

6.6 Joint Forces Analysis Using Individual Links

crank-slider mechanism Fig.6.8

$$AB=0.18 \text{ [m]}$$

$$BC=0.7 \text{ [m]}$$

$$h=0.01 \text{ [m]}$$

$$d=0.01 \text{ [m]}$$

$$hSlider=0.02 \text{ [m]}$$

$$wSlider=0.05 \text{ [m]}$$

$$\rho=8000 \text{ [kg/m}^3\text{]}$$

$$g=9.807 \text{ [m/s}^2\text{]}$$

$$\phi=0.785398 \text{ [rad]}=45. \text{ [deg]}$$

$$\omega=41.8879 \text{ [rad/s]}$$

$$AC1=\{0.0636396, 0.0636396, 0\} \text{ [m]}; AB=\{0.127279, 0.127279, 0\} \text{ [m]}$$

$$AC2=\{0.471445, 0.0636396, 0\} \text{ [m]}; AC3=AC=\{0.815611, 0, 0\} \text{ [m]}$$

$$aC1=\{-111.662, -111.662, 0\} \text{ [m/s}^2\text{]}; \alpha1=\{0, 0, 0\} \text{ [rad/s}^2\text{]}$$

$$aC2=\{-224.03, -111.662, 0\} \text{ [m/s}^2\text{]}; \alpha2=\{0, 0, 313.349\} \text{ [rad/s}^2\text{]}$$

$$aC3=aC\{-224.736, 0, 0\} \text{ [m/s}^2\text{]}; \alpha3=\{0, 0, 0\} \text{ [rad/s}^2\text{]}$$

$$F_{ext}=\{1000., 0, 0\} \text{ [N]}$$

$$m1=0.144 \text{ [kg]}; m2=0.56 \text{ [kg]}; m3=0.08 \text{ [kg]}$$

$$IC1=0.00039 \text{ [kg m}^2\text{]}; IC2=0.0228713 \text{ [kg m}^2\text{]}; IC3=0.0000193333 \text{ [kg m}^2\text{]}$$

$$F1=F_{in1}+G1=-m1*aC1-m1*g=\{16.0793, 14.6671, 0\} \text{ [N]}; M1=Min1=0 \text{ [N m]}$$

$$F2=F_{in2}+G2=-m2*aC2-m2*g=\{125.457, 57.0387, 0\} \text{ [N]}$$

$$M2=Min2=-IC2 \alpha2=\{0, 0, -7.16671\} \text{ [N m]}$$

$$F3=F_{in3}+G3=-m3*aC3-m3*g=\{17.9788, -0.78456, 0\} \text{ [N]}; M3=Min3=0 \text{ [N m]}$$

LINK 3

$$F03 \text{ perpendicular to x-axis: } F03=\{0, F03y, 0\}$$

$$\text{Sum F for link 3: } (F_{in3}+G3)+F03+F23+F_e=0 \Leftrightarrow F3+F03+F23+F_e=0 \text{ (} F23=-F32 \text{)}$$

$$(x): 1017.98 + F23x=0 \text{ (1); (y): } -0.78456 + F03y + F23y=0 \text{ (2)}$$

$$\text{Sum M for link 3 wrt C3: } CQ \times F03 + M3=0 \Rightarrow CQ=0, F03 \text{ acts @ C}$$

LINK 2

$$\text{Sum F for link 2: } (F_{in2}+G2)+F32+F12=0 \Leftrightarrow F2+F32+F12=0 \text{ (} F12=-F21 \text{)}$$

$$(x): 125.457 + F12x - F23x=0 \text{ (3); (y): } 57.0387 + F12y - F23y=0 \text{ (4)}$$

Sum M for link 2 wrt C2: $C2B \times F12 + C2C \times F32 + M2 = 0$

$C2B = \{-0.344166, 0.0636396, 0\} [m]$; $C2C = \{0.344166, -0.0636396, 0\} [m]$

(z): $-7.16671 - 0.0636396 F12x - 0.344166 F12y - 0.0636396 F23x - 0.344166 F23y = 0$ (5)

From Eqs. (1)-(5) => $\{F12x, F12y, F23x, F23y, F03y\}$

$F12 = \{F12x, F12y, 0\} = \{-1143.44, 160.902, 0\} [N]$

$F23 = \{F23x, F23y, 0\} = \{-1017.98, 217.941, 0\} [N]$

$F03 = \{0, F03y, 0\} = \{0, -217.156, 0\} [N]$

LINK 1

Sum F for link 1: $(F_{in1} + G) + F21 + F01 = 0 \Leftrightarrow F1 + F21 + F01 = 0$

(x): $16.0793 + F01x - F12x = 0$ (6); (y): $14.6671 + F01y - F12y = 0$ (7)

$F01 = \{F01x, F01y, 0\} = -F1 - F21 = \{-1159.51, 146.235, 0\} [N]$

Sum M for 1 wrt C1: $C1B \times F21 + C1A \times F01 + M1 + Mm = 0$

$C1B = \{0.0636396, 0.0636396, 0\} [m]$; $C1A = \{-0.0636396, -0.0636396, 0\} [m]$

(z): $0.0636396 F01x - 0.0636396 F01y + 0.0636396 F12x - 0.0636396 F12y + M = 0$ (8)

$M = \{0, 0, Mm\} = -(C1B \times F21 + C1A \times F01 + M1) = \{0., 0., 166.105\} [Nm]$

From Eqs. (1)-(8) => $\{F01x, F01y, F12x, F12y, F23x, F23y, F03y, M\}$

$F01 = \{F01x, F01y, 0\} = \{-1159.51, 146.235, 0\} [N]$

$F12 = \{F12x, F12y, 0\} = \{-1143.44, 160.902, 0\} [N]$

$F23 = \{F23x, F23y, 0\} = \{-1017.98, 217.941, 0\} [N]$

$F03 = \{0, F03y, 0\} = \{0, -217.156, 0\} [N]$

$M = M_{motor} = \{0, 0, Mm\} = \{0, 0, 166.105\} [Nm]$