$$\mathbf{A01} := \{\{\mathrm{Cos}[\theta_1], -\mathrm{Sin}[\theta_1]\mathrm{Cos}[\alpha_1], \mathrm{Sin}[\theta_1]\mathrm{Sin}[\alpha_1], a_1\mathrm{Cos}[\theta_1]\}, \{\mathrm{Sin}[\theta_1], \mathrm{Cos}[\theta_1]\mathrm{Cos}[\alpha_1], -\mathrm{Cos}[\theta_1]\mathrm{Sin}[\alpha_1], a_1$$

$$\theta_1 = -q_1;$$

$$a_1 = -658.07;$$

$$\alpha_1 = -\pi/2;$$

$$d_1 = 1134;$$

$$\mathbf{A12} := \{\{\mathrm{Cos}[\theta_2], -\mathrm{Sin}[\theta_2]\mathrm{Cos}[\alpha_2], \mathrm{Sin}[\theta_2]\mathrm{Sin}[\alpha_2], a_2\mathrm{Cos}[\theta_2]\}, \{\mathrm{Sin}[\theta_2], \mathrm{Cos}[\theta_2]\mathrm{Cos}[\alpha_2], -\mathrm{Cos}[\theta_2]\mathrm{Sin}[\alpha_2], a_2$$

$$\theta_2 = -q_2;$$

$$a_2 = -1689.31;$$

$$\alpha_2 = 0;$$

$$d_2 = 0;$$

$$\mathbf{A23} := \{\{\mathrm{Cos}[\theta_3], -\mathrm{Sin}[\theta_3]\mathrm{Cos}[\alpha_3], \mathrm{Sin}[\theta_3]\mathrm{Sin}[\alpha_3], a_3\mathrm{Cos}[\theta_3]\}, \{\mathrm{Sin}[\theta_3], \mathrm{Cos}[\theta_3]\mathrm{Cos}[\alpha_3], -\mathrm{Cos}[\theta_3]\mathrm{Sin}[\alpha_3], a_3$$

$$\theta_3 = \pi/2 + q_3;$$

$$a_3 = -2128.98;$$

$$\alpha_3 = \pi/2;$$

$$d_3 = 367.5;$$

$$\mathbf{A34} := \{\{\mathrm{Cos}[\theta_4], -\mathrm{Sin}[\theta_4]\mathrm{Cos}[\alpha_4], \mathrm{Sin}[\theta_4]\mathrm{Sin}[\alpha_4], a_4\mathrm{Cos}[\theta_4]\}, \{\mathrm{Sin}[\theta_4], \mathrm{Cos}[\theta_4]\mathrm{Cos}[\alpha_4], -\mathrm{Cos}[\theta_4]\mathrm{Sin}[\alpha_4], a_4$$

$$\theta_4 = \pi/2 + q_4;$$

$$a_4 = 353.87;$$

$$\alpha_4 = \pi/2;$$

$$d_4 = 0;$$

$$\mathbf{A45} := \{\{\mathrm{Cos}[\theta_5], -\mathrm{Sin}[\theta_5]\mathrm{Cos}[\alpha_5], \mathrm{Sin}[\theta_5]\mathrm{Sin}[\alpha_5], a_5\mathrm{Cos}[\theta_5]\}, \{\mathrm{Sin}[\theta_5], \mathrm{Cos}[\theta_5]\mathrm{Cos}[\alpha_5], -\mathrm{Cos}[\theta_5]\mathrm{Sin}[\alpha_5], a_5$$

$$\theta_5 = q_5;$$

$$a_5 = -452;$$

$$\alpha_5 = -\pi/2;$$

$$d_5 = 0;$$

A23//MatrixForm

A34//MatrixForm

A45//MatrixForm

$$\begin{pmatrix} -\text{Sin}[q_3] & 0 & \text{Cos}[q_3] & 2128.98\text{Sin}[q_3] \\ \text{Cos}[q_3] & 0 & \text{Sin}[q_3] & -2128.98\text{Cos}[q_3] \\ 0 & 1 & 0 & 367.5 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

