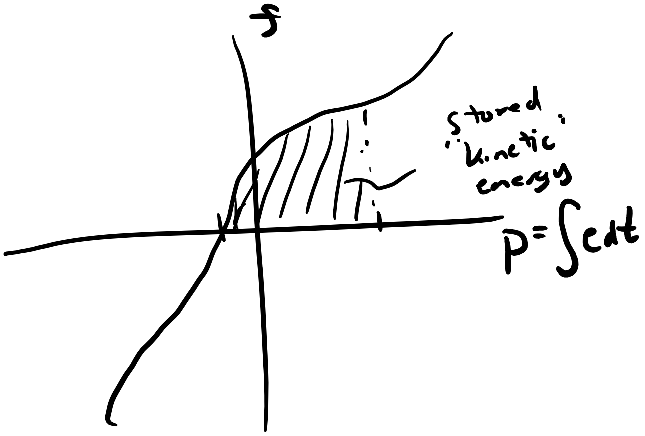
eme171-l04-p01

Monday, January 21, 2019 8:42 AM

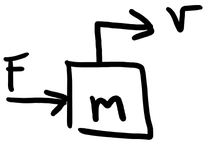
1 port inertia : relates flow and momentum
$\overset{f}{\text{flow}}$ $\overset{p}{\text{momentum}}$

$$\xrightarrow[f]{e} I$$

$$p = \Phi_I(f)$$
$$f = \Phi_I^{-1}(p)$$



Examples

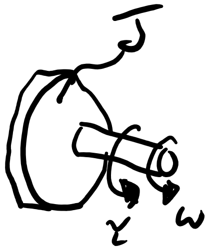


$$\xrightarrow[v]{F} I : m$$

$p = mv$

$\dot{p} = F$

F: force
v: velocity
m: mass



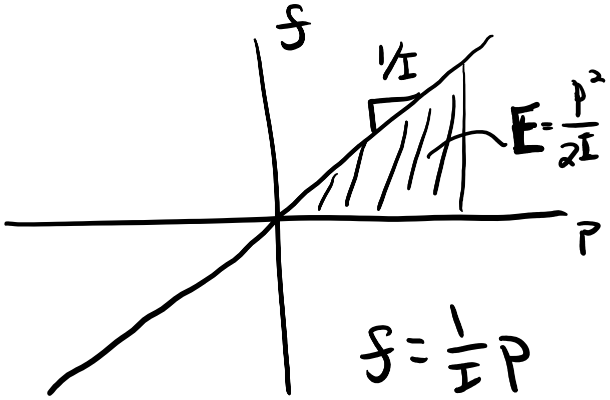
$$\xrightarrow[\omega]{\tau} I : J$$

$h = J\omega$

$\dot{h} = \tau$

τ: torque
ω: angular velocity
J: moment of inertia

non-linear

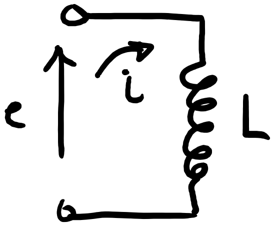


$$f = \frac{1}{I} p$$
$$p = I f$$

non-linear example : relativity

$$p = \frac{mv}{(1 - v^2/c^2)^{1/2}}$$

speed of light



$$\xrightarrow[i]{e} I : L$$

Inductor (linear)

