- 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. ①

Robotica version 4.01.

In[*]:= DataFile["TeleJapet_4D0F.txt"]

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

Dynamics Input Data

Gravity vector: [0, 0, g]

Link mass com vector

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

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

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

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

In[.]:= FKin[]

In[*]:= SimplifyTrigNotation[]

In[o]:= APrint[]

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

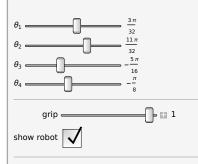
$$A[2]= \begin{pmatrix} \text{Cos}[q2] & -\text{Sin}[q2] & 0 & \text{a2 Cos}[q2] \\ \text{Sin}[q2] & \text{Cos}[q2] & 0 & \text{a2 Sin}[q2] \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

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

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

In[-]:= TPrint[]

```
Cos[q1] 0 Sin[q1]
                      Sin[q1] 0 -Cos[q1]
T[0,1]=
                                                                       d1
                      Cos[q1] Cos[q2] -Cos[q1] Sin[q2] Sin[q1] a2 Cos[q1] Cos[q2]
                      Cos[q2] Sin[q1] -Sin[q1] Sin[q2] -Cos[q1] a2 Cos[q2] Sin[q1]
T[0, 2]=
                               Sin[q2]
                                                                                                                               d1 + a2 Sin[q2]
                                                                      Cos[q2]
                                                                                                             0
                                      0
                      Cos[q1] Cos[q2 + q3] - Cos[q1] Sin[q2 + q3] Sin[q1] Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3])
                      Cos[q2 + q3] Sin[q1] - Sin[q1] Sin[q2 + q3] - Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3]) Sin[q1]
T[0,3]=
                                                                                                                                                     d1 + a2 Sin[q2] + a3 Sin[q2 + q3]
                               Sin[q2 + q3]
                                                                                Cos[q2 + q3]
                                           0
                                                                                             0
                      Cos[q1] Cos[q2 + q3 + q4] - Cos[q1] Sin[q2 + q3 + q4] Sin[q1] Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3] + a3 Cos[q3] Cos[q3] + a3 Cos[q3] Cos[q3] + a3 Cos[q3] Cos[q3] + a3 Cos[q3] + a3 Cos[q3] Cos[q3] Cos[q3] + a3 Cos[q3] Cos[q3] Cos[q3] Cos[q3] + a3 Cos[q3] Cos[q3] Cos[q3] Cos[q3] + a3 Cos[q3] Cos[
                      T[0,4]=
                               Sin[q2 + q3 + q4]
                                                                                           Cos[q2 + q3 + q4]
                                                                                                                                                      0
                                                                                                                                                                         d1 + a2 Sin[q2] + a3 Sin[q2 + q3] + a4
                      Cos[q2] - Sin[q2] 0 a2 Cos[q2]
                      Sin[q2] Cos[q2] 0 a2 Sin[q2]
T[1,2]=
                      Cos[q2 + q3] - Sin[q2 + q3] 0 a2 Cos[q2] + a3 Cos[q2 + q3]
                      Sin[q2 + q3] Cos[q2 + q3] 0 a2 Sin[q2] + a3 Sin[q2 + q3]
T[1,3]=
                                  0
                      Cos[q2 + q3 + q4] - Sin[q2 + q3 + q4] = 0 a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4]
                      Sin[q2 + q3 + q4] Cos[q2 + q3 + q4] 0 a2 Sin[q2 + a3] Sin[q2 + a4] a4 Sin[q2 + q3]
T[1,4]=
                                                                                                                                                                       1
                      Cos[q3] - Sin[q3] 0 a3 Cos[q3]
                      Sin[q3] Cos[q3] 0 a3 Sin[q3]
T[2,3]=
                      Cos[q3 + q4] - Sin[q3 + q4] = 0 \quad a3 Cos[q3] + a4 Cos[q3 + q4]
                      Sin[q3 + q4] Cos[q3 + q4] 0 a3 Sin[q3] + a4 Sin[q3 + q4]
T[2,4]=
                                  0
                                                                                                                          1
                      Cos[q4] -Sin[q4] 0 a4 Cos[q4]
                      Sin[q4] Cos[q4] 0 a4 Sin[q4]
T[3,4]=
```

