

Force analysis via contour method

```
{AB → 0.14, AC → 0.06, CF → 0.2, 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] → 9.8696, phi''[t] → 0}
```

Inertia forces and moments

Link 1

```
m1 = ro AB h d = 0.112 [kg]
```

```
IC1 = m1 (AB^2+h^2)/12 = 0.000183867 [kg m^2]
```

```
Fin1 = -m1 aC1 = {0.381844, 0.661373, 0} [N]
```

```
F1 = Fin1 + G1 = {0.381844, -0.437011, 0} [N]
```

```
Min1 = M1 = -IC1 alpha10 = {0, 0, 0} [N m]
```

Link 2

```
m2 = ro hSlider wSlider d = 0.08 [kg]
```

```
IC2 = m2 (hSlider^2+wSlider^2)/12 = 0.0000193333 [kg m^2]
```

```
Fin2 = -m2 aC2 = {0.545491, 0.944818, 0} [N]
```

```
F2 = Fin2 + G2 = {0.545491, 0.160258, 0} [N]
```

```
Min2 = M2 = -IC2 alpha20 = 0 [N m]
```

Link 3

```
m3 = ro CF h d = 0.16 [kg]
```

```
IC3 = m3 (CF^2+h^2)/12 = 0.000534667 [kg m^2]
```

```
Fin3 = -m3 aC3 = {3.30266, 1.02997, 0} [N]
```

```
F3 = Fin3 + G3 = {3.30266, -0.539153, 0} [N]
```

```
Min3 = M3 = -IC3 alpha30 = {0, 0, -0.0467673} [N m]
```

```
M3e = -Sign[omega2]{ 0, 0, Me } = {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: (F3+F03).rCB = 0
```

```
0.07 (3.30266 + F03x) + 0.0612436 (-0.539153 + F03y) == 0 (1)
```

```
B_R: Sum M wrt B for 3 & 2:
```

```
rBC x F03+ rBC3 x F3 + M3 + M3e + M2 = 0
```

```
-1000.06 + 0.0612436 F03x - 0.07 F03y == 0 (2)
```

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

$$F_{03} = \{F_{03x}, F_{03y}, 0\} = \{7078.4, -8093.69, 0\} \text{ [N]}$$

Joint B_T

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

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

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

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

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

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

I: C_R: Sum M wrt C for 3

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

$$-1000.3 + 0.06 F_{23x} + F_{23y} x_Q - F_{23x} y_Q = 0 \quad (5)$$

II: B_R: Sum M wrt B for 2

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

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

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

$$F_{23} = \{F_{23x}, F_{23y}, 0\} = \{-7081.71, 8094.23, 0\} \text{ [N]}$$

$$r_Q = \{x_Q, y_Q, 0\} = \{0.07, 0.121244, 0\} \text{ [m]}$$

REMARK: $r_{BQ} \times F_{32} + M_2 = 0$ & $M_2=0 \Rightarrow r_Q = r_B$

Joint B_R

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

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

$$0.07 (0.545491 + F_{12x}) + 0.0612436 (0.160258 + F_{12y}) = 0 \quad (7)$$

C_R: Sum M wrt C for 2 & 3

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

$$-1000.33 - 0.0612436 F_{12x} + 0.07 F_{12y} = 0 \quad (8)$$

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

$$F_{12} = \{F_{12x}, F_{12y}, 0\} = \{-7082.25, 8094.07, 0\} \text{ [N]}$$

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

$$0.07 (0.927335 + F_{01x}) + 0.0612436 (-0.276753 + F_{01y}) == 0 \quad (10)$$

C_R: Sum M wrt C for 1, 2 & 3

$$r_{CAx} F_{01} + r_{CC1x} F_1 + r_{CBx} F_2 + r_{CC3x} F_3 + M_1 + M_m + M_2 + M_3 + M_3e = 0$$

$$-1000.34 + 0.06 F_{01x} + M_mz == 0 \quad (11)$$

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

$$F_{01} = \{F_{01x}, F_{01y}, 0\} = \{-7082.63, 8094.51, 0\} \text{ [N]}$$

$$M_m = \{0, 0, M_mz\} = \{0, 0, 1425.3\} \text{ [N m]}$$