

# Newton-Euler Method

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## Linearized System

$$\mathbf{A} = \begin{bmatrix} 0 & 1 & 0 & 0 \\ a_{21} & 0 & a_{23} & 0 \\ 0 & 0 & 0 & 1 \\ a_{41} & 0 & a_{43} & 0 \end{bmatrix}, \quad \mathbf{B} = \begin{bmatrix} 0 \\ b_2 \\ 0 \\ b_4 \end{bmatrix}$$

where  $D = I_b I_w + I_b M_b r^2 + I_b M_w r^2 + I_w L_b^2 M_b + L_b^2 M_b M_w r^2$

$$a_{21} = -\frac{L_b^2 M_b^2 g r}{D}, \quad a_{23} = -\frac{L_b^2 M_b^2 g r^2}{D}$$

$$a_{41} = \frac{I_w L_b M_b g + L_b^2 M_b^2 g r + L_b M_b^2 g r^2 + L_b M_b M_w g r^2}{r D}$$

$$a_{43} = \frac{I_w L_b M_b g r + L_b^2 M_b^2 g r^2 + L_b M_b^2 g r^3 + L_b M_b M_w g r^3}{r D}$$

$$b_2 = -\frac{I_b r + L_b^2 M_b r + L_b M_b r^2}{D}, \quad b_4 = \frac{I_b r + I_w r + L_b^2 M_b r + 2L_b M_b r^2 + M_b r^3 + M_w r^3}{r D}$$