$\lambda = L i$

$$\dot{\lambda} = e$$

$$i = \frac{1}{L}\lambda$$

$$\frac{di}{dt} = \frac{1}{L}\frac{d\lambda}{dt} = \frac{1}{L} e$$

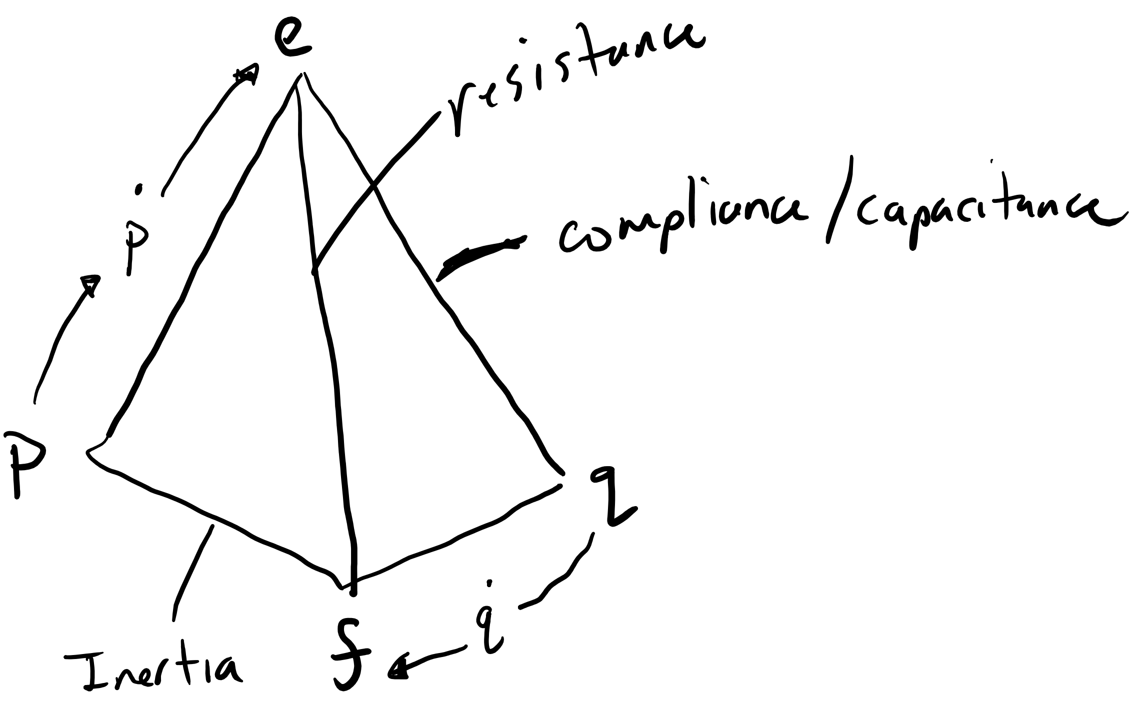
e: voltage

i: current

L: inductance

eme171-l04-p02

Thursday, January 17, 2019 12:25 PM



1-port effort/flow sources

S_e → supplies constant effort, draw the needed flow

S_f → supply constant flow, draw the needed effort

2-ports

Transformer

$$\xrightarrow[f_1]{e_1} \overset{m}{\overset{\cdot\cdot}{TF}} \xrightarrow[f_2]{e_2}$$

$e_1 = m e_2$

$\underset{\text{constant}}{m} f_1 = f_2$

effort & effort

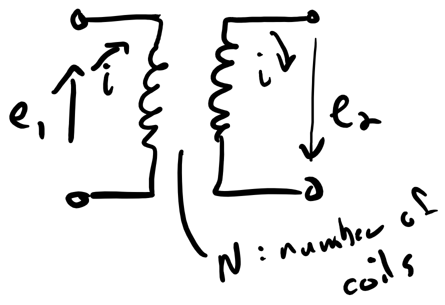
flow & flow

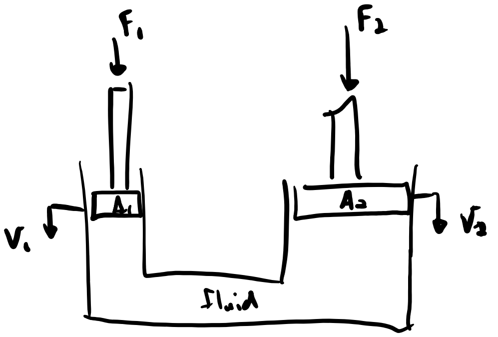
F_1 F_2

effort & effort

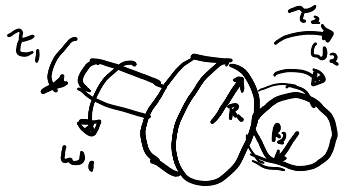
flow & flow

transformer





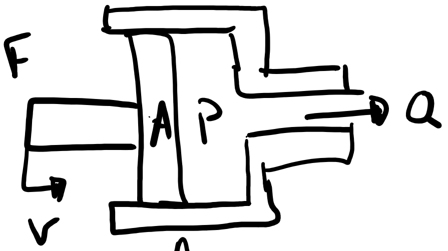
$$\xrightarrow[v_1]{f_1} \overset{A_2/A_1}{\overset{\cdot\,\cdot}{TF}} \xrightarrow[v_2]{f_2}$$



$$\xrightarrow[\omega_1]{\tau_1} \overset{R/R_2}{\overset{\cdot\,\cdot}{TF}} \xrightarrow[\omega_2]{\tau_2}$$

