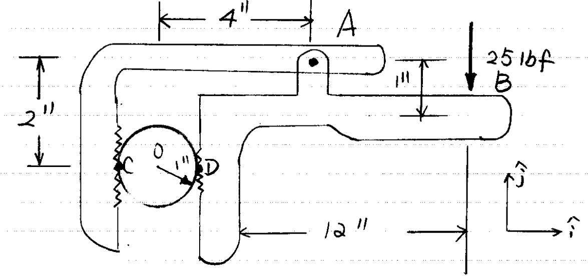
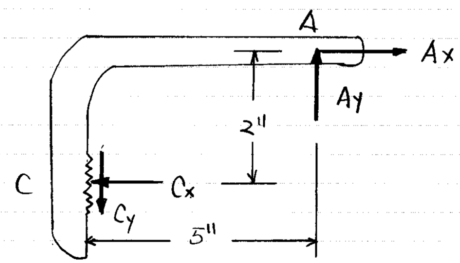
1. An idealization of a plumber's pipe wrench is like this:



Assuming the pipe doesn't move (it's hold by something), and the wrench doesn't slip, what're the forces on the pipe from wrench at C and D.

Solution:

The F.B.D of the left part of the wrentch is:

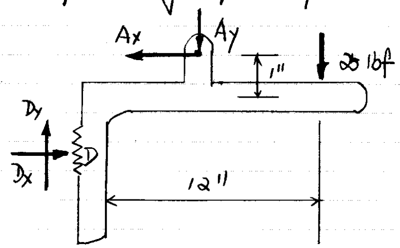


$\Sigma F_x = 0$: $A_x = C_x$ (1)

$\Sigma F_y = 0$: $A_y = C_y$ (2)

$\circlearrowleft + \Sigma M_C = 0$: $A_x(2'') - A_y(5'') = 0$ (3)

The F.B.D of the right part of the wrentch:



Cont. 1:

$\Sigma F_x = 0$: $A_x = D_x$ (4)

$\Sigma F_y = 0$: $D_y - A_y - 25\,\text{lbf} = 0$ (5)

$\circlearrowleft + \Sigma M_D = 0$: $A_x(2'') - A_y(3'') - 25\,\text{lbf}(12'') = 0$ (6)

We now have 6 eqns. 6 unknows

Put (1) and (2) into (3), we have:

$C_x(2'') - C_y(5'') = 0$ (7)

Put (1) and (2) into (6), we have:

$C_x(2'') - C_y(3'') = 300\,\text{lbf}\cdot\text{in}$ (8)

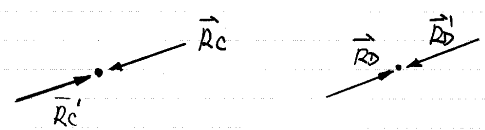
From (7) and (8), we have:

$$\left.\begin{array}{l} C_x = 375\ \text{lbf} \\ C_y = 150\ \text{lbf} \end{array}\right\} : \vec{R}_C = (-375\hat{i} - 150\hat{j})\ \text{lbf}$$

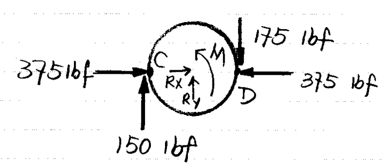
$\Rightarrow$

$$\left.\begin{array}{l} D_x = A_x = C_x = 375\ \text{lbf} \\ D_y = A_y + 25\ \text{lbf} \quad (5) \\ \quad = C_y + 25\ \text{lbf} \\ \quad = 175\ \text{lbf} \end{array}\right\} \vec{R}_D = (375\hat{i} + 175\hat{j})\ \text{lbf}$$

Those're the forces on the wrench from the pipe, they're on the opposite direction, the same value for the forces at C & D on the pipe from the wrench



$$\boxed{\begin{array}{l} \vec{R}_C' = -\vec{R}_C = (375\hat{i} + 150\hat{j})\ \text{lbf} \\ \vec{R}_D' = -\vec{R}_D = (-375\hat{i} - 175\hat{j})\ \text{lbf} \end{array}}$$



