a) $J\ddot{q} + K\dot{q} + mga\sin(q) = \tau$ $\qquad y = q$

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

$x_2 = \dot{q} \;;\; \dot{x}_2 = \ddot{q}$ $\qquad x_2 = \dot{y} = \dot{q}$

$$J\dot{x}_2 + K x_2 + mga\sin(x_1) = \tau$$

$$\dot{x}_2 = \frac{\tau - mga\sin(x_1) - Kx_2}{J}$$

$$\begin{cases} \dot{x}_1 = x_2 \\ \dot{x}_2 = \dfrac{\tau - mga\sin(x_1) - Kx_2}{J} \end{cases}$$

$$\begin{cases} \dot{x}_1 = 0x_1 + 1x_2 + 0\tau \\ \dot{x}_2 = \dfrac{\tau}{J} - \dfrac{mga\sin(x_1)}{J} - \dfrac{Kx_2}{J} \end{cases}$$

$$y = x_1 + 0x_2 + 0\tau$$

$$\sin(q) \approx q$$

$$\boxed{\dot{x} = \begin{bmatrix} 0 & 1 \\ -\dfrac{m\cdot g\cdot a\cdot q}{J} & -\dfrac{K}{J} \end{bmatrix} x + \begin{bmatrix} 0 \\ \dfrac{1}{J} \end{bmatrix} \tau \qquad y = \begin{bmatrix} 1 & 0 \end{bmatrix} x + 0\tau}$$

b) $L\ddot{q} + R\dot{q} + \frac{1}{c}q = E$

$y = q$

$x_1 = y = q$

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

$x_1 = q \;\}\; \dot{x}_1 = \dot{q}$

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

$x_2 = \dot{q} \;\}\; \dot{x}_2 = \ddot{q}$

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

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

$$\begin{cases} \dot{x}_1 = x_2 \\ \dot{x}_2 = \dfrac{E - \frac{1}{c}x_1 - R x_2}{L} \end{cases}$$

$$\begin{cases} \dot{x}_1 = x_1(0) + x_2(1) + E(0) \\ \dot{x}_2 = -\dfrac{1}{L(C)}x_1 - \dfrac{R}{L}x_2 + \dfrac{E}{L} \end{cases}$$

$y = x_1 + 0x_2 + 0E$

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

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

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

$y = q \quad x_1 = y = q$

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

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

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

$\tau^2\dot{x}_2 + 2\varepsilon\tau x_2 + x_1 = x$

$\dot{x}_2 = \dfrac{x - 2\varepsilon\tau x_2 - x_1}{\tau^2}$

$$\begin{cases} \dot{x}_1 = x_2 \\ \dot{x}_2 = \dfrac{x - x_1 - 2\varepsilon\tau x_2}{\tau^2} \end{cases}$$

$$\begin{cases} \dot{x}_1 = 0x_1 + 1x_2 + 0x \\ \dot{x}_2 = \dfrac{x_1}{t^2} - \dfrac{2\varepsilon\tau x_2}{\tau^2} + \dfrac{1}{t^2}x \end{cases}$$

$y = x_1 + 0x_2 + 0x$

$$\boxed{\begin{aligned} &\qquad\quad A \qquad\qquad\qquad\qquad B \\ \dot{x} &= \begin{bmatrix} 0 & 1 \\ -\frac{1}{t^2} & -\frac{2\varepsilon\tau}{\tau^2} \end{bmatrix} x + \begin{bmatrix} 0 \\ \frac{1}{t^2} \end{bmatrix} x \\ y &= \begin{bmatrix} 1 & 0 \end{bmatrix} x + 0x \end{aligned}}$$