Gear

power conserved!



$$\xrightarrow[v]{F} \overset{A}{\overset{\cdot\,\cdot}{TF}} \xrightarrow[Q]{P}$$

Gyrator

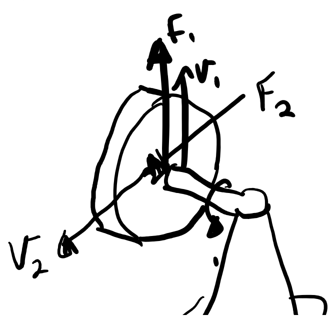
effort & flow

flow & effort

$$\xrightarrow[f_1]{e_1} \overset{r}{\overset{\cdot\,\cdot}{GY}} \xrightarrow[f_2]{e_2}$$

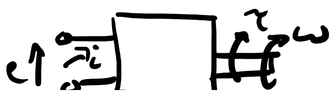
$e_1 = r f_2$

$r f_1 = e_2$

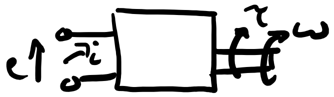


$$\xrightarrow[v]{F_1} \overset{J\omega}{\overset{\cdot\,\cdot}{GY}} \xrightarrow[V_2]{F_2}$$

DC motor



$$\xrightarrow[v_1]{F_1} GY \xrightarrow[V_2]{F_2}$$



k_τ – torque constant

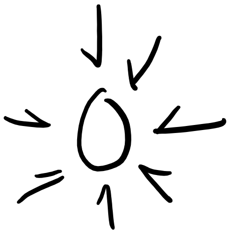
$$\xrightarrow[i]{e} \ddot{G}Y \xrightarrow[\omega]{\tau}$$

$$e = k_\tau \omega$$

$$k_\tau i = \tau$$

3-ports (or more ports)

$$\begin{tikzcd} & {} \arrow[d, "f_2"', "e_2"] & \\ {} \arrow[r, "e_1", "f_1"'] & 0 & {} \arrow[l, "e_3"', "f_3"] \end{tikzcd}$$



Common effort

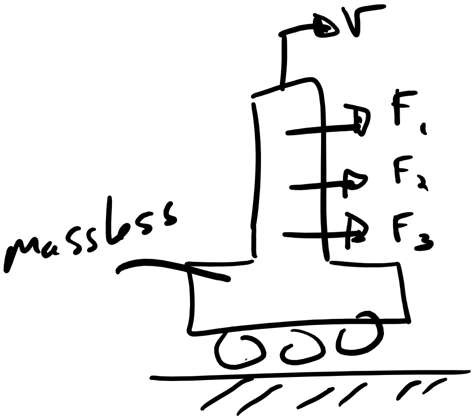
$$e_1 = e_2 = e_3$$

$$f_1 + f_2 + f_3 = 0$$

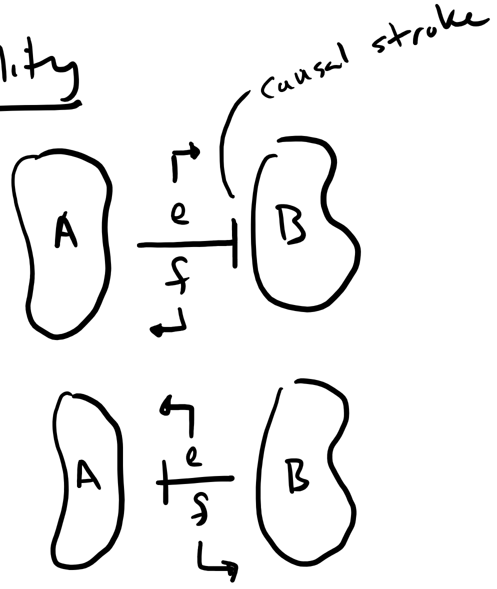
$$\begin{tikzcd} & {} \arrow[d, "f_2"', "e_2"] & \\ {} \arrow[r, "e_1", "f_1"'] & 1 & {} \arrow[l, "e_3"', "f_3"] \end{tikzcd}$$

