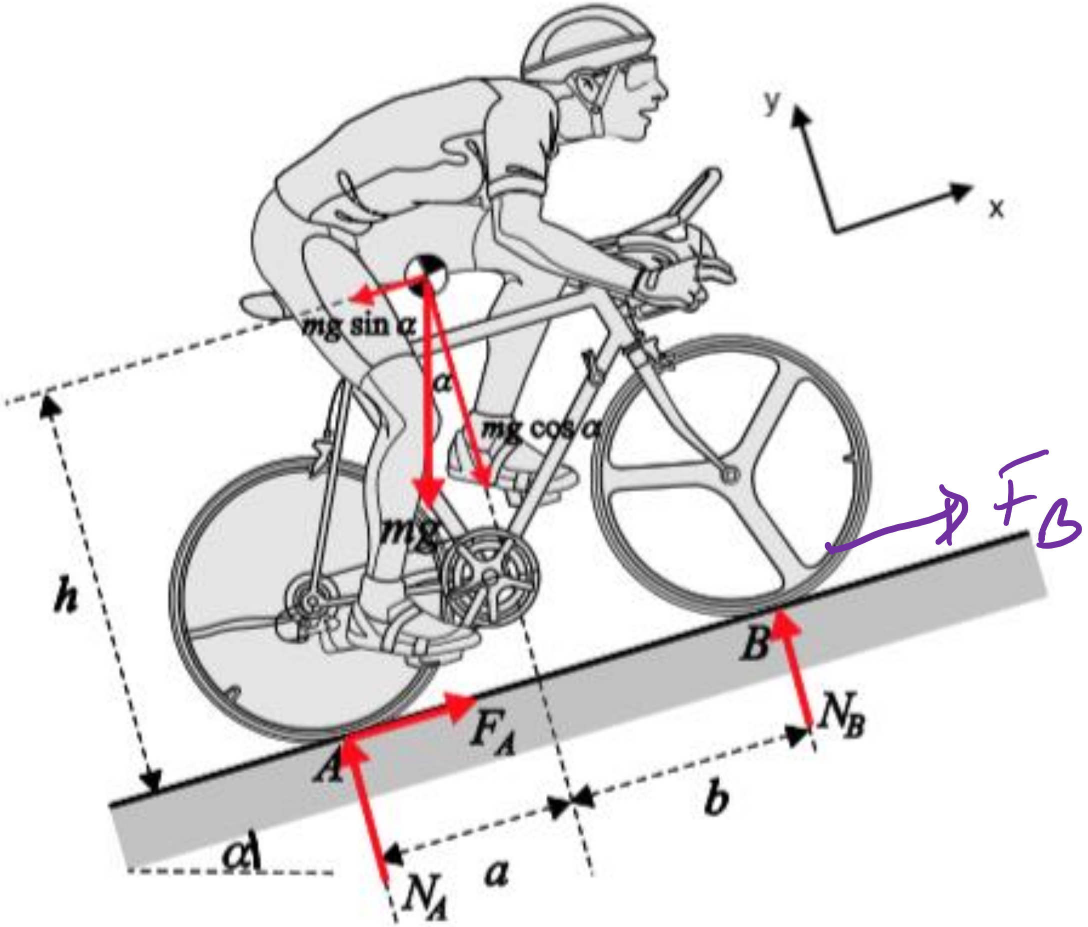
$$\Sigma F_y = 0 = N_A + N_B - mg\cos\alpha$$



Approach

- Find expression for propulsion force (EoE in x)

