1985
جامعة محمد بوضياف - المسيلة
Université Mohamed Boudiaf - M'sila

Robotique industrielle

Master I Fabrication mécanique et productique

Par : Dr. Slamani Mohamed

1985
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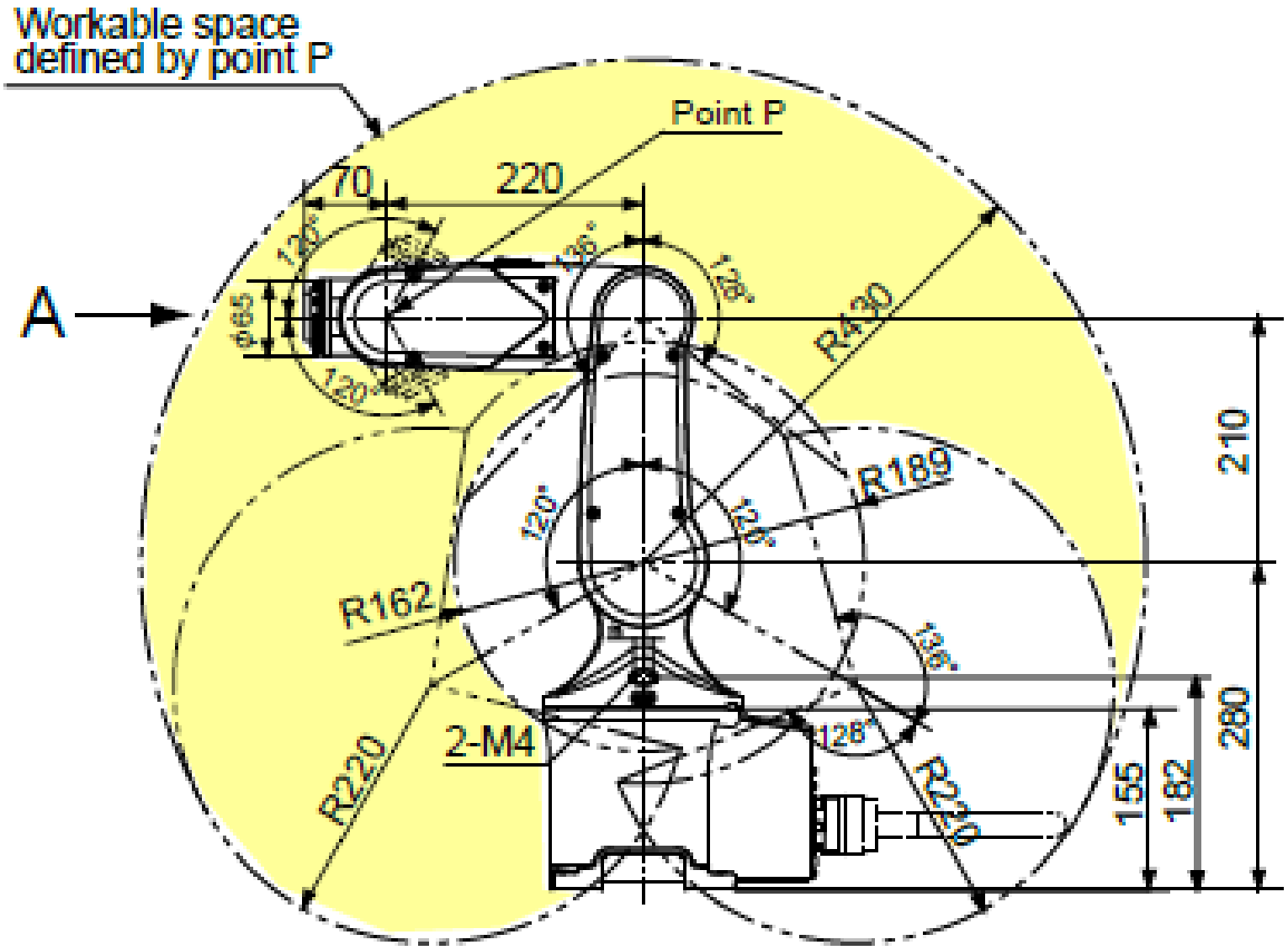
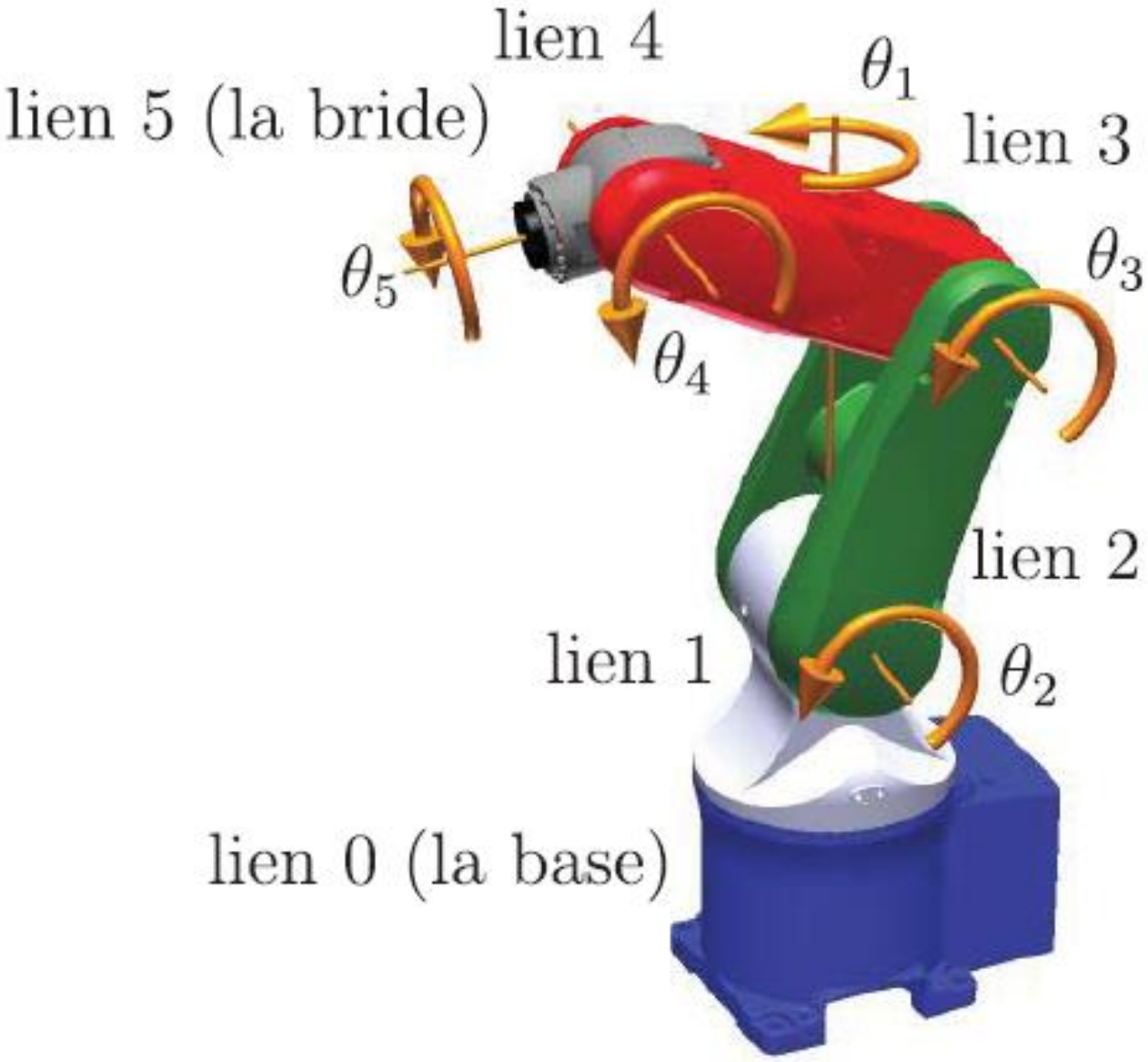
Université Mohamed Boudiaf - M'sila