A34

$$\begin{pmatrix} \text{Cos}[q_5] & 0 & -\text{Sin}[q_5] & -452\text{Cos}[q_5] \\ \text{Sin}[q_5] & 0 & \text{Cos}[q_5] & -452\text{Sin}[q_5] \\ 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

A01//MatrixForm

A12//MatrixForm

A02 = A01 * A12//MatrixForm

A02 = A01.A12//MatrixForm

$$\begin{pmatrix} \text{Cos}[q_1] & 0 & \text{Sin}[q_1] & -658.07\text{Cos}[q_1] \\ -\text{Sin}[q_1] & 0 & \text{Cos}[q_1] & 658.07\text{Sin}[q_1] \\ 0 & -1 & 0 & 1134 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$\begin{pmatrix} \text{Cos}[q_2] & \text{Sin}[q_2] & 0 & -1689.31\text{Cos}[q_2] \\ -\text{Sin}[q_2] & \text{Cos}[q_2] & 0 & 1689.31\text{Sin}[q_2] \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$\begin{pmatrix} \text{Cos}[q_1]\,\text{Cos}[q_2] & 0 & 0 & 1.11168\times 10^6\text{Cos}[q_1]\,\text{Cos}[q_2] \\ \text{Sin}[q_1]\,\text{Sin}[q_2] & 0 & 0 & 1.11168\times 10^6\text{Sin}[q_1]\,\text{Sin}[q_2] \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$\begin{pmatrix} 0.+\text{Cos}[q_1]\,\text{Cos}[q_2] & 0.+\text{Cos}[q_1]\,\text{Sin}[q_2] & 0.+\text{Sin}[q_1] & 0.-658.07\text{Cos}[q_1]-1689.31\text{Cos}[q_1]\,\text{Cos}[q_2] \\ 0.-\text{Cos}[q_2]\,\text{Sin}[q_1] & 0.-\text{Sin}[q_1]\,\text{Sin}[q_2] & 0.+\text{Cos}[q_1] & 0.+658.07\text{Sin}[q_1]+1689.31\text{Cos}[q_2]\,\text{Sin}[q_1] \\ \text{Sin}[q_2] & -\text{Cos}[q_2] & 0 & 1134.-1689.31\text{Sin}[q_2] \\ 0 & 0 & 0 & 1. \end{pmatrix}$$

A05 = A01.A12.A23.A34.A45

A05//MatrixForm

$$\{\{\text{Cos}[q_5]\,(\text{Cos}[q_4]\,(0.+\text{Sin}[q_1])-(\text{Cos}[q_3]\,(0.+\text{Cos}[q_1]\,\text{Sin}[q_2])-(0.+\text{Cos}[q_1]\,\text{Cos}[q_2])\,\text{Sin}[q_3])\,\text{Sin}[q_4])+((0$$

$$\begin{pmatrix} \text{Cos}[q_5]\,(\text{Cos}[q_4]\,(0.+\text{Sin}[q_1])-(\text{Cos}[q_3]\,(0.+\text{Cos}[q_1]\,\text{Sin}[q_2])-(0.+\text{Cos}[q_1]\,\text{Cos}[q_2])\,\text{Sin}[q_3])\,\text{Sin}[q_4])+(\\ \text{Cos}[q_5]\,((0.+\text{Cos}[q_1])\,\text{Cos}[q_4]-(\text{Cos}[q_3]\,(0.-\text{Sin}[q_1]\,\text{Sin}[q_2])-(0.-\text{Cos}[q_2]\,\text{Sin}[q_1])\,\text{Sin}[q_3])\,\text{Sin}[q_4])+(\\ -\text{Cos}[q_5]\,(-\text{Cos}[q_2]\,\text{Cos}[q_3]-\text{Sin}[q_2]\,\text{Sin}[q_3])\,\text{Sin}[q_4]+(\text{Cos}[q_3]\,\text{Sin}[\\ 0. \end{pmatrix}$$

