

PUP #2 - Planar exact constraint forces

Input		F	Force mag [N]				phi				Force dir [deg]				Force dir [rad]				Moment [N*m]							
	phi	Force dir [deg]	1.00	1.00	1.00	1.00	30.00	30.00	30.00	30.00	45.00	45.00	45.00	45.00	60.00	60.00	60.00	60.00	90.00	90.00	90.00	90.00	#####	#####	#####	#####
	M	Moment [N*m]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Relative pin locations		x1	0.25	0.50	0.75	0.90	0.25	0.50	0.75	0.90	0.25	0.50	0.75	0.90	0.25	0.50	0.75	0.90	0.25	0.50	0.75	0.90	0.25	0.50	0.75	0.90
	y1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	x2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
	y2	0.25	0.50	0.75	0.90	0.25	0.50	0.75	0.90	0.25	0.50	0.75	0.90	0.25	0.50	0.75	0.90	0.25	0.50	0.75	0.90	0.25	0.50	0.75	0.90	
	x3	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	
	y3	-0.25	-0.50	-0.75	-0.90	-0.25	-0.50	-0.75	-0.90	-0.25	-0.50	-0.75	-0.90	-0.25	-0.50	-0.75	-0.90	-0.25	-0.50	-0.75	-0.90	-0.25	-0.50	-0.75	-0.90	
Instant center		xIC =	0.25	0.50	0.75	0.90	0.25	0.50	0.75	0.90	0.25	0.50	0.75	0.90	0.25	0.50	0.75	0.90	0.25	0.50	0.75	0.90	0.25	0.50	0.75	0.90
	yIC =	0.25	0.50	0.75	0.90	0.25	0.50	0.75	0.90	0.25	0.50	0.75	0.90	0.25	0.50	0.75	0.90	0.25	0.50	0.75	0.90	0.25	0.50	0.75	0.90	
	beta =	arctan(y2/x1) [rad]	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79
	L =	sqrt(xIC^2+yIC^2) [m]	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00
			0.35	0.71	1.06	1.27	0.35	0.71	1.06	1.27	0.35	0.71	1.06	1.27	0.35	0.71	1.06	1.27	0.35	0.71	1.06	1.27	0.35	0.71	1.06	1.27
Pin 3 Lever		r =	1.35	1.80	2.30	2.62	1.35	1.80	2.30	2.62	1.35	1.80	2.30	2.62	1.35	1.80	2.30	2.62	1.35	1.80	2.30	2.62	1.35	1.80	2.30	2.62
	gamma =	arctan[(yIC-y3)/(xIC-x3)] [rad]	0.38	0.59	0.71	0.76	0.38	0.59	0.71	0.76	0.38	0.59	0.71	0.76	0.38	0.59	0.71	0.76	0.38	0.59	0.71	0.76	0.38	0.59	0.71	0.76
			21.80	33.69	40.60	43.45	21.80	33.69	40.60	43.45	21.80	33.69	40.60	43.45	21.80	33.69	40.60	43.45	21.80	33.69	40.60	43.45	21.80	33.69	40.60	43.45
Results		R3 =	-1.41	-0.71	-0.47	-0.39	-0.52	-0.26	-0.17	-0.14	0.00	0.00	0.00	0.00	0.52	0.26	0.17	0.14	1.41	0.71	0.47	0.39	2.00	1.00	0.67	0.56
	R2 =	R3 + Fcos(phi) + (M/L)sin(beta) [N]	-0.41	0.29	0.53	0.61	0.35	0.61	0.69	0.72	0.71	0.71	0.71	0.71	1.02	0.76	0.67	0.64	1.41	0.71	0.47	0.39	1.29	0.29	-0.04	-0.15
	R1 =	Fsin(phi) - (M/L)cos(beta) [N]	0.00	0.00	0.00	0.00	0.50	0.50	0.50	0.50	0.71	0.71	0.71	0.71	0.87	0.87	0.87	0.87	1.00	1.00	1.00	1.00	0.71	0.71	0.71	0.71

Inputs:
 F, ϕ, M
 (x_1, y_1)
 (x_2, y_2)
 (x_3, y_3)

Instant center:
 1. $(x_{IC}, y_{IC}) = (x_1, y_2)$
 2. $l = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$
 3. $\beta = \tan^{-1}(y_2/x_1)$

Wants to rotate about the instant center

Force balance: $\sum F_x = 0 = -R_2 + R_3 + F_x + f_x$
 $F_x = F \cos \phi$
 $f_x = (M/l) \sin \beta$
 8. $R_2 = R_3 + F \cos \phi + (M/l) \sin \beta$

$\sum F_y = 0 = -R_1 - f_y + F_y$
 $F_y = F \sin \phi$
 $f_y = (M/l) \cos \beta$
 4. $R_1 = F \sin \phi - (M/l) \cos \beta$

Moment balance:
 $\sum M = 0 = M - F \sin(\phi - \beta) + R_3 r \sin \gamma$
 $R_3 = \frac{F \sin(\phi - \beta) - M}{r \sin \gamma}$

7. $R_3 = \frac{F \sin(\phi - \beta) - M}{r \sin \gamma}$
 5. where $r = \sqrt{(x_1 - x_3)^2 + (y_2 - y_3)^2} / 2$
 6. and $\gamma = \tan^{-1} \left(\frac{y_2 - y_3}{x_1 - x_3} \right)$

(3) Spreadsheet based on these calcs.
 (4) Modified design: Include 6 moveable pins to allow user to play around with different configurations.