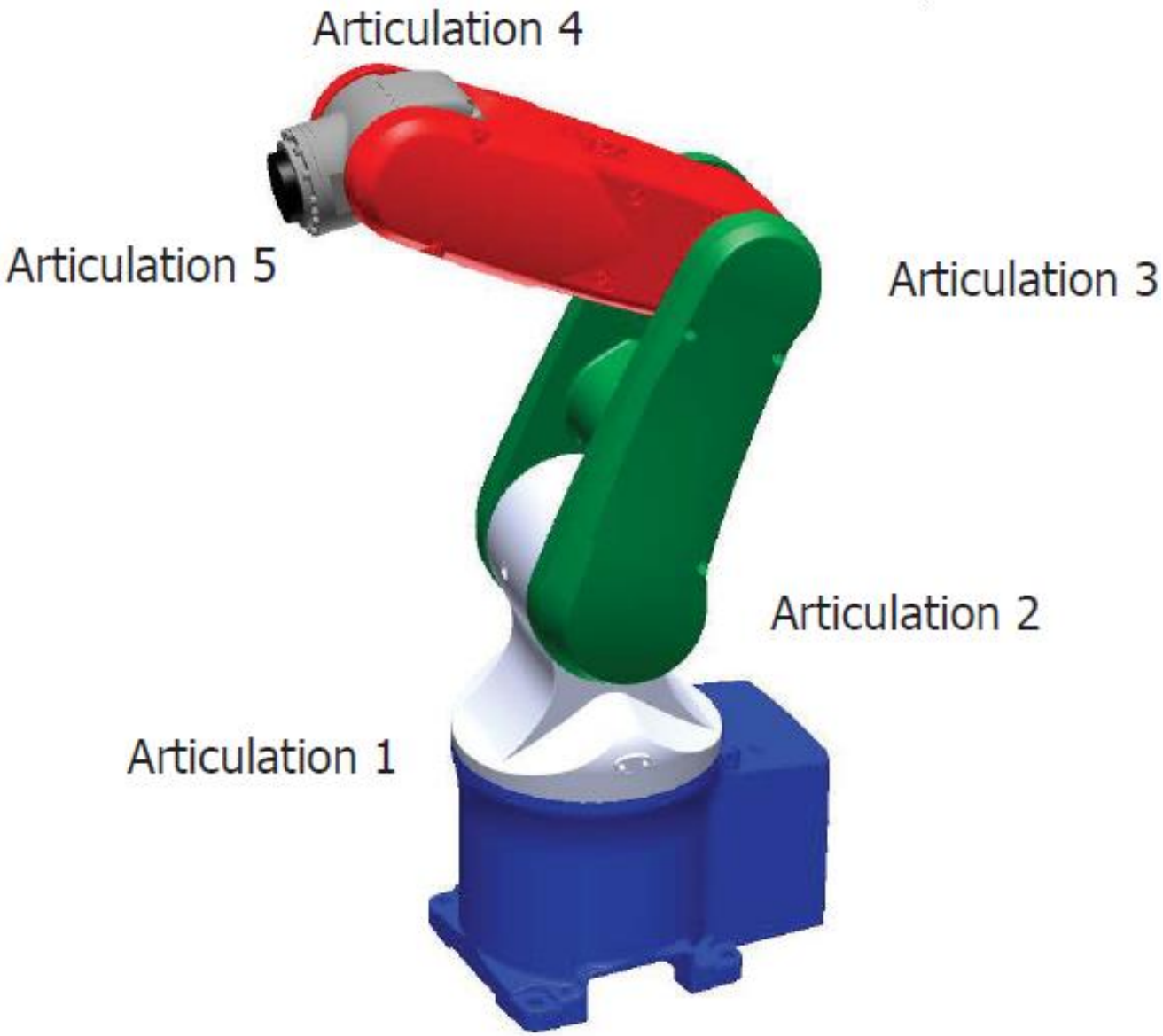
Cinématique directe

Exemple d'un robot sériel a cinq articulations rotoïdes

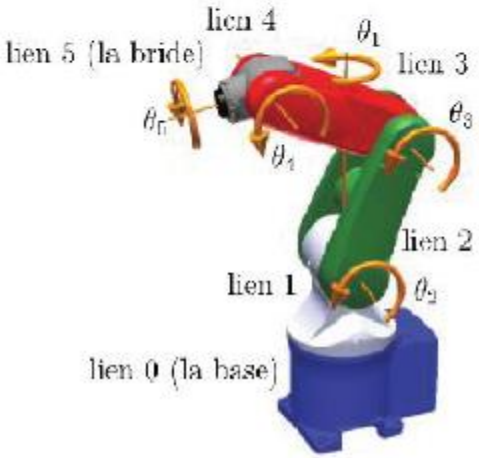




Placer les référentiels DH



Référentiel F_0



