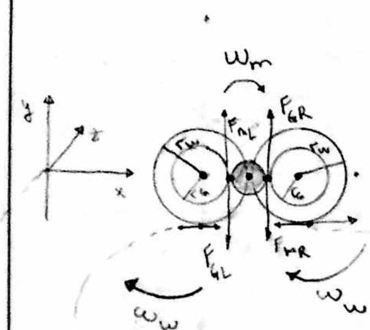
12/2/17 | Micro Mouse Drive train Design | DAN Vyenielo

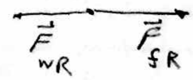
$r_G \equiv$ Radius of Gear

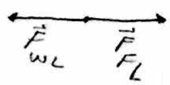
$r_m =$ Radius of Motor

$r_w =$ " " wheel

CW Torque is ⊕







Motor

$$\vec{\tau}_m = \vec{\tau}_{mL} + \vec{\tau}_{mR} = (\vec{r}_m \times \vec{F}_{mL}) + (\vec{r}_m \times \vec{F}_{mR})$$

$$= r_m F_{mL} \sin(90) + r_m F_{mR} \sin(90)$$

$$|\vec{\tau}_m| = r_m [F_{mL} + F_{mR}]$$

Gears

$$\vec{\tau}_G = \vec{r}_G \times \vec{F}_G$$

$$|\vec{\tau}_G| = |\vec{r}_G \times \vec{F}_G| = r_G F_G \sin(90)$$

$$|\vec{\tau}_G| = r_G F_G$$

$$|\vec{F}_G| = |\vec{F}_m|$$

$$\& \ |\vec{\tau}_G| = |\vec{\tau}_w|$$

$$r_G F_G = r_w F_f$$

$$F_m = \frac{r_w F_f}{r_G}$$

wheels

$$\vec{\tau}_w = \vec{r}_w \times \vec{F}_w$$

$$|\vec{F}_w| = |\vec{F}_f|$$

$$|\vec{\tau}_w| = |\vec{r}_w \times \vec{F}_f| = r_w F \sin(90)$$

$$|\vec{\tau}_w| = r_w F_f$$

$$\Rightarrow |\vec{\tau}_m| = r_m \left[\frac{r_w F_f}{r_G} + \frac{r_w F_f}{r_G} \right] = \frac{2 r_m r_w F_f}{r_G}$$

$$\tau_m = \frac{2 r_m}{r_G} \tau_w$$

$$\Rightarrow \boxed{\tau_w = \frac{r_G}{2 r_m} \tau_m}$$

The Torque on a wheel produced By the Torque of the motor is Dependent on the radii of motor and Large Gears.

$\vec{\tau}_w = \vec{r}_w \times \vec{f}_w$

$\tau_w = r_w f_w$

$f_w = \frac{\tau_w}{r_w} = \frac{r_G}{2 r_m r_w} \tau_m$

$f_w \quad f_f$

$|f_w| = |f_f|$

$f_f = \mu N$

"Such that"

$\therefore$

$\mu N = \frac{r_G}{2 r_m r_w} \tau_m$ | $\mu \approx 1$ for wood + rubber, according to a Journal article I found.

$\approx$

$N = \frac{r_G}{2 r_m r_w} \tau_m$

For No slip

$$\left[N \geq \frac{r_G}{2 r_m r_w} \tau_m \right]$$

$\tau_{m_{max}} \equiv \tau_{slip\ wheel} = \tau_s = 9.8\ mN_m$ for Design

$r_w \equiv 2\ cm = 2 \times 10^{-2}\ m$

$N \approx \frac{.5}{4}\ kg \quad \left(\frac{\text{weight of car}}{\#\ \text{of wheels}} \right)$

most likely potential for wheel slip when $\tau_m = \tau_s$

$\Rightarrow \quad N = \left[\frac{r_G}{r_m}\right] \frac{\tau_s}{2 r_w}$ | & $r_w = 2 \times 10^{-2}\ m$

$\therefore \quad \frac{2 r_w N}{\tau_s} \geq \left[\frac{r_G}{r_m}\right] = \frac{25}{49}$] "The ratio of r_G to r_m" for No slip @ Max Torque.