Px = Simplify[{{1, 0, 0, 0}, {0, 0, 0, 0}, {0, 0, 0, 0}}.A05.{0, 0, 0, 1}]

Py = Simplify[{{0, 0, 0, 0}, {0, 1, 0, 0}, {0, 0, 0, 0}}.A05.{0, 0, 0, 1}]

Pz = Simplify[{{0, 0, 0, 0}, {0, 0, 0, 0}, {0, 0, 1, 0}}.A05.{0, 0, 0, 1}]

$$\{-452.\,(-0.813053+\text{Cos}[q_4]\,(-0.782898+\text{Cos}[q_5]))\,\text{Sin}[q_1]+353.87\text{Cos}[q_1]\,(-1.85964+\text{Cos}[q_3]\,\text{Sin}[q_2]\,(-6.0$$

$$\{0.,-452.\text{Cos}[q_1]\,(-0.813053+\text{Cos}[q_4]\,(-0.782898+\text{Cos}[q_5]))-353.87\text{Sin}[q_1]\,(-1.85964+\text{Cos}[q_3]\,\text{Sin}[q_2]\,(-6$$

$$\{0.,0.,-452.\,(-2.50885+\text{Sin}[q_2]\,(3.73741\ +\text{Sin}[q_3]\,(-4.71013+(-0.782898+\text{Cos}[q_5])\,\text{Sin}[q_4])+\text{Cos}[q_3]\,\text{Sin}[$$

Jv:= $\{\{D[\mathbf{Px}, q_1], D[\mathbf{Px}, q_2], D[\mathbf{Px}, q_3], D[\mathbf{Px}, q_4], D[\mathbf{Px}, q_5]\}, \{D[\mathbf{Py}, q_1], D[\mathbf{Py}, q_2], D[\mathbf{Py}, q_3], D[\mathbf{Py}, q_4], D[\mathbf{Py},$

$\{D[\mathbf{Pz}, q_1], D[\mathbf{Pz}, q_2], D[\mathbf{Py}, q_3], D[\mathbf{Py}, q_4], D[\mathbf{Py}, q_5]\}\}$

***J*//MatrixForm**

Transpose[*J*]//MatrixForm

J

Transpose$[J]$

$R = \{\{1,0,0,0\},\{0,1,0,0\},\{0,0,1,0\}\}$**.A05.**$\{\{1,0,0\},\{0,1,0\},\{0,0,1\},\{0,0,0\}\}$

$\{\{0. + \text{Cos}[q_5](\text{Cos}[q_4](0. + \text{Sin}[q_1]) - (\text{Cos}[q_3](0. + \text{Cos}[q_1]\,\text{Sin}[q_2]) - (0. + \text{Cos}[q_1]\,\text{Cos}[q_2])\,\text{Sin}[q_3])\,\text{Sin}[q_4])$

$S_1 = D[R, q_1]$**.Transpose[*R*];**

$\mathbf{wx_1} = S_1[[3,2]];$

$\mathbf{wy_1} = S_1[[1,3]];$

$\mathbf{wz_1} = S_1[[2,1]];$

$S_2 = D[R, q_2]$**.Transpose[*R*];**

$\mathbf{wx_2} = S_2[[3,2]];$

$\mathbf{wy_2} = S_2[[1,3]];$

$\mathbf{wz_2} = S_2[[2,1]];$

$S_3 = D[R, q_3]$**.Transpose[*R*];**

$\mathbf{wx_3} = S_3[[3,2]];$

$\mathbf{wy_3} = S_3[[1,3]];$

$\mathbf{wz_3} = S_3[[2,1]];$

$S_4 = D[R, q_4].\text{Transpose}[R];$

$\text{wx}_4 = S_4[[3, 2]];$

$\text{wy}_4 = S_4[[1, 3]];$

$\text{wz}_4 = S_4[[2, 1]];$

$S_5 = D[R, q_5].\text{Transpose}[R];$

$\text{wx}_5 = S_5[[3, 2]];$

$\text{wy}_5 = S_5[[1, 3]];$

$\text{wz}_5 = S_5[[2, 1]];$

$J = \text{FullSimplify}[\{\{D[\text{Px}, q_1], D[\text{Px}, q_2], D[\text{Px}, q_3], D[\text{Px}, q_4], D[\text{Px}, q_5]\}, \{D[\text{Py}, q_1], D[\text{Py}, q_2], D[\text{Py}, q_3], D[\text{P}$