Articulation 4

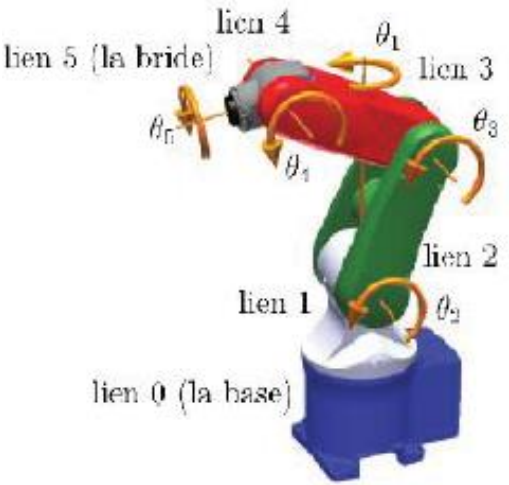
Articulation 5

Articulation 3

Articulation 2

Articulation 1

Référentiel F1



Articulation 4

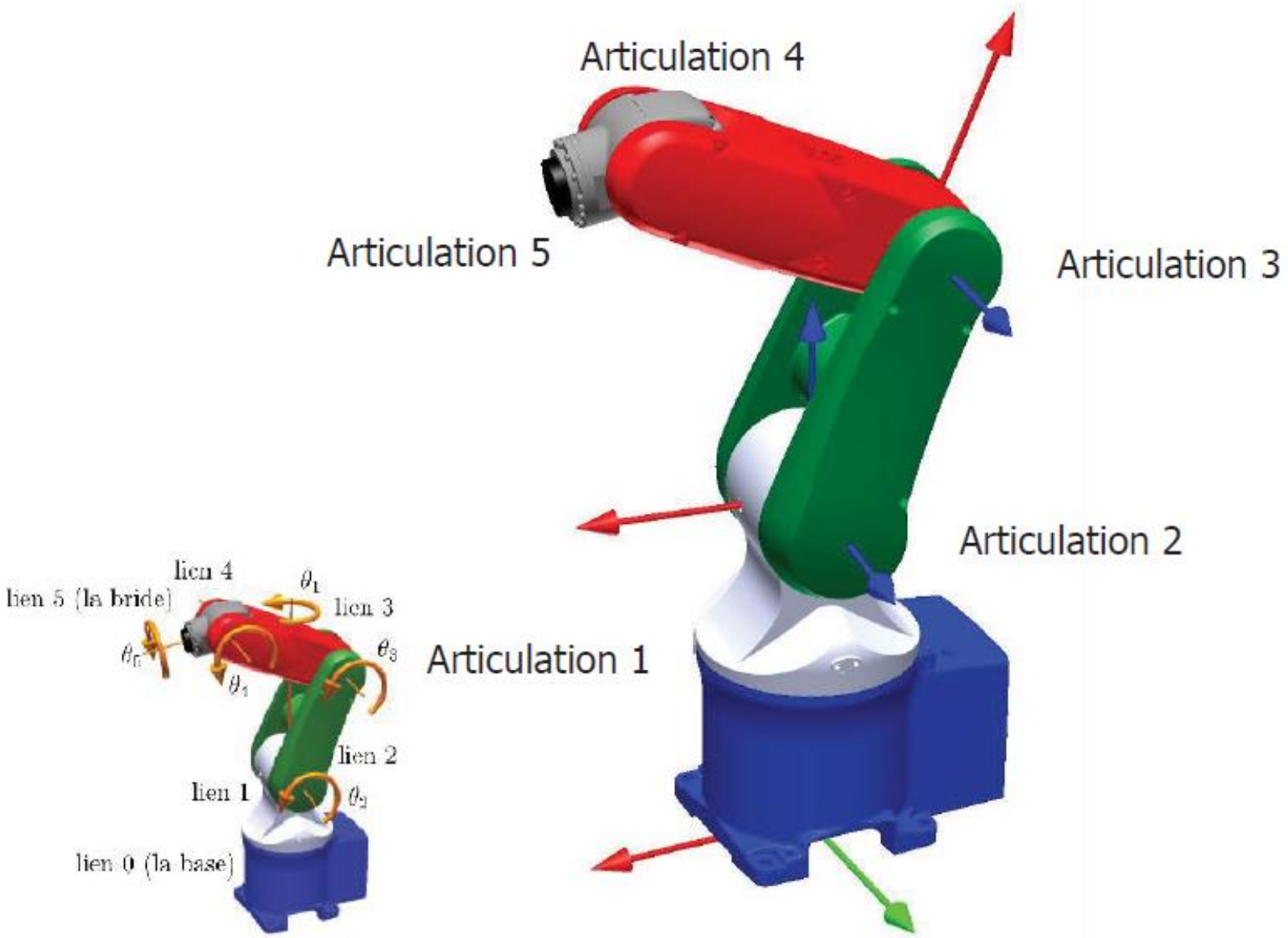
Articulation 5

Articulation 3