$$f_1 = f_2 = f_3$$

$$e_1 + e_2 + e_3 = 0$$



Causality



it is possible to control effort OR flow but not both

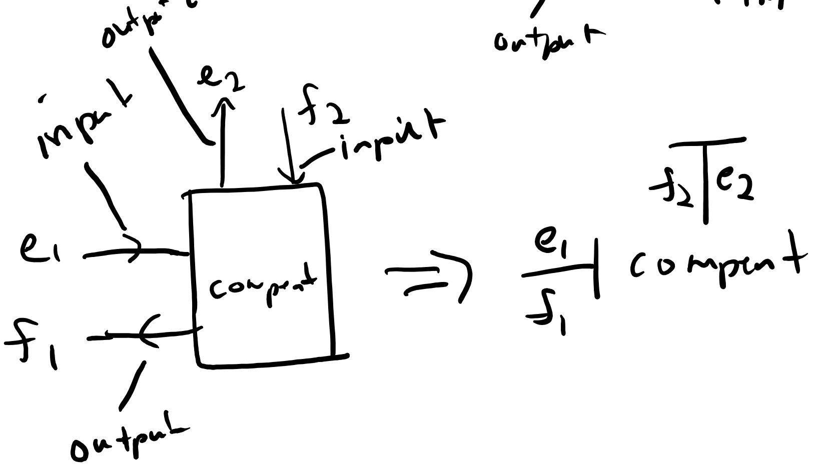
apply force → velocity happens

specify a velocity → some force is required

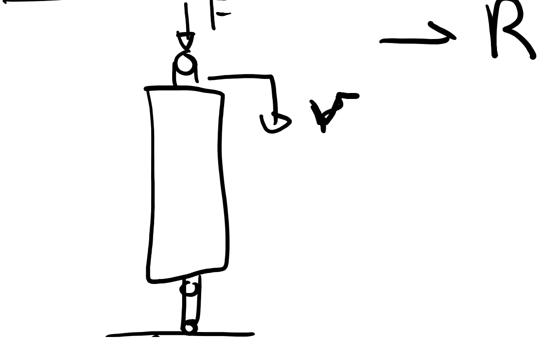
$\vert\!\xrightarrow[i]{e} R:R$ $\quad \underset{\text{output}}{e} = \underset{\text{input}}{i}$

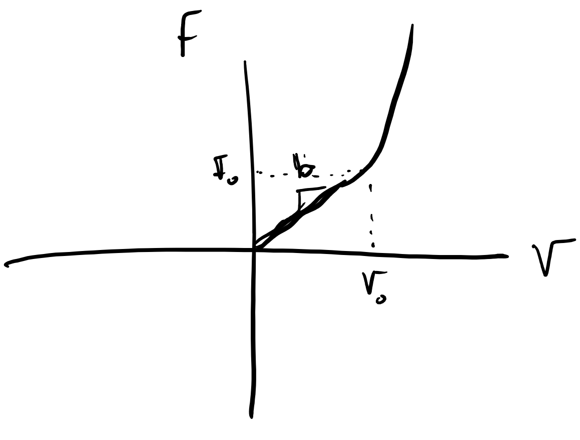
$\xrightarrow[i]{e}\!\vert\ R:R$ $\quad \underset{\text{output}}{i} = \frac{1}{R}\underset{\text{input}}{e}$

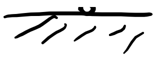
tells us whether to use $e = \Phi_R(f)$ or $f = \Phi_f^{-1}(e)$



Shock Aborber







$$F = \begin{cases} b v & 0 < v < v_0 \\ b^* v^3 & v > v_0 \end{cases}$$

$$F = \Phi_R(v)$$

$$v = \Phi_R^{-1}(F)$$

$$v = \begin{cases} \frac{1}{b} F & 0 < F < F_0 \\ \frac{1}{b^*} \sqrt[3]{F} & F > F_0 \end{cases}$$