$\frac{25}{49}$

The wheels will get ~~"loose"~~ @ .0098 Nm from the Motor

~~Mass~~ Weight of Car

Battery $\approx$ 200g
Chassis + Circuits $\approx$ 100g
Motors $= 80g$
rPi 0 $= 10g$

$\approx 500\ g = .5 kg$

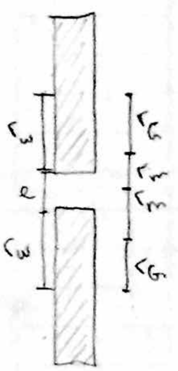
(accounting for error)

The Motor will operate w/in a range of $0 \rightarrow 9.8$ mNm $\mid \propto$ To $0 \rightarrow \sim 1.5$ A

The Gears will be set such that "free spin" will occur @ 9.8 mNm

$$\Rightarrow \frac{r_G}{r_m} = \left[\frac{25}{49}\right]$$ "Golden Ratio"

[Drivetrain Design Constraints]:



$$r_w + l + r_w = r_G + r_m + r_m + r_G$$

$$2r_w + l = 2r_G + 2r_m$$

$$-2r_m \qquad -2r_m$$

$$\frac{2r_G}{2} = \frac{2r_w + l - 2r_m}{2}$$

$$r_G = r_w + \frac{l}{2} - r_m$$

$$\left[N \geq \frac{r_G}{2r_m r_w}\tau_m\right] \equiv \text{Condition for no slip}$$

Find the gear ratio to meet the Design Constraints

$\equiv \tau_s$ as the "slip" torque = 9.8 mNm

$$\therefore N = \frac{r_G}{2r_m r_w}\tau_s = \frac{r_w + \frac{l}{2} - r_m}{2r_m r_w}\tau_s$$

$$N = \left[\frac{1}{2r_m} + \frac{l}{4r_m r_w} - \frac{1}{2r_w}\right]\tau_s$$

$$\frac{N}{\tau_s} = \frac{1}{2r_m} + \frac{l}{4r_m r_w} - \frac{1}{2r_w}$$

$$+\frac{1}{2r_w}$$

$$\frac{N}{\tau} + \frac{1}{2r_w} = \frac{1}{r_m}\left[\frac{1}{2} + \frac{l}{4r_w}\right]$$

$$r_m = \frac{\left(\frac{1}{2} + \frac{l}{4r_w}\right) 2r_w}{\left(\frac{N}{\tau_s} + \frac{1}{2r_w}\right) 2r_w}$$

$$r_m = \frac{r_w + \frac{\ell}{2}}{\frac{2Nr_w}{\tau_s} + 1} = \frac{\tau_s\left[r_w + \frac{\ell}{2}\right]}{2Nr_w + \tau_s}$$

$$\boxed{r_m = \frac{\tau_s\left[r_w + \ell/2\right]}{2Nr_w + \tau_s} \quad \& \quad r_G = r_w + \frac{\ell}{2} - r_m}$$

$$\left[\begin{array}{lll} \tau_s = 9.8\times10^{-3}\ \text{Nm} & & \\ \ell = .50\times10^{-2}\ \text{m} & (.5\ \text{cm}) \\ r_w = .02\ \text{m} & (2\ \text{cm}) \end{array}\right]$$ Design specs

$r_m = 1.489 \times 10^{-2}$ m   14.07 mm $\left[\frac{25}{49}\right]$ Gear ratio

$r_G = 7.601 \times 10^{-3}$ m   7.179 mm

$r_w = 2 \times 10^{-2}$ m   20 mm

Battery Ah requirement

$$5\,A \cdot 10\,\text{min} \cdot \frac{1\,\text{hr}}{60\,\text{min}} \times \frac{1000\,\text{mA}}{1\,\text{A}} = 833\ \text{mAh}$$

[The Battery needs more than 833 mAh.]