$$\Sigma F_x = 0 = F_A + F_B - mg\sin\alpha$$

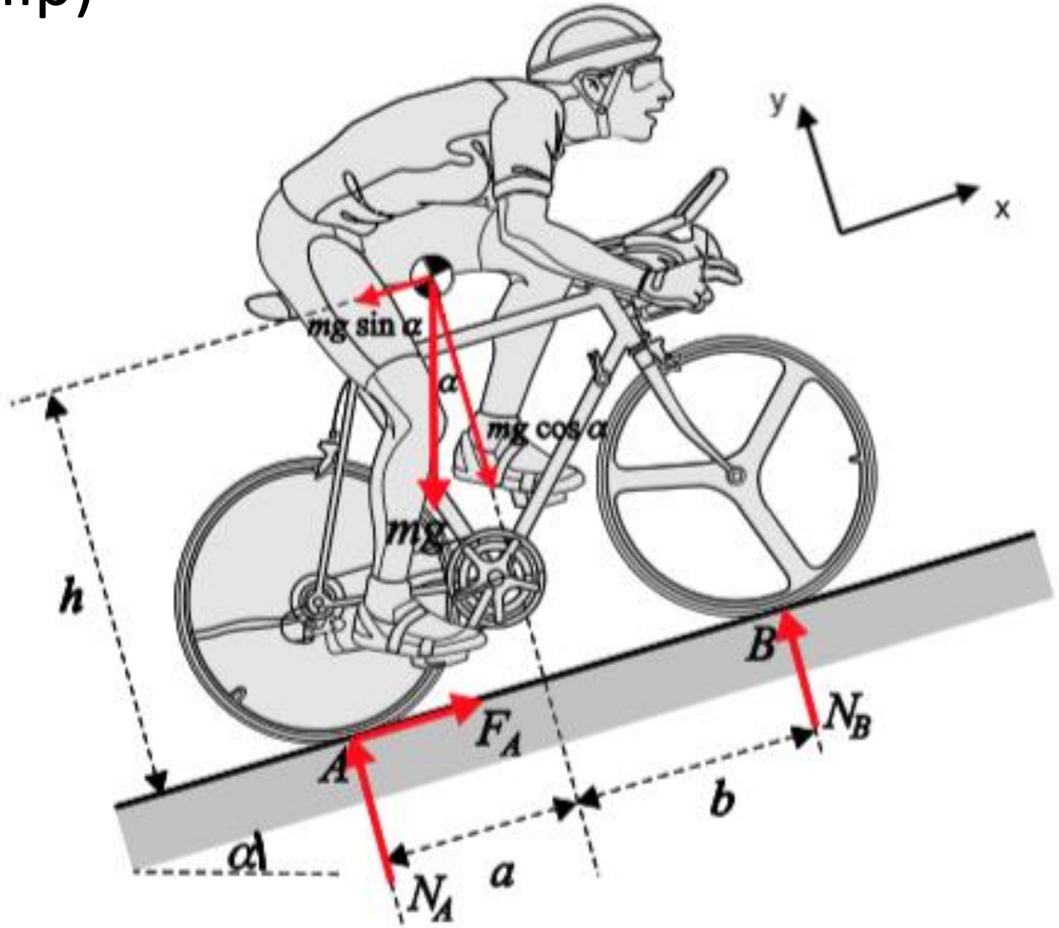


Approach

- Assume limiting case (just starts to slip)

