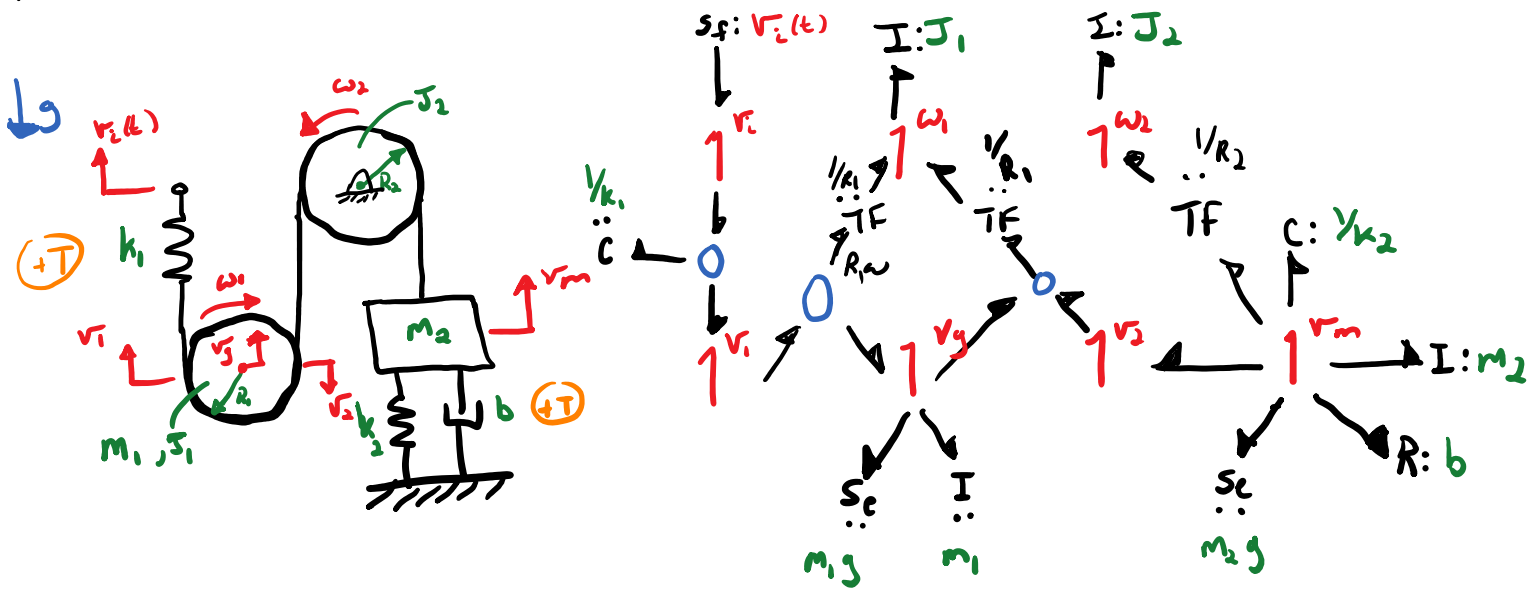
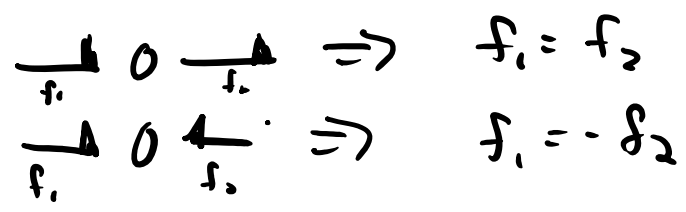


Exercise: Setup TF & O-junctions for kinematic relationships.

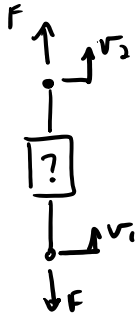


- ① $v_1 = v_3 + R_1 \omega_1$
 - ② $v_2 = -v_3 + R_2 \omega_2$
 - ③ $v_m = R_2 \omega_2 = v_2$
- 3 TF are needed!
- $$v_2 + v_3 - R_1 \omega_1 = 0$$
- $$\parallel$$
- $$-v_2 - v_3 + R_2 \omega_2 = 0$$

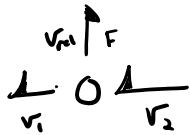


Mechanical Relative Velocities

translation

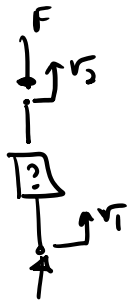


declare that tension produces + power to [?]