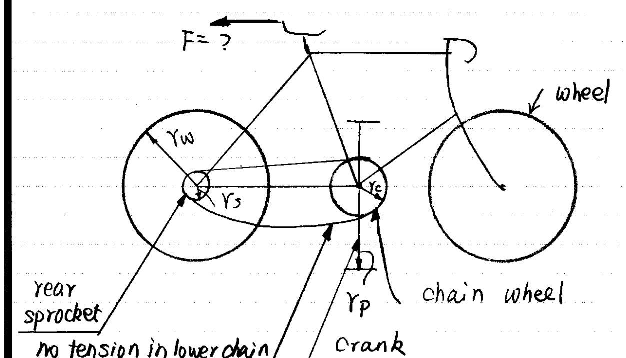
Prob 2:

The bicycle is balanced in & out of the plane. The right crank is straight down now. What force F's needed to keep the bick from moving if:

a) A person sitting in the bicycle pushes the right pedal backwards with a 10 lbf. For a real bike is $\vec{F} > 0$ or $\vec{F} < 0$

b). The person standing next to the bick pushes back on the right pedal with a 10 lbf. For a real bick is $\vec{F} > 0$ or $F < 0$?

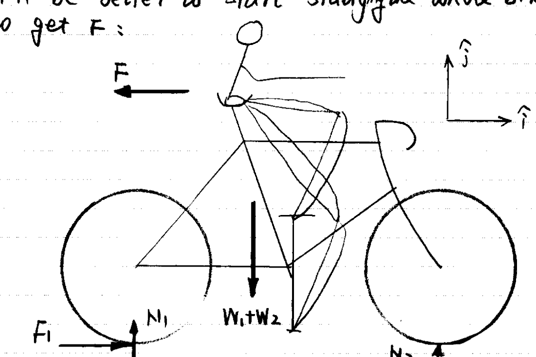
r_w = wheel radius
r_c = chain wheel radius
r_s = real sprocket radius
r_p = crank radius to pedal



Solution:

a): with the person

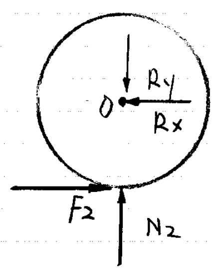
• It'll be better to start studying the whole bike with the person to get F:



Cont. 2 a)

There's no force acted on the right pedal, because now the person's sitting on the bick, the 10 lbf is an internal force.

Also there's no friction force acted on the front wheel, because the bick's back drive. if F_2 appeared:



F.B.D of the front wheel.

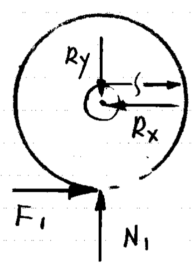
$\Sigma M_O \neq 0$, front wheel can't keep static

Thus:

$$F = F_1 \qquad (1)$$

We need to find F_1.

- Studying the back wheel,



F.B.D. of the back wheel.

The M_1 comes from the rear sprocket!

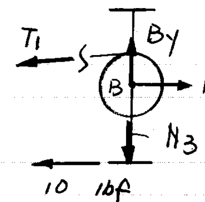
$\Sigma M_O = 0$: $\quad F_1 \cdot r_w = T_1 r_s$

$$\Rightarrow \quad F_1 = \frac{T_1 r_s}{r_w} \qquad (2)$$

We need to get T_1, since it's the force from the rear sprocket, and equal to the tension in the front chain, we study:

Cont. 2. a).