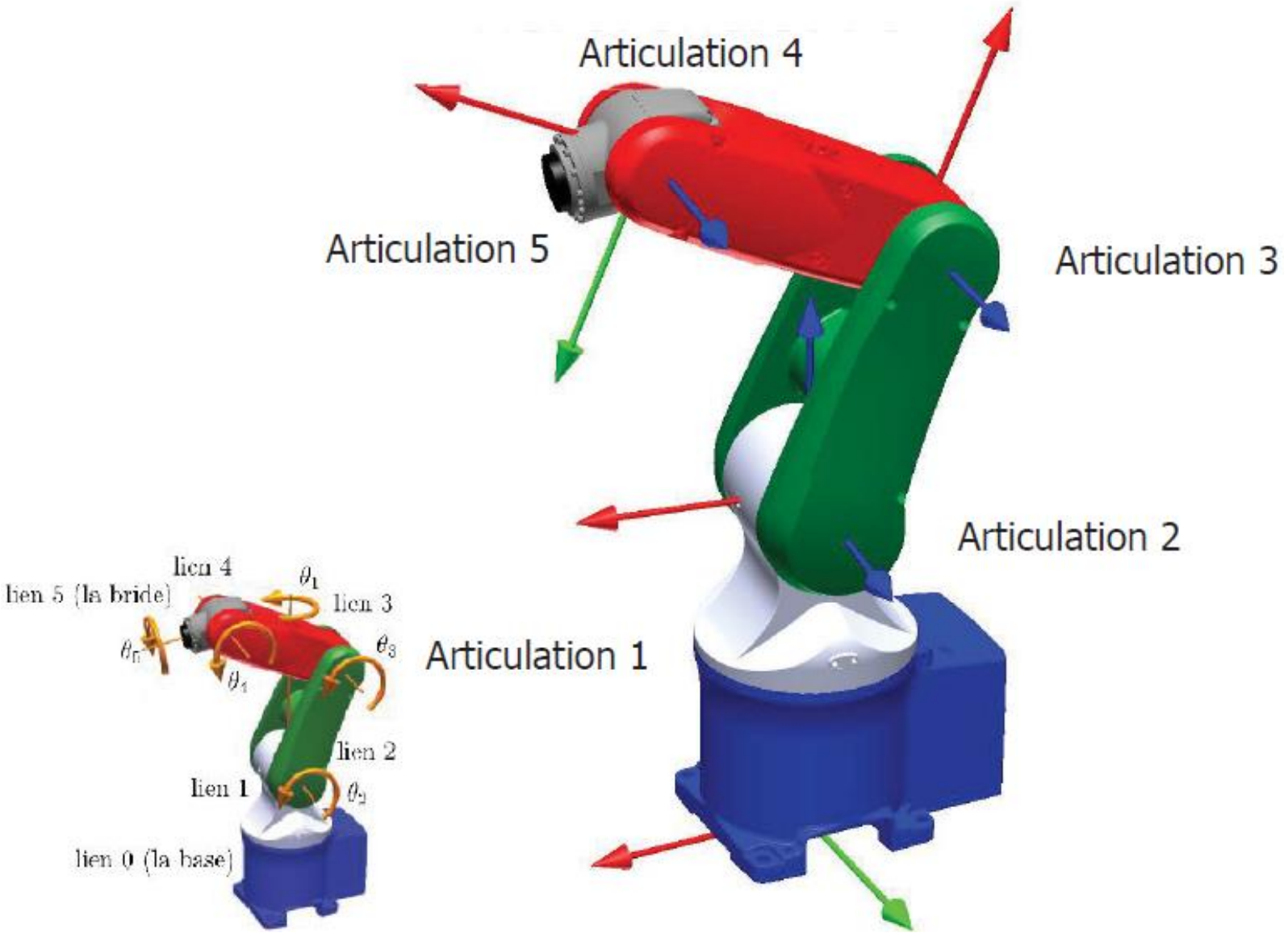
Articulation 2

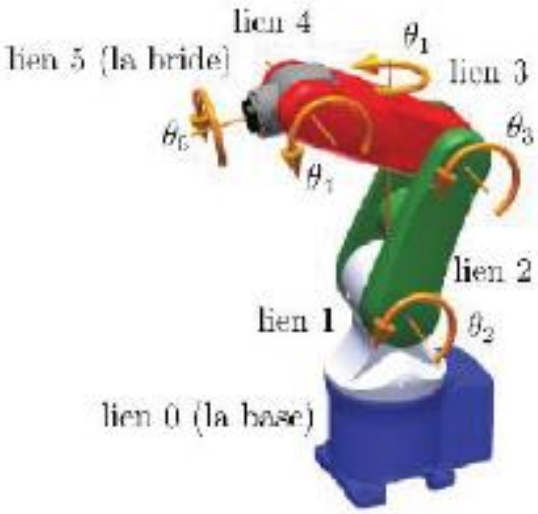
Articulation 1

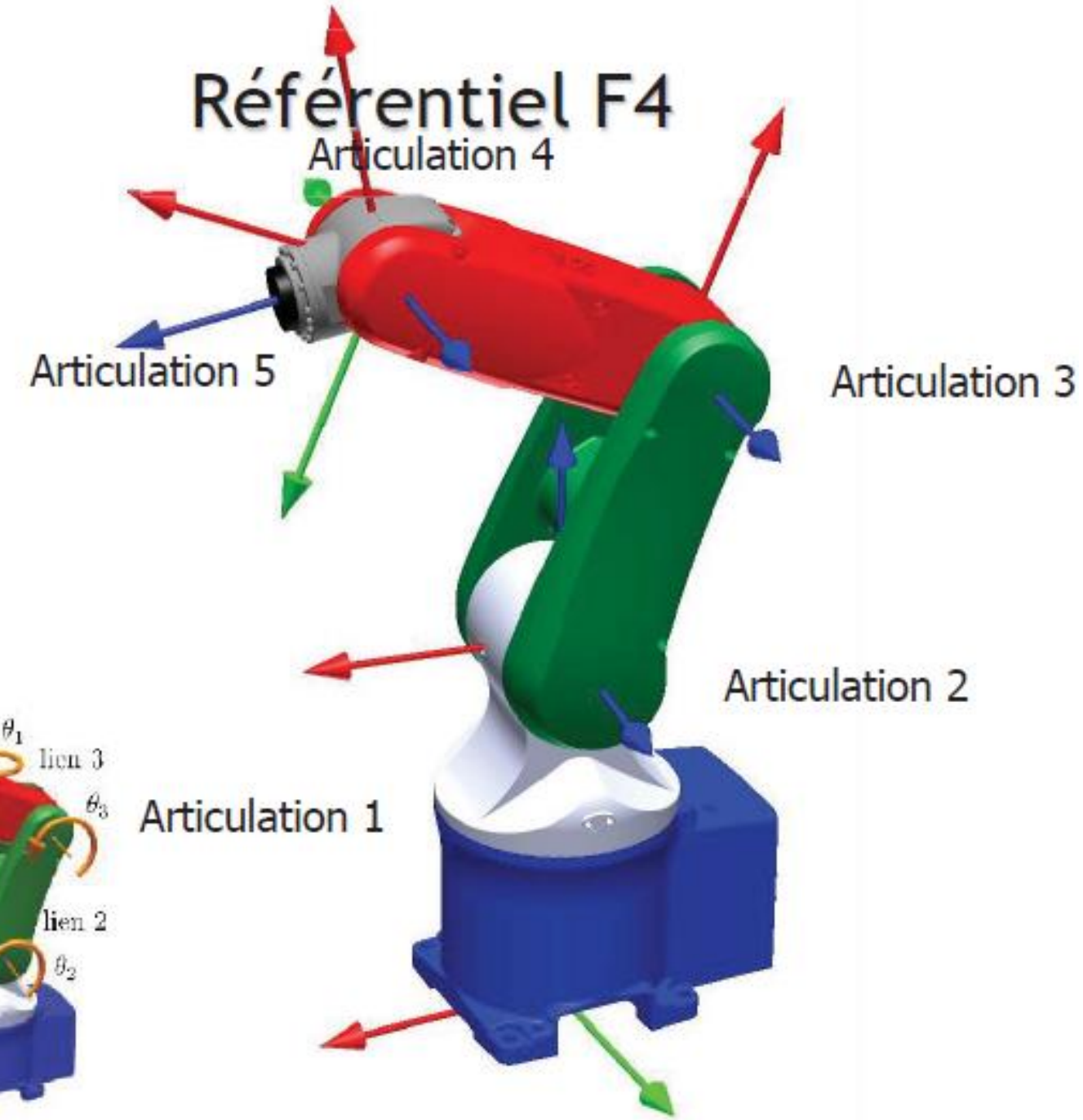
Référentiel F2

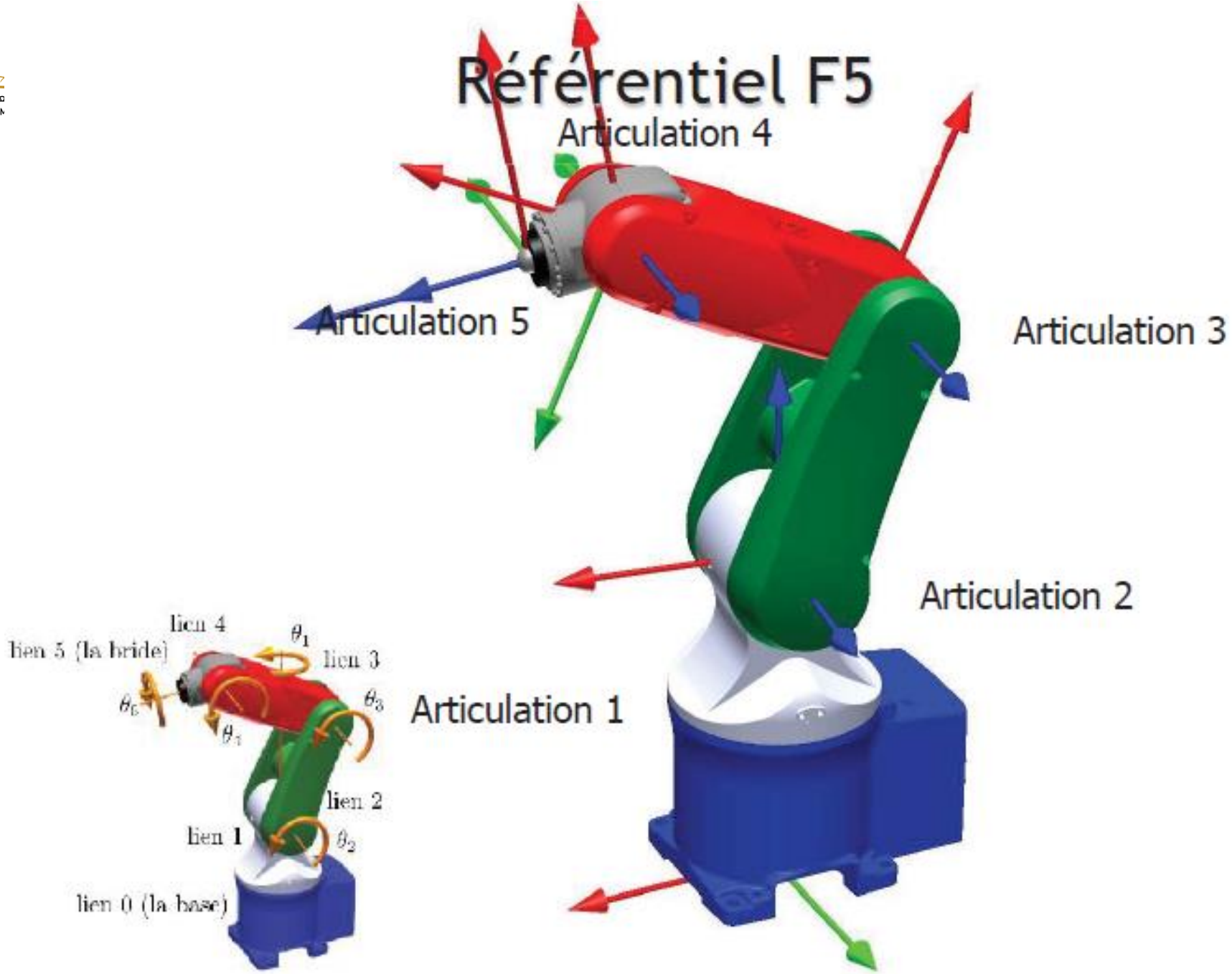


