In[•]:=
```
SetDirectory[NotebookDirectory[]]
<< robotica_v_4.m
```

Out[•]=
```
/home/albert/Downloads/robotica-master 1/robotica-master
```

G: Symbol G appears in multiple contexts {robotica`, Global`}; definitions in context robotica` may shadow or be shadowed by other definitions.

```
Robotica version 4.01.
```

In[•]:=
```
DataFile["TeleJapet_4DOF.txt"]
```

Kinematics Input Data:

Joint	Type	r	α	d	θ
1	revolute	0	$\frac{\pi}{2}$	d1	q1
2	revolute	a2	0	0	q2
3	revolute	a3	0	0	q3
4	revolute	a4	0	0	q4

Dynamics Input Data

Gravity vector: [0, 0, g]

Link	mass	com vector
1	m1	[0, -0.5*d1, 0]
2	m2	[-0.5*a2, 0, 0]
3	m3	[-0.5*a3, 0, 0]
4	m4	[-0.5*a4, 0, 0]

$$\text{Inertia}[1] = \begin{pmatrix} \frac{d1^2\, m1}{12} & 0 & 0 \\ 0 & \frac{d1^2\, m1}{12} & 0 \\ 0 & 0 & 0 \end{pmatrix}$$

$$\text{Inertia}[2] = \begin{pmatrix} 0 & 0 & 0 \\ 0 & \frac{a2^2\, m2}{12} & 0 \\ 0 & 0 & \frac{a2^2\, m2}{12} \end{pmatrix}$$

$$\text{Inertia}[3] = \begin{pmatrix} 0 & 0 & 0 \\ 0 & \frac{a3^2\, m3}{12} & 0 \\ 0 & 0 & \frac{a3^2\, m3}{12} \end{pmatrix}$$

$$\text{Inertia}[4] = \begin{pmatrix} 0 & 0 & 0 \\ 0 & \frac{a4^2\, m4}{12} & 0 \\ 0 & 0 & \frac{a4^2\, m4}{12} \end{pmatrix}$$

In[•]:= **FKin[]**

In[•]:= **SimplifyTrigNotation[]**

In[•]:= **APrint[]**

$$A[1]= \begin{pmatrix} \text{Cos}[q1] & 0 & \text{Sin}[q1] & 0 \\ \text{Sin}[q1] & 0 & -\text{Cos}[q1] & 0 \\ 0 & 1 & 0 & d1 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$A[2]= \begin{pmatrix} \text{Cos}[q2] & -\text{Sin}[q2] & 0 & a2\,\text{Cos}[q2] \\ \text{Sin}[q2] & \text{Cos}[q2] & 0 & a2\,\text{Sin}[q2] \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$A[3]= \begin{pmatrix} \text{Cos}[q3] & -\text{Sin}[q3] & 0 & a3\,\text{Cos}[q3] \\ \text{Sin}[q3] & \text{Cos}[q3] & 0 & a3\,\text{Sin}[q3] \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$A[4]= \begin{pmatrix} \text{Cos}[q4] & -\text{Sin}[q4] & 0 & a4\,\text{Cos}[q4] \\ \text{Sin}[q4] & \text{Cos}[q4] & 0 & a4\,\text{Sin}[q4] \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

In[•]:=
```
TPrint[]
```

$$T[0,1]=\begin{pmatrix} \text{Cos}[q1] & 0 & \text{Sin}[q1] & 0 \\ \text{Sin}[q1] & 0 & -\text{Cos}[q1] & 0 \\ 0 & 1 & 0 & d1 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$T[0,2]=\begin{pmatrix} \text{Cos}[q1]\,\text{Cos}[q2] & -\text{Cos}[q1]\,\text{Sin}[q2] & \text{Sin}[q1] & a2\,\text{Cos}[q1]\,\text{Cos}[q2] \\ \text{Cos}[q2]\,\text{Sin}[q1] & -\text{Sin}[q1]\,\text{Sin}[q2] & -\text{Cos}[q1] & a2\,\text{Cos}[q2]\,\text{Sin}[q1] \\ \text{Sin}[q2] & \text{Cos}[q2] & 0 & d1 + a2\,\text{Sin}[q2] \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$T[0,3]=\begin{pmatrix} \text{Cos}[q1]\,\text{Cos}[q2+q3] & -\text{Cos}[q1]\,\text{Sin}[q2+q3] & \text{Sin}[q1] & \text{Cos}[q1]\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]\right) \\ \text{Cos}[q2+q3]\,\text{Sin}[q1] & -\text{Sin}[q1]\,\text{Sin}[q2+q3] & -\text{Cos}[q1] & \left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]\right)\text{Sin}[q1] \\ \text{Sin}[q2+q3] & \text{Cos}[q2+q3] & 0 & d1 + a2\,\text{Sin}[q2] + a3\,\text{Sin}[q2+q3] \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$T[0,4]=\begin{pmatrix} \text{Cos}[q1]\,\text{Cos}[q2+q3+q4] & -\text{Cos}[q1]\,\text{Sin}[q2+q3+q4] & \text{Sin}[q1] & \text{Cos}[q1]\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a \\ \text{Cos}[q2+q3+q4]\,\text{Sin}[q1] & -\text{Sin}[q1]\,\text{Sin}[q2+q3+q4] & -\text{Cos}[q1] & \left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q \\ \text{Sin}[q2+q3+q4] & \text{Cos}[q2+q3+q4] & 0 & d1 + a2\,\text{Sin}[q2] + a3\,\text{Sin}[q2+q3] + a4 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$T[1,2]=\begin{pmatrix} \text{Cos}[q2] & -\text{Sin}[q2] & 0 & a2\,\text{Cos}[q2] \\ \text{Sin}[q2] & \text{Cos}[q2] & 0 & a2\,\text{Sin}[q2] \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$T[1,3]=\begin{pmatrix} \text{Cos}[q2+q3] & -\text{Sin}[q2+q3] & 0 & a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3] \\ \text{Sin}[q2+q3] & \text{Cos}[q2+q3] & 0 & a2\,\text{Sin}[q2]+a3\,\text{Sin}[q2+q3] \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$T[1,4]=\begin{pmatrix} \text{Cos}[q2+q3+q4] & -\text{Sin}[q2+q3+q4] & 0 & a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4] \\ \text{Sin}[q2+q3+q4] & \text{Cos}[q2+q3+q4] & 0 & a2\,\text{Sin}[q2]+a3\,\text{Sin}[q2+q3]+a4\,\text{Sin}[q2+q3+q4] \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$T[2,3]=\begin{pmatrix} \text{Cos}[q3] & -\text{Sin}[q3] & 0 & a3\,\text{Cos}[q3] \\ \text{Sin}[q3] & \text{Cos}[q3] & 0 & a3\,\text{Sin}[q3] \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$T[2,4]=\begin{pmatrix} \text{Cos}[q3+q4] & -\text{Sin}[q3+q4] & 0 & a3\,\text{Cos}[q3]+a4\,\text{Cos}[q3+q4] \\ \text{Sin}[q3+q4] & \text{Cos}[q3+q4] & 0 & a3\,\text{Sin}[q3]+a4\,\text{Sin}[q3+q4] \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$T[3,4]=\begin{pmatrix} \text{Cos}[q4] & -\text{Sin}[q4] & 0 & a4\,\text{Cos}[q4] \\ \text{Sin}[q4] & \text{Cos}[q4] & 0 & a4\,\text{Sin}[q4] \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

In[•]:=
```
drawRobot3[]
```

Out[•]=

θ_1 $\frac{3\pi}{32}$

θ_2 $\frac{11\pi}{32}$

θ_3 $-\frac{5\pi}{16}$

θ_4 $-\frac{\pi}{8}$

grip 1

show robot ☑

show Manipulability ellipses:

Σv ☑

Σw ☑

μ_V=

$-5.55112\times10^{-17}\,a2^5\,a3+0.153626\,a2^4\,a3^2+0.648654\,a2^3\,a3^3+0.6847\,a2^2\,a$

$-5.55112\times10^{-17}\,a2\,a3^5-3.46945\times10^{-17}\,a3^6+0.362429\,a2^4\,a3\,a4+2.15401\,a$

$a3^2\,a4+2.93209\,a2^2\,a3^3\,a4-1.66533\times10^{-16}\,a2\,a3^4\,a4-1.80411\times10^{-16}\,a3^5$

$+0.427515\,a2^4\,a4^2+3.44337\,a2^3\,a3\,a4^2+6.41436\,a2^2\,a3^2\,a4^2+1.01826\,$

$a3^3\,a4^2+0.290079\,a3^4\,a4^2+1.73572\,a2^3\,a4^3+5.83514\,a2^2\,a3\,a4^3+1.694\,$

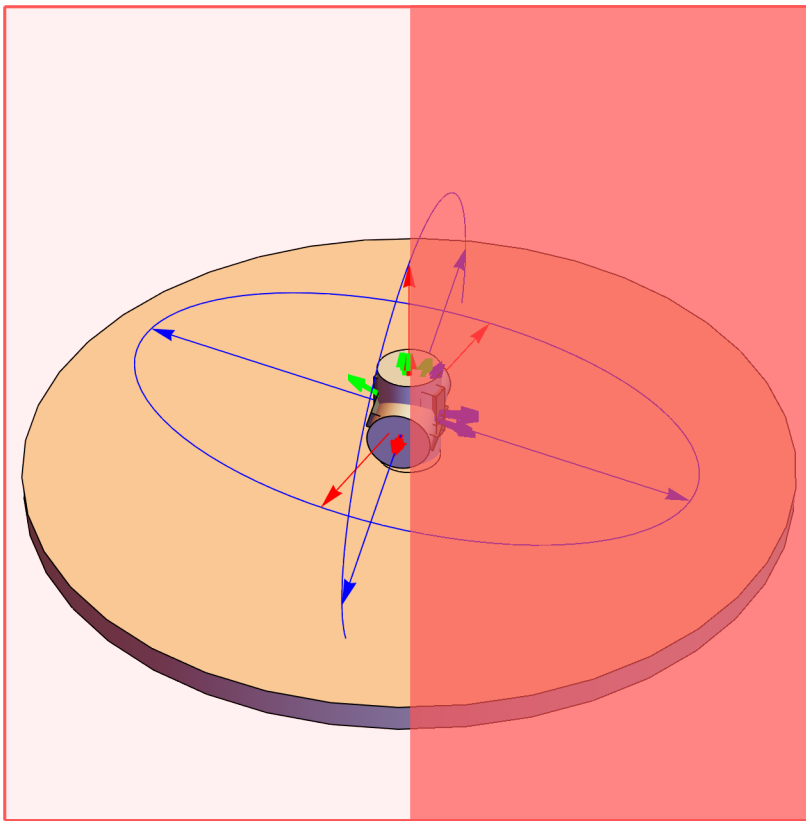
$a3^2\,a4^3+0.557863\,a3^3\,a4^3+1.76176\,a2^2\,a4^4+0.687406\,a2\,a3\,a4^4+0.2682$

$a3^2\,a4^4-2.22045\times10^{-16}\,a2\,a4^5-2.22045\times10^{-16}\,a3\,a4^5-1.11022\times10^{-16}\,a$

μ_W=-9.2521×10^{-17}

H=TransformationFunction[(

0.92	0.28	0.29	0.45 a2 + 0.95 a3 + 0.92 a4
0.28	0.084	-0.96	0.14 a2 + 0.29 a3 + 0.28 a4
-0.29	0.96	0	0.88 a2 + 0.098 a3 - 0.29 a4 + d
0	0	0	1.0



Part: Part 5 of {0, 0, 0, 0} does not exist.

Part: Part 5 of {0, 0, 0, 0} does not exist.

Part: Part 5 of {0, 0, 0, 0} does not exist.

General: Further output of Part::partw will be suppressed during this calculation.

Part: Part 5 of {0, 0, 0, 0} does not exist.

Part: Part 5 of {0, 0, 0, 0} does not exist.

Part: Part 5 of {0, 0, 0, 0} does not exist.

General: Further output of Part::partw will be suppressed during this calculation.

```
SingularValueDecomposition::svdnsvc: Cannot compute all the singular vectors.

Set::shape: Lists {robotica`Private`U$22859, robotica`Private`Σ$22859,
     robotica`Private`V$22859} and
    SingularValueDecomposition[{{-0.136839 a2 - 0.288887 a3 - 0.277785 a4,
       -0.843946 a2 - 0.0937966 a3 + 0.277785 a4,
       -0.0937966 a3 + 0.277785 a4, 0.277785 a4}, {<<4>>}, {0., <<3>>}}] are
     not the same shape.

Det::luc: Result for Det of badly conditioned matrix
    {{0.252796, -0.833355, 0.}, {-0.833355, 2.7472, 0.}, {0., 0., 1.}}
     may contain significant numerical errors.

Part::partd: Part specification robotica`Private`Σ$22859[[1,1]]
     is longer than depth of object.

Part::partd: Part specification robotica`Private`Σ$22859[[2,2]]
     is longer than depth of object.

Part::partd: Part specification robotica`Private`Σ$22859[[3,3]]
     is longer than depth of object.

General::stop: Further output of Part::partd
     will be suppressed during this calculation.
```

In[•]:=
```
ELDynamics[]
```

```
Mass Matrix MU(4 x 4) Formed.  No Trigonometric Simplification.


Christoffel Symbols Formed.


C Matrix CM(4 x 4) Formed.


Gravity Vector G(4 x 1) Formed.
```

In[•]:= **SimplifyExpression[MU]**

Out[•]=

$$\left\{\left\{\frac{1}{12}\left(d1^2\,m1 + 2\,a2^2\,m2 + 6\,a2^2\,m3 + 2\,a3^2\,m3 + 6\,a2^2\,m4 + 6\,a3^2\,m4 + 2\,a4^2\,m4 + 2\,a2^2\left(m2 + 3\,(m3 + m4)\right)\text{Cos}\left[2\,q2\right] + 6\,a2\,a3\left(m3 + 2\,m4\right)c_3 + 2\,a3^2\,m3\,\text{Cos}\left[2\,(q2 + q3)\right] + 6\,a3^2\,m4\,\text{Cos}\left[2\,(q2 + q3)\right] + 6\,a2\,a3\,m3\,\text{Cos}\left[2\,q2 + q3\right] + 12\,a2\,a3\,m4\,\text{Cos}\left[2\,q2 + q3\right] + 6\,a3\,a4\,m4\,c_4 + 6\,a2\,a4\,m4\,c_{34} + 2\,a4^2\,m4\,\text{Cos}\left[2\,(q2 + q3 + q4)\right] + 6\,a2\,a4\,m4\,\text{Cos}\left[2\,q2 + q3 + q4\right] + 6\,a3\,a4\,m4\,\text{Cos}\left[2\,q2 + 2\,q3 + q4\right]\right),\ 0,\ 0,\ 0\right\},\ \left\{0,\ a2\,a3\left(m3 + 2\,m4\right)c_3 + \frac{1}{3}\left(a2^2\,m2 + 3\,a2^2\,m3 + a3^2\,m3 + 3\,a2^2\,m4 + 3\,a3^2\,m4 + a4^2\,m4 + 3\,a3\,a4\,m4\,c_4 + 3\,a2\,a4\,m4\,c_{34}\right),\ \frac{1}{6}\left(2\,a3^2\,m3 + 6\,a3^2\,m4 + 2\,a4^2\,m4 + 3\,a2\,a3\left(m3 + 2\,m4\right)c_3 + 6\,a3\,a4\,m4\,c_4 + 3\,a2\,a4\,m4\,c_{34}\right),\ \frac{1}{6}\,a4\,m4\left(2\,a4 + 3\,a3\,c_4 + 3\,a2\,c_{34}\right)\right\},\ \left\{0,\ \frac{1}{6}\left(2\,a3^2\,m3 + 6\,a3^2\,m4 + 2\,a4^2\,m4 + 3\,a2\,a3\left(m3 + 2\,m4\right)c_3 + 6\,a3\,a4\,m4\,c_4 + 3\,a2\,a4\,m4\,c_{34}\right),\ \frac{1}{3}\left(a4^2\,m4 + a3^2\left(m3 + 3\,m4\right) + 3\,a3\,a4\,m4\,c_4\right),\ \frac{1}{6}\,a4\,m4\left(2\,a4 + 3\,a3\,c_4\right)\right\},\ \left\{0,\ \frac{1}{6}\,a4\,m4\left(2\,a4 + 3\,a3\,c_4 + 3\,a2\,c_{34}\right),\ \frac{1}{6}\,a4\,m4\left(2\,a4 + 3\,a3\,c_4\right),\ \frac{a4^2\,m4}{3}\right\}\right\}$$

In[•]:= **Grid[MU]**

$$\begin{array}{llll}
\frac{d1^2\,m1}{12} + & m3\left(-\left(\left(-\frac{1}{2}\,a3\,\text{Cos}[q1]\right.\right.\right. & m3\left(-\frac{1}{2}\,a3\left(-\frac{1}{2}\,a3\,\text{Cos}[q1]\right.\right. & m4\left(-\frac{1}{2}\,a4\right. \\
\frac{1}{12}\,a2^2\,m2\,\text{Cos}[q2]^2 + & \left.\left.\text{Cos}[q2 + q3] + \text{Cos}[q1]\left(a2\right.\right.\right. & \left.\left.\text{Cos}[q2 + q3] + \text{Cos}[q1]\left(a2\right.\right.\right. & \left(-\frac{1}{2}\,a4\,\text{Cos}[q1]\,\text{Cos}[\right. \\
\frac{1}{12}\,a3^2\,m3\,\text{Cos}[q2 + q3]^2 + & \left.\left.\text{Cos}[q2] + a3\right.\right. & \left.\left.\text{Cos}[q2] + a3\right.\right. & \left.q2 + q3 + q4] + \text{Cos}[q1]\right. \\
\frac{1}{12}\,a4^2\,m4 & \left.\left.\text{Cos}[q2 + q3]\right)\right) & \left.\left.\text{Cos}[q2 + q3]\right)\right) & \left(a2\,\text{Cos}[q2] + a3\right. \\
\text{Cos}[q2 + q3 + q4]^2 + & \text{Sin}[q1] & \text{Sin}[q1]\,\text{Sin}[& \left.\text{Cos}[q2 + q3] + a4\,\text{Cos}[\right. \\
m2\left(\frac{1}{4}\,a2^2\,\text{Cos}[q1]^2\right. & \left(a2\,\text{Sin}[q2] + \right.\right. & \left.q2 + q3] - \right. & \left.\left.q2 + q3 + q4]\right)\right) \\
\left.\text{Cos}[q2]^2 + \right. & \left.\frac{1}{2}\,a3\,\text{Sin}[\right. & \left.\frac{1}{2}\,a3\,\text{Cos}[q1]\right. & \text{Sin}[q1]\,\text{Sin}[\\
\left.\frac{1}{4}\,a2^2\,\text{Cos}[q2]^2\right. & \left.\left.q2 + q3]\right)\right) - & \left(\frac{1}{2}\,a3\,\text{Cos}[q2 + q3]\right. & \left.q2 + q3 + q4] - \right. \\
\left.\text{Sin}[q1]^2\right) + m3 & \text{Cos}[q1]\left(\frac{1}{2}\,a3\right. & \left.\text{Sin}[q1] - \right. & \frac{1}{2}\,a4\,\text{Cos}[q1] \\
\left(\left(-\frac{1}{2}\,a3\,\text{Cos}[q1]\,\text{Cos}[q2 + \right.\right. & \left.\text{Cos}[q2 + q3]\right. & \left.\left(a2\,\text{Cos}[q2] + a3\right.\right. & \left(\frac{1}{2}\,a4\right. \\
\left.\left.q3] + \text{Cos}[q1]\right.\right. & \left.\text{Sin}[q1] - \right. & \left.\left.\text{Cos}[q2 + q3]\right)\right. & \left.\text{Cos}[q2 + q3 + q4]\right. \\
\left.\left(a2\,\text{Cos}[q2] + \right.\right. & \left.\left(a2\,\text{Cos}[q2] + a3\right.\right. & \left.\text{Sin}[q1]\right) & \left.\text{Sin}[q1] - \right. \\
\left.\left.a3\,\text{Cos}[\right.\right. & \left.\left.\text{Cos}[q2 + q3]\right)\right. & \text{Sin}[q2 + q3]\Big) + & \left(a2\,\text{Cos}[q2] + a3\right. \\
\left.\left.q2 + q3]\right)\right)^2 + & \left.\text{Sin}[q1]\right) & m4\left(-\left(\left(-\frac{1}{2}\,a4\,\text{Cos}[q1]\,\text{Cos}[\right.\right.\right. & \left.\text{Cos}[q2 + q3] + a4\,\text{Cos}[\right. \\
\left(\frac{1}{2}\,a3\,\text{Cos}[q2 + q3]\right. & \left(a2\,\text{Sin}[q2] + \right. & \left.\left.q2 + q3 + q4] + \right.\right. & \left.q2 + q3 + q4]\right) \\
\left.\text{Sin}[q1] - \left(a2\right.\right. & \left.\frac{1}{2}\,a3\right. & \left.\text{Cos}[q1]\right. & \left.\text{Sin}[q1]\right) \\
\left.\text{Cos}[q2] + a3\right. & \left.\text{Sin}[q2 + q3]\right)) + & \left(a2\,\text{Cos}[q2] + \right. & \text{Sin}[q2 + q3 + q4]\Big) \\
\left.\text{Cos}[q2 + q3]\right) & m4\left(-\left(\left(-\frac{1}{2}\,a4\,\text{Cos}[q1]\,\text{Cos}[\right.\right.\right. & \left.a3\,\text{Cos}[q2 + \right. & \\
\left.\text{Sin}[q1]\right)^2\Big) + & \left.\left.q2 + q3 + q4] + \right.\right. & \left.q3] + a4\,\text{Cos}[\right. & \\
m4\left(-\frac{1}{2}\,a4\,\text{Cos}[q1]\,\text{Cos}[\right. & \text{Cos}[q1] & \left.q2 + q3 + q4]\right)\Big) & \\
 & \left(a2\,\text{Cos}[q2] + \right. & & \\
 & \left.a3\,\text{Cos}[q2 + \right. & & \\
 & \left.q3] + a4\,\text{Cos}[\right. & & \\
 & \left.q2 + q3 + q4]\right)\Big) & &
\end{array}$$

$$\left(\tfrac{1}{2}\,a4\,\mathrm{Cos}[q2+q3+q4]\,\mathrm{Sin}[q1]-\left(a2\,\mathrm{Cos}[q2]+a3\,\mathrm{Cos}[q2+q3]+a4\,\mathrm{Cos}[q2+q3+q4]\right)\mathrm{Sin}[q1]\right)^2\Big)$$

$$\mathrm{Cos}[q1]\left(a2\,\mathrm{Cos}[q2]+a3\,\mathrm{Cos}[q2+q3]+a4\,\mathrm{Cos}[q2+q3+q4]\right)\mathrm{Sin}[q1]\left(a2\,\mathrm{Cos}[q2]+a3\,\mathrm{Cos}[q2+q3]+a4\,\mathrm{Cos}[q2+q3+q4]\right)\mathrm{Sin}[q1]\left(a2\,\mathrm{Sin}[q2]+a3\,\mathrm{Sin}[q2+q3]+\tfrac{1}{2}\,a4\,\mathrm{Sin}[q2+q3+q4]\right)\Big)$$

$$\mathrm{Sin}[q1]\left(a3\,\mathrm{Sin}[q2+q3]+\tfrac{1}{2}\,a4\,\mathrm{Sin}[q2+q3+q4]\right)\Big)-\mathrm{Cos}[q1]\left(\tfrac{1}{2}\,a4\,\mathrm{Cos}[q2+q3+q4]\,\mathrm{Sin}[q1]-\left(a2\,\mathrm{Cos}[q2]+a3\,\mathrm{Cos}[q2+q3]+a4\,\mathrm{Cos}[q2+q3+q4]\right)\mathrm{Sin}[q1]\right)\left(a3\,\mathrm{Sin}[q2+q3]+\tfrac{1}{2}\,a4\,\mathrm{Sin}[q2+q3+q4]\right)\Big)$$

$$m3\left(-\left(\left(-\tfrac{1}{2}\,a3\,\mathrm{Cos}[q1]\,\mathrm{Cos}[q2+q3]+\mathrm{Cos}[q1]\left(a2\,\mathrm{Cos}[q2]+a3\,\mathrm{Cos}[q2+q3]\right)\right)\mathrm{Sin}[q1]\left(a2\,\mathrm{Sin}[q2]+\tfrac{1}{2}\,a3\,\mathrm{Sin}[q2+q3]\right)\right)-\mathrm{Cos}[q1]\left(\tfrac{1}{2}\,a3\,\mathrm{Cos}[q2+q3]\,\mathrm{Sin}[q1]-\left(a2\,\mathrm{Cos}[q2]+a3\,\mathrm{Cos}[q2+q3]\right)\mathrm{Sin}[q1]\right)\left(a2\,\mathrm{Sin}[q2]+\tfrac{1}{2}\,a3\,\mathrm{Sin}[q2+q3]\right)\Big)+m4\left(-\left(\left(-\tfrac{1}{2}\,a4\,\mathrm{Cos}[q1]\,\mathrm{Cos}[\right.\right.\right.$$