$\{D[\text{Pz}, q_1], D[\text{Pz}, q_2], D[\text{Py}, q_3], D[\text{Py}, q_4], D[\text{Py}, q_5]\}, \{\text{wx}_1, \text{wx}_2, \text{wx}_3, \text{wx}_4, \text{wx}_5\}, \{\text{wy}_1, \text{wy}_2, \text{wy}_3, \text{wy}_4, \text{wy}_5\}, \{$

$\text{Dimensions}[J]$

$\{\{\{\text{Cos}[q_1](367.5 + \text{Cos}[q_4](353.87 - 452.\text{Cos}[q_5])) + \text{Sin}[q_1](658.07 + \text{Cos}[q_2](1689.31 + \text{Sin}[q_3](-2128.98 -$

$\{6, 5\}$

$\text{Simplify}[\text{A34}]//\text{MatrixForm}$

$\text{Simplify}[\text{A45}]//\text{MatrixForm}$

$\text{Simplify}[\text{A05}]//\text{MatrixForm}$

$\text{FullSimplify}[\text{Px}]//\text{MatrixForm}$

$\text{FullSimplify}[\text{Py}]//\text{MatrixForm}$

$\text{FullSimplify}[\text{Pz}]//\text{MatrixForm}$

$\text{FullSimplify}[R]//\text{MatrixForm}$

$$\begin{pmatrix} -\text{Sin}[q_4] & 0 & \text{Cos}[q_4] & -353.87\text{Sin}[q_4] \\ \text{Cos}[q_4] & 0 & \text{Sin}[q_4] & 353.87\text{Cos}[q_4] \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$\begin{pmatrix} \text{Cos}[q_5] & 0 & -\text{Sin}[q_5] & -452\text{Cos}[q_5] \\ \text{Sin}[q_5] & 0 & \text{Cos}[q_5] & -452\text{Sin}[q_5] \\ 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$\begin{pmatrix} \text{Cos}[q_4]\,\text{Cos}[q_5]\,\text{Sin}[q_1] + \text{Cos}[q_1]\,(-\text{Cos}[q_5]\,\text{Sin}[q_2 - q_3]\,\text{Sin}[q_4] + \text{Cos}[q_2 - q_3]\,\text{Sin}[q_5]) & -\text{C} \\ \text{Cos}[q_1]\,\text{Cos}[q_4]\,\text{Cos}[q_5] + \text{Sin}[q_1]\,(\text{Cos}[q_5]\,\text{Sin}[q_2 - q_3]\,\text{Sin}[q_4] - \text{Cos}[q_2 - q_3]\,\text{Sin}[q_5]) & \text{Cos}[q_3]\,\text{Cos}[q_4]\,\text{Sin}[q \\ \text{Cos}[q_2 - q_3]\,\text{Cos}[q_5]\,\text{Sin}[q_4] + \text{Sin}[q_2 - q_3]\,\text{Sin}[q_5] & \\ 0. & \end{pmatrix}$$

FullSimplify [D [**Px**, q_1]]

FullSimplify [D [**Px**, q_2]]

FullSimplify [D [**Px**, q_3]]

FullSimplify [D [**Px**, q_4]]

FullSimplify [D [**Px**, q_5]]

FullSimplify [D [**Py**, q_1]]

FullSimplify [D [**Py**, q_2]]

FullSimplify [D [**Py**, q_3]]

FullSimplify [D [**Py**, q_4]]

FullSimplify [D [**Py**, q_5]]

FullSimplify [D [**Pz**, q_1]]

FullSimplify [D [**Pz**, q_2]]

FullSimplify [D [**Pz**, q_3]]