$F_A = \mu N_A$

$F_B = \mu N_B$



Approach

- Substitute limiting case

$$\tan\alpha = \mu$$

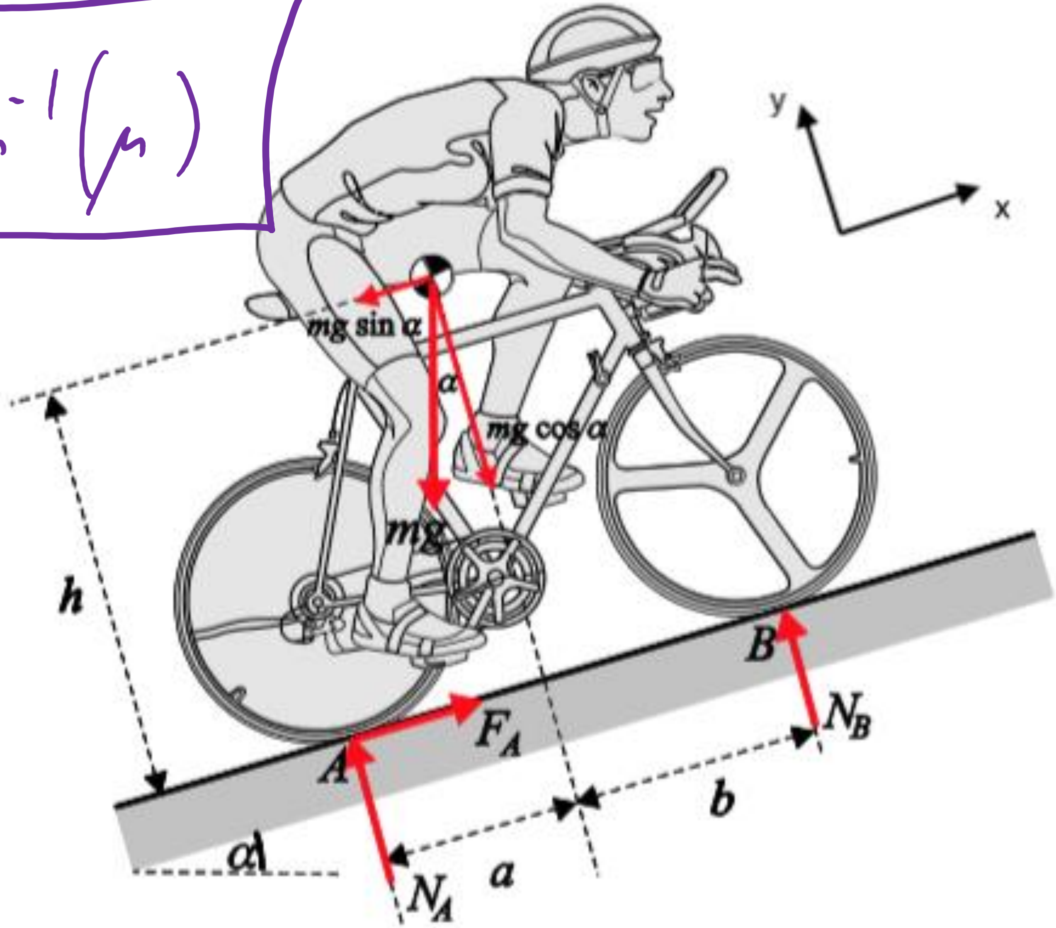
$$\boxed{\alpha = \tan^{-1}(\mu)}$$

$$F_A + F_B = mg\sin\alpha$$