- Studying the chain-crank system.



front sproket and crank

For the front chain wheel and crank:

$\Sigma M_B = 0$: $\quad T_1 r_c - 10\ \text{lbf}\ r_p = 0 \Rightarrow$

$$T_1 = \frac{10\ \text{lbf} \cdot r_p}{r_c} \qquad (3)$$

Plugging back $(3) \to (2) \to (1)$, we have

$$F = F_1 = \frac{T_1 r_s}{r_w} = 10\ \text{lbf} \cdot \frac{r_p r_s}{r_c r_w}$$

$$\boxed{F = 10 \frac{r_p r_s}{r_w r_c}\ \text{lbf} > 0}$$

You have to prevent bick from going forward w/ F

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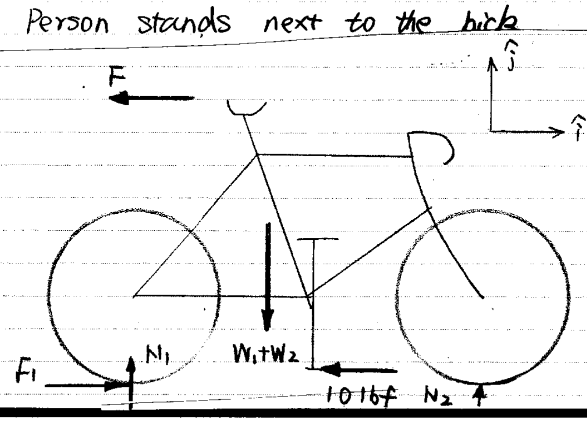
b). Person stands next to the bick



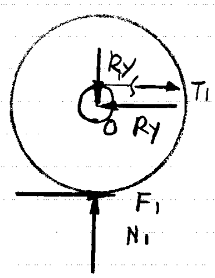
Cont. 2. b).

now 10 lbf is an external force

$\Sigma F_x = 0$: $F + 10\text{ lbf} = F_1 \Rightarrow$

$F = F_1 - 10\text{lbf}$ (1)

- Studying the back wheel, F.B.D is the same as a).

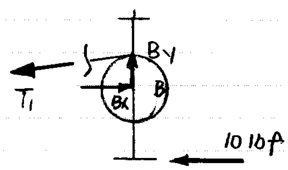


note: Rx, Ry are different from that of in a)

$\Sigma M_O = 0$: $F_1 r_w = T_1 r_s \Rightarrow$

$F_1 = T_1 \frac{r_s}{r_w}$ (2)

- Studying the chain wheel and the sproket



F.B.D.

For the chain wheel and crank:

$\Sigma M_B = 0$: $T_1 \cdot r_c - 10\text{lbf}\, r_p = 0 \Rightarrow$

$T_1 = 10 \frac{r_p}{r_c}$ lbf (3)

plugging (3) → (2) → (1):

$F = F_1 - 10\text{ lbf} = \frac{T_1 r_s}{r_w} - 10\text{ lbf}$

Cont 2. b)

$\Rightarrow$

$F = 10 \frac{r_p r_s}{r_c r_w} - 10$ lbf

$\Rightarrow$

$$\boxed{\begin{array}{l} F = 10\left(\frac{r_p r_s}{r_c r_w} - 1\right) \text{ lbf} \\ F > 0 \quad \text{when} \quad \frac{r_p r_s}{r_c r_w} > 1 \\ F < 0 \quad \text{when} \quad \frac{r_p r_s}{r_c r_w} < 1 \end{array}}$$

$\frac{r_p}{r_w} = \frac{\text{Pedal radius}}{\text{wheel radius}}$

$= \frac{8''}{13''} < 1$ typically

$\frac{r_s}{r_c} = \frac{\text{rear sprocket radius}}{\text{front chain wheel radus}}$

$= \frac{\text{rear circum}}{\text{front circum}}$

$= \frac{\text{rear \# of teets}}{\text{front \# of teets}}$

$= \frac{20}{42} < 1$ typically

So $F = 10\text{ lbf}\left(\underbrace{\left(\frac{r_p}{r_w}\right)\left(\frac{r_s}{r_c}\right)}_{<1} - 1\right)$ typically

< 0 typically

You've to push to keep bike from going backwards

If, say, r_c was very small, this bike would try to go forward in case (b) also:

(no real bike have r_c so small though)