FullSimplify [D [**Pz**, q_4]]

FullSimplify [D [**Pz**, q_5]]

Simplify [$\mathbf{wx}_1$]

Simplify [$\mathbf{wy}_1$]

Simplify [$\mathbf{wz}_1$]

Simplify [wx_2]

Simplify [wy_2]

Simplify [wz_2]

Simplify [wx_3]

Simplify [wy_3]

Simplify [wz_3]

Simplify [wx_4]

Simplify [wy_4]

Simplify [wz_4]

Simplify [wx_5]

Simplify [wy_5]

Simplify [wz_5]

$\{\text{Cos}[q_1](367.5 + \text{Cos}[q_4](353.87 - 452.\text{Cos}[q_5])) + \text{Sin}[q_1](658.07 + \text{Cos}[q_2](1689.31 + \text{Sin}[q_3](-2128.98 - 3$

$\{353.87\text{Cos}[q_1](\text{Sin}[q_2](4.77382 + \text{Sin}[q_3](-6.01628 - 1.\text{Sin}[q_4])) + \text{Cos}[q_2]\,\text{Cos}[q_3](-6.01628 - 1.\text{Sin}[q_4]) + 1.$

$\{353.87\text{Cos}[q_1](-1.27731\text{Cos}[q_2 - q_3]\,\text{Cos}[q_5]\,\text{Sin}[q_4] + \text{Cos}[q_2]\,\text{Cos}[q_3](6.01628 + 1.\text{Sin}[q_4]) + \text{Sin}[q_2]\,\text{Sin}[q_3](6$

$\{\text{Cos}[q_1]\,\text{Cos}[q_4](-353.87\text{Cos}[q_3]\,\text{Sin}[q_2] + 452.\text{Cos}[q_5]\,\text{Sin}[q_2 - q_3] + 353.87\text{Cos}[q_2]\,\text{Sin}[q_3]) + (-353.87 + 452.C$

$\{452.\text{Cos}[q_4]\,\text{Sin}[q_1]\,\text{Sin}[q_5] + \text{Cos}[q_1](-452.\text{Cos}[q_2 - q_3]\,\text{Cos}[q_5] - 452.\text{Sin}[q_2 - q_3]\,\text{Sin}[q_4]\,\text{Sin}[q_5]), 0, 0\}$

$\{0, (-367.5 + \text{Cos}[q_4](-353.87 + 452.\text{Cos}[q_5]))\,\text{Sin}[q_1] + \text{Cos}[q_1](658.07 + \text{Cos}[q_2](1689.31 + \text{Sin}[q_3](-2128.9$

$\{0, -353.87\text{Sin}[q_1](\text{Sin}[q_2](4.77382 + \text{Sin}[q_3](-6.01628 - 1.\text{Sin}[q_4])) + \text{Cos}[q_2]\,\text{Cos}[q_3](-6.01628 - 1.\text{Sin}[q_4])$

$\{0, -353.87\text{Sin}[q_1](-1.27731\text{Cos}[q_2 - q_3]\,\text{Cos}[q_5]\,\text{Sin}[q_4] + \text{Cos}[q_2]\,\text{Cos}[q_3](6.01628 + 1.\text{Sin}[q_4]) + \text{Sin}[q_2]\,\text{Sin}[q$

$\{0, \text{Cos}[q_4]\,\text{Sin}[q_1](353.87\text{Cos}[q_3]\,\text{Sin}[q_2] - 452.\text{Cos}[q_5]\,\text{Sin}[q_2 - q_3] - 353.87\text{Cos}[q_2]\,\text{Sin}[q_3]) + 452.\text{Cos}[q_1](-0.7$

$\{0, 452.\text{Cos}[q_2 - q_3]\,\text{Cos}[q_5]\,\text{Sin}[q_1] + (452.\text{Cos}[q_1]\,\text{Cos}[q_4] + 452.\text{Sin}[q_1]\,\text{Sin}[q_2 - q_3]\,\text{Sin}[q_4])\,\text{Sin}[q_5], 0\}$