$$\mu N_A + \mu N_B = mg\sin\alpha$$

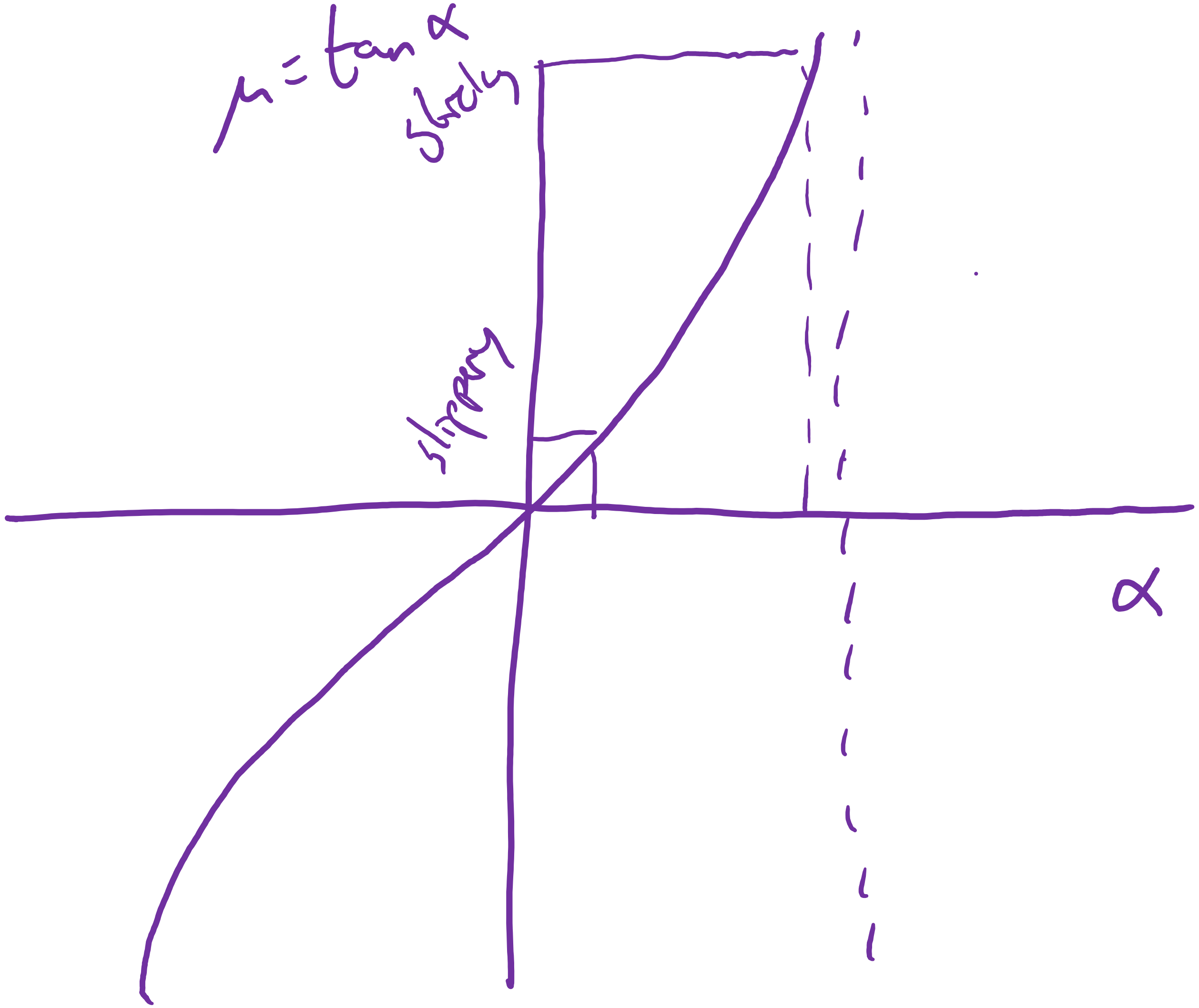
$$\mu(N_A + N_B) = mg\sin\alpha$$

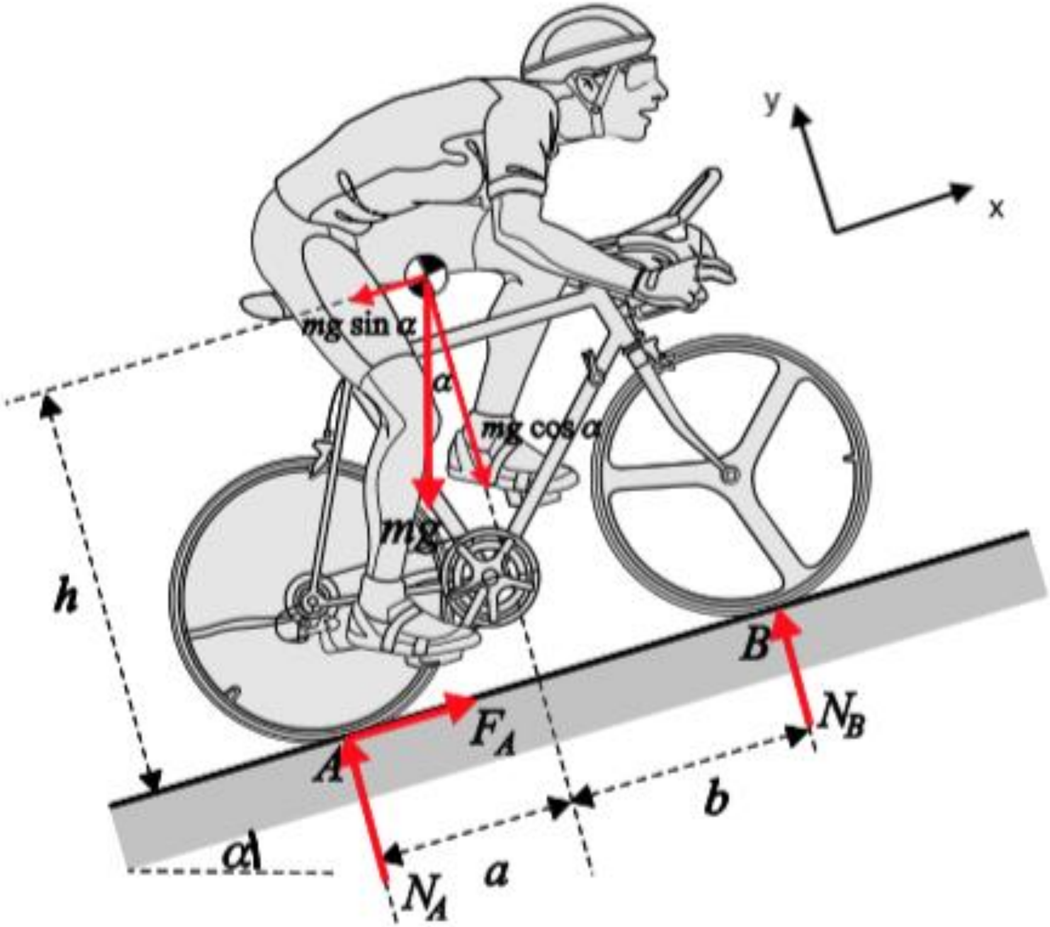
$$\mu(\cancel{mg}\cos\alpha) = \cancel{mg}\sin\alpha$$



