(1) $J\ddot{q} + k\dot{q} + mga\cos(q) = \tau$ $\quad a = \frac{l}{2}$ $\quad J = \frac{4}{3} m a^2$ $\quad$ "τ" - input

"q" - output

$y = q$ → salida del sistema (equivalencia)

$\left.\begin{aligned} x_1 &= y = q \\ x_2 &= \dot{y} = \dot{q} \end{aligned}\right\}$ equivalencias y derivadas

$x_1 = q \quad \therefore \quad \dot{x}_1 = \dot{q} \quad \therefore \quad \dot{x}_1 = x_2$

$x_2 = \dot{q} \quad \therefore \quad \dot{x}_2 = \ddot{q}$

$J\dot{x}_2 + kx_2 + mga\cos(x_1) = \tau$

$\dot{x}_2 = \left(\tau - kx_2 - mga\cos(x_1)\right)\frac{1}{J} \qquad \dot{x}_1 = x_2$

$\dot{x}_1 = 0x_1 + x_2 + 0\tau$

$\dot{x}_2 = -\frac{mga\cos(x_1)}{J} - \frac{k}{J}x_2 + \frac{\tau}{J}$

$$\dot{x} = \overbrace{\begin{bmatrix} 0 & 1 \\ -\frac{mga}{J}\cos(1) & -\frac{K}{J} \end{bmatrix}}^{A} x + \overbrace{\begin{bmatrix} 0 \\ \frac{1}{J} \end{bmatrix}}^{B} \tau$$

$$y = \overbrace{\begin{bmatrix} 0 & 1 \end{bmatrix}}^{C} x + \overbrace{0}^{D}\tau$$

② $L\ddot{q} + R\dot{q} + \frac{1}{c} q = E$ "E" – input "q" = output

$y = q$

$x_1 = y = q$

$x_2 = \dot{y} = \dot{q}$

$x_1 = q$

$\dot{x}_1 = \dot{q} = x_2$

$\dot{x}_2 = \ddot{q}$

$$L\dot{x}_2 + R x_2 + \frac{x_1}{c} = E$$

$$\dot{x}_2 = \left(E - R x_2 - \frac{x_1}{c}\right)\frac{1}{L}$$

$$\dot{x}_1 = 0 x_1 + x_2 + 0E$$

$$\dot{x}_2 = -\frac{x_1}{CL} - \frac{R}{L} x_2 + \frac{1}{L} E$$

$$\dot{x} = \overset{A}{\begin{bmatrix} 0 & 1 \\ -\frac{1}{CL} & -\frac{R}{L} \end{bmatrix}} x + \overset{B}{\begin{bmatrix} 0 \\ \frac{1}{L} \end{bmatrix}} E$$

$$y = \overset{C}{\begin{bmatrix} 0 & 1 \end{bmatrix}} x + \overset{D}{0} E$$

③ $\tau^2 \ddot{y} + 2\varepsilon\tau \dot{y} + y = x$

"x" – input
"y" – output

$y_1 = y$

$\dot{y}_1 = \dot{y} = y_2$

$\dot{y}_2 = \ddot{y}$

$\dot{y}_2 \tau + 2\varepsilon\tau y_2 + y_1 = x$

$\dot{y}_2 = \frac{1}{\tau}\left(x - 2\varepsilon\tau y_2 - y_1\right)$ $\qquad \dot{y}_1 = y_2$

$\dot{y}_1 = 0y_1 + y_2 + 0x$

$\dot{y}_2 = -\frac{y_1}{\tau} - 2\varepsilon y_2 + \frac{x}{\tau}$

$$\dot{x} = \overset{A}{\begin{bmatrix} 0 & 1 \\ -\frac{1}{\tau} & -2\varepsilon \end{bmatrix}} y + \overset{B}{\begin{bmatrix} 0 \\ \frac{1}{\tau} \end{bmatrix}} x$$

$$y = \overset{C}{\begin{bmatrix} 0 & 1 \end{bmatrix}} y + \overset{D}{0} x$$