Référentiel F3









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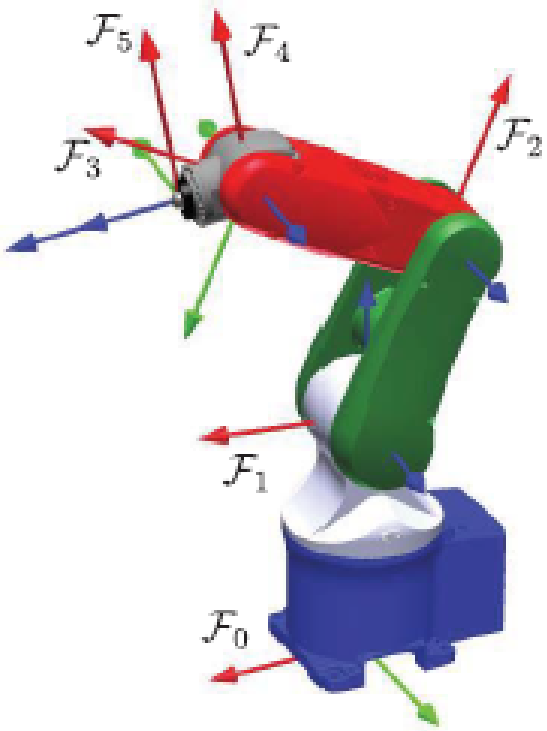
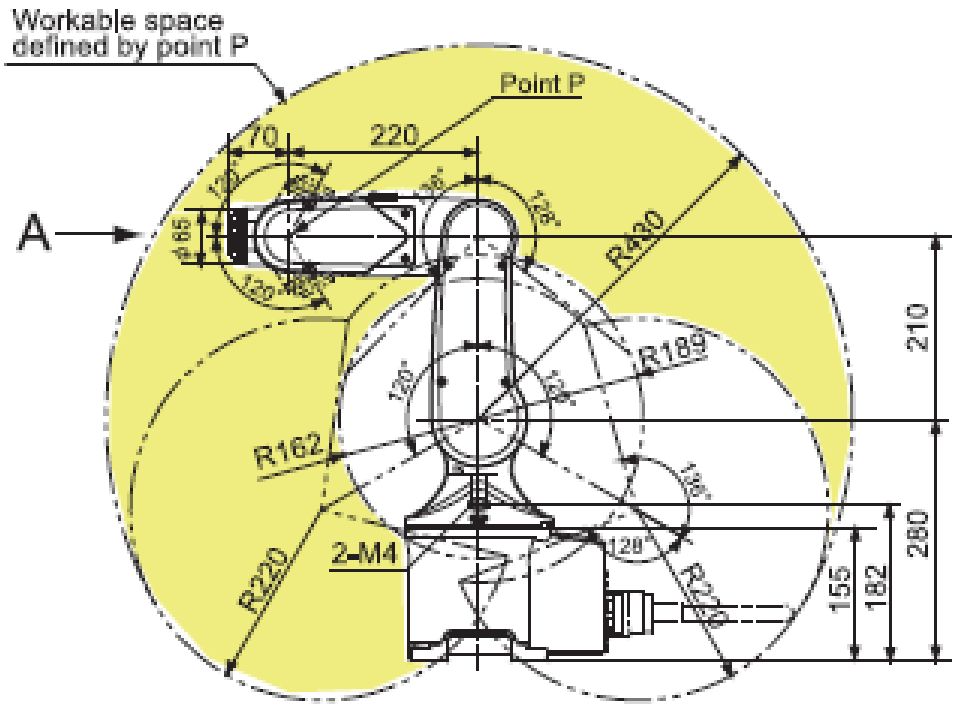
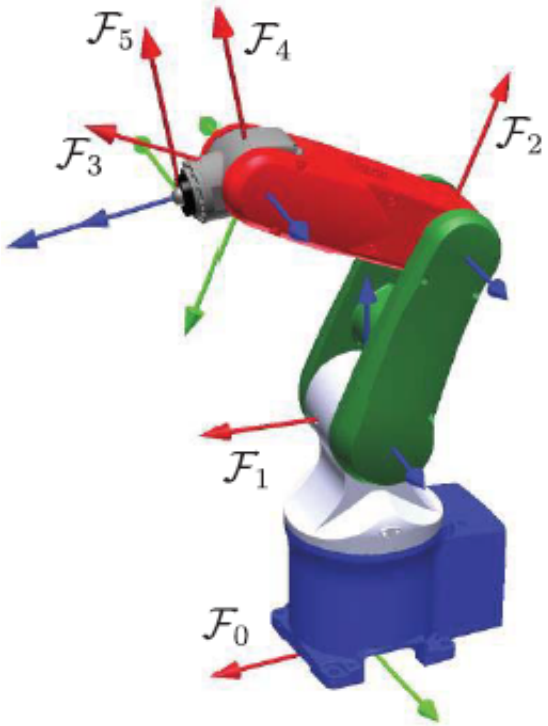
Paramètres DH