$$\tfrac{1}{12}\,a2^2\,m2\,\mathrm{Cos}[q1]^2\left(\mathrm{Cos}[q1]^2+\mathrm{Sin}[q1]^2\right)+\tfrac{1}{12}\,a3^2\,m3\,\mathrm{Cos}[q1]^2\left(\mathrm{Cos}[q1]^2+\mathrm{Sin}[q1]^2\right)+\tfrac{1}{12}\,a4^2\,m4\,\mathrm{Cos}[q1]^2\left(\mathrm{Cos}[q1]^2+\mathrm{Sin}[q1]^2\right)+\tfrac{1}{12}\,a2^2\,m2\,\mathrm{Sin}[q1]^2\left(\mathrm{Cos}[q1]^2+\mathrm{Sin}[q1]^2\right)+\tfrac{1}{12}\,a3^2\,m3\,\mathrm{Sin}[q1]^2\left(\mathrm{Cos}[q1]^2+\mathrm{Sin}[q1]^2\right)+\tfrac{1}{12}\,a4^2\,m4\,\mathrm{Sin}[q1]^2\left(\mathrm{Cos}[q1]^2+\mathrm{Sin}[q1]^2\right)+m2\left(\left(\tfrac{1}{2}\,a2\,\mathrm{Cos}[q1]^2\,\mathrm{Cos}[q2]+\tfrac{1}{2}\,a2\,\mathrm{Cos}[q2]\,\mathrm{Sin}[q1]^2\right)^2+\tfrac{1}{4}\,a2^2\,\mathrm{Cos}[q1]^2\,\mathrm{Sin}[q2]^2+\tfrac{1}{4}\,a2^2\,\mathrm{Sin}[q1]^2\right)$$

$$\tfrac{1}{12}\,a3^2\,m3\,\mathrm{Cos}[q1]^2\left(\mathrm{Cos}[q1]^2+\mathrm{Sin}[q1]^2\right)+\tfrac{1}{12}\,a4^2\,m4\,\mathrm{Cos}[q1]^2\left(\mathrm{Cos}[q1]^2+\mathrm{Sin}[q1]^2\right)+\tfrac{1}{12}\,a3^2\,m3\,\mathrm{Sin}[q1]^2\left(\mathrm{Cos}[q1]^2+\mathrm{Sin}[q1]^2\right)+\tfrac{1}{12}\,a4^2\,m4\,\mathrm{Sin}[q1]^2\left(\mathrm{Cos}[q1]^2+\mathrm{Sin}[q1]^2\right)+m3\left(\left(\mathrm{Cos}[q1]\left(-\tfrac{1}{2}\,a3\,\mathrm{Cos}[q1]\,\mathrm{Cos}[q2+q3]+\mathrm{Cos}[q1]\left(a2\,\mathrm{Cos}[q2]+a3\,\mathrm{Cos}[q2+q3]\right)\right)+\mathrm{Sin}[q1]\left(-\tfrac{1}{2}\,a3\,\mathrm{Cos}[q2+q3]\,\mathrm{Sin}[q1]+\left(a2\,\mathrm{Cos}[q2]+a3\,\mathrm{Cos}[q2+q3]\right)\mathrm{Sin}[q1]\right)\right)\left(a3\,\mathrm{Sin}[q2+q3]+\tfrac{1}{2}\,a4\,\mathrm{Sin}[q2+q3+q4]\right)\Big)$$

$$\tfrac{1}{12}\,a4^2\,m4\,\mathrm{Cos}[q1]^2\left(\mathrm{Cos}[q1]^2+\mathrm{Sin}[q1]^2\right)+\tfrac{1}{12}\,a4^2\,m4\,\mathrm{Sin}[q1]^2\left(\mathrm{Cos}[q1]^2+\mathrm{Sin}[q1]^2\right)+m4\left(\left(\mathrm{Cos}[q1]\left(-\tfrac{1}{2}\,a4\,\mathrm{Cos}[q1]\,\mathrm{Cos}[q2+q3+q4]+\mathrm{Cos}[q1]\left(a2\,\mathrm{Cos}[q2]+a3\,\mathrm{Cos}[q2+q3]+a4\,\mathrm{Cos}[q2+q3+q4]\right)\right)+\mathrm{Sin}[q1]\left(-\tfrac{1}{2}\,a4\,\mathrm{Cos}[q2+q3+q4]\,\mathrm{Sin}[q1]+\left(a2\,\mathrm{Cos}[q2]+a3\,\mathrm{Cos}[q2+q3]+a4\,\mathrm{Cos}[q2+q3+q4]\right)\right)\right)$$

$$
\begin{aligned}
&q2 + q3 + q4] + \\
&\text{Cos}[q1] \\
&\left(a2\ \text{Cos}[q2] + \right. \\
&a3\ \text{Cos}[q2 + \\
&q3] + a4\ \text{Cos}[\\
&\left. q2 + q3 + q4]\right)\Big) \\
&\text{Sin}[q1] \\
&\left(a2\ \text{Sin}[q2] + a3\right. \\
&\text{Sin}[q2 + q3] + \\
&\tfrac{1}{2}\ a4\ \text{Sin}[q2 + \\
&\left. q3 + q4]\right)\Big) - \\
&\text{Cos}[q1]\left(\tfrac{1}{2}\ a4\ \text{Cos}[\right. \\
&q2 + q3 + q4] \\
&\text{Sin}[q1] - \\
&\left(a2\ \text{Cos}[q2] + a3\right. \\
&\text{Cos}[q2 + q3] + \\
&a4\ \text{Cos}[\\
&\left. q2 + q3 + q4]\right) \\
&\text{Sin}[q1]\Big) \\
&\left(a2\ \text{Sin}[q2] + \right. \\
&a3\ \text{Sin}[q2 + q3] + \\
&\tfrac{1}{2}\ a4\ \text{Sin}[\\
&\left. q2 + q3 + q4]\right)\Big)
\end{aligned}
$$

$$
\begin{aligned}
&\text{Sin}[q2]^2\Big) + m3 \\
&\Big(\left(\text{Cos}[q1]\left(-\tfrac{1}{2}\ a3\ \text{Cos}[q1]\right.\right. \\
&\text{Cos}[q2 + q3] + \\
&\text{Cos}[q1] \\
&\left(a2\ \text{Cos}[q2] + \right. \\
&a3\ \text{Cos}[\\
&\left. q2 + q3]\right)\Big) + \\
&\text{Sin}[q1]\left(-\tfrac{1}{2}\ a3\right. \\
&\text{Cos}[q2 + q3] \\
&\text{Sin}[q1] + \left(a2\right. \\
&\text{Cos}[q2] + a3 \\
&\left.\text{Cos}[q2 + q3]\right) \\
&\left.\text{Sin}[q1]\right)\Big)^2 + \\
&\text{Cos}[q1]^2 \\
&\left(a2\ \text{Sin}[q2] + \right. \\
&\tfrac{1}{2}\ a3\ \text{Sin}[\\
&\left. q2 + q3]\right)^2 + \\
&\text{Sin}[q1]^2 \\
&\left(a2\ \text{Sin}[q2] + \right. \\
&\left.\tfrac{1}{2}\ a3\ \text{Sin}[\right. \\
&\left. q2 + q3]\right)^2\Big) + \\
&m4\ \Big(\left(\text{Cos}[q1]\left(-\tfrac{1}{2}\ a4\right.\right. \\
&\text{Cos}[q1]\ \text{Cos}[\\
&q2 + q3 + q4] + \\
&\text{Cos}[q1]\left(a2\right. \\
&\text{Cos}[q2] + a3 \\
&\text{Cos}[q2 + q3] + \\
&a4\ \text{Cos}[q2 + \\
&\left.q3 + q4]\right)\Big) + \\
&\text{Sin}[q1]\left(-\tfrac{1}{2}\ a4\right. \\
&\text{Cos}[q2 + q3 + \\
&q4]\ \text{Sin}[q1] + \\
&\left(a2\ \text{Cos}[q2] + \right. \\
&a3\ \text{Cos}[q2 + \\
&q3] + a4\ \text{Cos}[\\
&\left.\left. q2 + q3 + q4]\right) \right. \\
&\left.\left.\text{Sin}[q1]\right)\right)^2 + \\
&\text{Cos}[q1]^2 \\
&\left(a2\ \text{Sin}[q2] + a3\right. \\
&\text{Sin}[q2 + q3] + \\
&\tfrac{1}{2}\ a4\ \text{Sin}[q2 +
\end{aligned}
$$

$$
\begin{aligned}
&\left(\text{Cos}[q1]\left(-a2\ \text{Cos}[\right.\right. \\
&q1]\ \text{Cos}[q2] - \\
&\tfrac{1}{2}\ a3\ \text{Cos}[q1] \\
&\text{Cos}[q2 + q3] + \\
&\text{Cos}[q1] \\
&\left(a2\ \text{Cos}[q2] + \right. \\
&a3\ \text{Cos}[q2 + \\
&\left.\left.q3]\right)\right) + \text{Sin}[q1] \\
&\left(-a2\ \text{Cos}[q2]\right. \\
&\text{Sin}[q1] - \\
&\tfrac{1}{2}\ a3\ \text{Cos}[q2 + \\
&q3]\ \text{Sin}[q1] + \\
&\left(a2\ \text{Cos}[q2] + \right. \\
&\left.\left.a3\ \text{Cos}[q2 + \right.\right. \\
&\left.\left.q3]\right)\ \text{Sin}[q1]\right)\Big) + \\
&\tfrac{1}{2}\ a3\ \text{Cos}[q1]^2 \\
&\text{Sin}[\\
&q2 + q3] \\
&\left(a2\ \text{Sin}[q2] + \right. \\
&\tfrac{1}{2}\ a3 \\
&\left.\text{Sin}[q2 + q3]\right) + \\
&\tfrac{1}{2}\ a3\ \text{Sin}[q1]^2 \\
&\text{Sin}[\\
&q2 + q3] \\
&\left(a2\ \text{Sin}[q2] + \right. \\
&\tfrac{1}{2}\ a3 \\
&\left.\text{Sin}[q2 + q3]\right)\Big) + \\
&m4\ \Big(\left(\text{Cos}[q1]\left(-\tfrac{1}{2}\ a4\right.\right. \\
&\text{Cos}[q1]\ \text{Cos}[\\
&q2 + q3 + q4] + \\
&\text{Cos}[q1]\left(a2\right. \\
&\text{Cos}[q2] + a3 \\
&\text{Cos}[q2 + q3] + \\
&a4\ \text{Cos}[q2 + \\
&\left.q3 + q4]\right)\Big) + \\
&\text{Sin}[q1]\left(-\tfrac{1}{2}\ a4\right. \\
&\text{Cos}[q2 + q3 + \\
&q4]\ \text{Sin}[q1] + \\
&\left(a2\ \text{Cos}[q2] + \right. \\
&a3\ \text{Cos}[q2 + \\
&q3] + a4\ \text{Cos}[
\end{aligned}
$$

$$
\begin{aligned}
&\left.\left.\text{Sin}[q1]\right)\right) \\
&\left(\text{Cos}[q1]\left(-\text{Cos}[q1]\right.\right. \\
&\left(a2\ \text{Cos}[q2] + \right. \\
&a3\ \text{Cos}[q2 + \\
&\left.q3]\right) - \tfrac{1}{2}\ a4 \\
&\text{Cos}[q1]\ \text{Cos}[\\
&q2 + q3 + q4] + \\
&\text{Cos}[q1]\left(a2\right. \\
&\text{Cos}[q2] + a3 \\
&\text{Cos}[q2 + q3] + \\
&\left.a4\ \text{Cos}[q2 + \right. \\
&\left.\left.q3 + q4]\right)\right) + \\
&\text{Sin}[q1] \\
&\left(-\left(\left(a2\ \text{Cos}[q2] + \right.\right.\right. \\
&a3\ \text{Cos}[q2 + \\
&\left.\left.q3]\right)\ \text{Sin}[q1]\right) - \\
&\tfrac{1}{2}\ a4\ \text{Cos}[\\
&q2 + q3 + q4] \\
&\text{Sin}[q1] + \\
&\left(a2\ \text{Cos}[q2] + \right. \\
&a3\ \text{Cos}[q2 + \\
&q3] + a4\ \text{Cos}[\\
&\left.\left. q2 + q3 + q4]\right)\right. \\
&\left.\text{Sin}[q1]\right)\Big) + \\
&\tfrac{1}{2}\ a4\ \text{Cos}[q1]^2 \\
&\text{Sin}[\\
&q2 + \\
&q3 + \\
&q4] \\
&\left(a2\ \text{Sin}[q2] + \right. \\
&a3 \\
&\text{Sin}[q2 + q3] + \\
&\tfrac{1}{2}\ a4 \\
&\text{Sin}[\\
&\left. q2 + q3 + q4]\right) + \\
&\tfrac{1}{2}\ a4\ \text{Sin}[q1]^2 \\
&\text{Sin}[\\
&q2 + \\
&q3 + \\
&q4] \\
&\left(a2\ \text{Sin}[q2] + \right. \\
&a3
\end{aligned}
$$

$$\frac{1}{2}\,a4\,\mathrm{Sin}[q2+q3+q4]\Big)^2+\mathrm{Sin}[q1]^2\Big(a2\,\mathrm{Sin}[q2]+a3\,\mathrm{Sin}[q2+q3]+\frac{1}{2}\,a4\,\mathrm{Sin}[q2+q3+q4]\Big)^2\Big)$$

$$\Big(\mathrm{Cos}[q1]\Big(-a2\,\mathrm{Cos}[q1]\,\mathrm{Cos}[q2]-\frac{1}{2}\,a4\,\mathrm{Cos}[q1]\,\mathrm{Cos}[q2+q3+q4]+\mathrm{Cos}[q1]\Big(a2\,\mathrm{Cos}[q2]+a3\,\mathrm{Cos}[q2+q3]+a4\,\mathrm{Cos}[q2+q3+q4]\Big)+\mathrm{Sin}[q1]\Big(-a2\,\mathrm{Cos}[q2]\,\mathrm{Sin}[q1]-\frac{1}{2}\,a4\,\mathrm{Cos}[q2+q3+q4]\,\mathrm{Sin}[q1]+\Big(a2\,\mathrm{Cos}[q2]+a3\,\mathrm{Cos}[q2+q3]+a4\,\mathrm{Cos}[q2+q3+q4]\Big)\mathrm{Sin}[q1]\Big)+\mathrm{Cos}[q1]^2\Big(a3\,\mathrm{Sin}[q2+q3]+\frac{1}{2}\,a4\,\mathrm{Sin}[q2+q3+q4]\Big)\Big(a2\,\mathrm{Sin}[q2]+a3\,\mathrm{Sin}[q2+q3]+\frac{1}{2}\,a4\,\mathrm{Sin}[q2+q3+q4]\Big)+\mathrm{Sin}[q1]^2\Big(a3\,\mathrm{Sin}[q2+q3]+\frac{1}{2}\,a4\,\mathrm{Sin}[q2+q3+q4]\Big)\Big(a2\,\mathrm{Sin}[q2]+a3\,\mathrm{Sin}[q2+q3]+\frac{1}{2}\,a4\,\mathrm{Sin}[q2+q3+q4]\Big)\Big)$$

$$m3\Big(-\frac{1}{2}\,a3\Big(-\frac{1}{2}\,a3\,\mathrm{Cos}[q1]\,\mathrm{Sin}[q1]\Big)+\frac{1}{2}\,a3^2\,m3\,\mathrm{Cos}[q1]^2\,\mathrm{Sin}[q1]^2+\frac{1}{2}\,a3^2\,m3\,\mathrm{Cos}[q1]^2\,\mathrm{Sin}[q1]^2+\frac{1}{2}\,a4^2\,m4\,\mathrm{Cos}[q1]^2$$

Out[•]=

$$\begin{aligned}
&\cdots \left(\tfrac{1}{2}\,a3\right)\left(\tfrac{1}{2}\,a3\right)\cos[q1]\\
&\quad \cos[q2+q3]+\\
&\quad \cos[q1]\left(a2\,\cos[q2]+a3\,\cos[q2+q3]\right)\Big)\\
&\quad \sin[q1]\,\sin[q2+q3]-\\
&\quad \tfrac{1}{2}\,a3\,\cos[q1]\\
&\quad \left(\tfrac{1}{2}\,a3\,\cos[q2+q3]\,\sin[q1]-\left(a2\,\cos[q2]+a3\,\cos[q2+q3]\right)\sin[q1]\right)\sin[q2+q3]\Big)+\\
&m4\left(-\left(\left(-\tfrac{1}{2}\,a4\,\cos[q1]\,\cos[q2+q3+q4]+\cos[q1]\left(a2\,\cos[q2]+a3\,\cos[q2+q3]+a4\,\cos[q2+q3+q4]\right)\right)\sin[q1]\left(a3\,\sin[q2+q3]+\tfrac{1}{2}\,a4\,\sin[q2+q3+q4]\right)\right)-\cos[q1]\left(\tfrac{1}{2}\,a4\,\cos[q2+q3+q4]\,\sin[q1]-\left(a2\,\cos[q2]+a3\,\cos[q2+q3]+a4\,\cos[q2+q3+q4]\right)\sin[q1]\right)\left(a3\,\sin[q2+q3]+\tfrac{1}{2}\,a4\,\sin[q2+q3+q4]\right)\right)
\end{aligned}$$

$$\begin{aligned}
&\cdots \tfrac{1}{12}\,a3^2\,m3\,\cos[q1]\\
&\quad (\cos[q1]^2+\sin[q1]^2)+\\
&\quad \tfrac{1}{12}\,a4^2\,m4\,\cos[q1]^2\\
&\quad (\cos[q1]^2+\sin[q1]^2)+\\
&\quad \tfrac{1}{12}\,a3^2\,m3\,\sin[q1]^2\\
&\quad (\cos[q1]^2+\sin[q1]^2)+\\
&\quad \tfrac{1}{12}\,a4^2\,m4\,\sin[q1]^2\\
&\quad (\cos[q1]^2+\sin[q1]^2)+\\
&m3\left(\left(\cos[q1]\left(-\tfrac{1}{2}\,a3\,\cos[q1]\,\cos[q2+q3]+\cos[q1]\left(a2\,\cos[q2]+a3\,\cos[q2+q3]\right)\right)+\sin[q1]\left(-\tfrac{1}{2}\,a3\,\cos[q2+q3]\,\sin[q1]+\left(a2\,\cos[q2]+a3\,\cos[q2+q3]\right)\sin[q1]\right)\right)\left(\cos[q1]\left(-a2\,\cos[q1]\,\cos[q2]-\tfrac{1}{2}\,a3\,\cos[q1]\,\cos[q2+q3]+\cos[q1]\left(a2\,\cos[q2]+a3\,\cos[q2+q3]\right)\right)+\sin[q1]\left(-a2\,\cos[q2]\,\sin[q1]-\tfrac{1}{2}\,a3\,\cos[q2+q3]\,\sin[q1]+\left(a2\,\cos[q2]+a3\,\cos[q2+q3]\right)\sin[q1]\right)\right)+\\
&\quad \tfrac{1}{2}\,a3\,\cos[q1]^2\,\sin[q2+q3]\left(a2\,\sin[q2]+\tfrac{1}{2}\,a3\,\sin[q2+q3]\right)+\\
&\quad \tfrac{1}{2}\,a3\,\sin[q1]^2
\end{aligned}$$

$$\begin{aligned}
&\cdots \tfrac{1}{12}\,a3^2\,m3\,\cos[q1]\\
&\quad (\cos[q1]^2+\sin[q1]^2)+\\
&\quad \tfrac{1}{12}\,a4^2\,m4\,\cos[q1]^2\\
&\quad (\cos[q1]^2+\sin[q1]^2)+\\
&\quad \tfrac{1}{12}\,a3^2\,m3\,\sin[q1]^2\\
&\quad (\cos[q1]^2+\sin[q1]^2)+\\
&\quad \tfrac{1}{12}\,a4^2\,m4\,\sin[q1]^2\\
&\quad (\cos[q1]^2+\sin[q1]^2)+\\
&m3\left(\left(\cos[q1]\left(-a2\,\cos[q1]\,\cos[q2]-\tfrac{1}{2}\,a3\,\cos[q1]\,\cos[q2+q3]+\cos[q1]\left(a2\,\cos[q2]+a3\,\cos[q2+q3]\right)\right)+\sin[q1]\left(-a2\,\cos[q2]\,\sin[q1]-\tfrac{1}{2}\,a3\,\cos[q2+q3]\,\sin[q1]+\left(a2\,\cos[q2]+a3\,\cos[q2+q3]\right)\sin[q1]\right)\right)^2+\\
&\quad \tfrac{1}{4}\,a3^2\,\cos[q1]^2\,\sin[q2+q3]^2+\\
&\quad \tfrac{1}{4}\,a3^2\,\sin[q1]^2\,\sin[q2+q3]^2\Big)+\\
&m4\left(\left(\cos[q1]\left(-a2\,\cos[q1]\,\cos[q2]-\tfrac{1}{2}\,a4\,\cos[q1]\,\cos[q2+q3+q4]+\cos[q1]\left(a2\,\cos[q2]+a3\,\cos[q2+q3]+a4\,\cos[q2+q3+q4]\right)\right)+\sin[q1]\left(-a2\,\cos[q2]\,\sin[q1]-\tfrac{1}{2}\,a4\,\cos[q2+q3+q4]\,\sin[q1]+\left(a2\,\cos[q2]+a3\,\cos[q2+q3]+a4\,\cos[q2+q3+q4]\right)\sin[q1]\right)\right)\left(\cos[q1]\left(-\cos[q1]\left(a2\,\cos[q2]+a3\,\cos[q2+q3]\right)-\tfrac{1}{2}\,a4\,\cos[q1]\,\cos[q2+q3+q4]+\cos[q1]\left(a2\,\cos[q2]+a3\,\cos[q2+q3]+a4\,\cos[q2+q3+q4]\right)\right)+\sin[q1]\left(-\left(\left(a2\,\cos[q2]+a3\,\cos[q2+q3]\right)\sin[q1]\right)-\tfrac{1}{2}\,a4\,\cos[q2+q3+q4]\,\sin[q1]+
\end{aligned}$$

```
Sin[
  q2 + q3]
 (a2 Sin[q2] +
   1/2 a3
    Sin[q2 + q3])) +
m4 ((Cos[q1] (-1/2 a4
      Cos[q1] Cos[
      q2 + q3 + q4] +
      Cos[q1] (a2
      Cos[q2] + a3
      Cos[q2 + q3] +
      a4 Cos[q2 +
      q3 + q4])) +
    Sin[q1] (-1/2 a4
      Cos[q2 + q3 +
      q4] Sin[q1] +
      (a2 Cos[q2] +
      a3 Cos[q2 +
      q3] + a4 Cos[
      q2 + q3 + q4])
      Sin[q1]))
  (Cos[q1] (-a2 Cos[
      q1] Cos[q2] -
      1/2 a4 Cos[q1]
      Cos[
      q2 + q3 + q4] +
      Cos[q1] (a2
      Cos[q2] + a3
      Cos[q2 + q3] +
      a4 Cos[q2 +
      q3 + q4])) +
    Sin[q1]
     (-a2 Cos[q2]
      Sin[q1] -
      1/2 a4 Cos[
      q2 + q3 + q4]
      Sin[q1] +
      (a2 Cos[q2] +
      a3 Cos[q2 +
      q3] + a4 Cos[
      q2 + q3 + q4])
      Sin[q1])) +
```

```
      Sin[q1] -
      1/2 a4 Cos[
      q2 + q3 + q4]
      Sin[q1] +
      (a2 Cos[q2] +
      a3 Cos[q2 +
      q3] + a4 Cos[
      q2 + q3 + q4])
      Sin[q1])^2 +
Cos[q1]^2
 (a3 Sin[q2 + q3] +
   1/2 a4 Sin[q2 +
    q3 + q4])^2 +
Sin[q1]^2
 (a3 Sin[q2 + q3] +
   1/2 a4 Sin[q2 +
    q3 + q4])^2)
```

```
      (a2 Cos[q2] +
      a3 Cos[q2 +
      q3] + a4 Cos[
      q2 + q3 + q4])
      Sin[q1])) +
1/2 a4 Cos[q1]^2
 Sin[
  q2 +
   q3 +
   q4]
 (a3 Sin[q2 + q3] +
   1/2
    a4
    Sin[
     q2 + q3 + q4]) +
1/2 a4 Sin[q1]^2
 Sin[
  q2 +
   q3 +
   q4]
 (a3 Sin[q2 + q3] +
   1/2
    a4
    Sin[
     q2 + q3 + q4]))
```

```
Cos[q1]^2
 (a3 Sin[q2 + q3] +
    1/2 a4
     Sin[
      q2 + q3 + q4])
 (a2 Sin[q2] +
    a3
     Sin[q2 + q3] +
    1/2 a4 Sin[
      q2 + q3 + q4]) +
Sin[q1]^2
 (a3 Sin[q2 + q3] +
    1/2 a4 Sin[
      q2 + q3 + q4])
 (a2 Sin[q2] +
    a3 Sin[q2 + q3] +
    1/2 a4 Sin[
      q2 + q3 + q4]))
```

```
m4 (-1/2 a4
    (-1/2 a4 Cos[q1] Cos[
        q2 + q3 + q4] +
      Cos[q1]
       (a2 Cos[q2] + a3
          Cos[q2 + q3] +
          a4 Cos[
          q2 + q3 + q4]))
    Sin[q1] Sin[
      q2 + q3 + q4] -
   1/2 a4 Cos[q1]
    (1/2 a4
       Cos[q2 + q3 + q4]
       Sin[q1] -
      (a2 Cos[q2] + a3
          Cos[q2 + q3] +
          a4 Cos[
          q2 + q3 + q4])
       Sin[q1])
    Sin[q2 + q3 + q4])
```

```
1/12 a4^2 m4 Cos[q1]^2
 (Cos[q1]^2 + Sin[q1]^2) +
1/12 a4^2 m4 Sin[q1]^2
 (Cos[q1]^2 + Sin[q1]^2) +
m4
 ((Cos[q1] (-1/2 a4 Cos[q1]
       Cos[q2 + q3 +
       q4] + Cos[q1]
       (a2 Cos[q2] +
       a3 Cos[
       q2 + q3] +
       a4 Cos[q2 +
       q3 + q4])) +
    Sin[q1] (-1/2 a4
       Cos[q2 + q3 +
       q4] Sin[q1] +
       (a2 Cos[q2] +
       a3 Cos[q2 +
       q3] + a4 Cos[
       q2 + q3 + q4])
       Sin[q1]))
  (Cos[q1] (-Cos[q1]
       (a2 Cos[q2] +
```

```
1/12 a4^2 m4 Cos[q1]^2
 (Cos[q1]^2 + Sin[q1]^2) +
1/12 a4^2 m4 Sin[q1]^2
 (Cos[q1]^2 + Sin[q1]^2) +
m4 ((Cos[q1] (-a2 Cos[q1]
       Cos[q2] -
      1/2 a4
       Cos[q1] Cos[
       q2 + q3 + q4] +
       Cos[q1] (a2
       Cos[q2] + a3
       Cos[q2 + q3] +
       a4 Cos[q2 +
       q3 + q4])) +
    Sin[q1]
     (-a2 Cos[q2]
       Sin[q1] -
      1/2 a4 Cos[
       q2 + q3 + q4]
       Sin[q1] +
       (a2 Cos[q2] +
       a3 Cos[q2 +
       q3] + a4 Cos[
```

```
1/12 a4^2 m4 Cos[q1]^2
 (Cos[q1]^2 + Sin[q1]^2) +
1/12 a4^2 m4 Sin[q1]^2
 (Cos[q1]^2 + Sin[q1]^2) +
m4 ((Cos[q1] (-Cos[q1]
       (a2 Cos[q2] +
       a3 Cos[q2 +
       q3]) - 1/2 a4
       Cos[q1] Cos[
       q2 + q3 + q4] +
       Cos[q1] (a2
       Cos[q2] + a3
       Cos[q2 + q3] +
       a4 Cos[q2 +
       q3 + q4])) +
    Sin[q1] (-((a2
       Cos[q2] + a3
       Cos[q2 + q3])
       Sin[q1]) -
      1/2 a4 Cos[
       q2 + q3 + q4]
       Sin[q1] +
       (a2 Cos[q2] +
```

```
      a3 Cos[q2 +
      q3]) - 1/2 a4
      Cos[q1] Cos[
      q2 + q3 + q4] +
      Cos[q1] (a2
      Cos[q2] + a3
      Cos[q2 + q3] +
      a4 Cos[q2 +
      q3 + q4])) +
    Sin[q1]
     (-((a2 Cos[q2] +
      a3 Cos[q2 +
      q3]) Sin[q1]) -
      1/2 a4 Cos[
      q2 + q3 + q4]
      Sin[q1] +
      (a2 Cos[q2] +
      a3 Cos[q2 +
      q3] + a4 Cos[
      q2 + q3 + q4])
      Sin[q1])) +
  1/2 a4 Cos[q1]^2
   Sin[
    q2 +
     q3 +
     q4]
   (a2 Sin[q2] +
     a3
      Sin[q2 + q3] +
     1/2 a4
      Sin[
       q2 + q3 + q4]) +
  1/2 a4 Sin[q1]^2
   Sin[
    q2 +
     q3 +
     q4]
   (a2 Sin[q2] +
     a3
      Sin[q2 + q3] +
     1/2 a4 Sin[
      q2 + q3 + q4])
```

```
      q2 + q3 + q4])
      Sin[q1]))
   (Cos[q1] (-Cos[q1]
      (a2 Cos[q2] +
      a3 Cos[q2 +
      q3]) - 1/2 a4
      Cos[q1] Cos[
      q2 + q3 + q4] +
      Cos[q1] (a2
      Cos[q2] + a3
      Cos[q2 + q3] +
      a4 Cos[q2 +
      q3 + q4])) +
    Sin[q1]
     (-((a2 Cos[q2] +
      a3 Cos[q2 +
      q3]) Sin[q1]) -
      1/2 a4 Cos[
      q2 + q3 + q4]
      Sin[q1] +
      (a2 Cos[q2] +
      a3 Cos[q2 +
      q3] + a4 Cos[
      q2 + q3 + q4])
      Sin[q1])) +
  1/2 a4 Cos[q1]^2
   Sin[
    q2 +
     q3 +
     q4]
   (a3 Sin[q2 + q3] +
     1/2
      a4
      Sin[
       q2 + q3 + q4]) +
  1/2 a4 Sin[q1]^2
   Sin[
    q2 +
     q3 +
     q4]
   (a3 Sin[q2 + q3] +
     1/2
```

```
      a3 Cos[q2 +
      q3] + a4 Cos[
      q2 + q3 + q4])
      Sin[q1])^2 +
  1/4 a4^2 Cos[q1]^2
   Sin[
     q2 +
      q3 +
      q4]^2 +
  1/4 a4^2
   Sin[
     q1]^2
   Sin[q2 + q3 + q4]^2)
```

```
                                                                  a4
                                                                  Sin[
                                                                    q2 + q3 + q4]])
```

