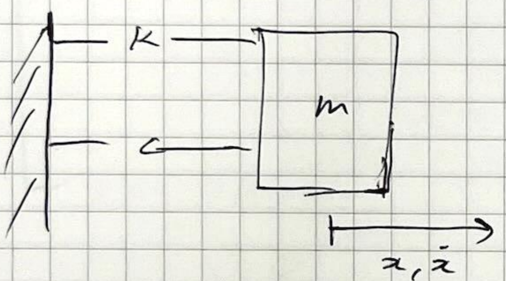
Title Euler - Lagrange Dynamics Date / Time 24/11/8 Page No.

$$L = T(q_1, \cdots q_n, \dot{q}_1, \cdots, \dot{q}_n) - V(q_1, q_2 \cdots q_n)$$

$$\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{q}_i}\right) - \frac{\partial L}{\partial q_i} = 0$$

Rayleigh dissipation function $R = \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} c_{ij}\,\dot{q}_i\,\dot{q}_j$

$$\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{q}_i}\right) - \frac{\partial L}{\partial q_i} + \frac{\partial R}{\partial \dot{q}_i} = Q_i = \tau_i$$



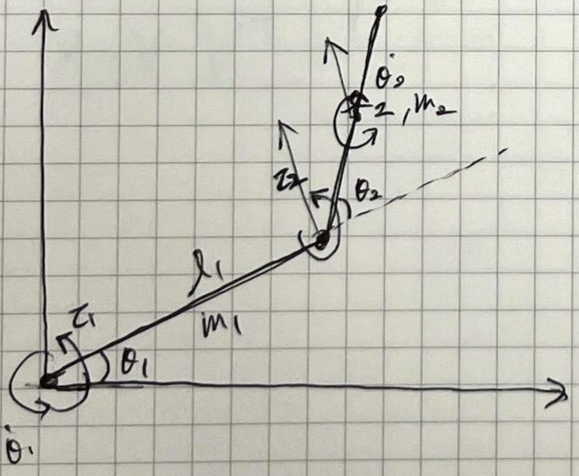
$$L = \frac{1}{2}m\dot{x}^2 - \frac{1}{2}kx^2$$

$$R = \frac{1}{2}c\dot{x}^2$$

$$\frac{d}{dt}(m\dot{x}) - (-kx) + c\dot{x} = 0$$

$$m\ddot{x} + kx + c\dot{x} = 0$$

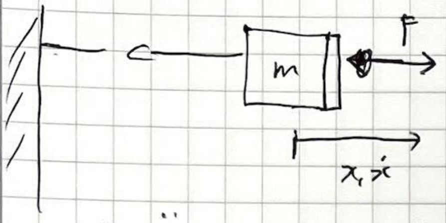
$$K = \frac{1}{2}\dot{q}^T M(q)\,\dot{q} = \cancel{T+V}$$



$$K = \cancel{\tfrac{1}{2}}\left(\tfrac{1}{3}m_1 l_1^2\right)\dot{\theta}_1^2 + \cancel{\tfrac{1}{2}}m_2(l_1\dot{\theta}_1)^2 + \cancel{\tfrac{1}{2}}\left(\tfrac{1}{3}m_2 l_2^2\right)\dot{\theta}_2^2 \quad ?$$

$$= \cancel{\tfrac{1}{2}}\begin{bmatrix}\dot{\theta}_1 & \dot{\theta}_2\end{bmatrix} M(\theta_1,\theta_2)\begin{bmatrix}\dot{\theta}_1\\ \dot{\theta}_2\end{bmatrix}$$

$$\cancel{M(\theta_1,\theta_2) = \Big[}$$



$m\ddot{x} + c\dot{x} = F$

$Z(s) = \frac{F(s)}{V(s)} = \frac{ms^2x + csx}{sx}$

$= ms + c$

$|Z(s)| = C \rightarrow$ resistive.

$$m\begin{bmatrix}\ddot{x}\\ \ddot{y}\\ \ddot{\phi}\end{bmatrix} + c\begin{bmatrix}\dot{x}\\ \dot{y}\\ \dot{\phi}\end{bmatrix} = \begin{bmatrix}F_x\\ F_y\\ T_z\end{bmatrix}$$

m : mass (Inertia)
c : damping (dissipation)
k : stiffness

$V = K_p\theta_e + K_i\int\theta_e\,dt + K_d\dot{\theta}_e$ $\quad \theta_d - \theta$

$\cancel{m\dot{v} + cv = F}$ $\quad m\dot{X} + cX = F$

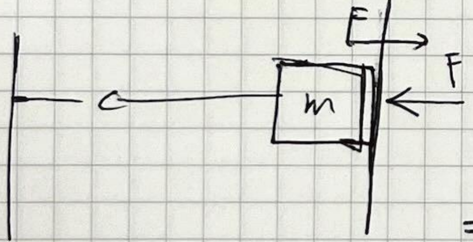
$m\dot{X} = F - cX$ $\quad \cancel{m}\frac{dX}{dt} + \frac{cX}{m} = \frac{F}{m}$

저항열?...

$\cancel{\int m\,dx = \int (F - cX)\,dt}$

$\cancel{L = \frac{1}{2}m_x\dot{x}^2 + \frac{1}{2}m_y\dot{y}^2}$

assist mode!
trajectory following



~~L(x~~

$L(x, \dot{x}, y, \dot{y}, \phi, \dot{\phi})$

$= \frac{1}{2}m_x\dot{x}^2 + \frac{1}{2}m_y\dot{y}^2 + \frac{1}{2}I_z\dot{\phi}^2$

$R = \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n}c_{ij}\dot{q}_i\dot{q}_j$ $\quad \rightarrow R(\dot{x}, \dot{y}, \dot{\phi}) = \frac{1}{2}c_x\dot{x}^2 + \frac{1}{2}c_y\dot{y}^2 + \frac{1}{2}c_z\dot{\phi}^2$

m

$m_x\ddot{x} + c_x\dot{x} = F_x$ $\quad \dot{x} = X$

$m\dot{X} + cX = f$ $\quad \cancel{(1 - \frac{F}{m})\frac{1}{X}dX =}$

$x(0) = 0$
$\dot{x}(0) = 0$

$\dot{X} + \frac{c}{m}X = \frac{F}{m}$

$x = \frac{f}{c}t + \frac{k_1}{c}me^{-\frac{c}{m}t} + k_2$

$\frac{dX}{dt} + \frac{c}{m}X = \frac{F}{m}$

$\dot{x} = \frac{f}{c} - k_1e^{-\frac{c}{m}t}$

$k_2 = -\frac{k_1}{c}m$
$k_1 = \frac{f}{c}$

$\frac{1}{X}\frac{dX}{dt} + \frac{c}{m} = \frac{F}{m}\frac{1}{X}$

$\ddot{x} = \frac{k_1}{m}ce^{-\frac{c}{m}t}$

$\cancel{k_1ce^{-\frac{c}{m}t}} + f - \cancel{ck_1e^{-\frac{c}{m}t}} = f.$

$K_1 = \frac{f}{c} - \dot{x}$