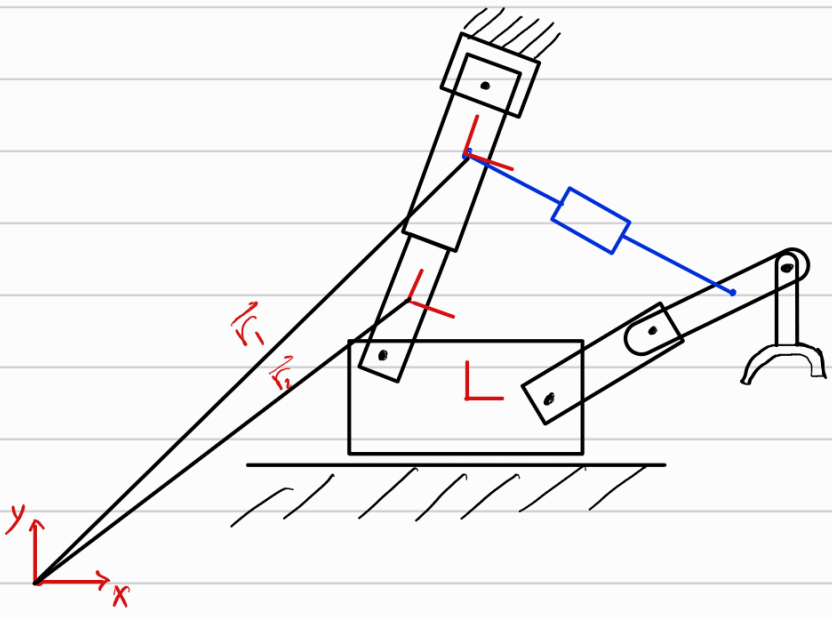
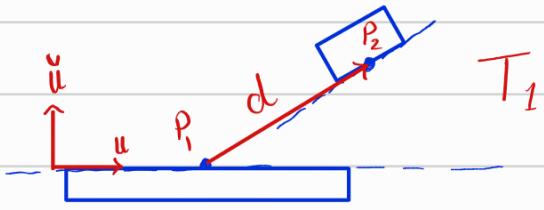
Ref-frame: 5
Vetors: 10
Constraints: 5



$\downarrow g$

for the translational joint



$\vec{r}_1$ R_1: $S_1^{R_1}$, $S_2^{R_1}$

$\vec{r}_2$ R_2: $S_2^{R_2}$, $S_3^{R_2}$

$\vec{r}_3$ R_3: $S_3^{R_3}$, $S_4^{R_3}$

$\vec{r}_4$ R_4: $S_1^{R_4}$, $S_5^{R_4}$

$\vec{r}_5$ R_5: $S_0^{R_5}$, $S_6^{R_5}$

$\vec{r}_6$

R_2:

$$\underline{r}_2 + \underline{S}_2^{R_2} - \underline{r}_3 - \underline{S}_3^{R_2} = \underline{0}$$

T_2:

$$\underline{\breve{u}}_6^T \cdot \underline{d} = 0$$

$$\phi_5 - \phi_6 - \phi_c = 0 \leftarrow \text{Constant angle between bodie 5 \& 6.}$$

$$DOF = 3 \times (n-1) - 2 \times l - h$$

(num. of links; to exclude ground; num. of joints)

or number of coordinates − num. of constraints

q3) a) 14

b) DoF = 4

C) Drive constraints = D.O.F. = 4

q4) a) $\underline{\underline{M}}_1 = \begin{bmatrix} m_1 & 0 & 0 \\ 0 & m_1 & 0 \\ 0 & 0 & J_1 \end{bmatrix}$ ------ $\underline{\underline{M}}_6$

b) $\underline{\underline{M}} = \begin{bmatrix} \underline{\underline{M}}_1 & & \\ & \ddots & \\ & & \underline{\underline{M}}_6 \end{bmatrix}$

C) $\underline{h}_1 = \begin{bmatrix} 0 \\ -m_1 g \\ 0 \end{bmatrix}$, h_2, h_4, h_5 all the same with diff. mass.

$\underline{h}_3 = \begin{bmatrix} {}^{a}f_x \\ {}^{a}f_y - m_3 g \\ 0 \end{bmatrix}$, $\underline{h}_6 = \begin{bmatrix} -{}^{a}f_x \\ -{}^{a}f_y - m_6 g \\ 0 \end{bmatrix}$

$n = \underline{\varsigma}^{aT} \cdot {}^{a}\underline{f}$

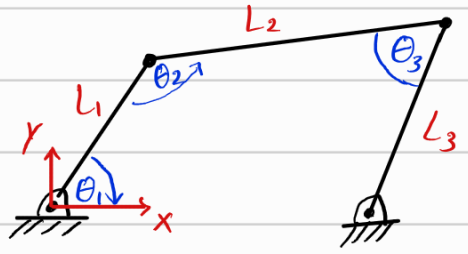
d) $\underline{h} = \begin{bmatrix} \underline{h}_1 \\ \vdots \\ \underline{h}_6 \end{bmatrix}$

e) $\ddot{\underline{C}}_1 = \begin{bmatrix} \ddot{x}_1 \\ \ddot{y}_1 \\ \ddot{\phi}_1 \end{bmatrix}$, $\ddot{\underline{C}} = \begin{bmatrix} \ddot{\underline{C}}_1 \\ \vdots \\ \ddot{\underline{C}}_6 \end{bmatrix}$

f)

	1	2	3	4	5	6
R_1	XX	XX				
R_2		XX	XX			
R_3			XX	XX		
R_4	XX				XX	
R_5						XX
T_1	XX					
T_2					XX	XX

Q5:



not in the question

	1	2	3	
R_1	XX			
R_2	XX	XX		
R_3		XX	XX	
R_4			XX	

num. of constraints

8×9 → num. of Coordinates (3 bodies * 3 Cooditions)

this answer is good.

b) 2 Constraints $\begin{cases} L_1 \cdot \cos\Phi_1 + L_2 \cdot \cos\Phi_2 + L_3 \cos\Phi_3 - a = 0 \\ L_1 \cdot \sin\Phi_1 + L_2 \cdot \sin\Phi_2 + L_3 \cdot \sin\Phi_3 - b = 0 \end{cases}$

3 coord.: Φ_1, Φ_2, Φ_3

DoF = $3 - 2 = 1$

There will be a question about Rotation matrix!

(inverse matrix = transpose matrix)

q6) A) → yes, it's a rotation matrix.

Columns & rows are perdicular to each other.

B) is a rotation matrix as well.

because if you multiply 2 rotation matrices, you will get a rotation matrix

q7) a)

$$2\dot{x}_1 + 7\dot{x}_2 - 2x_3\dot{x}_3 = 0$$

$$2\cos x_1 \dot{x}_1 + 7\cos x_2 \dot{x}_2 - \dot{x}_4 = 0$$

$$2\dot{x}_1 x_2 + 2x_1\dot{x}_2 + 7\dot{x}_2 x_3 x_4 + 7x_2\dot{x}_3 x_4 + 7x_2 x_3 \dot{x}_4 = 0$$

b) $\underline{D}_s =$

$\dot{x}_1$	$\dot{x}_2$	$\dot{x}_3$	$\dot{x}_4$
2	7	$-2x_3$	0
$2\cos x_1$	$7\cos x_2$	0	-1
$2x_2$	$7x_3x_4 + 2x_1$	$7x_2x_4$	$7x_2x_3$