In[•]:= **Grid[CM]**

$\frac{1}{6}$ ((-a2^2 m2 - 3 a2^2 m3 - 3 a2^2 m4) Sin[2 q2] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-a3^2 m3 - 3 a3^2 m4) Sin[2 q2 + 2 q3] - 3 a2 a4 m4 Sin[2 q2 + q3 + q4] - 3 a3 a4 m4 Sin[2 q2 + 2 q3 + q4] - a4^2 m4 Sin[2 q2 + 2 q3 + 2 q4]) q2'[t] + $\frac{1}{12}$ ((-3 a2 a3 m3 - 6 a2 a3 m4) Sin[q3] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-2 a3^2 m3 - 6 a3^2 m4) Sin[2 q2 + 2 q3] - 3 a2 a4 m4 Sin[q3 + q4] - 3 a2 a4 m4 Sin[2 q2 + q3 + q4] - 6 a3 a4 m4 Sin[2 q2 + 2 q3 + q4] - 2 a4^2 m4 Sin[2 q2 + 2 q3 + 2 q4]) q3'[t] - $\frac{1}{6}$ a4 m4 (3 a2 Cos[q2] + 3 a3 Cos[q2 + q3] + 2 a4	$\frac{1}{6}$ ((-a2^2 m2 - 3 a2^2 m3 - 3 a2^2 m4) Sin[2 q2] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-a3^2 m3 - 3 a3^2 m4) Sin[2 q2 + 2 q3] - 3 a2 a4 m4 Sin[2 q2 + q3 + q4] - 3 a3 a4 m4 Sin[2 q2 + 2 q3 + q4] - a4^2 m4 Sin[2 q2 + 2 q3 + 2 q4]) q1'[t]	$\frac{1}{12}$ ((-3 a2 a3 m3 - 6 a2 a3 m4) Sin[q3] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-2 a3^2 m3 - 6 a3^2 m4) Sin[2 q2 + 2 q3] - 3 a2 a4 m4 Sin[q3 + q4] - 3 a2 a4 m4 Sin[2 q2 + q3 + q4] - 6 a3 a4 m4 Sin[2 q2 + 2 q3 + q4] - 2 a4^2 m4 Sin[2 q2 + 2 q3 + 2 q4]) q1'[t]	- $\frac{1}{6}$ a4 m4 (3 a2 Cos[q2] + 3 a3 Cos[q2 + q3] + 2 a4 Cos[q2 + q3 + q4]) Sin[q2 + q3 + q4] q1'[t]

Out[•]=

$$\begin{pmatrix}
\frac{1}{6}\left(\left(a2^2\ m2+3\ a2^2\ m3+3\ a2^2\ m4\right)\ \text{Sin}[2\ q2]+\left(3\ a2\ a3\ m3+6\ a2\ a3\ m4\right)\ \text{Sin}[2\ q2+q3]+\left(a3^2\ m3+3\ a3^2\ m4\right)\ \text{Sin}[2\ q2+2\ q3]+3\ a2\ a4\ m4\ \text{Sin}[2\ q2+q3+q4]+3\ a3\ a4\ m4\ \text{Sin}[2\ q2+2\ q3+q4]+a4^2\ m4\ \text{Sin}[2\ q2+2\ q3+2\ q4]\right)\ q1'[t] & -\frac{1}{2}\ a2\left(\left(a3\ m3+2\ a3\ m4\right)\ \text{Sin}[q3]+a4\ m4\ \text{Sin}[q3+q4]\right)\ q3'[t]-\frac{1}{2}\ a4\ m4\left(a3\ \text{Sin}[q4]+a2\ \text{Sin}[q3+q4]\right)\ q4'[t] & -\frac{1}{2}\ a2\left(\left(a3\ m3+2\ a3\ m4\right)\ \text{Sin}[q3]+a4\ m4\ \text{Sin}[q3+q4]\right)\ q2'[t]-\frac{1}{2}\ a2\left(\left(a3\ m3+2\ a3\ m4\right)\ \text{Sin}[q3]+a4\ m4\ \text{Sin}[q3+q4]\right)\ q3'[t]-\frac{1}{2}\ a4\ m4\left(a3\ \text{Sin}[q4]+a2\ \text{Sin}[q3+q4]\right)\ q4'[t] & -\frac{1}{2}\ a4\ m4\left(a3\ \text{Sin}[q4]+a2\ \text{Sin}[q3+q4]\right)\ q2'[t]-\frac{1}{2}\ a4\ m4\left(a3\ \text{Sin}[q4]+a2\ \text{Sin}[q3+q4]\right)\ q3'[t]-\frac{1}{2}\ a4\ m4\left(a3\ \text{Sin}[q4]+a2\ \text{Sin}[q3+q4]\right)\ q4'[t] \\
\frac{1}{12}\left(\left(3\ a2\ a3\ m3+6\ a2\ a3\ m4\right)\ \text{Sin}[q3]+\left(3\ a2\ a3\ m3+6\ a2\ a3\ m4\right)\ \text{Sin}[2\ q2+q3]+\left(2\ a3^2\ m3+6\ a3^2\ m4\right)\ \text{Sin}[2\ q2+2\ q3]+3\ a2\ a4\ m4\ \text{Sin}[q3+q4]+3\ a2\ a4\ m4\ \text{Sin}[2\ q2+q3+q4]+6\ a3\ a4\ m4\ \text{Sin}[2\ q2+2\ q3+q4]+2\ a4^2\ m4\ \text{Sin}[2\ q2+2\ q3+2\ q4]\right)\ q1'[t] & \frac{1}{2}\ a2\left(\left(a3\ m3+2\ a3\ m4\right)\ \text{Sin}[q3]+a4\ m4\ \text{Sin}[q3+q4]\right)\ q2'[t]-a3\ a4\ m4\ \text{Cos}\left[\frac{q4}{2}\right]\ \text{Sin}\left[\frac{q4}{2}\right]\ q4'[t] & -a3\ a4\ m4\ \text{Cos}\left[\frac{q4}{2}\right]\ \text{Sin}\left[\frac{q4}{2}\right]\ q2'[t]-a3\ a4\ m4\ \text{Cos}\left[\frac{q4}{2}\right]\ \text{Sin}\left[\frac{q4}{2}\right]\ q3'[t]-a3\ a4\ m4\ \text{Cos}\left[\frac{q4}{2}\right]\ \text{Sin}\left[\frac{q4}{2}\right]\ q4'[t] \\
\frac{1}{6}\ a4\ m4\left(3\ a2\ \text{Cos}[q2]+3\ a3\ \text{Cos}[q2+q3]+2\ a4\ \text{Cos}[q2+q3+q4]\right)\ \text{Sin}[q2+q3+q4]\ q1'[t] & \frac{1}{2}\ a4\ m4\left(a3\ \text{Sin}[q4]+a2\ \text{Sin}[q3+q4]\right)\ q2'[t]+a3\ a4\ m4\ \text{Cos}\left[\frac{q4}{2}\right]\ \text{Sin}\left[\frac{q4}{2}\right]\ q3'[t] & a3\ a4\ m4\ \text{Cos}\left[\frac{q4}{2}\right]\ \text{Sin}\left[\frac{q4}{2}\right]\ q2'[t]+a3\ a4\ m4\ \text{Cos}\left[\frac{q4}{2}\right]\ \text{Sin}\left[\frac{q4}{2}\right]\ q3'[t] & 0
\end{pmatrix}$$

In[•]:=

```
EPrint[MU, "Mass matrix"]
```

In[•]:=
```
EPrint[CM, "C matrix"]
```

In[•]:=
```
Mprint[G, "Gravity Vector g ="]
```

Out[•]=
$$\text{Mprint}\left[\left\{0,\ \frac{1}{2}\, g \left(\left(a2\ m2 + 2\ a2\ m3 + 2\ a2\ m4\right) \text{Cos}[q2] + \left(a3\ m3 + 2\ a3\ m4\right) \text{Cos}[q2 + q3] + a4\ m4\ \text{Cos}[q2 + q3 + q4]\right),\right.\right.$$
$$\frac{1}{2}\, g \left(\left(a3\ m3 + 2\ a3\ m4\right) \text{Cos}[q2 + q3] + a4\ m4\ \text{Cos}[q2 + q3 + q4]\right),$$
$$\left.\left.\frac{1}{2}\, a4\ g\ m4\ \text{Cos}[q2 + q3 + q4]\right\},\ \text{Gravity Vector g =}\right]$$

In[•]:=
```
C[[1, 1, 1]]
```

Out[•]=
$$0$$

In[•]:=
```
C[[1, 1, 2]]
```

Out[•]=
$$\frac{1}{6} \left(\left(a2^2\ m2 + 3\ a2^2\ m3 + 3\ a2^2\ m4\right) \text{Sin}[2\ q2] + \left(3\ a2\ a3\ m3 + 6\ a2\ a3\ m4\right) \text{Sin}[2\ q2 + q3] + \left(a3^2\ m3 + 3\ a3^2\ m4\right) \text{Sin}[2\ q2 + 2\ q3] + 3\ a2\ a4\ m4\ \text{Sin}[2\ q2 + q3 + q4] + 3\ a3\ a4\ m4\ \text{Sin}[2\ q2 + 2\ q3 + q4] + a4^2\ m4\ \text{Sin}[2\ q2 + 2\ q3 + 2\ q4]\right)$$

In[•]:=
```
(*loads the package - after installation*)
Get@FileNameJoin[{NotebookDirectory[], "ToPython.wl"}]
```

In[•]:=
```
ToPython[1/6 ((a2^2 m2 + 3 a2^2 m3 + 3 a2^2 m4) Sin[2 q2] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] +
    (a3^2 m3 + 3 a3^2 m4) Sin[2 q2 + 2 q3] + 3 a2 a4 m4 Sin[2 q2 + q3 + q4] +
    3 a3 a4 m4 Sin[2 q2 + 2 q3 + q4] + a4^2 m4 Sin[2 q2 + 2 q3 + 2 q4]), NumpyPrefix → "np"]
```

Out[•]=
```
0.1666666666666667 * (((a2 ** 2) * m2 + 3 * (a2 ** 2) * m3 + 3 * (a2 ** 2) * m4) * np.sin(2 * q2)
  + (3 * a2 * a3 * m3 + 6 * a2 * a3 * m4) * np.sin(2 * q2 + q3) + ((a3 ** 2) * m3 + 3 * (a3 **
  2) * m4) * np.sin(2 * q2 + 2 * q3) + 3 * a2 * a4 * m4 * np.sin(2 * q2 + q3 + q4) + 3 * a3 *
  a4 * m4 * np.sin(2 * q2 + 2 * q3 + q4) + (a4 ** 2) * m4 * np.sin(2 * q2 + 2 * q3 + 2 * q4))
```

In[•]:=
```
C[[1, 1, 3]]
```

Out[•]=
$$\frac{1}{12} \left(\left(3\ a2\ a3\ m3 + 6\ a2\ a3\ m4\right) \text{Sin}[q3] + \left(3\ a2\ a3\ m3 + 6\ a2\ a3\ m4\right) \text{Sin}[2\ q2 + q3] + \left(2\ a3^2\ m3 + 6\ a3^2\ m4\right) \text{Sin}[2\ q2 + 2\ q3] + 3\ a2\ a4\ m4\ \text{Sin}[q3 + q4] + 3\ a2\ a4\ m4\ \text{Sin}[2\ q2 + q3 + q4] + 6\ a3\ a4\ m4\ \text{Sin}[2\ q2 + 2\ q3 + q4] + 2\ a4^2\ m4\ \text{Sin}[2\ q2 + 2\ q3 + 2\ q4]\right)$$

In[•]:=
```
ToPython[1/12 ((3 a2 a3 m3 + 6 a2 a3 m4) Sin[q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] +
    (2 a3^2 m3 + 6 a3^2 m4) Sin[2 q2 + 2 q3] + 3 a2 a4 m4 Sin[q3 + q4] + 3 a2 a4 m4 Sin[2 q2 + q3 + q4] +
    6 a3 a4 m4 Sin[2 q2 + 2 q3 + q4] + 2 a4^2 m4 Sin[2 q2 + 2 q3 + 2 q4]), NumpyPrefix → "np"]
```

Out[•]=
```
0.08333333333333333 * ((3 * a2 * a3 * m3 + 6 * a2 * a3 * m4) * np.sin(q3) + (3 *
  a2 * a3 * m3 + 6 * a2 * a3 * m4) * np.sin(2 * q2 + q3) + (2 * (a3 ** 2) * m3 + 6
  * (a3 ** 2) * m4) * np.sin(2 * q2 + 2 * q3) + 3 * a2 * a4 * m4 * np.sin(q3 + q4)
  + 3 * a2 * a4 * m4 * np.sin(2 * q2 + q3 + q4) + 6 * a3 * a4 * m4 * np.sin(2
  * q2 + 2 * q3 + q4) + 2 * (a4 ** 2) * m4 * np.sin(2 * q2 + 2 * q3 + 2 * q4))
```

In[•]:=
```
c[[1, 1, 4]]
```

Out[•]=
$$\frac{1}{6}\, a4\, m4 \left(3\, a2\, \text{Cos}[q2] + 3\, a3\, \text{Cos}[q2 + q3] + 2\, a4\, \text{Cos}[q2 + q3 + q4]\right) \text{Sin}[q2 + q3 + q4]$$

In[•]:=
```
ToPython[1/6 a4 m4 (3 a2 Cos[q2] + 3 a3 Cos[q2 + q3] + 2 a4 Cos[q2 + q3 + q4]) Sin[q2 + q3 + q4],
 NumpyPrefix → "np"]
```

Out[•]=
```
0.1666666666666667 * a4 * m4 * (3 * a2 * np.cos(q2) + 3 * a3
  * np.cos(q2 + q3) + 2 * a4 * np.cos(q2 + q3 + q4)) * np.sin(q2 + q3 + q4)
```

In[•]:=
```
c[[1, 2, 1]]
```

Out[•]=
$$\frac{1}{6} \left((-a2^2\, m2 - 3\, a2^2\, m3 - 3\, a2^2\, m4) \text{Sin}[2\, q2] + (-3\, a2\, a3\, m3 - 6\, a2\, a3\, m4) \text{Sin}[2\, q2 + q3] + (-a3^2\, m3 - 3\, a3^2\, m4) \text{Sin}[2\, q2 + 2\, q3] - 3\, a2\, a4\, m4\, \text{Sin}[2\, q2 + q3 + q4] - 3\, a3\, a4\, m4\, \text{Sin}[2\, q2 + 2\, q3 + q4] - a4^2\, m4\, \text{Sin}[2\, q2 + 2\, q3 + 2\, q4]\right)$$

In[•]:=
```
ToPython[1/6 ((-a2^2 m2 - 3 a2^2 m3 - 3 a2^2 m4) Sin[2 q2] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] +
    (-a3^2 m3 - 3 a3^2 m4) Sin[2 q2 + 2 q3] - 3 a2 a4 m4 Sin[2 q2 + q3 + q4] -
    3 a3 a4 m4 Sin[2 q2 + 2 q3 + q4] - a4^2 m4 Sin[2 q2 + 2 q3 + 2 q4]), NumpyPrefix → "np"]
```

Out[•]=
```
0.1666666666666667 * ((-((a2 ** 2) * m2) -3 * (a2 ** 2) * m3 -3 * (a2 ** 2) * m4) * np.sin(2 * q2)
  + (-3 * a2 * a3 * m3 -6 * a2 * a3 * m4) * np.sin(2 * q2 + q3) + (-((a3 ** 2) * m3) -3 * (a3 **
  2) * m4) * np.sin(2 * q2 + 2 * q3) -3 * a2 * a4 * m4 * np.sin(2 * q2 + q3 + q4) -3 * a3 *
  a4 * m4 * np.sin(2 * q2 + 2 * q3 + q4) -((a4 ** 2) * m4 * np.sin(2 * q2 + 2 * q3 + 2 * q4)))
```

In[•]:=
```
c[[1, 2, 2]]
```

Out[•]=
```
0
```

In[•]:=
```
c[[1, 2, 3]]
```

Out[•]=
```
0
```

In[•]:=
```
c[[1, 2, 4]]
```

Out[•]=
```
0
```

In[•]:= **c[[1, 3, 1]]**

Out[•]=
$$\frac{1}{12}\left(\left(-3\,a2\,a3\,m3-6\,a2\,a3\,m4\right)\text{Sin}[q3]+\left(-3\,a2\,a3\,m3-6\,a2\,a3\,m4\right)\text{Sin}\left[2\,q2+q3\right]+\left(-2\,a3^2\,m3-6\,a3^2\,m4\right)\text{Sin}\left[2\,q2+2\,q3\right]-3\,a2\,a4\,m4\,\text{Sin}[q3+q4]-3\,a2\,a4\,m4\,\text{Sin}\left[2\,q2+q3+q4\right]-6\,a3\,a4\,m4\,\text{Sin}\left[2\,q2+2\,q3+q4\right]-2\,a4^2\,m4\,\text{Sin}\left[2\,q2+2\,q3+2\,q4\right]\right)$$

In[•]:= **ToPython[1/12 ((-3 a2 a3 m3 - 6 a2 a3 m4) Sin[q3] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-2 a3^2 m3 - 6 a3^2 m4) Sin[2 q2 + 2 q3] - 3 a2 a4 m4 Sin[q3 + q4] - 3 a2 a4 m4 Sin[2 q2 + q3 + q4] - 6 a3 a4 m4 Sin[2 q2 + 2 q3 + q4] - 2 a4^2 m4 Sin[2 q2 + 2 q3 + 2 q4]), NumpyPrefix → "np"]**

Out[•]=
```
0.08333333333333333 * ((-3 * a2 * a3 * m3 -6 * a2 * a3 * m4) * np.sin(q3) + (-3
  * a2 * a3 * m3 -6 * a2 * a3 * m4) * np.sin(2 * q2 + q3) + (-2 * (a3 ** 2) * m3
  -6 * (a3 ** 2) * m4) * np.sin(2 * q2 + 2 * q3) -3 * a2 * a4 * m4 * np.sin(q3 +
  q4) -3 * a2 * a4 * m4 * np.sin(2 * q2 + q3 + q4) -6 * a3 * a4 * m4 * np.sin(2
  * q2 + 2 * q3 + q4) -2 * (a4 ** 2) * m4 * np.sin(2 * q2 + 2 * q3 + 2 * q4))
```

In[•]:= **c[[1, 3, 2]]**

Out[•]= 0

In[•]:= **c[[1, 3, 3]]**

Out[•]= 0

In[•]:= **c[[1, 3, 4]]**

Out[•]= 0

In[•]:= **c[[1, 4, 1]]**

Out[•]=
$$-\frac{1}{6}\,a4\,m4\left(3\,a2\,\text{Cos}[q2]+3\,a3\,\text{Cos}[q2+q3]+2\,a4\,\text{Cos}[q2+q3+q4]\right)\text{Sin}[q2+q3+q4]$$

In[•]:= **ToPython[-1/6 a4 m4 (3 a2 Cos[q2] + 3 a3 Cos[q2 + q3] + 2 a4 Cos[q2 + q3 + q4]) Sin[q2 + q3 + q4], NumpyPrefix → "np"]**

Out[•]=
```
-0.1666666666666667 * a4 * m4 * (3 * a2 * np.cos(q2) + 3 * a3
  * np.cos(q2 + q3) + 2 * a4 * np.cos(q2 + q3 + q4)) * np.sin(q2 + q3 + q4)
```

