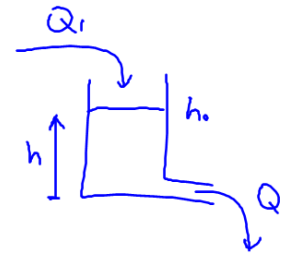
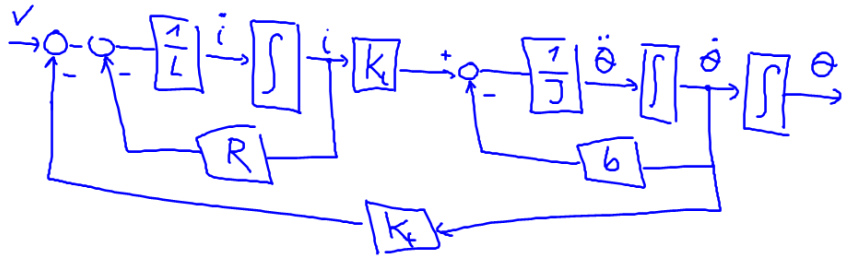


$$L i + R i = V - k_e \dot{\theta}, \quad J \ddot{\theta} + b \dot{\theta} = k_t i$$

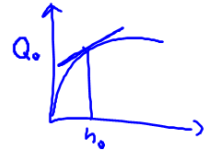
$$i = \frac{1}{L} (-R i - k_e \dot{\theta} + V), \quad \ddot{\theta} = \frac{1}{J} (-b \dot{\theta} + k_t i)$$



$$\dot{V} = Q_i - Q_o, \quad Q_o = r \sqrt{2gh}$$

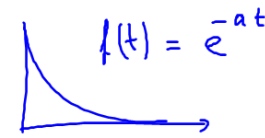
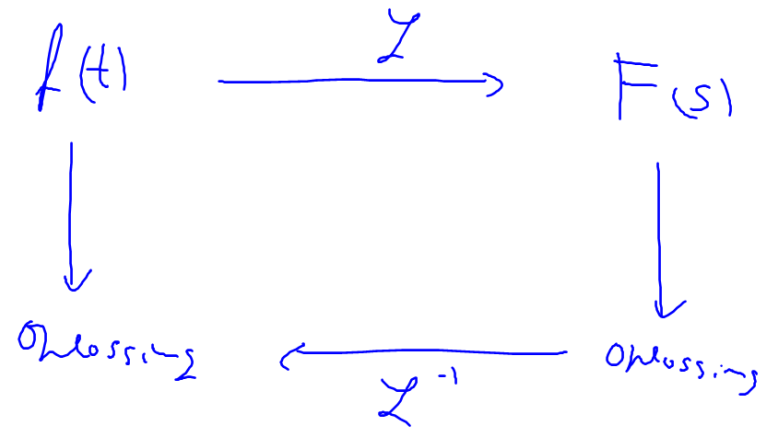
$$A \dot{h} = Q_i - K \sqrt{h} = K \sqrt{h}$$

$$\boxed{A \dot{h} + K \sqrt{h} = Q_i}$$



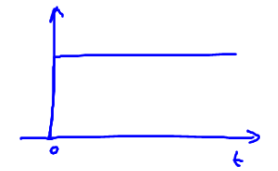
tijds-domein

s-domein



$$F(s) = \int_0^{\infty} e^{-at} \cdot e^{-st} dt = \int_0^{\infty} e^{-(s+a)t} dt$$

$$= \left[-\frac{1}{s+a} \cdot e^{-(s+a)t} \right]_0^{\infty} = \frac{1}{s+a}$$



$$f(t) = 1 \quad t \geq 0$$

$$f(t) = 0 \quad t < 0$$

$$F(s) = \frac{1}{s}$$

$$m \ddot{d}(t) = F(t) - b \dot{d}(t)$$

$$m s^2 D(s) = F(s) - b s D(s)$$

$$(m s^2 + b s) D(s) = F(s)$$

$$G(s) = \frac{D(s)}{F(s)} = \frac{1}{m s^2 + b s} = \frac{1}{s(m s + b)}$$



$$\dot{y} = u$$

$$s Y(s) = U(s)$$

$$\frac{Y(s)}{U(s)} = \frac{1}{s}$$



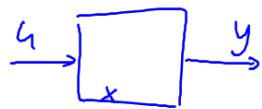
$$[\dot{i} + R i = V - K_t \dot{\theta} \quad , \quad J \ddot{\theta} + b \dot{\theta} = K_t i]$$

$$(L s + R) I(s) = V(s) - K_t s \Theta(s) \quad , \quad (J s^2 + b s) \Theta(s) = K_t I(s)$$

$$G(s) = \frac{\Theta(s)}{V(s)}$$

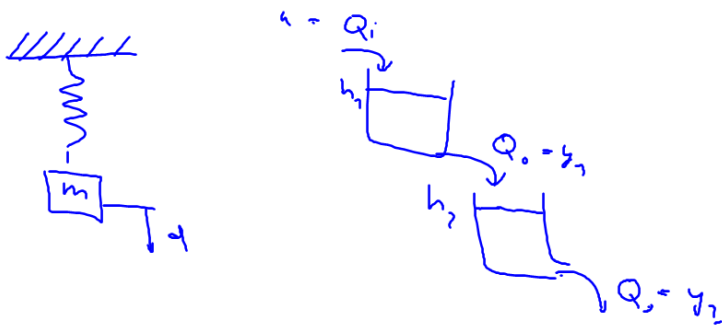
$$(L s + R) K_t I(s) = K_t (V(s) - K_t s \Theta(s))$$

$$(L s + R) (J s^2 + b s) \Theta(s) = (L s + R) K_t I(s)$$



$$\dot{x} = f(x, u)$$

$$y = g(x, u)$$



$$m \ddot{d} + b \dot{d} = F$$

$$\dot{v} = -\frac{b}{m} v + \frac{1}{m} F$$

$$\dot{d} = v$$

$$v = \dot{d}$$

$$x = \begin{pmatrix} v \\ d \end{pmatrix} = \begin{pmatrix} \dot{d} \\ d \end{pmatrix}$$

$$u = F, y = d$$

$$\dot{x} = \begin{pmatrix} \dot{v} \\ \dot{d} \end{pmatrix} = \begin{pmatrix} -\frac{b}{m} & 0 \\ 1 & 0 \end{pmatrix} \begin{pmatrix} v \\ d \end{pmatrix} + \begin{pmatrix} \frac{1}{m} \\ 0 \end{pmatrix} u$$

$$y = \begin{pmatrix} 0 & 1 \end{pmatrix} \begin{pmatrix} v \\ d \end{pmatrix} + \begin{pmatrix} 0 \end{pmatrix} u$$

$$\dot{i} = \frac{1}{L} (-Ri - k_t \omega + V)$$

$$\dot{\omega} = \frac{1}{J} (-b\omega + k_r i)$$

$$\dot{\theta} = \omega$$

$$x = \begin{pmatrix} i \\ \omega \\ \theta \end{pmatrix}$$

$$\underline{u} = \dot{\theta}$$

$$u = V$$

$$y = \theta$$

$$\begin{pmatrix} \dot{i} \\ \dot{\omega} \\ \dot{\theta} \end{pmatrix} = \begin{pmatrix} -\frac{R}{L} & -\frac{k_t}{L} & 0 \\ \frac{k_r}{J} & -\frac{b}{J} & 0 \\ 0 & 1 & 0 \end{pmatrix} \begin{pmatrix} i \\ \omega \\ \theta \end{pmatrix} + \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix} \cdot u$$