

Force analysis via FBD of individual links

{AB → 0.14, AC → 0.06, CF → 0.25, h → 0.01, d → 0.01, hSlider → 0.02, wSlider → 0.05,  
ro → 8000, g → 9.807, Me → 1000., phi[t] → 1.0472, phi'[t] → 52.3599, phi''[t] → 0}

Inertia forces and moments

Link 1

$m_1 = \rho \cdot AB \cdot h \cdot d = 0.112$  [kg]

$IC_1 = m_1 (AB^2 + h^2) / 12 = 0.000183867$  [kg m<sup>2</sup>]

$F_{in1} = -m_1 \cdot a_{C1} = \{10.7469, 18.6142, 0\}$  [N]

$F_1 = F_{in1} + G_1 = \{10.7469, 17.5158, 0\}$  [N]

$M_{in1} = M_1 = -IC_1 \cdot \alpha_{10} = \{0, 0, 0\}$  [N m]

Link 2

$m_2 = \rho \cdot hSlider \cdot wSlider \cdot d = 0.08$  [kg]

$IC_2 = m_2 (hSlider^2 + wSlider^2) / 12 = 0.0000193333$  [kg m<sup>2</sup>]

$F_{in2} = -m_2 \cdot a_{C2} = \{15.3527, 26.5917, 0\}$  [N]

$F_2 = F_{in2} + G_2 = \{15.3527, 25.8071, 0\}$  [N]

$M_{in2} = M_2 = -IC_2 \cdot \alpha_{20} = \{0, 0, -0.0475952\}$  [N m]

Link 3

$m_3 = \rho \cdot CF \cdot h \cdot d = 0.2$  [kg]

$IC_3 = m_3 (CF^2 + h^2) / 12 = 0.00104333$  [kg m<sup>2</sup>]

$F_{in3} = -m_3 \cdot a_{C3} = \{145.238, 45.2941, 0\}$  [N]

$F_3 = F_{in3} + G_3 = \{145.238, 43.3327, 0\}$  [N]

$M_{in3} = M_3 = -IC_3 \cdot \alpha_{30} = \{0, 0, -2.5685\}$  [N m]

$M_{3e} = -\text{Sign}[\omega_2] \{0, 0, M_e\} = \{0, 0, -1000.\}$  [N m]

Joint reactions

Link 3

Sum F for link 3:  $F_3 + F_{03} + F_{23} = 0$

(x):  $145.238 + F_{03x} + F_{23x} = 0$  (1)

(y):  $43.3327 + F_{03y} + F_{23y} = 0$  (2)

Sum M for link 3 wrt C3:  $r_{C3C} \times F_{03} + r_{C3Q} \times F_{23} + M_3 + M_{3e} = 0$

(z):  $-1002.57 + 0.0823082 F_{03x} - 0.0940764 F_{03y} + 0.142308 F_{23x} - 0.0940764 F_{23y} + F_{23y} \cdot x_Q - F_{23x} \cdot y_Q = 0$  (3)

F23 perpendicular to BC:  $F_{23} \cdot BC = 0 \Rightarrow$

$F_{23} \cdot \{-0.07, -0.0612436, 0\} = 0$  (4)

point Q is on BC:  $(y_B - y_C) / (x_B - x_C) = (y_Q - y_C) / (x_Q - x_C) \Rightarrow$

$$0.874908 - \frac{-0.06 + y_Q}{x_Q} = 0 \quad (5)$$

Link 2

Sum F for link 2:  $F_2 + F_{32} + F_{12} = 0$

$$(x): 15.3527 + F_{12x} - F_{23x} = 0 \quad (6)$$

$$(y): 25.8071 + F_{12y} - F_{23y} = 0 \quad (7)$$

Sum M for link 2 wrt C2(B):  $BQ \times F_{32} + M_2 = 0$

$$(z): -0.0475952 - 0.121244 F_{23x} + 0.07 F_{23y} - F_{23y} x_Q + F_{23x} y_Q = 0 \quad (8)$$

From Eqs. (1)-(8)  $\Rightarrow F_{03x}, F_{03y}, F_{23x}, F_{23y}, F_{12x}, F_{12y}, x_Q, y_Q$

$$F_{03} = \{F_{03x}, F_{03y}, 0\} = \{7008.6, -8220.01, 0\} \text{ [N]}$$

$$F_{23} = \{F_{23x}, F_{23y}, 0\} = \{-7153.84, 8176.68, 0\} \text{ [N]}$$

$$F_{12} = \{F_{12x}, F_{12y}, 0\} = \{-7169.19, 8150.87, 0\} \text{ [N]}$$

$$r_Q = \{x_Q, y_Q, 0\} = \{0.0699967, 0.121241, 0\} \text{ [m]}$$

Link 1

Sum F for link 1:  $F_1 + F_{21} + F_{01} = 0 \Leftrightarrow F_{01} = -F_{21} - F_1$

$$F_{01} = \{-7179.94, 8133.35, 0\} \text{ [N]}$$

Sum M for 1 wrt C1:  $C_{1B} \times F_{21} + C_{1A} \times F_{01} + M_1 + M_m = 0 \Leftrightarrow$

$$M_m = - ( C_{1B} \times F_{21} + C_{1A} \times F_{01} + M_1 )$$

$$M_m = \{0., 0., 1439.82\} \text{ [Nm]}$$