In[•]:= **c[[1, 4, 2]]**

Out[•]= 0

In[•]:= **c[[1, 4, 3]]**

Out[•]= 0

In[•]:= **c[[1, 4, 4]]**

Out[•]= 0

In[•]:= **c[[2, 1, 1]]**

Out[•]=
$$\frac{1}{6}\left(\left(-a2^2\ m2 - 3\ a2^2\ m3 - 3\ a2^2\ m4\right)\ \text{Sin}\left[2\ q2\right] + \left(-3\ a2\ a3\ m3 - 6\ a2\ a3\ m4\right)\ \text{Sin}\left[2\ q2 + q3\right] + \left(-a3^2\ m3 - 3\ a3^2\ m4\right)\ \text{Sin}\left[2\ q2 + 2\ q3\right] - 3\ a2\ a4\ m4\ \text{Sin}\left[2\ q2 + q3 + q4\right] - 3\ a3\ a4\ m4\ \text{Sin}\left[2\ q2 + 2\ q3 + q4\right] - a4^2\ m4\ \text{Sin}\left[2\ q2 + 2\ q3 + 2\ q4\right]\right)$$

In[•]:= **ToPython[1/6 ((-a2^2 m2 - 3 a2^2 m3 - 3 a2^2 m4) Sin[2 q2] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-a3^2 m3 - 3 a3^2 m4) Sin[2 q2 + 2 q3] - 3 a2 a4 m4 Sin[2 q2 + q3 + q4] - 3 a3 a4 m4 Sin[2 q2 + 2 q3 + q4] - a4^2 m4 Sin[2 q2 + 2 q3 + 2 q4]), NumpyPrefix → "np"]**

Out[•]=
```
0.1666666666666667 * ((-((a2 ** 2) * m2) -3 * (a2 ** 2) * m3 -3 * (a2 ** 2) * m4) * np.sin(2 * q2)
  + (-3 * a2 * a3 * m3 -6 * a2 * a3 * m4) * np.sin(2 * q2 + q3) + (-((a3 ** 2) * m3) -3 * (a3 **
  2) * m4) * np.sin(2 * q2 + 2 * q3) -3 * a2 * a4 * m4 * np.sin(2 * q2 + q3 + q4) -3 * a3 *
  a4 * m4 * np.sin(2 * q2 + 2 * q3 + q4) -((a4 ** 2) * m4 * np.sin(2 * q2 + 2 * q3 + 2 * q4)))
```

In[•]:= **c[[2, 1, 2]]**

Out[•]= 0

In[•]:= **c[[2, 1, 3]]**

Out[•]= 0

In[•]:= **c[[2, 1, 4]]**

Out[•]= 0

In[•]:= **c[[2, 2, 1]]**

Out[•]= 0

In[•]:= **c[[2, 2, 2]]**

Out[•]= 0

In[•]:= **c[[2, 2, 3]]**

Out[•]=
$$\frac{1}{2}\ a2\ \left(\left(a3\ m3 + 2\ a3\ m4\right)\ \text{Sin}[q3] + a4\ m4\ \text{Sin}[q3 + q4]\right)$$

In[•]:= **ToPython[1/2 a2 ((a3 m3 + 2 a3 m4) Sin[q3] + a4 m4 Sin[q3 + q4]), NumpyPrefix → "np"]**

Out[•]=
```
0.5 * a2 * ((a3 * m3 + 2 * a3 * m4) * np.sin(q3) + a4 * m4 * np.sin(q3 + q4))
```

In[•]:= **c[[2, 2, 4]]**

Out[•]=
$$\frac{1}{2}\ a4\ m4\ \left(a3\ \text{Sin}[q4] + a2\ \text{Sin}[q3 + q4]\right)$$

In[•]:= **ToPython[1/2 a4 m4 (a3 Sin[q4] + a2 Sin[q3 + q4]), NumpyPrefix → "np"]**

Out[•]=
```
0.5 * a4 * m4 * (a3 * np.sin(q4) + a2 * np.sin(q3 + q4))
```

In[•]:= **c[[2, 3, 1]]**

Out[•]= 0

In[•]:= **c[[2, 3, 2]]**

Out[•]= $-\frac{1}{2}$ a2 ((a3 m3 + 2 a3 m4) Sin[q3] + a4 m4 Sin[q3 + q4])

In[•]:= **ToPython[$-\frac{1}{2}$ a2 ((a3 m3 + 2 a3 m4) Sin[q3] + a4 m4 Sin[q3 + q4]), NumpyPrefix → "np"]**

Out[•]= -0.5 * a2 * ((a3 * m3 + 2 * a3 * m4) * np.sin(q3) + a4 * m4 * np.sin(q3 + q4))

In[•]:= **c[[2, 3, 3]]**

Out[•]= 0

In[•]:= **c[[2, 3, 4]]**

Out[•]= a3 a4 m4 Cos[$\frac{q4}{2}$] Sin[$\frac{q4}{2}$]

In[•]:= **ToPython[a3 a4 m4 Cos[$\frac{q4}{2}$] Sin[$\frac{q4}{2}$], NumpyPrefix → "np"]**

"a3 * a4 * m4 * np.cos(0.5 * q4) * np.sin(0.5 * q4)"

In[•]:= **c[[2, 4, 1]]**

Out[•]= 0

In[•]:= **c[[2, 4, 2]]**

Out[•]= $-\frac{1}{2}$ a4 m4 (a3 Sin[q4] + a2 Sin[q3 + q4])

In[•]:= **ToPython[$-\frac{1}{2}$ a4 m4 (a3 Sin[q4] + a2 Sin[q3 + q4]), NumpyPrefix → "np"]**

Out[•]= -0.5 * a4 * m4 * (a3 * np.sin(q4) + a2 * np.sin(q3 + q4))

In[•]:= **c[[2, 4, 3]]**

Out[•]= -a3 a4 m4 Cos[$\frac{q4}{2}$] Sin[$\frac{q4}{2}$]

In[•]:= **ToPython[-a3 a4 m4 Cos[$\frac{q4}{2}$] Sin[$\frac{q4}{2}$], NumpyPrefix → "np"]**

Out[•]= -(a3 * a4 * m4 * np.cos(0.5 * q4) * np.sin(0.5 * q4))

In[•]:= **c[[2, 4, 4]]**

Out[•]= 0

In[•]:= **c[[3, 1, 1]]**

Out[•]= $\frac{1}{12}\left(\left(-3\ a2\ a3\ m3 - 6\ a2\ a3\ m4\right) \text{Sin}[q3] + \left(-3\ a2\ a3\ m3 - 6\ a2\ a3\ m4\right) \text{Sin}\left[2\ q2 + q3\right] + \left(-2\ a3^2\ m3 - 6\ a3^2\ m4\right) \text{Sin}\left[2\ q2 + 2\ q3\right] - 3\ a2\ a4\ m4\ \text{Sin}[q3 + q4] - 3\ a2\ a4\ m4\ \text{Sin}\left[2\ q2 + q3 + q4\right] - 6\ a3\ a4\ m4\ \text{Sin}\left[2\ q2 + 2\ q3 + q4\right] - 2\ a4^2\ m4\ \text{Sin}\left[2\ q2 + 2\ q3 + 2\ q4\right]\right)$

In[•]:= **ToPython[$\frac{1}{12}\left(\left(-3\ a2\ a3\ m3 - 6\ a2\ a3\ m4\right) \text{Sin}[q3] + \left(-3\ a2\ a3\ m3 - 6\ a2\ a3\ m4\right) \text{Sin}\left[2\ q2 + q3\right] + \left(-2\ a3^2\ m3 - 6\ a3^2\ m4\right) \text{Sin}\left[2\ q2 + 2\ q3\right] - 3\ a2\ a4\ m4\ \text{Sin}[q3 + q4] - 3\ a2\ a4\ m4\ \text{Sin}\left[2\ q2 + q3 + q4\right] - 6\ a3\ a4\ m4\ \text{Sin}\left[2\ q2 + 2\ q3 + q4\right] - 2\ a4^2\ m4\ \text{Sin}\left[2\ q2 + 2\ q3 + 2\ q4\right]\right)$, NumpyPrefix → "np"]**

Out[•]= 0.08333333333333333 * ((-3 * a2 * a3 * m3 -6 * a2 * a3 * m4) * np.sin(q3) + (-3 * a2 * a3 * m3 -6 * a2 * a3 * m4) * np.sin(2 * q2 + q3) + (-2 * (a3 ** 2) * m3 -6 * (a3 ** 2) * m4) * np.sin(2 * q2 + 2 * q3) -3 * a2 * a4 * m4 * np.sin(q3 + q4) -3 * a2 * a4 * m4 * np.sin(2 * q2 + q3 + q4) -6 * a3 * a4 * m4 * np.sin(2 * q2 + 2 * q3 + q4) -2 * (a4 ** 2) * m4 * np.sin(2 * q2 + 2 * q3 + 2 * q4))

In[•]:= **c[[3, 1, 2]]**

Out[•]= 0

In[•]:= **c[[3, 1, 3]]**

Out[•]= 0

In[•]:= **c[[3, 1, 4]]**

Out[•]= 0

In[•]:= **c[[3, 2, 1]]**

Out[•]= 0

In[•]:= **c[[3, 2, 2]]**

Out[•]= $-\frac{1}{2}\ a2\left(\left(a3\ m3 + 2\ a3\ m4\right) \text{Sin}[q3] + a4\ m4\ \text{Sin}[q3 + q4]\right)$

In[•]:= **ToPython[$-\frac{1}{2}\ a2\left(\left(a3\ m3 + 2\ a3\ m4\right) \text{Sin}[q3] + a4\ m4\ \text{Sin}[q3 + q4]\right)$, NumpyPrefix → "np"]**

Out[•]= -0.5 * a2 * ((a3 * m3 + 2 * a3 * m4) * np.sin(q3) + a4 * m4 * np.sin(q3 + q4))

In[•]:= **c[[3, 2, 3]]**

Out[•]= 0

In[•]:= **c[[3, 2, 4]]**

Out[•]= $a3\ a4\ m4\ \text{Cos}\left[\frac{q4}{2}\right] \text{Sin}\left[\frac{q4}{2}\right]$

In[•]:= **ToPython[$a3\ a4\ m4\ \text{Cos}\left[\frac{q4}{2}\right] \text{Sin}\left[\frac{q4}{2}\right]$, NumpyPrefix → "np"]**

Out[•]= a3 * a4 * m4 * np.cos(0.5 * q4) * np.sin(0.5 * q4)

In[•]:= **c[[3, 3, 1]]**

Out[•]= 0

In[•]:= **c[[3, 3, 2]]**

Out[•]= $-\frac{1}{2}$ a2 ((a3 m3 + 2 a3 m4) Sin[q3] + a4 m4 Sin[q3 + q4])

In[•]:= **ToPython[-1/2 a2 ((a3 m3 + 2 a3 m4) Sin[q3] + a4 m4 Sin[q3 + q4]), NumpyPrefix → "np"]**

Out[•]= -0.5 * a2 * ((a3 * m3 + 2 * a3 * m4) * np.sin(q3) + a4 * m4 * np.sin(q3 + q4))

In[•]:= **c[[3, 3, 3]]**

Out[•]= 0

In[•]:= **c[[3, 3, 4]]**

Out[•]= a3 a4 m4 Cos[$\frac{q4}{2}$] Sin[$\frac{q4}{2}$]

In[•]:= **ToPython[a3 a4 m4 Cos[q4/2] Sin[q4/2], NumpyPrefix → "np"]**

Out[•]= a3 * a4 * m4 * np.cos(0.5 * q4) * np.sin(0.5 * q4)

In[•]:= **c[[3, 4, 1]]**

Out[•]= 0

In[•]:= **c[[3, 4, 2]]**

Out[•]= $-\frac{1}{2}$ a4 m4 (a3 Sin[q4] + a2 Sin[q3 + q4])

In[•]:= **ToPython[-1/2 a4 m4 (a3 Sin[q4] + a2 Sin[q3 + q4]), NumpyPrefix → "np"]**

Out[•]= -0.5 * a4 * m4 * (a3 * np.sin(q4) + a2 * np.sin(q3 + q4))

In[•]:= **c[[3, 4, 3]]**

Out[•]= -a3 a4 m4 Cos[$\frac{q4}{2}$] Sin[$\frac{q4}{2}$]

In[•]:= **ToPython[-a3 a4 m4 Cos[q4/2] Sin[q4/2], NumpyPrefix → "np"]**

Out[•]= -(a3 * a4 * m4 * np.cos(0.5 * q4) * np.sin(0.5 * q4))

In[•]:= **c[[3, 4, 4]]**

Out[•]= 0

In[•]:= **c[[4, 1, 1]]**

Out[•]= $-\frac{1}{6}$ a4 m4 (3 a2 Cos[q2] + 3 a3 Cos[q2 + q3] + 2 a4 Cos[q2 + q3 + q4]) Sin[q2 + q3 + q4]

In[•]:=
```
ToPython[-1/6 a4 m4 (3 a2 Cos[q2] + 3 a3 Cos[q2 + q3] + 2 a4 Cos[q2 + q3 + q4]) Sin[q2 + q3 + q4],
 NumpyPrefix → "np"]
```

Out[•]=
```
-0.1666666666666667 * a4 * m4 * (3 * a2 * np.cos(q2) + 3 * a3
  * np.cos(q2 + q3) + 2 * a4 * np.cos(q2 + q3 + q4)) * np.sin(q2 + q3 + q4)
```

In[•]:=
```
c[[4, 1, 2]]
```

Out[•]= 0

In[•]:=
```
c[[4, 1, 3]]
```

Out[•]= 0

In[•]:=
```
c[[4, 1, 4]]
```

Out[•]= 0

In[•]:=
```
c[[4, 2, 1]]
```

Out[•]= 0

In[•]:=
```
c[[4, 2, 2]]
```

Out[•]= $-\frac{1}{2}$ a4 m4 (a3 Sin[q4] + a2 Sin[q3 + q4])

In[•]:=
```
ToPython[-1/2 a4 m4 (a3 Sin[q4] + a2 Sin[q3 + q4]), NumpyPrefix → "np"]
```

Out[•]=
```
-0.5 * a4 * m4 * (a3 * np.sin(q4) + a2 * np.sin(q3 + q4))
```

In[•]:=
```
c[[4, 2, 3]]
```

Out[•]= $-a3\ a4\ m4\ \text{Cos}\left[\frac{q4}{2}\right]\text{Sin}\left[\frac{q4}{2}\right]$

In[•]:=
```
ToPython[-a3 a4 m4 Cos[q4/2] Sin[q4/2], NumpyPrefix → "np"]
```

Out[•]=
```
-(a3 * a4 * m4 * np.cos(0.5 * q4) * np.sin(0.5 * q4))
```

In[•]:=
```
c[[4, 2, 4]]
```

Out[•]= 0

In[•]:=
```
c[[4, 3, 1]]
```

Out[•]= 0

In[•]:=
```
c[[4, 3, 2]]
```

Out[•]= $-\frac{1}{2}$ a4 m4 (a3 Sin[q4] + a2 Sin[q3 + q4])

In[•]:=
```
ToPython[-1/2 a4 m4 (a3 Sin[q4] + a2 Sin[q3 + q4]), NumpyPrefix → "np"]
```

Out[•]=
```
-0.5 * a4 * m4 * (a3 * np.sin(q4) + a2 * np.sin(q3 + q4))
```

In[•]:= **c[[4, 3, 3]]**

Out[•]= $-a3\ a4\ m4\ \text{Cos}\left[\frac{q4}{2}\right]\ \text{Sin}\left[\frac{q4}{2}\right]$

In[•]:= **ToPython[-a3 a4 m4 Cos[q4/2] Sin[q4/2], NumpyPrefix → "np"]**

Out[•]=
```
-(a3 * a4 * m4 * np.cos(0.5 * q4) * np.sin(0.5 * q4))
```

In[•]:= **c[[4, 3, 4]]**

Out[•]= 0

In[•]:= **c[[4, 4, 1]]**

Out[•]= 0

In[•]:= **c[[4, 4, 2]]**

Out[•]= $-\frac{1}{2}\ a4\ m4\ \left(a3\ \text{Sin}[q4] + a2\ \text{Sin}[q3 + q4]\right)$

In[•]:= **ToPython[-1/2 a4 m4 (a3 Sin[q4] + a2 Sin[q3 + q4]), NumpyPrefix → "np"]**

Out[•]=
```
-0.5 * a4 * m4 * (a3 * np.sin(q4) + a2 * np.sin(q3 + q4))
```

In[•]:= **c[[4, 4, 3]]**

Out[•]= $-a3\ a4\ m4\ \text{Cos}\left[\frac{q4}{2}\right]\ \text{Sin}\left[\frac{q4}{2}\right]$

In[•]:= **ToPython[-a3 a4 m4 Cos[q4/2] Sin[q4/2], NumpyPrefix → "np"]**

Out[•]=
```
-(a3 * a4 * m4 * np.cos(0.5 * q4) * np.sin(0.5 * q4))
```

In[•]:= **c[[4, 4, 4]]**

Out[•]= 0

In[•]:= **MU[[1, 1]]**

Out[•]=
$$\frac{d1^2\ m1}{12} + \frac{1}{12}\ a2^2\ m2\ \text{Cos}[q2]^2 + \frac{1}{12}\ a3^2\ m3\ \text{Cos}[q2 + q3]^2 +$$
$$\frac{1}{12}\ a4^2\ m4\ \text{Cos}[q2 + q3 + q4]^2 + m2\left(\frac{1}{4}\ a2^2\ \text{Cos}[q1]^2\ \text{Cos}[q2]^2 + \frac{1}{4}\ a2^2\ \text{Cos}[q2]^2\ \text{Sin}[q1]^2\right) +$$
$$m3\left(\left(-\frac{1}{2}\ a3\ \text{Cos}[q1]\ \text{Cos}[q2 + q3] + \text{Cos}[q1]\left(a2\ \text{Cos}[q2] + a3\ \text{Cos}[q2 + q3]\right)\right)^2 +\right.$$
$$\left.\left(\frac{1}{2}\ a3\ \text{Cos}[q2 + q3]\ \text{Sin}[q1] - \left(a2\ \text{Cos}[q2] + a3\ \text{Cos}[q2 + q3]\right)\text{Sin}[q1]\right)^2\right) +$$
$$m4\left(\left(-\frac{1}{2}\ a4\ \text{Cos}[q1]\ \text{Cos}[q2 + q3 + q4] + \text{Cos}[q1]\left(a2\ \text{Cos}[q2] + a3\ \text{Cos}[q2 + q3] + a4\ \text{Cos}[q2 + q3 + q4]\right)\right)^2 +\right.$$
$$\left.\left(\frac{1}{2}\ a4\ \text{Cos}[q2 + q3 + q4]\ \text{Sin}[q1] - \left(a2\ \text{Cos}[q2] + a3\ \text{Cos}[q2 + q3] + a4\ \text{Cos}[q2 + q3 + q4]\right)\text{Sin}[q1]\right)^2\right)$$

In[•]:=
```
ToPython[d1^2 m1/12 + 1/12 a2^2 m2 Cos[q2]^2 + 1/12 a3^2 m3 Cos[q2 + q3]^2 +
 1/12 a4^2 m4 Cos[q2 + q3 + q4]^2 + m2 (1/4 a2^2 Cos[q1]^2 Cos[q2]^2 + 1/4 a2^2 Cos[q2]^2 Sin[q1]^2) +
 m3 ((-1/2 a3 Cos[q1] Cos[q2 + q3] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3]))^2 +
    (1/2 a3 Cos[q2 + q3] Sin[q1] - (a2 Cos[q2] + a3 Cos[q2 + q3]) Sin[q1])^2) +
 m4 ((-1/2 a4 Cos[q1] Cos[q2 + q3 + q4] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4]))^2 +
    (1/2 a4 Cos[q2 + q3 + q4] Sin[q1] -
       (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4]) Sin[q1])^2), NumpyPrefix → "np"]
```

Out[•]=
```
0.08333333333333333 * (d1 ** 2) * m1 + 0.08333333333333333 * (a2 ** 2) * m2 * (np.cos(q2) **
2) + 0.08333333333333333 * (a3 ** 2) * m3 * (np.cos(q2 + q3) ** 2) + 0.08333333333333333
* (a4 ** 2) * m4 * (np.cos(q2 + q3 + q4) ** 2) + m2 * (0.25 * (a2 ** 2) * (np.cos(q1)
** 2) * (np.cos(q2) ** 2) + 0.25 * (a2 ** 2) * (np.cos(q2) ** 2) * (np.sin(q1) ** 2))
+ m3 * ((-0.5 * a3 * np.cos(q1) * np.cos(q2 + q3) + np.cos(q1) * (a2 * np.cos(q2)
+ a3 * np.cos(q2 + q3))) ** 2 + (0.5 * a3 * np.cos(q2 + q3) * np.sin(q1) -((a2 *
np.cos(q2) + a3 * np.cos(q2 + q3)) * np.sin(q1))) ** 2) + m4 * ((-0.5 * a4 * np.cos(q1)
* np.cos(q2 + q3 + q4) + np.cos(q1) * (a2 * np.cos(q2) + a3 * np.cos(q2 + q3) + a4
* np.cos(q2 + q3 + q4))) ** 2 + (0.5 * a4 * np.cos(q2 + q3 + q4) * np.sin(q1) -((a2
* np.cos(q2) + a3 * np.cos(q2 + q3) + a4 * np.cos(q2 + q3 + q4)) * np.sin(q1))) ** 2)
```

In[•]:=
```
MU[[1, 2]]
```

Out[•]=
```
m3 (-((-1/2 a3 Cos[q1] Cos[q2 + q3] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3]))
      Sin[q1] (a2 Sin[q2] + 1/2 a3 Sin[q2 + q3])) - Cos[q1]
   (1/2 a3 Cos[q2 + q3] Sin[q1] - (a2 Cos[q2] + a3 Cos[q2 + q3]) Sin[q1]) (a2 Sin[q2] + 1/2 a3 Sin[q2 + q3])) +
 m4 (-((-1/2 a4 Cos[q1] Cos[q2 + q3 + q4] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4]))
      Sin[q1] (a2 Sin[q2] + a3 Sin[q2 + q3] + 1/2 a4 Sin[q2 + q3 + q4])) -
   Cos[q1] (1/2 a4 Cos[q2 + q3 + q4] Sin[q1] - (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4]) Sin[q1])
    (a2 Sin[q2] + a3 Sin[q2 + q3] + 1/2 a4 Sin[q2 + q3 + q4]))
```

In[•]:=
```
ToPython[m3 (-(((-1/2 a3 Cos[q1] Cos[q2 + q3] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3])) Sin[q1] (a2 Sin[q2] + 1/2 a3 Sin[q2 + q3])) - Cos[q1] (1/2 a3 Cos[q2 + q3] Sin[q1] - (a2 Cos[q2] + a3 Cos[q2 + q3]) Sin[q1]) (a2 Sin[q2] + 1/2 a3 Sin[q2 + q3])) + m4 (-(((-1/2 a4 Cos[q1] Cos[q2 + q3 + q4] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4])) Sin[q1] (a2 Sin[q2] + a3 Sin[q2 + q3] + 1/2 a4 Sin[q2 + q3 + q4])) - Cos[q1] (1/2 a4 Cos[q2 + q3 + q4] Sin[q1] - (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4]) Sin[q1]) (a2 Sin[q2] + a3 Sin[q2 + q3] + 1/2 a4 Sin[q2 + q3 + q4])), NumpyPrefix → "np"]
```

Out[•]=
```
m3 * (-((-0.5 * a3 * np.cos(q1) * np.cos(q2 + q3) + np.cos(q1) * (a2 * np.cos(q2) + a3 *
np.cos(q2 + q3))) * np.sin(q1) * (a2 * np.sin(q2) + 0.5 * a3 * np.sin(q2 + q3))) -(np.cos(q1)
* (0.5 * a3 * np.cos(q2 + q3) * np.sin(q1) -((a2 * np.cos(q2) + a3 * np.cos(q2 + q3))
* np.sin(q1))) * (a2 * np.sin(q2) + 0.5 * a3 * np.sin(q2 + q3)))) + m4 * (-((-0.5 * a4 *
np.cos(q1) * np.cos(q2 + q3 + q4) + np.cos(q1) * (a2 * np.cos(q2) + a3 * np.cos(q2 +
q3) + a4 * np.cos(q2 + q3 + q4))) * np.sin(q1) * (a2 * np.sin(q2) + a3 * np.sin(q2 +
q3) + 0.5 * a4 * np.sin(q2 + q3 + q4))) -(np.cos(q1) * (0.5 * a4 * np.cos(q2 + q3 + q4)
* np.sin(q1) -((a2 * np.cos(q2) + a3 * np.cos(q2 + q3) + a4 * np.cos(q2 + q3 + q4)) *
np.sin(q1))) * (a2 * np.sin(q2) + a3 * np.sin(q2 + q3) + 0.5 * a4 * np.sin(q2 + q3 + q4))))
```