$\{0, 0, 0\}$

$$\{0, 0, \text{Cos}\,[q_3]\,\text{Sin}\,[q_2]\,(-2128.98 + (-353.87 + 452.\text{Cos}\,[q_5])\,\text{Sin}\,[q_4]) + \text{Cos}\,[q_2]\,(-1689.31 + \text{Sin}\,[q_3]\,(2128.98 + (35$$

$$\{0, 0, -452.\text{Cos}\,[q_3]\,(\text{Sin}\,[q_2]\,(-4.71013 + (-0.782898 + \text{Cos}\,[q_5])\,\text{Sin}\,[q_4]) - 1.\text{Cos}\,[q_2]\,\text{Sin}\,[q_5]) + 452.\text{Sin}\,[q_3]\,(\text{Cos}\,[$$

$$\{0, 0, -452.\text{Cos}\,[q_2 - q_3]\,\text{Cos}\,[q_4]\,(-0.782898 + \text{Cos}\,[q_5])\}$$

$$\{0, 0, -452.\,(\text{Cos}\,[q_3]\,(\text{Cos}\,[q_5]\,\text{Sin}\,[q_2] - \text{Cos}\,[q_2]\,\text{Sin}\,[q_4]\,\text{Sin}\,[q_5]) + \text{Sin}\,[q_3]\,(-1.\text{Cos}\,[q_2]\,\text{Cos}\,[q_5] - \text{Sin}\,[q_2]\,\text{Sin}\,[q_4]\,\text{Sin}$$

$$0$$

$$0$$

$$-1$$

$$-\text{Sin}\,[q_1]$$

$$-\text{Cos}\,[q_1]$$

$$0$$

$$\text{Sin}\,[q_1]$$

$$\text{Cos}\,[q_1]$$

$$0$$

$$\text{Cos}\,[q_1]\,\text{Cos}\,[q_2 - q_3]$$

$$-\text{Cos}\,[q_2 - q_3]\,\text{Sin}\,[q_1]$$

$$\text{Sin}\,[q_2 - q_3]$$

$$\text{Cos}\,[q_1]\,\text{Cos}\,[q_4]\,\text{Sin}\,[q_2 - q_3] + \text{Sin}\,[q_1]\,\text{Sin}\,[q_4]$$

$$-\text{Cos}\,[q_3]\,\text{Cos}\,[q_4]\,\text{Sin}\,[q_1]\,\text{Sin}\,[q_2] + \text{Cos}\,[q_2]\,\text{Cos}\,[q_4]\,\text{Sin}\,[q_1]\,\text{Sin}\,[q_3] + \text{Cos}\,[q_1]\,\text{Sin}\,[q_4]$$

$$-\text{Cos}\,[q_2 - q_3]\,\text{Cos}\,[q_4]$$

FullSimplify [{{wx$_1$, wx$_2$, wx$_3$, wx$_4$, wx$_5$}, {wy$_1$, wy$_2$, wy$_3$, wy$_4$, wy$_5$}, {wz$_1$, wz$_2$, wz$_3$, wz$_4$, wz$_5$}}] //MatrixForm

$$\begin{pmatrix} 0 & -\text{Sin}[q_1] & \text{Sin}[q_1] & \text{Cos}[q_1]\,\text{Cos}[q_2-q_3] & \text{Cos}[q_1]\,\text{Cos}[q_4]\,\text{Sin}[q_2-q_3]+\text{Sin}[q_1]\,\text{Sin}[q_4] \\ 0 & -\text{Cos}[q_1] & \text{Cos}[q_1] & -\text{Cos}[q_2-q_3]\,\text{Sin}[q_1] & -\text{Cos}[q_4]\,\text{Sin}[q_1]\,\text{Sin}[q_2-q_3]+\text{Cos}[q_1]\,\text{Sin}[q_4] \\ -1 & 0 & 0 & \text{Sin}[q_2-q_3] & -\text{Cos}[q_2-q_3]\,\text{Cos}[q_4] \end{pmatrix}$$