

2.23

$$\begin{bmatrix} \dot{\theta}_2 \\ \ddot{\theta}_2 \\ \dot{\theta}_1 \\ \ddot{\theta}_1 \\ \dot{i}_1 \\ \ddot{i}_1 \end{bmatrix} = \begin{bmatrix} 0 & - & 0 & 0 & 0 \\ 0 & \frac{1}{J_2} k & -\frac{b}{J_2} & \frac{k}{J_2} & \frac{b}{J_2} & 0 \\ 0 & \frac{1}{J_1} k & \frac{b}{J_1} & -\frac{k}{J_1} & -\frac{(b+k)}{J_1} & 0 \\ 0 & 0 & 0 & 0 & \frac{1}{L_a} k_e & -\frac{R_a}{L_a} \\ 0 & 0 & 0 & -\frac{k}{L_a} & -\frac{R_a}{L_a} & \frac{1}{L_a} \end{bmatrix} \begin{bmatrix} \theta_2 \\ \dot{\theta}_2 \\ \theta_1 \\ \dot{\theta}_1 \\ i_1 \\ \dot{i}_1 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ \frac{1}{L_a} \end{bmatrix} v_a$$

3.14

$$\frac{\Theta_2(s)}{V_a(s)} = \frac{k_f(b s + k)}{L_a J_1 J_2 s^5 + [R_a J_1 J_2 + L_a (J_1 b + J_2 (b + B))] s^4 + [R_a (J_1 b + J_2 (b + B)) + L_a (J_1 k + B b + J_2 k) + \dots + k_f k_e J_2] s^3 + [R_a (J_1 k + B b + J_2 k) + L_a B k + k_f k_e b] s^2 + [R_a B k + k_f k_e k] s}$$

3.7

(b)  $f(t) = 1 - \frac{10}{9} e^{-t} + \frac{1}{9} e^{-10t}$

3.7

(d)  $f(t) = \frac{6}{5} e^{-2t} + \frac{9}{5} e^{-\frac{5}{2}t} \cos\left(t\sqrt{\frac{19}{4}}\right) - \frac{51}{5\sqrt{19}} e^{-\frac{5}{2}t} \sin\left(t\sqrt{\frac{19}{4}}\right)$

3.9

(d)  $y(t) = \frac{1}{2} \sin t + \cos(t\sqrt{3}) + \frac{\sqrt{3}}{2} \sin(t\sqrt{3})$

The others are for you to do ...