In[•]:=
```
MU[[1, 3]]
```

Out[•]=
```
m3 (-1/2 a3 (-1/2 a3 Cos[q1] Cos[q2 + q3] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3])) Sin[q1] Sin[q2 + q3] - 1/2 a3 Cos[q1] (1/2 a3 Cos[q2 + q3] Sin[q1] - (a2 Cos[q2] + a3 Cos[q2 + q3]) Sin[q1]) Sin[q2 + q3]) + m4 (-(((-1/2 a4 Cos[q1] Cos[q2 + q3 + q4] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4])) Sin[q1] (a3 Sin[q2 + q3] + 1/2 a4 Sin[q2 + q3 + q4])) - Cos[q1] (1/2 a4 Cos[q2 + q3 + q4] Sin[q1] - (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4]) Sin[q1]) (a3 Sin[q2 + q3] + 1/2 a4 Sin[q2 + q3 + q4]))
```

In[•]:=
```
ToPython[
 m3 (-1/2 a3 (-1/2 a3 Cos[q1] Cos[q2 + q3] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3])) Sin[q1] Sin[q2 + q3] -
    1/2 a3 Cos[q1] (1/2 a3 Cos[q2 + q3] Sin[q1] - (a2 Cos[q2] + a3 Cos[q2 + q3]) Sin[q1]) Sin[q2 + q3]) +
  m4 (-((-1/2 a4 Cos[q1] Cos[q2 + q3 + q4] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4]))
       Sin[q1] (a3 Sin[q2 + q3] + 1/2 a4 Sin[q2 + q3 + q4])) -
     Cos[q1] (1/2 a4 Cos[q2 + q3 + q4] Sin[q1] - (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4]) Sin[q1])
      (a3 Sin[q2 + q3] + 1/2 a4 Sin[q2 + q3 + q4])), NumpyPrefix → "np"]
```

Out[•]=
```
m3 * (-0.5 * a3 * (-0.5 * a3 * np.cos(q1) * np.cos(q2 + q3) + np.cos(q1) * (a2 * np.cos(q2) +
  a3 * np.cos(q2 + q3))) * np.sin(q1) * np.sin(q2 + q3) -0.5 * a3 * np.cos(q1) * (0.5 * a3
  * np.cos(q2 + q3) * np.sin(q1) -((a2 * np.cos(q2) + a3 * np.cos(q2 + q3)) * np.sin(q1))) *
  np.sin(q2 + q3)) + m4 * (-((-0.5 * a4 * np.cos(q1) * np.cos(q2 + q3 + q4) + np.cos(q1) *
  (a2 * np.cos(q2) + a3 * np.cos(q2 + q3) + a4 * np.cos(q2 + q3 + q4))) * np.sin(q1) * (a3 *
  np.sin(q2 + q3) + 0.5 * a4 * np.sin(q2 + q3 + q4))) -(np.cos(q1) * (0.5 * a4 * np.cos(q2
  + q3 + q4) * np.sin(q1) -((a2 * np.cos(q2) + a3 * np.cos(q2 + q3) + a4 * np.cos(q2
  + q3 + q4)) * np.sin(q1))) * (a3 * np.sin(q2 + q3) + 0.5 * a4 * np.sin(q2 + q3 + q4))))
```

In[•]:=
```
MU[[1, 4]]
```

Out[•]=
```
m4
 (-1/2 a4 (-1/2 a4 Cos[q1] Cos[q2 + q3 + q4] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4])) Sin[q1]
    Sin[q2 + q3 + q4] - 1/2 a4 Cos[q1] (1/2 a4 Cos[q2 + q3 + q4] Sin[q1] -
      (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4]) Sin[q1]) Sin[q2 + q3 + q4])
```

In[•]:=
```
ToPython[
 m4 (-1/2 a4 (-1/2 a4 Cos[q1] Cos[q2 + q3 + q4] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4]))
    Sin[q1] Sin[q2 + q3 + q4] - 1/2 a4 Cos[q1]
    (1/2 a4 Cos[q2 + q3 + q4] Sin[q1] - (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4]) Sin[q1])
    Sin[q2 + q3 + q4]), NumpyPrefix → "np"]
```

Out[•]=
```
m4 * (-0.5 * a4 * (-0.5 * a4 * np.cos(q1) * np.cos(q2 + q3 + q4) +
  np.cos(q1) * (a2 * np.cos(q2) + a3 * np.cos(q2 + q3) + a4 * np.cos(q2 + q3
  + q4))) * np.sin(q1) * np.sin(q2 + q3 + q4) -0.5 * a4 * np.cos(q1) * (0.5 *
  a4 * np.cos(q2 + q3 + q4) * np.sin(q1) -((a2 * np.cos(q2) + a3 * np.cos(q2
  + q3) + a4 * np.cos(q2 + q3 + q4)) * np.sin(q1))) * np.sin(q2 + q3 + q4))
```

In[•]:=
```
MU[[2, 1]]
```

Out[•]=
$$m3\left(-\left(\left(-\frac{1}{2}\,a3\,\text{Cos}[q1]\,\text{Cos}[q2+q3]+\text{Cos}[q1]\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]\right)\right)\right.\right.$$
$$\left.\left.\text{Sin}[q1]\left(a2\,\text{Sin}[q2]+\frac{1}{2}\,a3\,\text{Sin}[q2+q3]\right)\right)-\text{Cos}[q1]\right.$$
$$\left.\left(\frac{1}{2}\,a3\,\text{Cos}[q2+q3]\,\text{Sin}[q1]-\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]\right)\text{Sin}[q1]\right)\left(a2\,\text{Sin}[q2]+\frac{1}{2}\,a3\,\text{Sin}[q2+q3]\right)\right)+$$
$$m4\left(-\left(\left(-\frac{1}{2}\,a4\,\text{Cos}[q1]\,\text{Cos}[q2+q3+q4]+\text{Cos}[q1]\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4]\right)\right)\right.\right.$$
$$\left.\left.\text{Sin}[q1]\left(a2\,\text{Sin}[q2]+a3\,\text{Sin}[q2+q3]+\frac{1}{2}\,a4\,\text{Sin}[q2+q3+q4]\right)\right)-\right.$$
$$\left.\text{Cos}[q1]\left(\frac{1}{2}\,a4\,\text{Cos}[q2+q3+q4]\,\text{Sin}[q1]-\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4]\right)\text{Sin}[q1]\right)\right.$$
$$\left.\left(a2\,\text{Sin}[q2]+a3\,\text{Sin}[q2+q3]+\frac{1}{2}\,a4\,\text{Sin}[q2+q3+q4]\right)\right)$$

In[•]:=
```
ToPython[m3 (-((-1/2 a3 Cos[q1] Cos[q2 + q3] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3])) Sin[q1] (a2 Sin[q2] + 1/2 a3 Sin[q2 + q3])) - Cos[q1] (1/2 a3 Cos[q2 + q3] Sin[q1] - (a2 Cos[q2] + a3 Cos[q2 + q3]) Sin[q1]) (a2 Sin[q2] + 1/2 a3 Sin[q2 + q3])) + m4 (-((-1/2 a4 Cos[q1] Cos[q2 + q3 + q4] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4])) Sin[q1] (a2 Sin[q2] + a3 Sin[q2 + q3] + 1/2 a4 Sin[q2 + q3 + q4])) - Cos[q1] (1/2 a4 Cos[q2 + q3 + q4] Sin[q1] - (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4]) Sin[q1]) (a2 Sin[q2] + a3 Sin[q2 + q3] + 1/2 a4 Sin[q2 + q3 + q4])), NumpyPrefix → "np"]
```

Out[•]=
```
m3 * (-((-0.5 * a3 * np.cos(q1) * np.cos(q2 + q3) + np.cos(q1) * (a2 * np.cos(q2) + a3 *
  np.cos(q2 + q3))) * np.sin(q1) * (a2 * np.sin(q2) + 0.5 * a3 * np.sin(q2 + q3))) -(np.cos(q1)
  * (0.5 * a3 * np.cos(q2 + q3) * np.sin(q1) -((a2 * np.cos(q2) + a3 * np.cos(q2 + q3))
  * np.sin(q1))) * (a2 * np.sin(q2) + 0.5 * a3 * np.sin(q2 + q3)))) + m4 * (-((-0.5 * a4 *
  np.cos(q1) * np.cos(q2 + q3 + q4) + np.cos(q1) * (a2 * np.cos(q2) + a3 * np.cos(q2 +
  q3) + a4 * np.cos(q2 + q3 + q4))) * np.sin(q1) * (a2 * np.sin(q2) + a3 * np.sin(q2 +
  q3) + 0.5 * a4 * np.sin(q2 + q3 + q4))) -(np.cos(q1) * (0.5 * a4 * np.cos(q2 + q3 + q4)
  * np.sin(q1) -((a2 * np.cos(q2) + a3 * np.cos(q2 + q3) + a4 * np.cos(q2 + q3 + q4)) *
  np.sin(q1))) * (a2 * np.sin(q2) + a3 * np.sin(q2 + q3) + 0.5 * a4 * np.sin(q2 + q3 + q4))))
```

In[•]:= MU[[2, 2]]

Out[•]=
$$\frac{1}{12}\,a2^2\,m2\,\text{Cos}[q1]^2\left(\text{Cos}[q1]^2+\text{Sin}[q1]^2\right)+\frac{1}{12}\,a3^2\,m3\,\text{Cos}[q1]^2\left(\text{Cos}[q1]^2+\text{Sin}[q1]^2\right)+$$
$$\frac{1}{12}\,a4^2\,m4\,\text{Cos}[q1]^2\left(\text{Cos}[q1]^2+\text{Sin}[q1]^2\right)+\frac{1}{12}\,a2^2\,m2\,\text{Sin}[q1]^2\left(\text{Cos}[q1]^2+\text{Sin}[q1]^2\right)+$$
$$\frac{1}{12}\,a3^2\,m3\,\text{Sin}[q1]^2\left(\text{Cos}[q1]^2+\text{Sin}[q1]^2\right)+\frac{1}{12}\,a4^2\,m4\,\text{Sin}[q1]^2\left(\text{Cos}[q1]^2+\text{Sin}[q1]^2\right)+$$
$$m2\left(\left(\frac{1}{2}\,a2\,\text{Cos}[q1]^2\,\text{Cos}[q2]+\frac{1}{2}\,a2\,\text{Cos}[q2]\,\text{Sin}[q1]^2\right)^2+\frac{1}{4}\,a2^2\,\text{Cos}[q1]^2\,\text{Sin}[q2]^2+\frac{1}{4}\,a2^2\,\text{Sin}[q1]^2\,\text{Sin}[q2]^2\right)+$$
$$m3\left(\left(\text{Cos}[q1]\left(-\frac{1}{2}\,a3\,\text{Cos}[q1]\,\text{Cos}[q2+q3]+\text{Cos}[q1]\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]\right)\right)+\right.\right.$$
$$\left.\left.\text{Sin}[q1]\left(-\frac{1}{2}\,a3\,\text{Cos}[q2+q3]\,\text{Sin}[q1]+\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]\right)\text{Sin}[q1]\right)\right)^2+\right.$$
$$\left.\text{Cos}[q1]^2\left(a2\,\text{Sin}[q2]+\frac{1}{2}\,a3\,\text{Sin}[q2+q3]\right)^2+\text{Sin}[q1]^2\left(a2\,\text{Sin}[q2]+\frac{1}{2}\,a3\,\text{Sin}[q2+q3]\right)^2\right)+$$
$$m4\left(\left(\text{Cos}[q1]\left(-\frac{1}{2}\,a4\,\text{Cos}[q1]\,\text{Cos}[q2+q3+q4]+\text{Cos}[q1]\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4]\right)\right)+\right.\right.$$
$$\left.\left.\text{Sin}[q1]\left(-\frac{1}{2}\,a4\,\text{Cos}[q2+q3+q4]\,\text{Sin}[q1]+\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4]\right)\right.\right.\right.$$
$$\left.\left.\left.\text{Sin}[q1]\right)\right)^2+\text{Cos}[q1]^2\left(a2\,\text{Sin}[q2]+a3\,\text{Sin}[q2+q3]+\frac{1}{2}\,a4\,\text{Sin}[q2+q3+q4]\right)^2+$$
$$\left.\text{Sin}[q1]^2\left(a2\,\text{Sin}[q2]+a3\,\text{Sin}[q2+q3]+\frac{1}{2}\,a4\,\text{Sin}[q2+q3+q4]\right)^2\right)$$

In[•]:=
```
ToPython[1/12 a2^2 m2 Cos[q1]^2 (Cos[q1]^2 + Sin[q1]^2) + 1/12 a3^2 m3 Cos[q1]^2 (Cos[q1]^2 + Sin[q1]^2) +
 1/12 a4^2 m4 Cos[q1]^2 (Cos[q1]^2 + Sin[q1]^2) + 1/12 a2^2 m2 Sin[q1]^2 (Cos[q1]^2 + Sin[q1]^2) +
 1/12 a3^2 m3 Sin[q1]^2 (Cos[q1]^2 + Sin[q1]^2) + 1/12 a4^2 m4 Sin[q1]^2 (Cos[q1]^2 + Sin[q1]^2) + m2
  ((1/2 a2 Cos[q1]^2 Cos[q2] + 1/2 a2 Cos[q2] Sin[q1]^2)^2 + 1/4 a2^2 Cos[q1]^2 Sin[q2]^2 + 1/4 a2^2 Sin[q1]^2 Sin[q2]^2) +
 m3 ((Cos[q1] (-1/2 a3 Cos[q1] Cos[q2 + q3] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3])) +
       Sin[q1] (-1/2 a3 Cos[q2 + q3] Sin[q1] + (a2 Cos[q2] + a3 Cos[q2 + q3]) Sin[q1]))^2 +
    Cos[q1]^2 (a2 Sin[q2] + 1/2 a3 Sin[q2 + q3])^2 + Sin[q1]^2 (a2 Sin[q2] + 1/2 a3 Sin[q2 + q3])^2) +
 m4 ((Cos[q1] (-1/2 a4 Cos[q1] Cos[q2 + q3 + q4] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4])) +
       Sin[q1] (-1/2 a4 Cos[q2 + q3 + q4] Sin[q1] + (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4])
          Sin[q1]))^2 + Cos[q1]^2 (a2 Sin[q2] + a3 Sin[q2 + q3] + 1/2 a4 Sin[q2 + q3 + q4])^2 +
    Sin[q1]^2 (a2 Sin[q2] + a3 Sin[q2 + q3] + 1/2 a4 Sin[q2 + q3 + q4])^2), NumpyPrefix → "np"]
```

Out[•]=
```
0.08333333333333333 * (a2 ** 2) * m2 * (np.cos(q1) ** 2) * (np.cos(q1) ** 2 + np.sin(q1)
** 2) + 0.08333333333333333 * (a3 ** 2) * m3 * (np.cos(q1) ** 2) * (np.cos(q1) **
2 + np.sin(q1) ** 2) + 0.08333333333333333 * (a4 ** 2) * m4 * (np.cos(q1) ** 2) *
(np.cos(q1) ** 2 + np.sin(q1) ** 2) + 0.08333333333333333 * (a2 ** 2) * m2 * (np.sin(q1)
** 2) * (np.cos(q1) ** 2 + np.sin(q1) ** 2) + 0.08333333333333333 * (a3 ** 2) * m3 *
(np.sin(q1) ** 2) * (np.cos(q1) ** 2 + np.sin(q1) ** 2) + 0.08333333333333333 * (a4
** 2) * m4 * (np.sin(q1) ** 2) * (np.cos(q1) ** 2 + np.sin(q1) ** 2) + m2 * ((0.5 * a2
* (np.cos(q1) ** 2) * np.cos(q2) + 0.5 * a2 * np.cos(q2) * (np.sin(q1) ** 2)) ** 2 +
0.25 * (a2 ** 2) * (np.cos(q1) ** 2) * (np.sin(q2) ** 2) + 0.25 * (a2 ** 2) * (np.sin(q1)
** 2) * (np.sin(q2) ** 2)) + m3 * ((np.cos(q1) * (-0.5 * a3 * np.cos(q1) * np.cos(q2
+ q3) + np.cos(q1) * (a2 * np.cos(q2) + a3 * np.cos(q2 + q3))) + np.sin(q1) * (-0.5
* a3 * np.cos(q2 + q3) * np.sin(q1) + (a2 * np.cos(q2) + a3 * np.cos(q2 + q3)) *
np.sin(q1))) ** 2 + (np.cos(q1) ** 2) * ((a2 * np.sin(q2) + 0.5 * a3 * np.sin(q2 + q3))
** 2) + (np.sin(q1) ** 2) * ((a2 * np.sin(q2) + 0.5 * a3 * np.sin(q2 + q3)) ** 2)) + m4
* ((np.cos(q1) * (-0.5 * a4 * np.cos(q1) * np.cos(q2 + q3 + q4) + np.cos(q1) * (a2 *
np.cos(q2) + a3 * np.cos(q2 + q3) + a4 * np.cos(q2 + q3 + q4))) + np.sin(q1) * (-0.5
* a4 * np.cos(q2 + q3 + q4) * np.sin(q1) + (a2 * np.cos(q2) + a3 * np.cos(q2 + q3)
+ a4 * np.cos(q2 + q3 + q4)) * np.sin(q1))) ** 2 + (np.cos(q1) ** 2) * ((a2 * np.sin(q2)
+ a3 * np.sin(q2 + q3) + 0.5 * a4 * np.sin(q2 + q3 + q4)) ** 2) + (np.sin(q1) ** 2)
* ((a2 * np.sin(q2) + a3 * np.sin(q2 + q3) + 0.5 * a4 * np.sin(q2 + q3 + q4)) ** 2))
```

In[•]:= MU[[2, 3]]

Out[•]=
$$\frac{1}{12}\,a3^2\,m3\,\text{Cos}[q1]^2\left(\text{Cos}[q1]^2+\text{Sin}[q1]^2\right)+\frac{1}{12}\,a4^2\,m4\,\text{Cos}[q1]^2\left(\text{Cos}[q1]^2+\text{Sin}[q1]^2\right)+$$
$$\frac{1}{12}\,a3^2\,m3\,\text{Sin}[q1]^2\left(\text{Cos}[q1]^2+\text{Sin}[q1]^2\right)+\frac{1}{12}\,a4^2\,m4\,\text{Sin}[q1]^2\left(\text{Cos}[q1]^2+\text{Sin}[q1]^2\right)+$$
$$m3\left(\left(\text{Cos}[q1]\left(-\frac{1}{2}\,a3\,\text{Cos}[q1]\,\text{Cos}[q2+q3]+\text{Cos}[q1]\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]\right)\right)+\right.\right.$$
$$\left.\text{Sin}[q1]\left(-\frac{1}{2}\,a3\,\text{Cos}[q2+q3]\,\text{Sin}[q1]+\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]\right)\text{Sin}[q1]\right)\right)$$
$$\left(\text{Cos}[q1]\left(-a2\,\text{Cos}[q1]\,\text{Cos}[q2]-\frac{1}{2}\,a3\,\text{Cos}[q1]\,\text{Cos}[q2+q3]+\text{Cos}[q1]\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]\right)\right)+\right.$$
$$\left.\text{Sin}[q1]\left(-a2\,\text{Cos}[q2]\,\text{Sin}[q1]-\frac{1}{2}\,a3\,\text{Cos}[q2+q3]\,\text{Sin}[q1]+\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]\right)\text{Sin}[q1]\right)\right)+$$
$$\frac{1}{2}\,a3\,\text{Cos}[q1]^2\,\text{Sin}[q2+q3]\left(a2\,\text{Sin}[q2]+\frac{1}{2}\,a3\,\text{Sin}[q2+q3]\right)+$$
$$\left.\frac{1}{2}\,a3\,\text{Sin}[q1]^2\,\text{Sin}[q2+q3]\left(a2\,\text{Sin}[q2]+\frac{1}{2}\,a3\,\text{Sin}[q2+q3]\right)\right)+$$
$$m4\left(\left(\text{Cos}[q1]\left(-\frac{1}{2}\,a4\,\text{Cos}[q1]\,\text{Cos}[q2+q3+q4]+\text{Cos}[q1]\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4]\right)\right)+\right.\right.$$
$$\text{Sin}[q1]\left(-\frac{1}{2}\,a4\,\text{Cos}[q2+q3+q4]\,\text{Sin}[q1]+\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4]\right)\right.$$
$$\left.\left.\text{Sin}[q1]\right)\right)\left(\text{Cos}[q1]\left(-a2\,\text{Cos}[q1]\,\text{Cos}[q2]-\frac{1}{2}\,a4\,\text{Cos}[q1]\,\text{Cos}[q2+q3+q4]+\right.\right.$$
$$\left.\text{Cos}[q1]\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4]\right)\right)+\text{Sin}[q1]\left(-a2\,\text{Cos}[q2]\,\text{Sin}[q1]-$$
$$\left.\frac{1}{2}\,a4\,\text{Cos}[q2+q3+q4]\,\text{Sin}[q1]+\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4]\right)\text{Sin}[q1]\right)\right)+$$
$$\text{Cos}[q1]^2\left(a3\,\text{Sin}[q2+q3]+\frac{1}{2}\,a4\,\text{Sin}[q2+q3+q4]\right)\left(a2\,\text{Sin}[q2]+a3\,\text{Sin}[q2+q3]+\frac{1}{2}\,a4\,\text{Sin}[q2+q3+q4]\right)+$$
$$\left.\text{Sin}[q1]^2\left(a3\,\text{Sin}[q2+q3]+\frac{1}{2}\,a4\,\text{Sin}[q2+q3+q4]\right)\left(a2\,\text{Sin}[q2]+a3\,\text{Sin}[q2+q3]+\frac{1}{2}\,a4\,\text{Sin}[q2+q3+q4]\right)\right)$$

In[•]:=
```
ToPython[1/12 a3^2 m3 Cos[q1]^2 (Cos[q1]^2 + Sin[q1]^2) + 1/12 a4^2 m4 Cos[q1]^2 (Cos[q1]^2 + Sin[q1]^2) +
 1/12 a3^2 m3 Sin[q1]^2 (Cos[q1]^2 + Sin[q1]^2) + 1/12 a4^2 m4 Sin[q1]^2 (Cos[q1]^2 + Sin[q1]^2) +
 m3 ((Cos[q1] (-1/2 a3 Cos[q1] Cos[q2 + q3] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3])) +
      Sin[q1] (-1/2 a3 Cos[q2 + q3] Sin[q1] + (a2 Cos[q2] + a3 Cos[q2 + q3]) Sin[q1]))
     (Cos[q1] (-a2 Cos[q1] Cos[q2] - 1/2 a3 Cos[q1] Cos[q2 + q3] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3])) +
      Sin[q1] (-a2 Cos[q2] Sin[q1] - 1/2 a3 Cos[q2 + q3] Sin[q1] + (a2 Cos[q2] + a3 Cos[q2 + q3]) Sin[q1])) +
     1/2 a3 Cos[q1]^2 Sin[q2 + q3] (a2 Sin[q2] + 1/2 a3 Sin[q2 + q3]) +
     1/2 a3 Sin[q1]^2 Sin[q2 + q3] (a2 Sin[q2] + 1/2 a3 Sin[q2 + q3])) +
 m4 ((Cos[q1] (-1/2 a4 Cos[q1] Cos[q2 + q3 + q4] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4])) +
      Sin[q1] (-1/2 a4 Cos[q2 + q3 + q4] Sin[q1] + (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4])
          Sin[q1]))(Cos[q1] (-a2 Cos[q1] Cos[q2] - 1/2 a4 Cos[q1] Cos[q2 + q3 + q4] +
          Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4])) + Sin[q1] (-a2 Cos[q2] Sin[q1] -
          1/2 a4 Cos[q2 + q3 + q4] Sin[q1] + (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4]) Sin[q1])) +
     Cos[q1]^2 (a3 Sin[q2 + q3] + 1/2 a4 Sin[q2 + q3 + q4]) (a2 Sin[q2] + a3 Sin[q2 + q3] +
      1/2 a4 Sin[q2 + q3 + q4]) + Sin[q1]^2 (a3 Sin[q2 + q3] + 1/2 a4 Sin[q2 + q3 + q4])
     (a2 Sin[q2] + a3 Sin[q2 + q3] + 1/2 a4 Sin[q2 + q3 + q4])), NumpyPrefix → "np"]
```