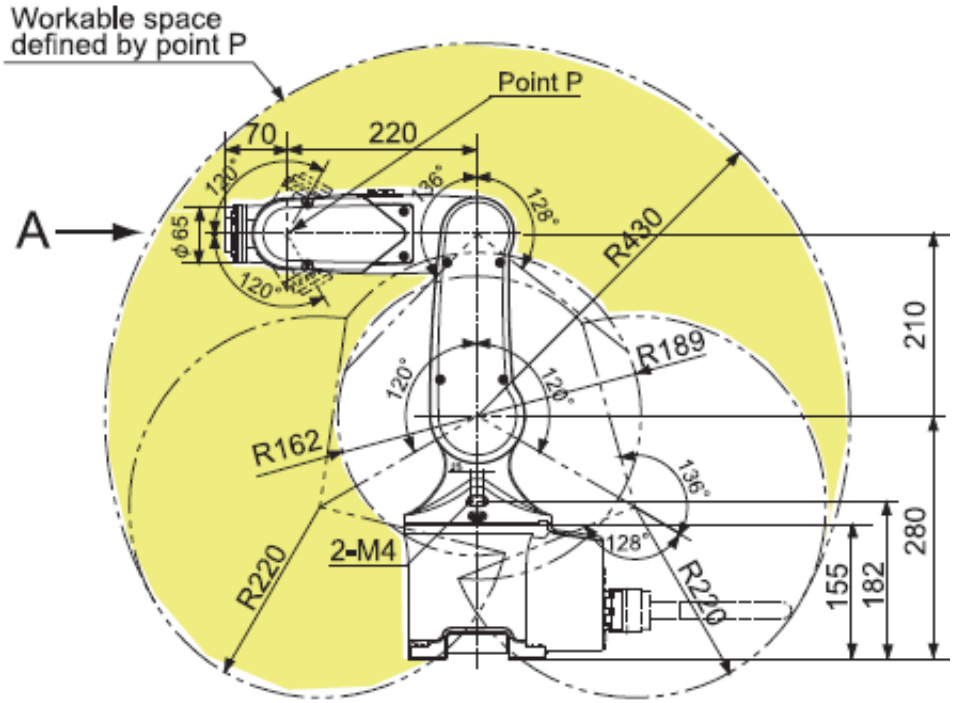




i	Θ_i	d_i	a_i	α_i
1				
2				
3				
4				
5				

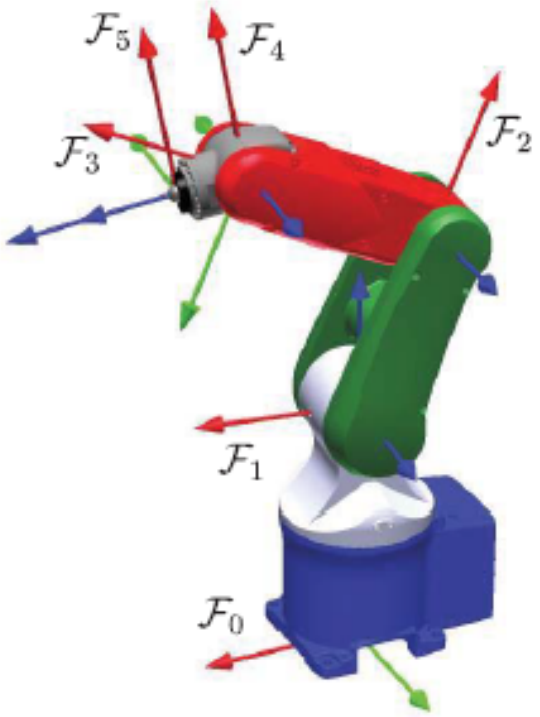
Paramètres DH

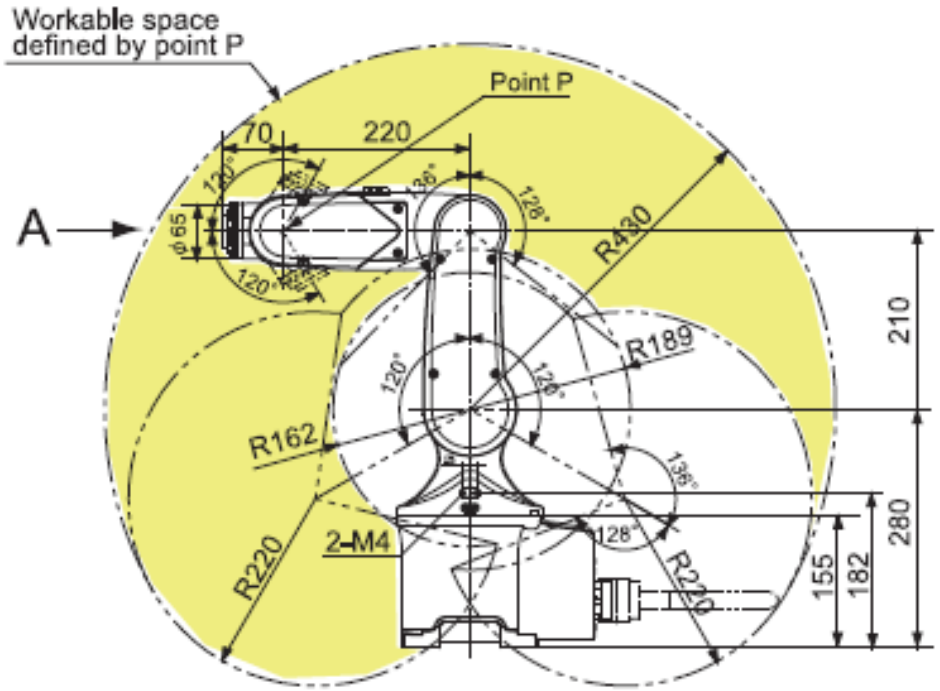




i	θ_i	d_i	a_i	α_i
1	θ_1	280 mm	0 mm	$-90°$
2	θ_2	0 mm	210 mm	$0°$
3	θ_3	0 mm	220 mm	$0°$
4	θ_4	0 mm	0 mm	$-90°$
5	θ_5	70 mm	0 mm	$0°$

Paramètres DH conformes avec le robot réel





i	θ_i	d_i	a_i	α_i
1	θ_1	280 mm	0 mm	$-90°$
2	$\theta_2 - 90°$	0 mm	210 mm	$0°$
3	θ_3	0 mm	220 mm	$0°$
4	$\theta_4 - 90°$	0 mm	0 mm	$-90°$
5	θ_5	70 mm	0 mm	$0°$

$$\mathbf{H}_1^0 = \mathbf{H}_{rot,x}(\theta_1)\mathbf{H}_{trans}(0,0,280)\mathbf{H}_{trans}(0,0,0)\mathbf{H}_{rot,x}(-90°)$$

$$= \begin{bmatrix} \cos\theta_1 & 0 & -\sin\theta_1 & 0 \\ \sin\theta_1 & 0 & \cos\theta_1 & 0 \\ 0 & -1 & 0 & 280 \\ 0 & 0 & 0 & 1 \end{bmatrix},$$

$$\mathbf{H}_2^1 = \mathbf{H}_{rot,x}(\theta_2 - 90°)\mathbf{H}_{trans}(0,0,0)\mathbf{H}_{trans}(210,0,0)\mathbf{H}_{rot,x}(0°)$$

$$= \begin{bmatrix} \sin\theta_2 & \cos\theta_2 & 0 & 210\sin\theta_2 \\ -\cos\theta_2 & \sin\theta_2 & 0 & -210\cos\theta_2 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix},$$

$$\mathbf{H}_3^2 = \mathbf{H}_{rot,x}(\theta_3)\mathbf{H}_{trans}(0,0,0)\mathbf{H}_{trans}(220,0,0)\mathbf{H}_{rot,x}(0°)$$

$$= \begin{bmatrix} \cos\theta_3 & -\sin\theta_3 & 0 & 220\cos\theta_3 \\ \sin\theta_3 & \cos\theta_3 & 0 & 220\sin\theta_3 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix},$$