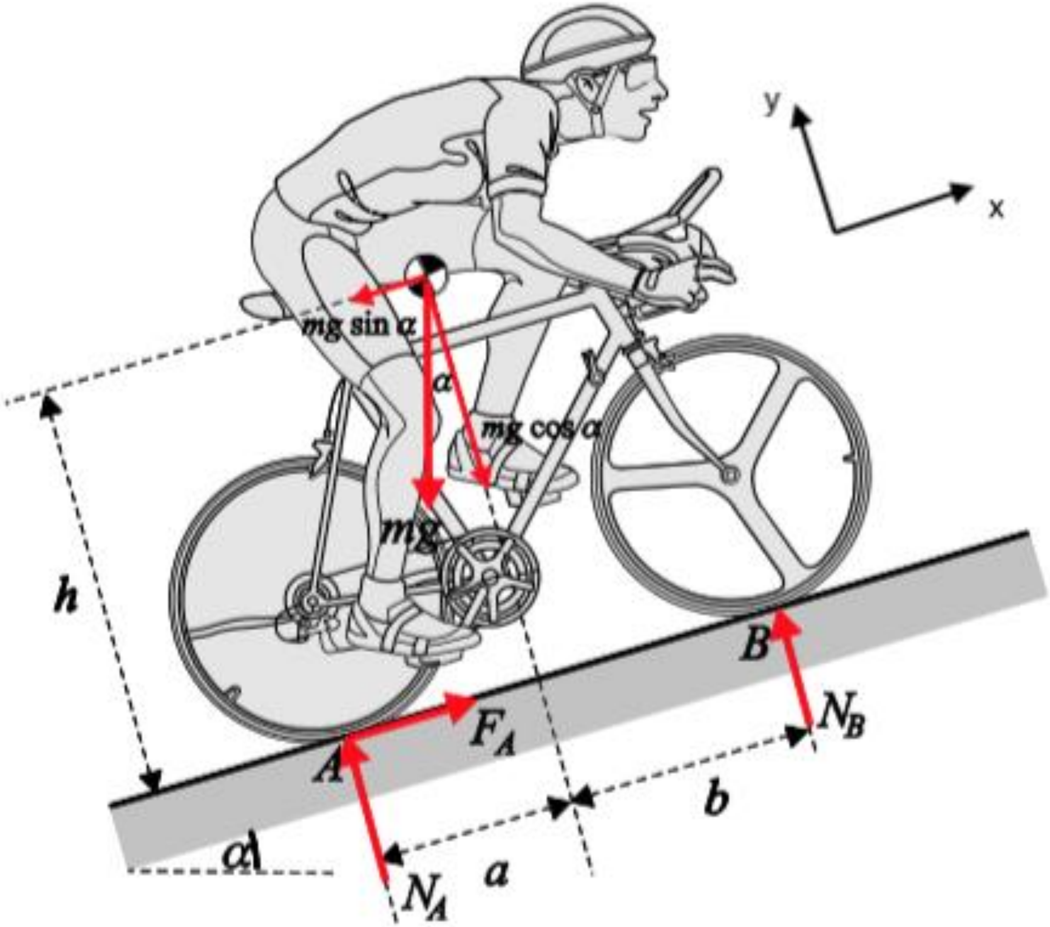
Ta da!

$\alpha = \tan^{-1}(\mu)$





2WD case



More on mechanics

- WPI playlist on Force Analysis