Out[•]=
```
0.08333333333333333 * (a3 ** 2) * m3 * (np.cos(q1) ** 2) * (np.cos(q1) ** 2 + np.sin(q1) ** 2) +
 0.08333333333333333 * (a4 ** 2) * m4 * (np.cos(q1) ** 2) * (np.cos(q1) ** 2 + np.sin(q1)
 ** 2) + 0.08333333333333333 * (a3 ** 2) * m3 * (np.sin(q1) ** 2) * (np.cos(q1) ** 2 +
 np.sin(q1) ** 2) + 0.08333333333333333 * (a4 ** 2) * m4 * (np.sin(q1) ** 2) * (np.cos(q1)
 ** 2 + np.sin(q1) ** 2) + m3 * ((np.cos(q1) * (-0.5 * a3 * np.cos(q1) * np.cos(q2 + q3)
 + np.cos(q1) * (a2 * np.cos(q2) + a3 * np.cos(q2 + q3))) + np.sin(q1) * (-0.5 * a3 *
 np.cos(q2 + q3) * np.sin(q1) + (a2 * np.cos(q2) + a3 * np.cos(q2 + q3)) * np.sin(q1)))
 * (np.cos(q1) * (-(a2 * np.cos(q1) * np.cos(q2)) -0.5 * a3 * np.cos(q1) * np.cos(q2
 + q3) + np.cos(q1) * (a2 * np.cos(q2) + a3 * np.cos(q2 + q3))) + np.sin(q1) * (-(a2 *
 np.cos(q2) * np.sin(q1)) -0.5 * a3 * np.cos(q2 + q3) * np.sin(q1) + (a2 * np.cos(q2)
 + a3 * np.cos(q2 + q3)) * np.sin(q1))) + 0.5 * a3 * (np.cos(q1) ** 2) * np.sin(q2 +
 q3) * (a2 * np.sin(q2) + 0.5 * a3 * np.sin(q2 + q3)) + 0.5 * a3 * (np.sin(q1) ** 2) *
 np.sin(q2 + q3) * (a2 * np.sin(q2) + 0.5 * a3 * np.sin(q2 + q3))) + m4 * ((np.cos(q1)
 * (-0.5 * a4 * np.cos(q1) * np.cos(q2 + q3 + q4) + np.cos(q1) * (a2 * np.cos(q2) + a3
 * np.cos(q2 + q3) + a4 * np.cos(q2 + q3 + q4))) + np.sin(q1) * (-0.5 * a4 * np.cos(q2
 + q3 + q4) * np.sin(q1) + (a2 * np.cos(q2) + a3 * np.cos(q2 + q3) + a4 * np.cos(q2
 + q3 + q4)) * np.sin(q1))) * (np.cos(q1) * (-(a2 * np.cos(q1) * np.cos(q2)) -0.5 * a4 *
 np.cos(q1) * np.cos(q2 + q3 + q4) + np.cos(q1) * (a2 * np.cos(q2) + a3 * np.cos(q2 +
 q3) + a4 * np.cos(q2 + q3 + q4))) + np.sin(q1) * (-(a2 * np.cos(q2) * np.sin(q1)) -0.5 *
 a4 * np.cos(q2 + q3 + q4) * np.sin(q1) + (a2 * np.cos(q2) + a3 * np.cos(q2 + q3) + a4
 * np.cos(q2 + q3 + q4)) * np.sin(q1))) + (np.cos(q1) ** 2) * (a3 * np.sin(q2 + q3) + 0.5
 * a4 * np.sin(q2 + q3 + q4)) * (a2 * np.sin(q2) + a3 * np.sin(q2 + q3) + 0.5 * a4 *
 np.sin(q2 + q3 + q4)) + (np.sin(q1) ** 2) * (a3 * np.sin(q2 + q3) + 0.5 * a4 * np.sin(q2
 + q3 + q4)) * (a2 * np.sin(q2) + a3 * np.sin(q2 + q3) + 0.5 * a4 * np.sin(q2 + q3 + q4)))
```

In[•]:= **MU[[2, 3]]**

Out[•]=
$$\frac{1}{12}\,a3^2\,m3\,\text{Cos}[q1]^2\left(\text{Cos}[q1]^2+\text{Sin}[q1]^2\right)+\frac{1}{12}\,a4^2\,m4\,\text{Cos}[q1]^2\left(\text{Cos}[q1]^2+\text{Sin}[q1]^2\right)+$$
$$\frac{1}{12}\,a3^2\,m3\,\text{Sin}[q1]^2\left(\text{Cos}[q1]^2+\text{Sin}[q1]^2\right)+\frac{1}{12}\,a4^2\,m4\,\text{Sin}[q1]^2\left(\text{Cos}[q1]^2+\text{Sin}[q1]^2\right)+$$
$$m3\left(\left(\text{Cos}[q1]\left(-\frac{1}{2}\,a3\,\text{Cos}[q1]\,\text{Cos}[q2+q3]+\text{Cos}[q1]\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]\right)\right)+\right.\right.$$
$$\left.\text{Sin}[q1]\left(-\frac{1}{2}\,a3\,\text{Cos}[q2+q3]\,\text{Sin}[q1]+\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]\right)\text{Sin}[q1]\right)\right)$$
$$\left(\text{Cos}[q1]\left(-a2\,\text{Cos}[q1]\,\text{Cos}[q2]-\frac{1}{2}\,a3\,\text{Cos}[q1]\,\text{Cos}[q2+q3]+\text{Cos}[q1]\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]\right)\right)+\right.$$
$$\left.\text{Sin}[q1]\left(-a2\,\text{Cos}[q2]\,\text{Sin}[q1]-\frac{1}{2}\,a3\,\text{Cos}[q2+q3]\,\text{Sin}[q1]+\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]\right)\text{Sin}[q1]\right)\right)+$$
$$\frac{1}{2}\,a3\,\text{Cos}[q1]^2\,\text{Sin}[q2+q3]\left(a2\,\text{Sin}[q2]+\frac{1}{2}\,a3\,\text{Sin}[q2+q3]\right)+$$
$$\left.\frac{1}{2}\,a3\,\text{Sin}[q1]^2\,\text{Sin}[q2+q3]\left(a2\,\text{Sin}[q2]+\frac{1}{2}\,a3\,\text{Sin}[q2+q3]\right)\right)+$$
$$m4\left(\left(\text{Cos}[q1]\left(-\frac{1}{2}\,a4\,\text{Cos}[q1]\,\text{Cos}[q2+q3+q4]+\text{Cos}[q1]\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4]\right)\right)+\right.\right.$$
$$\text{Sin}[q1]\left(-\frac{1}{2}\,a4\,\text{Cos}[q2+q3+q4]\,\text{Sin}[q1]+\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4]\right)\right.$$
$$\left.\left.\text{Sin}[q1]\right)\right)\left(\text{Cos}[q1]\left(-a2\,\text{Cos}[q1]\,\text{Cos}[q2]-\frac{1}{2}\,a4\,\text{Cos}[q1]\,\text{Cos}[q2+q3+q4]+\right.\right.$$
$$\left.\text{Cos}[q1]\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4]\right)\right)+\text{Sin}[q1]\left(-a2\,\text{Cos}[q2]\,\text{Sin}[q1]-$$
$$\left.\left.\frac{1}{2}\,a4\,\text{Cos}[q2+q3+q4]\,\text{Sin}[q1]+\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4]\right)\text{Sin}[q1]\right)\right)+$$
$$\text{Cos}[q1]^2\left(a3\,\text{Sin}[q2+q3]+\frac{1}{2}\,a4\,\text{Sin}[q2+q3+q4]\right)\left(a2\,\text{Sin}[q2]+a3\,\text{Sin}[q2+q3]+\frac{1}{2}\,a4\,\text{Sin}[q2+q3+q4]\right)+$$
$$\left.\text{Sin}[q1]^2\left(a3\,\text{Sin}[q2+q3]+\frac{1}{2}\,a4\,\text{Sin}[q2+q3+q4]\right)\left(a2\,\text{Sin}[q2]+a3\,\text{Sin}[q2+q3]+\frac{1}{2}\,a4\,\text{Sin}[q2+q3+q4]\right)\right)$$

In[•]:=
```
ToPython[1/12 a3^2 m3 Cos[q1]^2 (Cos[q1]^2 + Sin[q1]^2) + 1/12 a4^2 m4 Cos[q1]^2 (Cos[q1]^2 + Sin[q1]^2) +
 1/12 a3^2 m3 Sin[q1]^2 (Cos[q1]^2 + Sin[q1]^2) + 1/12 a4^2 m4 Sin[q1]^2 (Cos[q1]^2 + Sin[q1]^2) +
 m3 ((Cos[q1] (-1/2 a3 Cos[q1] Cos[q2 + q3] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3])) +
      Sin[q1] (-1/2 a3 Cos[q2 + q3] Sin[q1] + (a2 Cos[q2] + a3 Cos[q2 + q3]) Sin[q1]))
     (Cos[q1] (-a2 Cos[q1] Cos[q2] - 1/2 a3 Cos[q1] Cos[q2 + q3] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3])) +
      Sin[q1] (-a2 Cos[q2] Sin[q1] - 1/2 a3 Cos[q2 + q3] Sin[q1] + (a2 Cos[q2] + a3 Cos[q2 + q3]) Sin[q1])) +
     1/2 a3 Cos[q1]^2 Sin[q2 + q3] (a2 Sin[q2] + 1/2 a3 Sin[q2 + q3]) +
     1/2 a3 Sin[q1]^2 Sin[q2 + q3] (a2 Sin[q2] + 1/2 a3 Sin[q2 + q3])) +
 m4 ((Cos[q1] (-1/2 a4 Cos[q1] Cos[q2 + q3 + q4] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4])) +
      Sin[q1] (-1/2 a4 Cos[q2 + q3 + q4] Sin[q1] + (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4])
          Sin[q1])) (Cos[q1] (-a2 Cos[q1] Cos[q2] - 1/2 a4 Cos[q1] Cos[q2 + q3 + q4] +
          Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4])) + Sin[q1] (-a2 Cos[q2] Sin[q1] -
          1/2 a4 Cos[q2 + q3 + q4] Sin[q1] + (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4]) Sin[q1])) +
     Cos[q1]^2 (a3 Sin[q2 + q3] + 1/2 a4 Sin[q2 + q3 + q4]) (a2 Sin[q2] + a3 Sin[q2 + q3] +
      1/2 a4 Sin[q2 + q3 + q4]) + Sin[q1]^2 (a3 Sin[q2 + q3] + 1/2 a4 Sin[q2 + q3 + q4])
      (a2 Sin[q2] + a3 Sin[q2 + q3] + 1/2 a4 Sin[q2 + q3 + q4])), NumpyPrefix → "np"]
```

Out[•]=
```
0.08333333333333333 * (a3 ** 2) * m3 * (np.cos(q1) ** 2) * (np.cos(q1) ** 2 + np.sin(q1) ** 2) +
0.08333333333333333 * (a4 ** 2) * m4 * (np.cos(q1) ** 2) * (np.cos(q1) ** 2 + np.sin(q1)
** 2) + 0.08333333333333333 * (a3 ** 2) * m3 * (np.sin(q1) ** 2) * (np.cos(q1) ** 2 +
np.sin(q1) ** 2) + 0.08333333333333333 * (a4 ** 2) * m4 * (np.sin(q1) ** 2) * (np.cos(q1)
** 2 + np.sin(q1) ** 2) + m3 * ((np.cos(q1) * (-0.5 * a3 * np.cos(q1) * np.cos(q2 + q3)
+ np.cos(q1) * (a2 * np.cos(q2) + a3 * np.cos(q2 + q3))) + np.sin(q1) * (-0.5 * a3 *
np.cos(q2 + q3) * np.sin(q1) + (a2 * np.cos(q2) + a3 * np.cos(q2 + q3)) * np.sin(q1)))
* (np.cos(q1) * (-(a2 * np.cos(q1) * np.cos(q2)) -0.5 * a3 * np.cos(q1) * np.cos(q2
+ q3) + np.cos(q1) * (a2 * np.cos(q2) + a3 * np.cos(q2 + q3))) + np.sin(q1) * (-(a2 *
np.cos(q2) * np.sin(q1)) -0.5 * a3 * np.cos(q2 + q3) * np.sin(q1) + (a2 * np.cos(q2)
+ a3 * np.cos(q2 + q3)) * np.sin(q1))) + 0.5 * a3 * (np.cos(q1) ** 2) * np.sin(q2 +
q3) * (a2 * np.sin(q2) + 0.5 * a3 * np.sin(q2 + q3)) + 0.5 * a3 * (np.sin(q1) ** 2) *
np.sin(q2 + q3) * (a2 * np.sin(q2) + 0.5 * a3 * np.sin(q2 + q3))) + m4 * ((np.cos(q1)
* (-0.5 * a4 * np.cos(q1) * np.cos(q2 + q3 + q4) + np.cos(q1) * (a2 * np.cos(q2) + a3
* np.cos(q2 + q3) + a4 * np.cos(q2 + q3 + q4))) + np.sin(q1) * (-0.5 * a4 * np.cos(q2
+ q3 + q4) * np.sin(q1) + (a2 * np.cos(q2) + a3 * np.cos(q2 + q3) + a4 * np.cos(q2
+ q3 + q4)) * np.sin(q1))) * (np.cos(q1) * (-(a2 * np.cos(q1) * np.cos(q2)) -0.5 * a4 *
np.cos(q1) * np.cos(q2 + q3 + q4) + np.cos(q1) * (a2 * np.cos(q2) + a3 * np.cos(q2 +
q3) + a4 * np.cos(q2 + q3 + q4))) + np.sin(q1) * (-(a2 * np.cos(q2) * np.sin(q1)) -0.5 *
a4 * np.cos(q2 + q3 + q4) * np.sin(q1) + (a2 * np.cos(q2) + a3 * np.cos(q2 + q3) + a4
* np.cos(q2 + q3 + q4)) * np.sin(q1))) + (np.cos(q1) ** 2) * (a3 * np.sin(q2 + q3) + 0.5
* a4 * np.sin(q2 + q3 + q4)) * (a2 * np.sin(q2) + a3 * np.sin(q2 + q3) + 0.5 * a4 *
np.sin(q2 + q3 + q4)) + (np.sin(q1) ** 2) * (a3 * np.sin(q2 + q3) + 0.5 * a4 * np.sin(q2
+ q3 + q4)) * (a2 * np.sin(q2) + a3 * np.sin(q2 + q3) + 0.5 * a4 * np.sin(q2 + q3 + q4)))
```

In[•]:= **MU[[2, 4]]**

Out[•]=
$$\frac{1}{12}\,a4^2\,m4\,\text{Cos[q1]}^2\left(\text{Cos[q1]}^2+\text{Sin[q1]}^2\right)+\frac{1}{12}\,a4^2\,m4\,\text{Sin[q1]}^2\left(\text{Cos[q1]}^2+\text{Sin[q1]}^2\right)+$$
$$m4\left(\left(\text{Cos[q1]}\left(-\frac{1}{2}\,a4\,\text{Cos[q1]}\,\text{Cos[q2+q3+q4]}+\text{Cos[q1]}\left(a2\,\text{Cos[q2]}+a3\,\text{Cos[q2+q3]}+a4\,\text{Cos[q2+q3+q4]}\right)\right)+\right.\right.$$
$$\text{Sin[q1]}\left(-\frac{1}{2}\,a4\,\text{Cos[q2+q3+q4]}\,\text{Sin[q1]}+\left(a2\,\text{Cos[q2]}+a3\,\text{Cos[q2+q3]}+a4\,\text{Cos[q2+q3+q4]}\right)\text{Sin[q1]}\right)\Bigg)$$
$$\left(\text{Cos[q1]}\left(-\text{Cos[q1]}\left(a2\,\text{Cos[q2]}+a3\,\text{Cos[q2+q3]}\right)-\frac{1}{2}\,a4\,\text{Cos[q1]}\,\text{Cos[q2+q3+q4]}+\right.\right.$$
$$\left.\text{Cos[q1]}\left(a2\,\text{Cos[q2]}+a3\,\text{Cos[q2+q3]}+a4\,\text{Cos[q2+q3+q4]}\right)\right)+$$
$$\text{Sin[q1]}\left(-\left(\left(a2\,\text{Cos[q2]}+a3\,\text{Cos[q2+q3]}\right)\text{Sin[q1]}\right)-\frac{1}{2}\,a4\,\text{Cos[q2+q3+q4]}\,\text{Sin[q1]}+\right.$$
$$\left.\left.\left(a2\,\text{Cos[q2]}+a3\,\text{Cos[q2+q3]}+a4\,\text{Cos[q2+q3+q4]}\right)\text{Sin[q1]}\right)\right)+$$
$$\frac{1}{2}\,a4\,\text{Cos[q1]}^2\,\text{Sin[q2+q3+q4]}\left(a2\,\text{Sin[q2]}+a3\,\text{Sin[q2+q3]}+\frac{1}{2}\,a4\,\text{Sin[q2+q3+q4]}\right)+$$
$$\frac{1}{2}\,a4\,\text{Sin[q1]}^2\,\text{Sin[q2+q3+q4]}\left(a2\,\text{Sin[q2]}+a3\,\text{Sin[q2+q3]}+\frac{1}{2}\,a4\,\text{Sin[q2+q3+q4]}\right)\Bigg)$$

In[•]:=
```
ToPython[1/12 a4^2 m4 Cos[q1]^2 (Cos[q1]^2 + Sin[q1]^2) + 1/12 a4^2 m4 Sin[q1]^2 (Cos[q1]^2 + Sin[q1]^2) +
 m4 (((Cos[q1] (-1/2 a4 Cos[q1] Cos[q2 + q3 + q4] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4])) +
      Sin[q1] (-1/2 a4 Cos[q2 + q3 + q4] Sin[q1] + (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4])
        Sin[q1])) (Cos[q1] (-Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3]) -
        1/2 a4 Cos[q1] Cos[q2 + q3 + q4] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4])) +
      Sin[q1] (-((a2 Cos[q2] + a3 Cos[q2 + q3]) Sin[q1]) - 1/2 a4 Cos[q2 + q3 + q4] Sin[q1] +
        (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4]) Sin[q1])) +
   1/2 a4 Cos[q1]^2 Sin[q2 + q3 + q4] (a2 Sin[q2] + a3 Sin[q2 + q3] + 1/2 a4 Sin[q2 + q3 + q4]) +
   1/2 a4 Sin[q1]^2 Sin[q2 + q3 + q4]
    (a2 Sin[q2] + a3 Sin[q2 + q3] + 1/2 a4 Sin[q2 + q3 + q4])), NumpyPrefix → "np"]
```

Out[•]=
```
0.08333333333333333 * (a4 ** 2) * m4 * (np.cos(q1) ** 2) * (np.cos(q1) ** 2 + np.sin(q1) **
    2) + 0.08333333333333333 * (a4 ** 2) * m4 * (np.sin(q1) ** 2) * (np.cos(q1) ** 2 +
    np.sin(q1) ** 2) + m4 * ((np.cos(q1) * (-0.5 * a4 * np.cos(q1) * np.cos(q2 + q3 + q4)
    + np.cos(q1) * (a2 * np.cos(q2) + a3 * np.cos(q2 + q3) + a4 * np.cos(q2 + q3 + q4)))
    + np.sin(q1) * (-0.5 * a4 * np.cos(q2 + q3 + q4) * np.sin(q1) + (a2 * np.cos(q2)
    + a3 * np.cos(q2 + q3) + a4 * np.cos(q2 + q3 + q4)) * np.sin(q1))) * (np.cos(q1)
    * (-(np.cos(q1) * (a2 * np.cos(q2) + a3 * np.cos(q2 + q3))) -0.5 * a4 * np.cos(q1)
    * np.cos(q2 + q3 + q4) + np.cos(q1) * (a2 * np.cos(q2) + a3 * np.cos(q2 + q3) +
    a4 * np.cos(q2 + q3 + q4))) + np.sin(q1) * (-((a2 * np.cos(q2) + a3 * np.cos(q2 +
    q3)) * np.sin(q1)) -0.5 * a4 * np.cos(q2 + q3 + q4) * np.sin(q1) + (a2 * np.cos(q2)
    + a3 * np.cos(q2 + q3) + a4 * np.cos(q2 + q3 + q4)) * np.sin(q1))) + 0.5 * a4 *
    (np.cos(q1) ** 2) * np.sin(q2 + q3 + q4) * (a2 * np.sin(q2) + a3 * np.sin(q2 + q3)
    + 0.5 * a4 * np.sin(q2 + q3 + q4)) + 0.5 * a4 * (np.sin(q1) ** 2) * np.sin(q2 + q3
    + q4) * (a2 * np.sin(q2) + a3 * np.sin(q2 + q3) + 0.5 * a4 * np.sin(q2 + q3 + q4)))
```

In[•]:=
```
MU[[3, 1]]
```

Out[•]=
$$m3\left(-\frac{1}{2}\,a3\left(-\frac{1}{2}\,a3\,\text{Cos}[q1]\,\text{Cos}[q2+q3]+\text{Cos}[q1]\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]\right)\right)\text{Sin}[q1]\,\text{Sin}[q2+q3]-\frac{1}{2}\,a3\,\text{Cos}[q1]\left(\frac{1}{2}\,a3\,\text{Cos}[q2+q3]\,\text{Sin}[q1]-\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]\right)\text{Sin}[q1]\right)\text{Sin}[q2+q3]\right)+m4\left(-\left(\left(-\frac{1}{2}\,a4\,\text{Cos}[q1]\,\text{Cos}[q2+q3+q4]+\text{Cos}[q1]\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4]\right)\right)\text{Sin}[q1]\left(a3\,\text{Sin}[q2+q3]+\frac{1}{2}\,a4\,\text{Sin}[q2+q3+q4]\right)\right)-\text{Cos}[q1]\left(\frac{1}{2}\,a4\,\text{Cos}[q2+q3+q4]\,\text{Sin}[q1]-\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4]\right)\text{Sin}[q1]\right)\left(a3\,\text{Sin}[q2+q3]+\frac{1}{2}\,a4\,\text{Sin}[q2+q3+q4]\right)\right)$$

In[•]:=
```
ToPython[
  m3 (-1/2 a3 (-1/2 a3 Cos[q1] Cos[q2 + q3] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3])) Sin[q1] Sin[q2 + q3] -
      1/2 a3 Cos[q1] (1/2 a3 Cos[q2 + q3] Sin[q1] - (a2 Cos[q2] + a3 Cos[q2 + q3]) Sin[q1]) Sin[q2 + q3]) +
   m4 (-(((-1/2 a4 Cos[q1] Cos[q2 + q3 + q4] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4]))
          Sin[q1] (a3 Sin[q2 + q3] + 1/2 a4 Sin[q2 + q3 + q4])) -
       Cos[q1] (1/2 a4 Cos[q2 + q3 + q4] Sin[q1] - (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4]) Sin[q1])
        (a3 Sin[q2 + q3] + 1/2 a4 Sin[q2 + q3 + q4])), NumpyPrefix → "np"]
```

Out[•]=
```
m3 * (-0.5 * a3 * (-0.5 * a3 * np.cos(q1) * np.cos(q2 + q3) + np.cos(q1) * (a2 * np.cos(q2) +
  a3 * np.cos(q2 + q3))) * np.sin(q1) * np.sin(q2 + q3) -0.5 * a3 * np.cos(q1) * (0.5 * a3
  * np.cos(q2 + q3) * np.sin(q1) -((a2 * np.cos(q2) + a3 * np.cos(q2 + q3)) * np.sin(q1))) *
  np.sin(q2 + q3)) + m4 * (-((-0.5 * a4 * np.cos(q1) * np.cos(q2 + q3 + q4) + np.cos(q1) *
  (a2 * np.cos(q2) + a3 * np.cos(q2 + q3) + a4 * np.cos(q2 + q3 + q4))) * np.sin(q1) * (a3 *
  np.sin(q2 + q3) + 0.5 * a4 * np.sin(q2 + q3 + q4))) -(np.cos(q1) * (0.5 * a4 * np.cos(q2
  + q3 + q4) * np.sin(q1) -((a2 * np.cos(q2) + a3 * np.cos(q2 + q3) + a4 * np.cos(q2
  + q3 + q4)) * np.sin(q1))) * (a3 * np.sin(q2 + q3) + 0.5 * a4 * np.sin(q2 + q3 + q4))))
```

In[•]:= MU[[3, 2]]

Out[•]=
$$\frac{1}{12}\,a3^2\,m3\,\text{Cos}[q1]^2\left(\text{Cos}[q1]^2+\text{Sin}[q1]^2\right)+\frac{1}{12}\,a4^2\,m4\,\text{Cos}[q1]^2\left(\text{Cos}[q1]^2+\text{Sin}[q1]^2\right)+$$
$$\frac{1}{12}\,a3^2\,m3\,\text{Sin}[q1]^2\left(\text{Cos}[q1]^2+\text{Sin}[q1]^2\right)+\frac{1}{12}\,a4^2\,m4\,\text{Sin}[q1]^2\left(\text{Cos}[q1]^2+\text{Sin}[q1]^2\right)+$$
$$m3\left(\left(\text{Cos}[q1]\left(-\frac{1}{2}\,a3\,\text{Cos}[q1]\,\text{Cos}[q2+q3]+\text{Cos}[q1]\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]\right)\right)+\right.\right.$$
$$\left.\text{Sin}[q1]\left(-\frac{1}{2}\,a3\,\text{Cos}[q2+q3]\,\text{Sin}[q1]+\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]\right)\text{Sin}[q1]\right)\right)$$
$$\left(\text{Cos}[q1]\left(-a2\,\text{Cos}[q1]\,\text{Cos}[q2]-\frac{1}{2}\,a3\,\text{Cos}[q1]\,\text{Cos}[q2+q3]+\text{Cos}[q1]\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]\right)\right)+\right.$$
$$\left.\text{Sin}[q1]\left(-a2\,\text{Cos}[q2]\,\text{Sin}[q1]-\frac{1}{2}\,a3\,\text{Cos}[q2+q3]\,\text{Sin}[q1]+\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]\right)\text{Sin}[q1]\right)\right)+$$
$$\frac{1}{2}\,a3\,\text{Cos}[q1]^2\,\text{Sin}[q2+q3]\left(a2\,\text{Sin}[q2]+\frac{1}{2}\,a3\,\text{Sin}[q2+q3]\right)+$$
$$\left.\frac{1}{2}\,a3\,\text{Sin}[q1]^2\,\text{Sin}[q2+q3]\left(a2\,\text{Sin}[q2]+\frac{1}{2}\,a3\,\text{Sin}[q2+q3]\right)\right)+$$
$$m4\left(\left(\text{Cos}[q1]\left(-\frac{1}{2}\,a4\,\text{Cos}[q1]\,\text{Cos}[q2+q3+q4]+\text{Cos}[q1]\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4]\right)\right)+\right.\right.$$
$$\left.\text{Sin}[q1]\left(-\frac{1}{2}\,a4\,\text{Cos}[q2+q3+q4]\,\text{Sin}[q1]+\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4]\right)\right.\right.$$
$$\left.\left.\text{Sin}[q1]\right)\right)\left(\text{Cos}[q1]\left(-a2\,\text{Cos}[q1]\,\text{Cos}[q2]-\frac{1}{2}\,a4\,\text{Cos}[q1]\,\text{Cos}[q2+q3+q4]+\right.\right.$$
$$\left.\text{Cos}[q1]\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4]\right)\right)+\text{Sin}[q1]\left(-a2\,\text{Cos}[q2]\,\text{Sin}[q1]-$$
$$\left.\left.\frac{1}{2}\,a4\,\text{Cos}[q2+q3+q4]\,\text{Sin}[q1]+\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4]\right)\text{Sin}[q1]\right)\right)+$$
$$\text{Cos}[q1]^2\left(a3\,\text{Sin}[q2+q3]+\frac{1}{2}\,a4\,\text{Sin}[q2+q3+q4]\right)\left(a2\,\text{Sin}[q2]+a3\,\text{Sin}[q2+q3]+\frac{1}{2}\,a4\,\text{Sin}[q2+q3+q4]\right)+$$
$$\left.\text{Sin}[q1]^2\left(a3\,\text{Sin}[q2+q3]+\frac{1}{2}\,a4\,\text{Sin}[q2+q3+q4]\right)\left(a2\,\text{Sin}[q2]+a3\,\text{Sin}[q2+q3]+\frac{1}{2}\,a4\,\text{Sin}[q2+q3+q4]\right)\right)$$