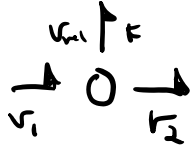


$$v_{rel} = v_2 - v_1$$

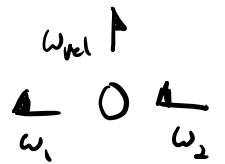
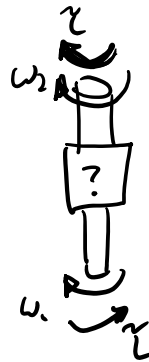
$$v_{rel} - v_2 + v_1 = 0$$



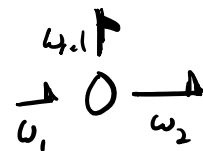
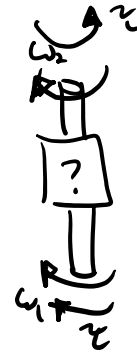
declare that compression produces + power to [?]



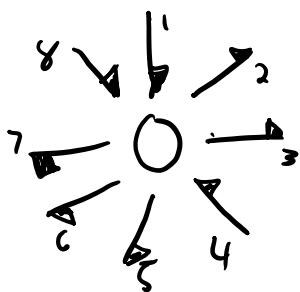
$$v_{rel} = v_1 - v_2$$



$$\omega_{rel} = \omega_2 - \omega_1$$



$$\omega_{rel} = \omega_1 - \omega_2$$

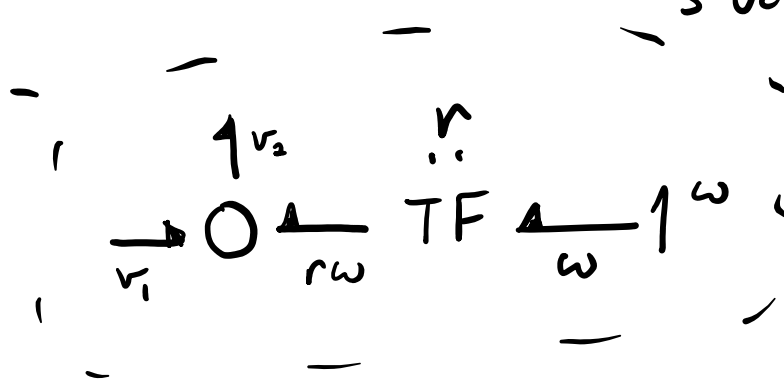


$$\left\{ \begin{aligned} f_1 - f_2 - f_3 + f_4 - f_5 - f_6 - f_7 + f_8 &= 0 \\ -f_1 + f_2 + f_3 - f_4 + f_5 + f_6 + f_7 - f_8 &= 0 \end{aligned} \right.$$

Same equation

Kinematics as bonds (Kinematics = velocity relationships)

$$v_2 = v_1 + r\omega \Rightarrow \underbrace{v_2 - v_1 - r\omega}_{\text{3 velocities summed}} = 0$$



$$\frac{e_1}{f_1} \overset{M}{TF} \frac{e_2}{f_2}$$

$$e_1 = m e_2$$

$$m f_1 = f_2$$

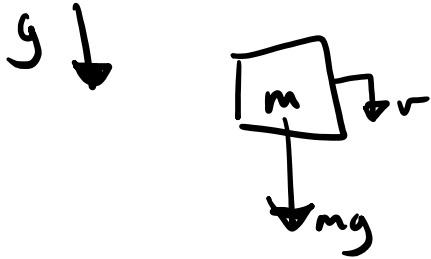


$$v_2 = v_1 + r\omega$$

Power Sign Conventions

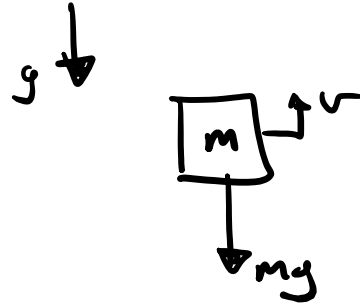
Gravitational force Source

mg : constant force, we desire a sign convention such that power imparts kinetic energy to the inertia: $\rightarrow I$



$$\dot{p} = m\dot{v} = mg$$

$$m\dot{v} - mg = 0$$



$$\dot{p} = m\dot{v} = -mg$$

$$m\dot{v} + mg = 0$$

$$mg : S_e \rightarrow 1 \xrightarrow{m\dot{v}} I : m$$

$$mg : S_e \leftarrow 1 \xrightarrow{m\dot{v}} I : m$$

2-Ports : TF and GY

Transformer: effort & effort, flow & flow

Gyrator: effort & flow, flow & effort

$$\begin{array}{c} m \\ \leftarrow \frac{e_1}{f_1} \text{ TF } \frac{e_2}{f_2} \rightarrow \end{array}$$

$$e_1 = m e_2$$

$$m f_1 = f_2$$

$$\begin{array}{c} r \\ \leftarrow \frac{e_1}{f_1} \text{ GY } \frac{e_2}{f_2} \rightarrow \end{array}$$

