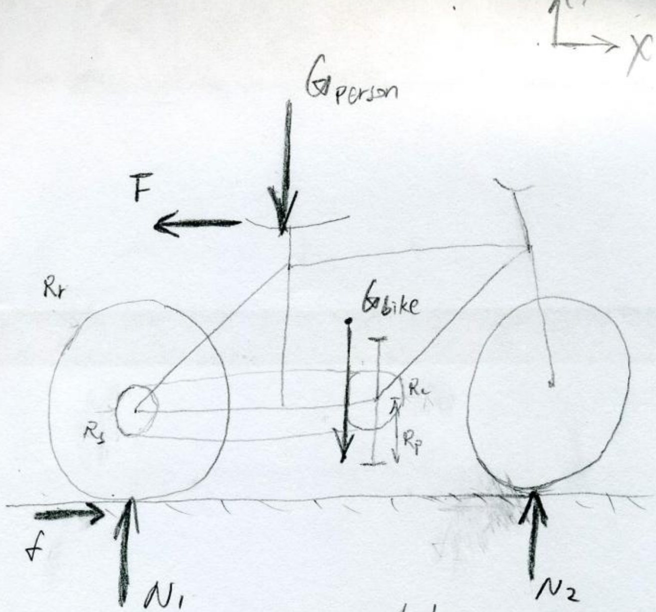
6.3.15)

a) Person on the bike

$\Sigma F_x = 0$

$\Rightarrow -F + f = 0$

$F = f$ (1)

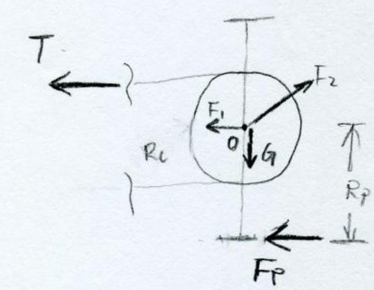


FBD 1 : Whole bike

$\Sigma M_O = 0$

$\Rightarrow T R_c = F_p R_p$

$T = \frac{R_p}{R_c} F_p$ (2)



FBD 2 = crank - pedal - chain - wheel

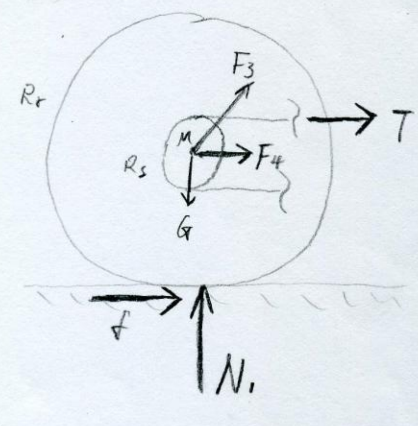
$\Sigma M_m = 0$

$\Rightarrow T R_s = f R_r$ (3)

substitute (2) in :

$\frac{R_p R_s}{R_c} F_p = f R_r$

$\Rightarrow \boxed{f = \frac{R_p R_s}{R_c R_r} \cdot F_p}$ *



FBD 3 : rear wheel & rear sprocket

substitute in (1) :

$\Rightarrow \boxed{F = \frac{R_p R_s}{R_c R_r} \cdot F_p}$

since R_p, R_s, R_c & $R_r > 0$

F has the same sign as F_p

$\Rightarrow \boxed{F < 0}$

b) Person standing next to the bike

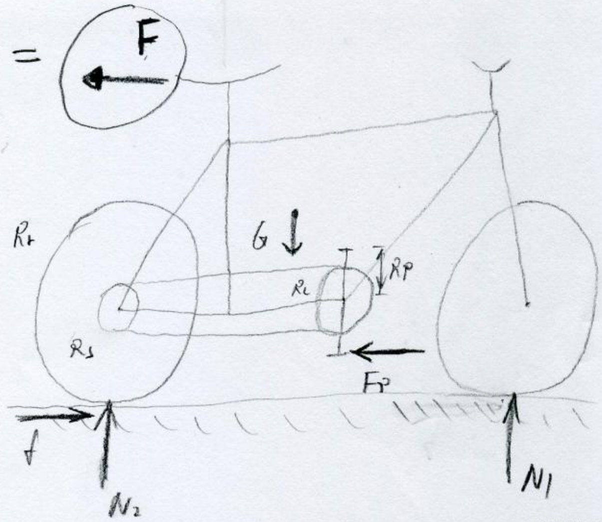
Relation ② & ③ remain unchanged as FBD 2 & 3 stay the same.

FBD 1 needs to be updated:

$\Sigma F_x = 0$

$\Rightarrow F + F_P = f$ ④

$F(-\hat{i}) =$



How do you know $f < F_p$ for real bikes? Because purpose of bike is to amplify foot motion, so it must attenuate foot force.

As derived in part a)

$$\boxed{f = \frac{R_P R_S}{R_c R_r} \cdot F_P}$$ *(Same as part a)

$$\Rightarrow F + F_P = \frac{R_P R_S}{R_c R_r} \cdot F_P$$

$$\boxed{F = \left(\frac{R_P R_S}{R_c R_r} - 1\right) F_P}$$

$$\frac{R_P R_S}{R_c R_r} = \frac{f}{F_P}$$

If $f < F_p$, which it is for all commercial bicycles in all gears, then $F < 0$! (Bike tries to go backwards).

Since $\overbrace{R_r > R_P}^{\text{always}}$ and $\underbrace{R_c > R_S}_{\text{often}}$ then the gearing says

$R_c R_r > R_P R_S$

$\Rightarrow \frac{R_P R_S}{R_c R_r} - 1 < 0 \Rightarrow F$ has an opposite sign to F_P.

$\Rightarrow \boxed{F < 0}$