In[•]:=
```
ToPython[1/12 a3^2 m3 Cos[q1]^2 (Cos[q1]^2 + Sin[q1]^2) + 1/12 a4^2 m4 Cos[q1]^2 (Cos[q1]^2 + Sin[q1]^2) +
 1/12 a3^2 m3 Sin[q1]^2 (Cos[q1]^2 + Sin[q1]^2) + 1/12 a4^2 m4 Sin[q1]^2 (Cos[q1]^2 + Sin[q1]^2) +
 m3 ((Cos[q1] (-1/2 a3 Cos[q1] Cos[q2 + q3] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3])) +
      Sin[q1] (-1/2 a3 Cos[q2 + q3] Sin[q1] + (a2 Cos[q2] + a3 Cos[q2 + q3]) Sin[q1]))
     (Cos[q1] (-a2 Cos[q1] Cos[q2] - 1/2 a3 Cos[q1] Cos[q2 + q3] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3])) +
      Sin[q1] (-a2 Cos[q2] Sin[q1] - 1/2 a3 Cos[q2 + q3] Sin[q1] + (a2 Cos[q2] + a3 Cos[q2 + q3]) Sin[q1])) +
     1/2 a3 Cos[q1]^2 Sin[q2 + q3] (a2 Sin[q2] + 1/2 a3 Sin[q2 + q3]) +
     1/2 a3 Sin[q1]^2 Sin[q2 + q3] (a2 Sin[q2] + 1/2 a3 Sin[q2 + q3])) +
 m4 ((Cos[q1] (-1/2 a4 Cos[q1] Cos[q2 + q3 + q4] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4])) +
      Sin[q1] (-1/2 a4 Cos[q2 + q3 + q4] Sin[q1] + (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4])
          Sin[q1])) (Cos[q1] (-a2 Cos[q1] Cos[q2] - 1/2 a4 Cos[q1] Cos[q2 + q3 + q4] +
          Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4])) + Sin[q1] (-a2 Cos[q2] Sin[q1] -
          1/2 a4 Cos[q2 + q3 + q4] Sin[q1] + (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4]) Sin[q1])) +
     Cos[q1]^2 (a3 Sin[q2 + q3] + 1/2 a4 Sin[q2 + q3 + q4]) (a2 Sin[q2] + a3 Sin[q2 + q3] +
       1/2 a4 Sin[q2 + q3 + q4]) + Sin[q1]^2 (a3 Sin[q2 + q3] + 1/2 a4 Sin[q2 + q3 + q4])
      (a2 Sin[q2] + a3 Sin[q2 + q3] + 1/2 a4 Sin[q2 + q3 + q4])), NumpyPrefix → "np"]
```

Out[•]=
```
0.08333333333333333 * (a3 ** 2) * m3 * (np.cos(q1) ** 2) * (np.cos(q1) ** 2 + np.sin(q1) ** 2) +
 0.08333333333333333 * (a4 ** 2) * m4 * (np.cos(q1) ** 2) * (np.cos(q1) ** 2 + np.sin(q1)
 ** 2) + 0.08333333333333333 * (a3 ** 2) * m3 * (np.sin(q1) ** 2) * (np.cos(q1) ** 2 +
 np.sin(q1) ** 2) + 0.08333333333333333 * (a4 ** 2) * m4 * (np.sin(q1) ** 2) * (np.cos(q1)
 ** 2 + np.sin(q1) ** 2) + m3 * ((np.cos(q1) * (-0.5 * a3 * np.cos(q1) * np.cos(q2 + q3)
 + np.cos(q1) * (a2 * np.cos(q2) + a3 * np.cos(q2 + q3))) + np.sin(q1) * (-0.5 * a3 *
 np.cos(q2 + q3) * np.sin(q1) + (a2 * np.cos(q2) + a3 * np.cos(q2 + q3)) * np.sin(q1)))
 * (np.cos(q1) * (-(a2 * np.cos(q1) * np.cos(q2)) -0.5 * a3 * np.cos(q1) * np.cos(q2
 + q3) + np.cos(q1) * (a2 * np.cos(q2) + a3 * np.cos(q2 + q3))) + np.sin(q1) * (-(a2 *
 np.cos(q2) * np.sin(q1)) -0.5 * a3 * np.cos(q2 + q3) * np.sin(q1) + (a2 * np.cos(q2)
 + a3 * np.cos(q2 + q3)) * np.sin(q1))) + 0.5 * a3 * (np.cos(q1) ** 2) * np.sin(q2 +
 q3) * (a2 * np.sin(q2) + 0.5 * a3 * np.sin(q2 + q3)) + 0.5 * a3 * (np.sin(q1) ** 2) *
 np.sin(q2 + q3) * (a2 * np.sin(q2) + 0.5 * a3 * np.sin(q2 + q3))) + m4 * ((np.cos(q1)
 * (-0.5 * a4 * np.cos(q1) * np.cos(q2 + q3 + q4) + np.cos(q1) * (a2 * np.cos(q2) + a3
 * np.cos(q2 + q3) + a4 * np.cos(q2 + q3 + q4))) + np.sin(q1) * (-0.5 * a4 * np.cos(q2
 + q3 + q4) * np.sin(q1) + (a2 * np.cos(q2) + a3 * np.cos(q2 + q3) + a4 * np.cos(q2
 + q3 + q4)) * np.sin(q1))) * (np.cos(q1) * (-(a2 * np.cos(q1) * np.cos(q2)) -0.5 * a4 *
 np.cos(q1) * np.cos(q2 + q3 + q4) + np.cos(q1) * (a2 * np.cos(q2) + a3 * np.cos(q2 +
 q3) + a4 * np.cos(q2 + q3 + q4))) + np.sin(q1) * (-(a2 * np.cos(q2) * np.sin(q1)) -0.5 *
 a4 * np.cos(q2 + q3 + q4) * np.sin(q1) + (a2 * np.cos(q2) + a3 * np.cos(q2 + q3) + a4
 * np.cos(q2 + q3 + q4)) * np.sin(q1))) + (np.cos(q1) ** 2) * (a3 * np.sin(q2 + q3) + 0.5
 * a4 * np.sin(q2 + q3 + q4)) * (a2 * np.sin(q2) + a3 * np.sin(q2 + q3) + 0.5 * a4 *
 np.sin(q2 + q3 + q4)) + (np.sin(q1) ** 2) * (a3 * np.sin(q2 + q3) + 0.5 * a4 * np.sin(q2
 + q3 + q4)) * (a2 * np.sin(q2) + a3 * np.sin(q2 + q3) + 0.5 * a4 * np.sin(q2 + q3 + q4)))
```

In[•]:= **MU[[3, 2]]**

Out[•]=
$$\frac{1}{12}\,a3^2\,m3\,\text{Cos}[q1]^2\left(\text{Cos}[q1]^2+\text{Sin}[q1]^2\right)+\frac{1}{12}\,a4^2\,m4\,\text{Cos}[q1]^2\left(\text{Cos}[q1]^2+\text{Sin}[q1]^2\right)+$$
$$\frac{1}{12}\,a3^2\,m3\,\text{Sin}[q1]^2\left(\text{Cos}[q1]^2+\text{Sin}[q1]^2\right)+\frac{1}{12}\,a4^2\,m4\,\text{Sin}[q1]^2\left(\text{Cos}[q1]^2+\text{Sin}[q1]^2\right)+$$
$$m3\left(\left(\text{Cos}[q1]\left(-\frac{1}{2}\,a3\,\text{Cos}[q1]\,\text{Cos}[q2+q3]+\text{Cos}[q1]\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]\right)\right)+\right.\right.$$
$$\left.\left.\text{Sin}[q1]\left(-\frac{1}{2}\,a3\,\text{Cos}[q2+q3]\,\text{Sin}[q1]+\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]\right)\text{Sin}[q1]\right)\right)\right.$$
$$\left(\text{Cos}[q1]\left(-a2\,\text{Cos}[q1]\,\text{Cos}[q2]-\frac{1}{2}\,a3\,\text{Cos}[q1]\,\text{Cos}[q2+q3]+\text{Cos}[q1]\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]\right)\right)+\right.$$
$$\left.\text{Sin}[q1]\left(-a2\,\text{Cos}[q2]\,\text{Sin}[q1]-\frac{1}{2}\,a3\,\text{Cos}[q2+q3]\,\text{Sin}[q1]+\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]\right)\text{Sin}[q1]\right)\right)+$$
$$\frac{1}{2}\,a3\,\text{Cos}[q1]^2\,\text{Sin}[q2+q3]\left(a2\,\text{Sin}[q2]+\frac{1}{2}\,a3\,\text{Sin}[q2+q3]\right)+$$
$$\left.\frac{1}{2}\,a3\,\text{Sin}[q1]^2\,\text{Sin}[q2+q3]\left(a2\,\text{Sin}[q2]+\frac{1}{2}\,a3\,\text{Sin}[q2+q3]\right)\right)+$$
$$m4\left(\left(\text{Cos}[q1]\left(-\frac{1}{2}\,a4\,\text{Cos}[q1]\,\text{Cos}[q2+q3+q4]+\text{Cos}[q1]\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4]\right)\right)+\right.\right.$$
$$\left.\left.\text{Sin}[q1]\left(-\frac{1}{2}\,a4\,\text{Cos}[q2+q3+q4]\,\text{Sin}[q1]+\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4]\right)\right.\right.\right.$$
$$\left.\left.\left.\text{Sin}[q1]\right)\right)\left(\text{Cos}[q1]\left(-a2\,\text{Cos}[q1]\,\text{Cos}[q2]-\frac{1}{2}\,a4\,\text{Cos}[q1]\,\text{Cos}[q2+q3+q4]+\right.\right.\right.$$
$$\left.\left.\left.\text{Cos}[q1]\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4]\right)\right)+\text{Sin}[q1]\left(-a2\,\text{Cos}[q2]\,\text{Sin}[q1]-\right.\right.\right.$$
$$\left.\left.\left.\frac{1}{2}\,a4\,\text{Cos}[q2+q3+q4]\,\text{Sin}[q1]+\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4]\right)\text{Sin}[q1]\right)\right)+$$
$$\text{Cos}[q1]^2\left(a3\,\text{Sin}[q2+q3]+\frac{1}{2}\,a4\,\text{Sin}[q2+q3+q4]\right)\left(a2\,\text{Sin}[q2]+a3\,\text{Sin}[q2+q3]+\frac{1}{2}\,a4\,\text{Sin}[q2+q3+q4]\right)+$$
$$\left.\text{Sin}[q1]^2\left(a3\,\text{Sin}[q2+q3]+\frac{1}{2}\,a4\,\text{Sin}[q2+q3+q4]\right)\left(a2\,\text{Sin}[q2]+a3\,\text{Sin}[q2+q3]+\frac{1}{2}\,a4\,\text{Sin}[q2+q3+q4]\right)\right)$$

In[•]:=
```
ToPython[1/12 a3^2 m3 Cos[q1]^2 (Cos[q1]^2 + Sin[q1]^2) + 1/12 a4^2 m4 Cos[q1]^2 (Cos[q1]^2 + Sin[q1]^2) +
 1/12 a3^2 m3 Sin[q1]^2 (Cos[q1]^2 + Sin[q1]^2) + 1/12 a4^2 m4 Sin[q1]^2 (Cos[q1]^2 + Sin[q1]^2) +
 m3 ((Cos[q1] (-1/2 a3 Cos[q1] Cos[q2 + q3] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3])) +
      Sin[q1] (-1/2 a3 Cos[q2 + q3] Sin[q1] + (a2 Cos[q2] + a3 Cos[q2 + q3]) Sin[q1]))
     (Cos[q1] (-a2 Cos[q1] Cos[q2] - 1/2 a3 Cos[q1] Cos[q2 + q3] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3])) +
      Sin[q1] (-a2 Cos[q2] Sin[q1] - 1/2 a3 Cos[q2 + q3] Sin[q1] + (a2 Cos[q2] + a3 Cos[q2 + q3]) Sin[q1])) +
     1/2 a3 Cos[q1]^2 Sin[q2 + q3] (a2 Sin[q2] + 1/2 a3 Sin[q2 + q3]) +
     1/2 a3 Sin[q1]^2 Sin[q2 + q3] (a2 Sin[q2] + 1/2 a3 Sin[q2 + q3])) +
 m4 ((Cos[q1] (-1/2 a4 Cos[q1] Cos[q2 + q3 + q4] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4])) +
      Sin[q1] (-1/2 a4 Cos[q2 + q3 + q4] Sin[q1] + (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4])
          Sin[q1])) (Cos[q1] (-a2 Cos[q1] Cos[q2] - 1/2 a4 Cos[q1] Cos[q2 + q3 + q4] +
          Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4])) + Sin[q1] (-a2 Cos[q2] Sin[q1] -
          1/2 a4 Cos[q2 + q3 + q4] Sin[q1] + (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4]) Sin[q1])) +
     Cos[q1]^2 (a3 Sin[q2 + q3] + 1/2 a4 Sin[q2 + q3 + q4]) (a2 Sin[q2] + a3 Sin[q2 + q3] +
       1/2 a4 Sin[q2 + q3 + q4]) + Sin[q1]^2 (a3 Sin[q2 + q3] + 1/2 a4 Sin[q2 + q3 + q4])
      (a2 Sin[q2] + a3 Sin[q2 + q3] + 1/2 a4 Sin[q2 + q3 + q4])), NumpyPrefix → "np"]
```

Out[•]=
```
0.08333333333333333 * (a3 ** 2) * m3 * (np.cos(q1) ** 2) * (np.cos(q1) ** 2 + np.sin(q1) ** 2) +
 0.08333333333333333 * (a4 ** 2) * m4 * (np.cos(q1) ** 2) * (np.cos(q1) ** 2 + np.sin(q1)
 ** 2) + 0.08333333333333333 * (a3 ** 2) * m3 * (np.sin(q1) ** 2) * (np.cos(q1) ** 2 +
 np.sin(q1) ** 2) + 0.08333333333333333 * (a4 ** 2) * m4 * (np.sin(q1) ** 2) * (np.cos(q1)
 ** 2 + np.sin(q1) ** 2) + m3 * ((np.cos(q1) * (-0.5 * a3 * np.cos(q1) * np.cos(q2 + q3)
 + np.cos(q1) * (a2 * np.cos(q2) + a3 * np.cos(q2 + q3))) + np.sin(q1) * (-0.5 * a3 *
 np.cos(q2 + q3) * np.sin(q1) + (a2 * np.cos(q2) + a3 * np.cos(q2 + q3)) * np.sin(q1)))
 * (np.cos(q1) * (-(a2 * np.cos(q1) * np.cos(q2)) -0.5 * a3 * np.cos(q1) * np.cos(q2
 + q3) + np.cos(q1) * (a2 * np.cos(q2) + a3 * np.cos(q2 + q3))) + np.sin(q1) * (-(a2 *
 np.cos(q2) * np.sin(q1)) -0.5 * a3 * np.cos(q2 + q3) * np.sin(q1) + (a2 * np.cos(q2)
 + a3 * np.cos(q2 + q3)) * np.sin(q1))) + 0.5 * a3 * (np.cos(q1) ** 2) * np.sin(q2 +
 q3) * (a2 * np.sin(q2) + 0.5 * a3 * np.sin(q2 + q3)) + 0.5 * a3 * (np.sin(q1) ** 2) *
 np.sin(q2 + q3) * (a2 * np.sin(q2) + 0.5 * a3 * np.sin(q2 + q3))) + m4 * ((np.cos(q1)
 * (-0.5 * a4 * np.cos(q1) * np.cos(q2 + q3 + q4) + np.cos(q1) * (a2 * np.cos(q2) + a3
 * np.cos(q2 + q3) + a4 * np.cos(q2 + q3 + q4))) + np.sin(q1) * (-0.5 * a4 * np.cos(q2
 + q3 + q4) * np.sin(q1) + (a2 * np.cos(q2) + a3 * np.cos(q2 + q3) + a4 * np.cos(q2
 + q3 + q4)) * np.sin(q1))) * (np.cos(q1) * (-(a2 * np.cos(q1) * np.cos(q2)) -0.5 * a4 *
 np.cos(q1) * np.cos(q2 + q3 + q4) + np.cos(q1) * (a2 * np.cos(q2) + a3 * np.cos(q2 +
 q3) + a4 * np.cos(q2 + q3 + q4))) + np.sin(q1) * (-(a2 * np.cos(q2) * np.sin(q1)) -0.5 *
 a4 * np.cos(q2 + q3 + q4) * np.sin(q1) + (a2 * np.cos(q2) + a3 * np.cos(q2 + q3) + a4
 * np.cos(q2 + q3 + q4)) * np.sin(q1))) + (np.cos(q1) ** 2) * (a3 * np.sin(q2 + q3) + 0.5
 * a4 * np.sin(q2 + q3 + q4)) * (a2 * np.sin(q2) + a3 * np.sin(q2 + q3) + 0.5 * a4 *
 np.sin(q2 + q3 + q4)) + (np.sin(q1) ** 2) * (a3 * np.sin(q2 + q3) + 0.5 * a4 * np.sin(q2
 + q3 + q4)) * (a2 * np.sin(q2) + a3 * np.sin(q2 + q3) + 0.5 * a4 * np.sin(q2 + q3 + q4)))
```

In[•]:= **MU[[3, 3]]**

Out[•]=
$$\frac{1}{12}\,a3^2\,m3\,\text{Cos}[q1]^2\left(\text{Cos}[q1]^2+\text{Sin}[q1]^2\right)+\frac{1}{12}\,a4^2\,m4\,\text{Cos}[q1]^2\left(\text{Cos}[q1]^2+\text{Sin}[q1]^2\right)+$$
$$\frac{1}{12}\,a3^2\,m3\,\text{Sin}[q1]^2\left(\text{Cos}[q1]^2+\text{Sin}[q1]^2\right)+\frac{1}{12}\,a4^2\,m4\,\text{Sin}[q1]^2\left(\text{Cos}[q1]^2+\text{Sin}[q1]^2\right)+$$
$$m3\left(\left(\text{Cos}[q1]\left(-a2\,\text{Cos}[q1]\,\text{Cos}[q2]-\frac{1}{2}\,a3\,\text{Cos}[q1]\,\text{Cos}[q2+q3]+\text{Cos}[q1]\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]\right)\right)+\right.\right.$$
$$\left.\left.\text{Sin}[q1]\left(-a2\,\text{Cos}[q2]\,\text{Sin}[q1]-\frac{1}{2}\,a3\,\text{Cos}[q2+q3]\,\text{Sin}[q1]+\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]\right)\text{Sin}[q1]\right)\right)^2+\right.$$
$$\left.\frac{1}{4}\,a3^2\,\text{Cos}[q1]^2\,\text{Sin}[q2+q3]^2+\frac{1}{4}\,a3^2\,\text{Sin}[q1]^2\,\text{Sin}[q2+q3]^2\right)+$$
$$m4\left(\left(\text{Cos}[q1]\left(-a2\,\text{Cos}[q1]\,\text{Cos}[q2]-\frac{1}{2}\,a4\,\text{Cos}[q1]\,\text{Cos}[q2+q3+q4]+\right.\right.\right.$$
$$\left.\left.\left.\text{Cos}[q1]\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4]\right)+\text{Sin}[q1]\left(-a2\,\text{Cos}[q2]\,\text{Sin}[q1]-\right.\right.\right.\right.$$
$$\left.\left.\left.\left.\frac{1}{2}\,a4\,\text{Cos}[q2+q3+q4]\,\text{Sin}[q1]+\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4]\right)\text{Sin}[q1]\right)\right)^2+\right.$$
$$\left.\text{Cos}[q1]^2\left(a3\,\text{Sin}[q2+q3]+\frac{1}{2}\,a4\,\text{Sin}[q2+q3+q4]\right)^2+\text{Sin}[q1]^2\left(a3\,\text{Sin}[q2+q3]+\frac{1}{2}\,a4\,\text{Sin}[q2+q3+q4]\right)^2\right)$$

In[•]:=
```
ToPython[1/12 a3^2 m3 Cos[q1]^2 (Cos[q1]^2 + Sin[q1]^2) + 1/12 a4^2 m4 Cos[q1]^2 (Cos[q1]^2 + Sin[q1]^2) +
 1/12 a3^2 m3 Sin[q1]^2 (Cos[q1]^2 + Sin[q1]^2) + 1/12 a4^2 m4 Sin[q1]^2 (Cos[q1]^2 + Sin[q1]^2) +
 m3 (((Cos[q1] (-a2 Cos[q1] Cos[q2] - 1/2 a3 Cos[q1] Cos[q2 + q3] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3])) + Sin[
          q1] (-a2 Cos[q2] Sin[q1] - 1/2 a3 Cos[q2 + q3] Sin[q1] + (a2 Cos[q2] + a3 Cos[q2 + q3]) Sin[q1]))^2 +
    1/4 a3^2 Cos[q1]^2 Sin[q2 + q3]^2 + 1/4 a3^2 Sin[q1]^2 Sin[q2 + q3]^2) +
 m4 (((Cos[q1] (-a2 Cos[q1] Cos[q2] - 1/2 a4 Cos[q1] Cos[q2 + q3 + q4] + Cos[q1]
          (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4])) + Sin[q1] (-a2 Cos[q2] Sin[q1] - 1/2 a4
          Cos[q2 + q3 + q4] Sin[q1] + (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4]) Sin[q1]))^2 +
    Cos[q1]^2 (a3 Sin[q2 + q3] + 1/2 a4 Sin[q2 + q3 + q4])^2 + Sin[q1]^2
     (a3 Sin[q2 + q3] + 1/2 a4 Sin[q2 + q3 + q4])^2), NumpyPrefix → "np"]
```

Out[•]=
```
0.08333333333333333 * (a3 ** 2) * m3 * (np.cos(q1) ** 2) * (np.cos(q1) ** 2 + np.sin(q1)
** 2) + 0.08333333333333333 * (a4 ** 2) * m4 * (np.cos(q1) ** 2) * (np.cos(q1) **
2 + np.sin(q1) ** 2) + 0.08333333333333333 * (a3 ** 2) * m3 * (np.sin(q1) ** 2) *
(np.cos(q1) ** 2 + np.sin(q1) ** 2) + 0.08333333333333333 * (a4 ** 2) * m4 * (np.sin(q1)
** 2) * (np.cos(q1) ** 2 + np.sin(q1) ** 2) + m3 * ((np.cos(q1) * (-(a2 * np.cos(q1) *
np.cos(q2)) -0.5 * a3 * np.cos(q1) * np.cos(q2 + q3) + np.cos(q1) * (a2 * np.cos(q2)
+ a3 * np.cos(q2 + q3))) + np.sin(q1) * (-(a2 * np.cos(q2) * np.sin(q1)) -0.5 * a3 *
np.cos(q2 + q3) * np.sin(q1) + (a2 * np.cos(q2) + a3 * np.cos(q2 + q3)) * np.sin(q1)))
** 2 + 0.25 * (a3 ** 2) * (np.cos(q1) ** 2) * (np.sin(q2 + q3) ** 2) + 0.25 * (a3 ** 2)
* (np.sin(q1) ** 2) * (np.sin(q2 + q3) ** 2)) + m4 * ((np.cos(q1) * (-(a2 * np.cos(q1)
* np.cos(q2)) -0.5 * a4 * np.cos(q1) * np.cos(q2 + q3 + q4) + np.cos(q1) * (a2 *
np.cos(q2) + a3 * np.cos(q2 + q3) + a4 * np.cos(q2 + q3 + q4))) + np.sin(q1) * (-(a2
* np.cos(q2) * np.sin(q1)) -0.5 * a4 * np.cos(q2 + q3 + q4) * np.sin(q1) + (a2 *
np.cos(q2) + a3 * np.cos(q2 + q3) + a4 * np.cos(q2 + q3 + q4))) ** 2
+ (np.cos(q1) ** 2) * ((a3 * np.sin(q2 + q3) + 0.5 * a4 * np.sin(q2 + q3 + q4)) ** 2)
+ (np.sin(q1) ** 2) * ((a3 * np.sin(q2 + q3) + 0.5 * a4 * np.sin(q2 + q3 + q4)) ** 2))
```

