

Force analysis via contour method

{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 m²]

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

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

$M_{in1} = M_1 = -IC_1 \alpha_{10} = \{0, 0, 0\}$ [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 m²]

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

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

$M_{in2} = M_2 = -IC_2 \alpha_{20} = \{0, 0, -0.0475952\}$ [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 m²]

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

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

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

$M_{3e} = -\text{Sign}[\omega^2] \{0, 0, M_e\} = \{0, 0, -1000.\}$ [N m]

Joint reactions

Joint C_R

F03-3-B_T-2-B_R

B_T: Sum F for 3 upon rCB direction: $(F_3 + F_{03}) \cdot r_{CB} = 0$

$0.07(145.238 + F_{03x}) + 0.0612436(43.3327 + F_{03y}) == 0$ (1)

B_R: Sum M wrt B for 3 & 2:

$r_{BC} \times F_{03} + r_{BC3} \times F_3 + M_3 + M_{3e} + M_2 = 0$

$-1004.63 + 0.0612436 F_{03x} - 0.07 F_{03y} == 0$ (2)

From Eqs. (1) (2) => F_{03x} , F_{03y}

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

Joint B_T

$$I: F_{23-3-C_R-0}$$

$$II: F_{32-2-B_R-1}$$

F23 perpendicular to BC: $F_{32} \cdot BC = 0$ =>

$$-0.07 F_{23x} - 0.0612436 F_{23y} = 0 \quad (3)$$

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

$$0.874908 = \frac{-0.06 + y_Q}{x_Q} \quad (4)$$

I: C_R: Sum M wrt C for 3

$$r_{CQ} \times F_{23} + r_{CC3} \times F_3 + M_{3e} + M_3 = 0$$

$$-1010.45 + 0.06 F_{23x} + F_{23y} x_Q - F_{23x} y_Q = 0 \quad (5)$$

II: B_R: Sum M wrt B for 2

$$r_{BQ} \times F_{32} + M_2 = 0$$

$$-0.0475952 - 0.121244 F_{23x} + 0.07 F_{23y} - F_{23y} x_Q + F_{23x} y_Q = 0 \quad (6)$$

From Eqs. (3)-(6) => F_{23x} , F_{23y} , x_Q , y_Q

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

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

Joint B_R

$$F_{12-2-B_T-3-C_R}$$

B_T: Sum F for 2 upon r_{CB} direction: $(F_2 + F_{12Sol}) \cdot r_{CB} = 0$

$$0.07 (15.3527 + F_{12x}) + 0.0612436 (25.8071 + F_{12y}) = 0 \quad (7)$$

C_R: Sum M wrt C for 2 & 3

$$r_{CB} \times F_{12} + r_{CB} \times F_2 + r_{CC3} \times F_3 + M_3 + M_{3e} + M_2 = 0$$

$$-1009.63 - 0.0612436 F_{12x} + 0.07 F_{12y} = 0 \quad (8)$$

From Eqs. (7) (8) => F_{12x} , F_{12y}

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

Joint A_R

$$F_{01-1-B_R-2-B_T-3-C_R}$$

B_R: Sum M wrt B for 1

$$r_{BA} \times F_{01} + r_{BC1} \times F_1 + M_1 + M_m = 0$$

$$0.0384434 + 0.121244 F_{01x} - 0.07 F_{01y} + M_{mz} == 0 \quad (9)$$

$$B_T: \text{Sum } F \text{ for } 1 \text{ \& } 2 \text{ upon } r_{CB} \text{ direction: } (F_{01} + F_1 + F_2) \cdot r_{CB} = 0$$

$$0.07 (26.0996 + F_{01x}) + 0.0612436 (43.3229 + F_{01y}) == 0 \quad (10)$$

$$C_R: \text{Sum } M \text{ wrt } C \text{ for } 1, 2 \text{ \& } 3$$

$$r_{CA} \times F_{01} + r_{CC1} \times F_1 + r_{CB} \times F_2 + r_{CC3} \times F_3 + M_1 + M_m + M_2 + M_3 + M_3 e = 0$$

$$-1009.02 + 0.06 F_{01x} + M_{mz} == 0 \quad (11)$$

$$\text{From Eqs. (9) (10) (11) } \Rightarrow F_{01x}, F_{01y}, M_{mz}$$

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

$$M_m = \{0, 0, M_{mz}\} = \{0, 0, 1439.82\} \text{ [N m]}$$