$$e_1 = r f_2$$

$$r f_1 = e_2$$

$$\begin{array}{c} m \\ \leftarrow \frac{e_1}{f_1} \text{ TF } \frac{e_2}{f_2} \rightarrow \end{array}$$

$$e_2 = m e_1$$

$$m f_2 = f_1$$

$$\begin{array}{c} r \\ \leftarrow \frac{e_1}{f_1} \text{ GY } \frac{e_2}{f_2} \rightarrow \end{array}$$

$$e_2 = r f_1$$

$$r f_2 = e_1$$

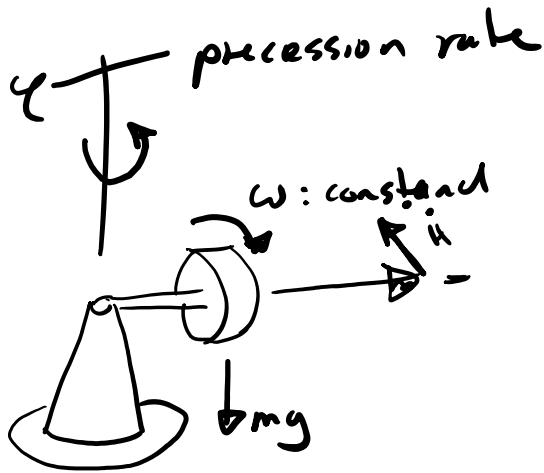
Can technically do:

$$\begin{array}{c} m \\ \leftarrow \frac{e_1}{f_1} \text{ TF } \frac{e_2}{f_2} \rightarrow \end{array}$$

$$\begin{array}{c} -m \\ \leftarrow \frac{e_1}{f_1} \text{ TF } \frac{e_2}{f_2} \rightarrow \end{array}$$

$$e = -m e_2$$

$$m f_1 = -f_2$$



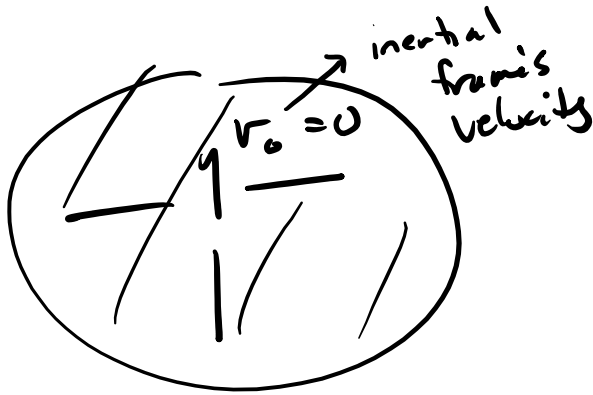
$$e_1 = -m e_2$$

$$m f_1 = f_2$$

$$\dot{H} = \Sigma T$$

Simplification Rules

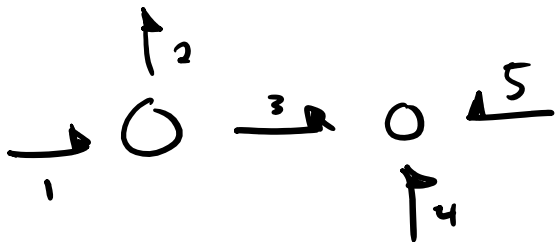
- remove bonds with zero power



- remove through junctions

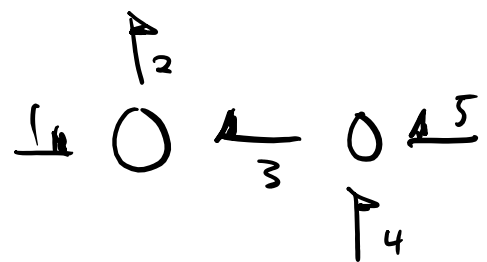


- combine common junctions



$$f_1 - f_1 - f_3 = 0 \quad f_3 + f_4 + f_5 = 0$$

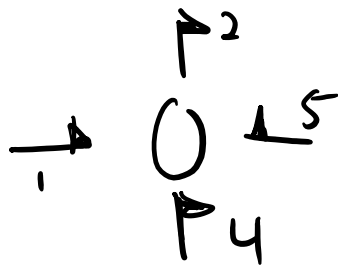
$f_3 = f_1 - f_2$ solve for f_3



$$f_1 - f_2 + f_3 = 0$$

$f_3 = f_1 - f_2$ solve for f_3

$$f_1 - f_2 + f_4 + f_5 = 0$$



same

$$f_1 - f_2 + f_3 = 0$$



$$-f_3 + f_4 + f_5 = 0$$

$$-f_3 = f_1 - f_2$$

$$f_1 - f_2 + f_4 + f_5 = 0$$