In[•]:= **MU[[3, 4]]**

Out[•]=
$$\frac{1}{12}\,a4^2\,m4\,\text{Cos}[q1]^2\left(\text{Cos}[q1]^2+\text{Sin}[q1]^2\right)+\frac{1}{12}\,a4^2\,m4\,\text{Sin}[q1]^2\left(\text{Cos}[q1]^2+\text{Sin}[q1]^2\right)+$$
$$m4\left(\left(\text{Cos}[q1]\left(-a2\,\text{Cos}[q1]\,\text{Cos}[q2]-\frac{1}{2}\,a4\,\text{Cos}[q1]\,\text{Cos}[q2+q3+q4]+\right.\right.\right.$$
$$\left.\text{Cos}[q1]\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4]\right)\right)+\text{Sin}[q1]\left(-a2\,\text{Cos}[q2]\,\text{Sin}[q1]-$$
$$\left.\left.\frac{1}{2}\,a4\,\text{Cos}[q2+q3+q4]\,\text{Sin}[q1]+\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4]\right)\text{Sin}[q1]\right)\right)$$
$$\left(\text{Cos}[q1]\left(-\text{Cos}[q1]\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]\right)-\frac{1}{2}\,a4\,\text{Cos}[q1]\,\text{Cos}[q2+q3+q4]+\right.\right.$$
$$\left.\text{Cos}[q1]\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4]\right)\right)+$$
$$\text{Sin}[q1]\left(-\left(\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]\right)\text{Sin}[q1]\right)-\frac{1}{2}\,a4\,\text{Cos}[q2+q3+q4]\,\text{Sin}[q1]+\right.$$
$$\left.\left.\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4]\right)\text{Sin}[q1]\right)\right)+$$
$$\frac{1}{2}\,a4\,\text{Cos}[q1]^2\,\text{Sin}[q2+q3+q4]\left(a3\,\text{Sin}[q2+q3]+\frac{1}{2}\,a4\,\text{Sin}[q2+q3+q4]\right)+$$
$$\left.\frac{1}{2}\,a4\,\text{Sin}[q1]^2\,\text{Sin}[q2+q3+q4]\left(a3\,\text{Sin}[q2+q3]+\frac{1}{2}\,a4\,\text{Sin}[q2+q3+q4]\right)\right)$$

In[•]:=
```
ToPython[1/12 a4^2 m4 Cos[q1]^2 (Cos[q1]^2 + Sin[q1]^2) + 1/12 a4^2 m4 Sin[q1]^2 (Cos[q1]^2 + Sin[q1]^2) +
 m4 (((Cos[q1] (-a2 Cos[q1] Cos[q2] - 1/2 a4 Cos[q1] Cos[q2 + q3 + q4] +
        Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4])) + Sin[q1] (-a2 Cos[q2] Sin[q1] -
        1/2 a4 Cos[q2 + q3 + q4] Sin[q1] + (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4]) Sin[q1]))
   (Cos[q1] (-Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3]) - 1/2 a4 Cos[q1] Cos[q2 + q3 + q4] +
        Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4])) +
      Sin[q1] (-((a2 Cos[q2] + a3 Cos[q2 + q3]) Sin[q1]) - 1/2 a4 Cos[q2 + q3 + q4] Sin[q1] +
        (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4]) Sin[q1])) +
   1/2 a4 Cos[q1]^2 Sin[q2 + q3 + q4] (a3 Sin[q2 + q3] + 1/2 a4 Sin[q2 + q3 + q4]) +
   1/2 a4 Sin[q1]^2 Sin[q2 + q3 + q4] (a3 Sin[q2 + q3] + 1/2 a4 Sin[q2 + q3 + q4])), NumpyPrefix → "np"]
```

Out[•]=
```
0.08333333333333333 * (a4 ** 2) * m4 * (np.cos(q1) ** 2) * (np.cos(q1) ** 2 + np.sin(q1) ** 2) +
  0.08333333333333333 * (a4 ** 2) * m4 * (np.sin(q1) ** 2) * (np.cos(q1) ** 2 + np.sin(q1)
  ** 2) + m4 * ((np.cos(q1) * (-(a2 * np.cos(q1) * np.cos(q2)) -0.5 * a4 * np.cos(q1) *
  np.cos(q2 + q3 + q4) + np.cos(q1) * (a2 * np.cos(q2) + a3 * np.cos(q2 + q3) + a4
  * np.cos(q2 + q3 + q4))) + np.sin(q1) * (-(a2 * np.cos(q2) * np.sin(q1)) -0.5 * a4 *
  np.cos(q2 + q3 + q4) * np.sin(q1) + (a2 * np.cos(q2) + a3 * np.cos(q2 + q3) + a4 *
  np.cos(q2 + q3 + q4)) * np.sin(q1))) * (np.cos(q1) * (-(np.cos(q1) * (a2 * np.cos(q2) +
  a3 * np.cos(q2 + q3))) -0.5 * a4 * np.cos(q1) * np.cos(q2 + q3 + q4) + np.cos(q1) *
  (a2 * np.cos(q2) + a3 * np.cos(q2 + q3) + a4 * np.cos(q2 + q3 + q4))) + np.sin(q1)
  * (-((a2 * np.cos(q2) + a3 * np.cos(q2 + q3)) * np.sin(q1)) -0.5 * a4 * np.cos(q2 +
  q3 + q4) * np.sin(q1) + (a2 * np.cos(q2) + a3 * np.cos(q2 + q3) + a4 * np.cos(q2 +
  q3 + q4)) * np.sin(q1))) + 0.5 * a4 * (np.cos(q1) ** 2) * np.sin(q2 + q3 + q4) * (a3
  * np.sin(q2 + q3) + 0.5 * a4 * np.sin(q2 + q3 + q4)) + 0.5 * a4 * (np.sin(q1) ** 2)
  * np.sin(q2 + q3 + q4) * (a3 * np.sin(q2 + q3) + 0.5 * a4 * np.sin(q2 + q3 + q4)))
```

In[•]:=
```
MU[[4, 1]]
```

Out[•]=
```
m4 (-1/2 a4 (-1/2 a4 Cos[q1] Cos[q2 + q3 + q4] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4])) Sin[q1]
   Sin[q2 + q3 + q4] - 1/2 a4 Cos[q1] (1/2 a4 Cos[q2 + q3 + q4] Sin[q1] -
     (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4]) Sin[q1]) Sin[q2 + q3 + q4])
```

In[•]:=
```
ToPython[
  m4 (-1/2 a4 (-1/2 a4 Cos[q1] Cos[q2 + q3 + q4] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4])) Sin[q1] Sin[q2 + q3 + q4] - 1/2 a4 Cos[q1] (1/2 a4 Cos[q2 + q3 + q4] Sin[q1] - (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4]) Sin[q1]) Sin[q2 + q3 + q4]), NumpyPrefix → "np"]
```

Out[•]=
```
m4 * (-0.5 * a4 * (-0.5 * a4 * np.cos(q1) * np.cos(q2 + q3 + q4) +
  np.cos(q1) * (a2 * np.cos(q2) + a3 * np.cos(q2 + q3) + a4 * np.cos(q2 + q3
  + q4))) * np.sin(q1) * np.sin(q2 + q3 + q4) -0.5 * a4 * np.cos(q1) * (0.5 *
  a4 * np.cos(q2 + q3 + q4) * np.sin(q1) -((a2 * np.cos(q2) + a3 * np.cos(q2
  + q3) + a4 * np.cos(q2 + q3 + q4)) * np.sin(q1))) * np.sin(q2 + q3 + q4))
```

In[•]:=
```
MU[[4, 2]]
```

Out[•]=
$$\frac{1}{12}\,a4^2\,m4\,\text{Cos}[q1]^2\left(\text{Cos}[q1]^2+\text{Sin}[q1]^2\right)+\frac{1}{12}\,a4^2\,m4\,\text{Sin}[q1]^2\left(\text{Cos}[q1]^2+\text{Sin}[q1]^2\right)+$$
$$m4\left(\left(\text{Cos}[q1]\left(-\frac{1}{2}\,a4\,\text{Cos}[q1]\,\text{Cos}[q2+q3+q4]+\text{Cos}[q1]\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4]\right)\right)+\right.\right.$$
$$\left.\text{Sin}[q1]\left(-\frac{1}{2}\,a4\,\text{Cos}[q2+q3+q4]\,\text{Sin}[q1]+\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4]\right)\text{Sin}[q1]\right)\right)$$
$$\left(\text{Cos}[q1]\left(-\text{Cos}[q1]\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]\right)-\frac{1}{2}\,a4\,\text{Cos}[q1]\,\text{Cos}[q2+q3+q4]+\right.\right.$$
$$\left.\text{Cos}[q1]\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4]\right)\right)+$$
$$\text{Sin}[q1]\left(-\left(\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]\right)\text{Sin}[q1]\right)-\frac{1}{2}\,a4\,\text{Cos}[q2+q3+q4]\,\text{Sin}[q1]+\right.$$
$$\left.\left.\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4]\right)\text{Sin}[q1]\right)\right)+$$
$$\frac{1}{2}\,a4\,\text{Cos}[q1]^2\,\text{Sin}[q2+q3+q4]\left(a2\,\text{Sin}[q2]+a3\,\text{Sin}[q2+q3]+\frac{1}{2}\,a4\,\text{Sin}[q2+q3+q4]\right)+$$
$$\frac{1}{2}\,a4\,\text{Sin}[q1]^2\,\text{Sin}[q2+q3+q4]\left(a2\,\text{Sin}[q2]+a3\,\text{Sin}[q2+q3]+\frac{1}{2}\,a4\,\text{Sin}[q2+q3+q4]\right)\Big)$$

In[•]:=
```
ToPython[1/12 a4^2 m4 Cos[q1]^2 (Cos[q1]^2 + Sin[q1]^2) + 1/12 a4^2 m4 Sin[q1]^2 (Cos[q1]^2 + Sin[q1]^2) +
 m4 (((Cos[q1] (-1/2 a4 Cos[q1] Cos[q2 + q3 + q4] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4])) +
      Sin[q1] (-1/2 a4 Cos[q2 + q3 + q4] Sin[q1] + (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4])
        Sin[q1])) (Cos[q1] (-Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3]) -
        1/2 a4 Cos[q1] Cos[q2 + q3 + q4] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4])) +
      Sin[q1] (-((a2 Cos[q2] + a3 Cos[q2 + q3]) Sin[q1]) - 1/2 a4 Cos[q2 + q3 + q4] Sin[q1] +
        (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4]) Sin[q1])) +
   1/2 a4 Cos[q1]^2 Sin[q2 + q3 + q4] (a2 Sin[q2] + a3 Sin[q2 + q3] + 1/2 a4 Sin[q2 + q3 + q4]) +
   1/2 a4 Sin[q1]^2 Sin[q2 + q3 + q4]
    (a2 Sin[q2] + a3 Sin[q2 + q3] + 1/2 a4 Sin[q2 + q3 + q4])), NumpyPrefix → "np"]
```

Out[•]=
```
0.08333333333333333 * (a4 ** 2) * m4 * (np.cos(q1) ** 2) * (np.cos(q1) ** 2 + np.sin(q1) **
2) + 0.08333333333333333 * (a4 ** 2) * m4 * (np.sin(q1) ** 2) * (np.cos(q1) ** 2 +
np.sin(q1) ** 2) + m4 * ((np.cos(q1) * (-0.5 * a4 * np.cos(q1) * np.cos(q2 + q3 + q4)
+ np.cos(q1) * (a2 * np.cos(q2) + a3 * np.cos(q2 + q3) + a4 * np.cos(q2 + q3 + q4)))
+ np.sin(q1) * (-0.5 * a4 * np.cos(q2 + q3 + q4) * np.sin(q1) + (a2 * np.cos(q2)
+ a3 * np.cos(q2 + q3) + a4 * np.cos(q2 + q3 + q4)) * np.sin(q1))) * (np.cos(q1)
* (-(np.cos(q1) * (a2 * np.cos(q2) + a3 * np.cos(q2 + q3))) -0.5 * a4 * np.cos(q1)
* np.cos(q2 + q3 + q4) + np.cos(q1) * (a2 * np.cos(q2) + a3 * np.cos(q2 + q3) +
a4 * np.cos(q2 + q3 + q4))) + np.sin(q1) * (-((a2 * np.cos(q2) + a3 * np.cos(q2 +
q3)) * np.sin(q1)) -0.5 * a4 * np.cos(q2 + q3 + q4) * np.sin(q1) + (a2 * np.cos(q2)
+ a3 * np.cos(q2 + q3) + a4 * np.cos(q2 + q3 + q4)) * np.sin(q1))) + 0.5 * a4 *
(np.cos(q1) ** 2) * np.sin(q2 + q3 + q4) * (a2 * np.sin(q2) + a3 * np.sin(q2 + q3)
+ 0.5 * a4 * np.sin(q2 + q3 + q4)) + 0.5 * a4 * (np.sin(q1) ** 2) * np.sin(q2 + q3
+ q4) * (a2 * np.sin(q2) + a3 * np.sin(q2 + q3) + 0.5 * a4 * np.sin(q2 + q3 + q4)))
```

In[•]:= **MU[[4, 3]]**

Out[•]=
$$\frac{1}{12}\,a4^2\,m4\,\text{Cos}[q1]^2\left(\text{Cos}[q1]^2+\text{Sin}[q1]^2\right)+\frac{1}{12}\,a4^2\,m4\,\text{Sin}[q1]^2\left(\text{Cos}[q1]^2+\text{Sin}[q1]^2\right)+$$
$$m4\left(\left(\text{Cos}[q1]\left(-a2\,\text{Cos}[q1]\,\text{Cos}[q2]-\frac{1}{2}\,a4\,\text{Cos}[q1]\,\text{Cos}[q2+q3+q4]+\right.\right.\right.$$
$$\left.\text{Cos}[q1]\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4]\right)\right)+\text{Sin}[q1]\left(-a2\,\text{Cos}[q2]\,\text{Sin}[q1]-$$
$$\left.\left.\frac{1}{2}\,a4\,\text{Cos}[q2+q3+q4]\,\text{Sin}[q1]+\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4]\right)\text{Sin}[q1]\right)\right)$$
$$\left(\text{Cos}[q1]\left(-\text{Cos}[q1]\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]\right)-\frac{1}{2}\,a4\,\text{Cos}[q1]\,\text{Cos}[q2+q3+q4]+\right.\right.$$
$$\left.\text{Cos}[q1]\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4]\right)\right)+$$
$$\text{Sin}[q1]\left(-\left(\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]\right)\text{Sin}[q1]\right)-\frac{1}{2}\,a4\,\text{Cos}[q2+q3+q4]\,\text{Sin}[q1]+\right.$$
$$\left.\left.\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4]\right)\text{Sin}[q1]\right)\right)+$$
$$\frac{1}{2}\,a4\,\text{Cos}[q1]^2\,\text{Sin}[q2+q3+q4]\left(a3\,\text{Sin}[q2+q3]+\frac{1}{2}\,a4\,\text{Sin}[q2+q3+q4]\right)+$$
$$\left.\frac{1}{2}\,a4\,\text{Sin}[q1]^2\,\text{Sin}[q2+q3+q4]\left(a3\,\text{Sin}[q2+q3]+\frac{1}{2}\,a4\,\text{Sin}[q2+q3+q4]\right)\right)$$

In[•]:=
```
ToPython[1/12 a4^2 m4 Cos[q1]^2 (Cos[q1]^2 + Sin[q1]^2) + 1/12 a4^2 m4 Sin[q1]^2 (Cos[q1]^2 + Sin[q1]^2) +
 m4 (((Cos[q1] (-a2 Cos[q1] Cos[q2] - 1/2 a4 Cos[q1] Cos[q2 + q3 + q4] +
        Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4])) + Sin[q1] (-a2 Cos[q2] Sin[q1] -
        1/2 a4 Cos[q2 + q3 + q4] Sin[q1] + (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4]) Sin[q1]))
   (Cos[q1] (-Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3]) - 1/2 a4 Cos[q1] Cos[q2 + q3 + q4] +
        Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4])) +
      Sin[q1] (-((a2 Cos[q2] + a3 Cos[q2 + q3]) Sin[q1]) - 1/2 a4 Cos[q2 + q3 + q4] Sin[q1] +
        (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4]) Sin[q1])) +
   1/2 a4 Cos[q1]^2 Sin[q2 + q3 + q4] (a3 Sin[q2 + q3] + 1/2 a4 Sin[q2 + q3 + q4]) +
   1/2 a4 Sin[q1]^2 Sin[q2 + q3 + q4] (a3 Sin[q2 + q3] + 1/2 a4 Sin[q2 + q3 + q4])), NumpyPrefix → "np"]
```

Out[•]=
```
0.08333333333333333 * (a4 ** 2) * m4 * (np.cos(q1) ** 2) * (np.cos(q1) ** 2 + np.sin(q1) ** 2) +
0.08333333333333333 * (a4 ** 2) * m4 * (np.sin(q1) ** 2) * (np.cos(q1) ** 2 + np.sin(q1)
** 2) + m4 * ((np.cos(q1) * (-(a2 * np.cos(q1) * np.cos(q2)) -0.5 * a4 * np.cos(q1) *
np.cos(q2 + q3 + q4) + np.cos(q1) * (a2 * np.cos(q2) + a3 * np.cos(q2 + q3) + a4
* np.cos(q2 + q3 + q4))) + np.sin(q1) * (-(a2 * np.cos(q2) * np.sin(q1)) -0.5 * a4 *
np.cos(q2 + q3 + q4) * np.sin(q1) + (a2 * np.cos(q2) + a3 * np.cos(q2 + q3) + a4 *
np.cos(q2 + q3 + q4)) * np.sin(q1))) * (np.cos(q1) * (-(np.cos(q1) * (a2 * np.cos(q2) +
a3 * np.cos(q2 + q3))) -0.5 * a4 * np.cos(q1) * np.cos(q2 + q3 + q4) + np.cos(q1) *
(a2 * np.cos(q2) + a3 * np.cos(q2 + q3) + a4 * np.cos(q2 + q3 + q4))) + np.sin(q1)
* (-((a2 * np.cos(q2) + a3 * np.cos(q2 + q3)) * np.sin(q1)) -0.5 * a4 * np.cos(q2 +
q3 + q4) * np.sin(q1) + (a2 * np.cos(q2) + a3 * np.cos(q2 + q3) + a4 * np.cos(q2 +
q3 + q4)) * np.sin(q1))) + 0.5 * a4 * (np.cos(q1) ** 2) * np.sin(q2 + q3 + q4) * (a3
* np.sin(q2 + q3) + 0.5 * a4 * np.sin(q2 + q3 + q4)) + 0.5 * a4 * (np.sin(q1) ** 2)
* np.sin(q2 + q3 + q4) * (a3 * np.sin(q2 + q3) + 0.5 * a4 * np.sin(q2 + q3 + q4)))
```

In[•]:=
```
MU[[4, 4]]
```

Out[•]=
$$\frac{1}{12}\,a4^2\,m4\,\text{Cos}[q1]^2\left(\text{Cos}[q1]^2+\text{Sin}[q1]^2\right)+\frac{1}{12}\,a4^2\,m4\,\text{Sin}[q1]^2\left(\text{Cos}[q1]^2+\text{Sin}[q1]^2\right)+$$
$$m4\left(\left(\text{Cos}[q1]\left(-\text{Cos}[q1]\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]\right)-\frac{1}{2}\,a4\,\text{Cos}[q1]\,\text{Cos}[q2+q3+q4]+\right.\right.\right.$$
$$\left.\left.\left.\text{Cos}[q1]\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4]\right)\right)+\right.$$
$$\left.\text{Sin}[q1]\left(-\left(\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]\right)\text{Sin}[q1]\right)-\frac{1}{2}\,a4\,\text{Cos}[q2+q3+q4]\,\text{Sin}[q1]+\right.\right.$$
$$\left.\left.\left(a2\,\text{Cos}[q2]+a3\,\text{Cos}[q2+q3]+a4\,\text{Cos}[q2+q3+q4]\right)\text{Sin}[q1]\right)\right)^2+$$
$$\left.\frac{1}{4}\,a4^2\,\text{Cos}[q1]^2\,\text{Sin}[q2+q3+q4]^2+\frac{1}{4}\,a4^2\,\text{Sin}[q1]^2\,\text{Sin}[q2+q3+q4]^2\right)$$

In[•]:=
```
ToPython[1/12 a4^2 m4 Cos[q1]^2 (Cos[q1]^2 + Sin[q1]^2) + 1/12 a4^2 m4 Sin[q1]^2 (Cos[q1]^2 + Sin[q1]^2) +
 m4 ((Cos[q1] (-Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3]) - 1/2 a4 Cos[q1] Cos[q2 + q3 + q4] +
       Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4])) +
     Sin[q1] (-((a2 Cos[q2] + a3 Cos[q2 + q3]) Sin[q1]) - 1/2 a4 Cos[q2 + q3 + q4] Sin[q1] +
       (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4]) Sin[q1]))^2 +
  1/4 a4^2 Cos[q1]^2 Sin[q2 + q3 + q4]^2 + 1/4 a4^2 Sin[q1]^2 Sin[q2 + q3 + q4]^2), NumpyPrefix → "np"]
```

Out[•]=
```
0.08333333333333333 * (a4 ** 2) * m4 * (np.cos(q1) ** 2) * (np.cos(q1) ** 2 + np.sin(q1)
  ** 2) + 0.08333333333333333 * (a4 ** 2) * m4 * (np.sin(q1) ** 2) * (np.cos(q1) **
  2 + np.sin(q1) ** 2) + m4 * ((np.cos(q1) * (-(np.cos(q1) * (a2 * np.cos(q2) + a3 *
  np.cos(q2 + q3))) -0.5 * a4 * np.cos(q1) * np.cos(q2 + q3 + q4) + np.cos(q1) * (a2
  * np.cos(q2) + a3 * np.cos(q2 + q3) + a4 * np.cos(q2 + q3 + q4))) + np.sin(q1) *
  (-((a2 * np.cos(q2) + a3 * np.cos(q2 + q3)) * np.sin(q1)) -0.5 * a4 * np.cos(q2 +
  q3 + q4) * np.sin(q1) + (a2 * np.cos(q2) + a3 * np.cos(q2 + q3) + a4 * np.cos(q2
  + q3 + q4)) * np.sin(q1))) ** 2 + 0.25 * (a4 ** 2) * (np.cos(q1) ** 2) * (np.sin(q2
  + q3 + q4) ** 2) + 0.25 * (a4 ** 2) * (np.sin(q1) ** 2) * (np.sin(q2 + q3 + q4) ** 2))
```

In[•]:=
```
Mprint[G, "Gravity Vector g ="]
```

Out[•]=
$$\text{Mprint}\left[\left\{0,\ \frac{1}{2}\,g\left(\left(a2\,m2+2\,a2\,m3+2\,a2\,m4\right)\text{Cos}[q2]+\left(a3\,m3+2\,a3\,m4\right)\text{Cos}[q2+q3]+a4\,m4\,\text{Cos}[q2+q3+q4]\right),\right.\right.$$
$$\frac{1}{2}\,g\left(\left(a3\,m3+2\,a3\,m4\right)\text{Cos}[q2+q3]+a4\,m4\,\text{Cos}[q2+q3+q4]\right),$$
$$\left.\left.\frac{1}{2}\,a4\,g\,m4\,\text{Cos}[q2+q3+q4]\right\},\ \text{Gravity Vector g =}\right]$$

In[•]:=
```
ToPython[1/2 g ((a2 m2 + 2 a2 m3 + 2 a2 m4) Cos[q2] + (a3 m3 + 2 a3 m4) Cos[q2 + q3] + a4 m4 Cos[q2 + q3 + q4]),
 NumpyPrefix → "np"]
```

Out[•]=
```
0.5 * g * ((a2 * m2 + 2 * a2 * m3 + 2 * a2 * m4) * np.cos(q2) +
  (a3 * m3 + 2 * a3 * m4) * np.cos(q2 + q3) + a4 * m4 * np.cos(q2 + q3 + q4))
```

In[•]:=
```
ToPython[1/2 g ((a3 m3 + 2 a3 m4) Cos[q2 + q3] + a4 m4 Cos[q2 + q3 + q4]), NumpyPrefix → "np"]
```

Out[•]=
```
0.5 * g * ((a3 * m3 + 2 * a3 * m4) * np.cos(q2 + q3) + a4 * m4 * np.cos(q2 + q3 + q4))
```

In[•]:=
```
ToPython[1/2 a4 g m4 Cos[q2 + q3 + q4], NumpyPrefix → "np"]
```

Out[•]=
```
0.5 * a4 * g * m4 * np.cos(q2 + q3 + q4)
```