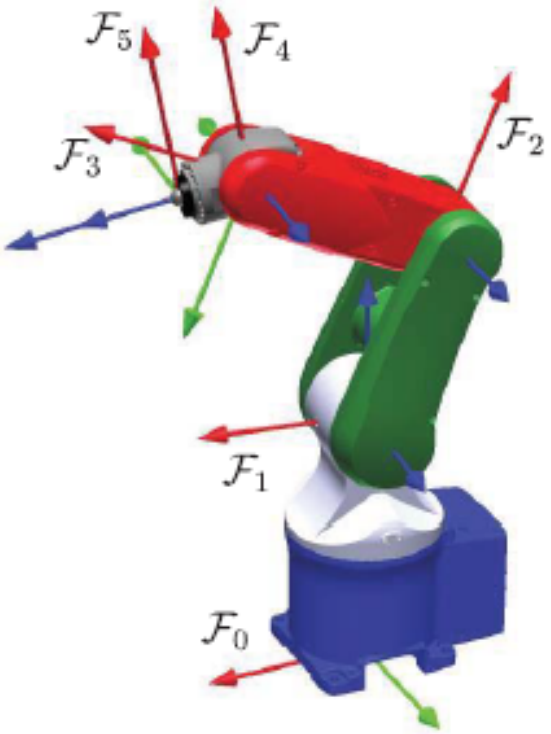
$$\mathbf{H}_4^3 = \mathbf{H}_{rot,x}(\theta_4 - 90°)\mathbf{H}_{trans}(0,0,0)\mathbf{H}_{trans}(0,0,0)\mathbf{H}_{rot,x}(-90°)$$

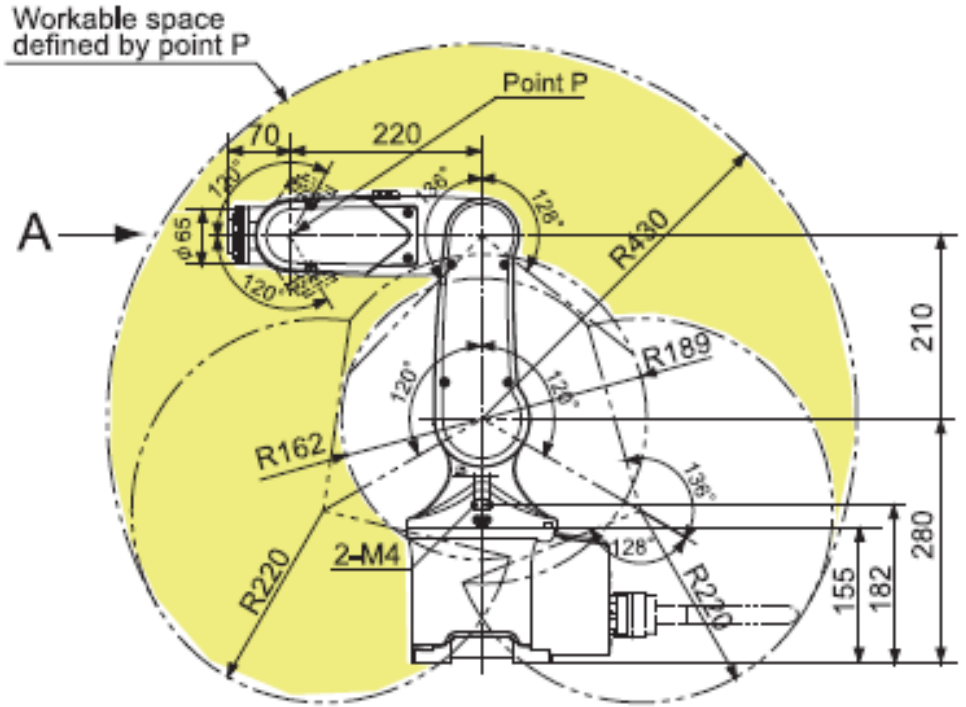
$$= \begin{bmatrix} \sin\theta_4 & 0 & \cos\theta_4 & 0 \\ -\cos\theta_4 & 0 & \sin\theta_4 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix},$$

$$\mathbf{H}_5^4 = \mathbf{H}_{rot,x}(\theta_5)\mathbf{H}_{trans}(0,0,70)\mathbf{H}_{trans}(0,0,0)\mathbf{H}_{rot,x}(0°)$$

$$= \begin{bmatrix} \cos\theta_5 & -\sin\theta_5 & 0 & 0 \\ \sin\theta_5 & \cos\theta_5 & 0 & 0 \\ 0 & 0 & 1 & 70 \\ 0 & 0 & 0 & 1 \end{bmatrix}.$$

Équation de la cinématique directe

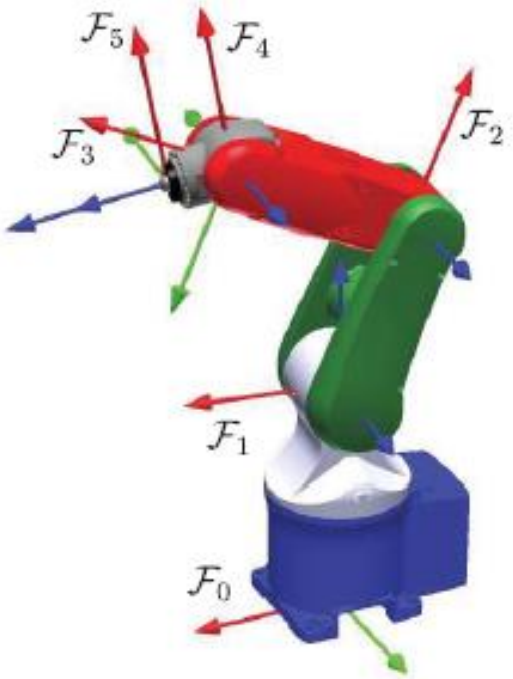


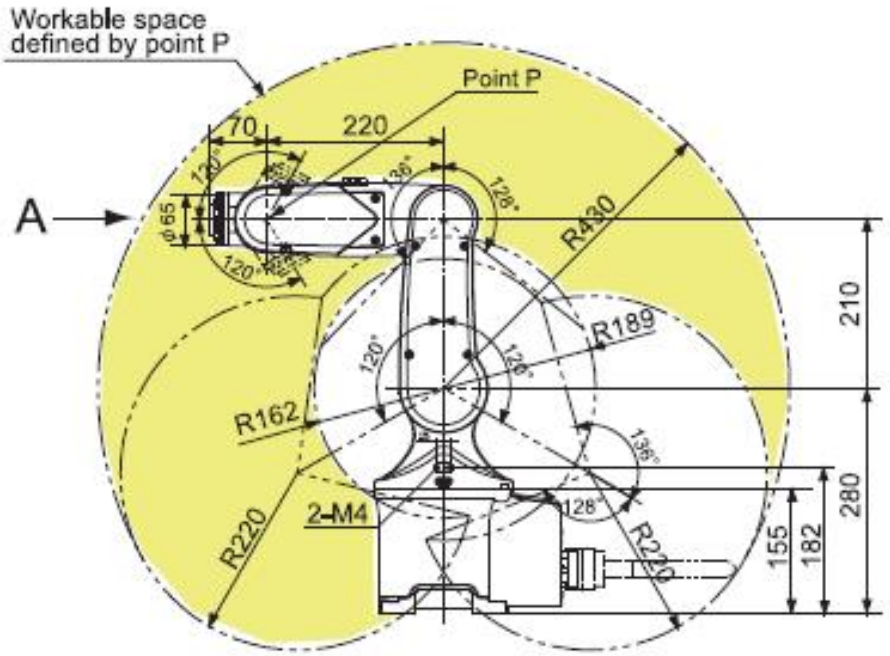


$$\mathbf{H}_5^0 = \mathbf{H}_1^0\mathbf{H}_2^1\mathbf{H}_3^2\mathbf{H}_4^3\mathbf{H}_5^4$$

$$= \begin{bmatrix} -c_1c_{234}c_5 + s_1s_5 & c_1c_{234}s_5 + s_1c_5 & c_1s_{234} & c_1(70s_{234} + 220s_{23} + 210s_2) \\ -s_1c_{234}c_5 - c_1s_5 & s_1c_{234}s_5 - c_1c_5 & s_1s_{234} & s_1(70s_{234} + 220s_{23} + 210s_2) \\ s_{234}c_5 & -s_{234}s_5 & c_{234} & 280 + 70c_{234} + 220c_{23} + 210c_2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Validation dans la configuration zéro



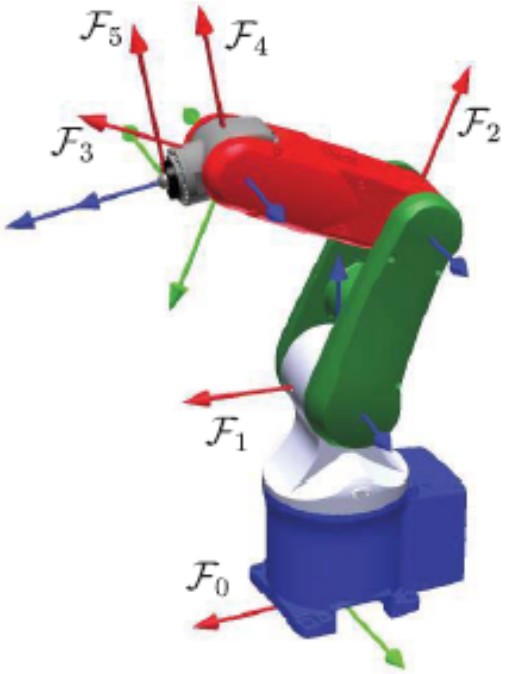


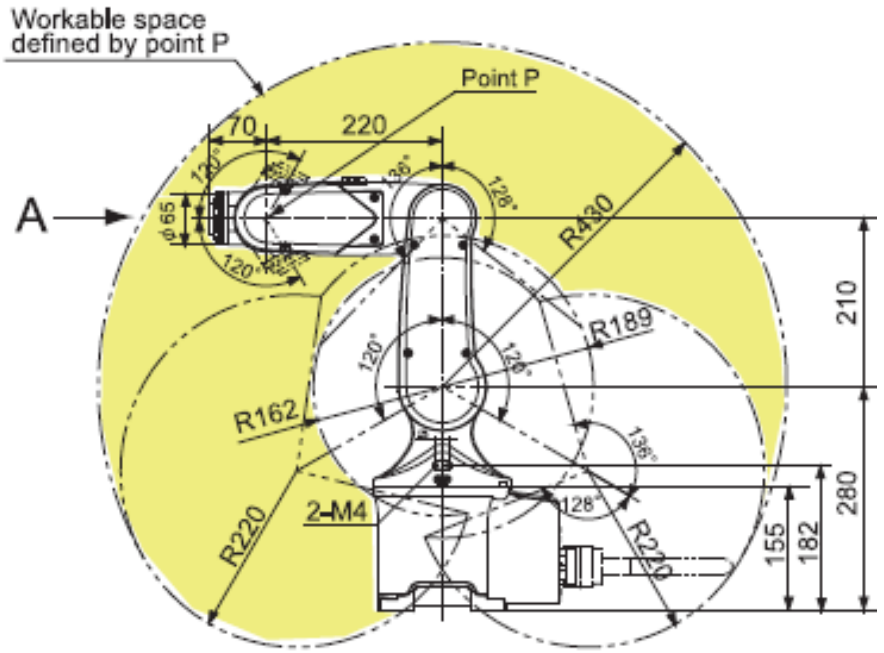
$$\theta_1 = 0°, \theta_2 = 0°, \theta_3 = 0°, \theta_4 = 0°, \theta_5 = 0° \longrightarrow \mathbf{H}_5^0 = \begin{bmatrix} -1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & 1 & 780 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\mathbf{H}_5^0 = \mathbf{H}_1^0\mathbf{H}_2^1\mathbf{H}_3^2\mathbf{H}_4^3\mathbf{H}_5^4$$

$$= \begin{bmatrix} -c_1c_{234}c_5 + s_1s_5 & c_1c_{234}s_5 + s_1c_5 & c_1s_{234} & c_1(70s_{234} + 220s_{23} + 210s_2) \\ -s_1c_{234}c_5 - c_1s_5 & s_1c_{234}s_5 - c_1c_5 & s_1s_{234} & s_1(70s_{234} + 220s_{23} + 210s_2) \\ s_{234}c_5 & -s_{234}s_5 & c_{234} & 280 + 70c_{234} + 220c_{23} + 210c_2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Validation dans une autre configuration





$$\theta_1 = 0°, \theta_2 = 0°, \theta_3 = 90°, \theta_4 = 0°, \theta_5 = 0° \longrightarrow \mathbf{H}_5^0 = \begin{bmatrix} 0 & 0 & 1 & 290 \\ 0 & -1 & 0 & 0 \\ 1 & 0 & 0 & 490 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\mathbf{H}_5^0 = \mathbf{H}_1^0\mathbf{H}_2^1\mathbf{H}_3^2\mathbf{H}_4^3\mathbf{H}_5^4$$

$$= \begin{bmatrix} -c_1c_{234}c_5 + s_1s_5 & c_1c_{234}s_5 + s_1c_5 & c_1s_{234} & c_1(70s_{234} + 220s_{23} + 210s_2) \\ -s_1c_{234}c_5 - c_1s_5 & s_1c_{234}s_5 - c_1c_5 & s_1s_{234} & s_1(70s_{234} + 220s_{23} + 210s_2) \\ s_{234}c_5 & -s_{234}s_5 & c_{234} & 280 + 70c_{234} + 220c_{23} + 210c_2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$