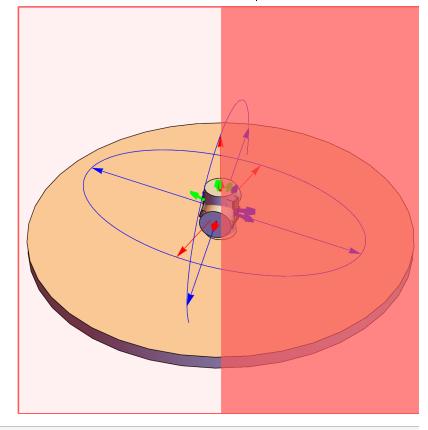


show Manipulability ellipses:



 $-5.55112 \times 10^{-17} \text{ a}2^5 \text{ a}3 + 0.153626 \text{ a}2^4 \text{ a}3^2 + 0.648654 \text{ a}2^3 \text{ a}3^3 + 0.6847 \text{ a}2^2 \text{ a}3^3 + 0.6847 \text{ a}2^3 \text{ a}3^3 + 0.68$ -5.55112×10^{-17} a2 a3⁵ - 3.46945 × 10⁻¹⁷ a3⁶ + 0.362429 a2⁴ a3 a4 + 2.15401 a $a3^2 a4 + 2.93209 a2^2 a3^3 a4 - 1.66533 \times 10^{-16} a2 a3^4 a4 - 1.80411 \times 10^{-16} a3^5$ $a3^2 a4^3 + 0.557863 a3^3 a4^3 + 1.76176 a2^2 a4^4 + 0.687406 a2 a3 a4^4 + 0.2682$ $a3^{2} a4^{4} - 2.22045 \times 10^{-16} a2 a4^{5} - 2.22045 \times 10^{-16} a3 a4^{5} - 1.11022 \times 10^{-16} a$

 μ_{w} =-9.2521 × 10⁻¹⁷ 0.92 0.28 0.29 0.45 a2 + 0.95 a3 + 0.92 a40.28 0.084 -0.96 0.14 a2 + 0.29 a3 + 0.28 a4 *H*=TransformationFunction[(0.88 a2 + 0.098 a3 - 0.29 a4 + d -0.29 0.96 1.0



Out[0]=

- ••• Part: Part 5 of {0, 0, 0, 0} does not exist. 1
- ••• Part: Part 5 of {0, 0, 0, 0} does not exist. 0
- ••• Part: Part 5 of {0, 0, 0, 0} does not exist. 1
- General: Further output of Part::partw will be suppressed during this calculation.
- ••• Part: Part 5 of {0, 0, 0, 0} does not exist. 0

```
••• Part: Part 5 of {0, 0, 0, 0} does not exist. 0
     ••• Part: Part 5 of {0, 0, 0, 0} does not exist. 1
     \cdots 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]

$$\begin{aligned} & \text{Out}[\cdot] = \ \left\{ \left\{ \frac{1}{12} \right. \\ & \left. \left(\text{d1}^2 \text{ m1} + 2 \text{ a2}^2 \text{ m2} + 6 \text{ a2}^2 \text{ m3} + 2 \text{ a3}^2 \text{ m3} + 6 \text{ a2}^2 \text{ m4} + 6 \text{ a3}^2 \text{ m4} + 2 \text{ a4}^2 \text{ m4} + 2 \text{ a2}^2 \left(\text{m2} + 3 \right) \text{ (m3} + \text{m4}) \right) \text{Cos}[2 \text{ q2}] + 6 \text{ a2 a3} \left(\text{m3} + 2 \text{ m4} \right) \text{ c}_3 + 2 \text{ a3}^2 \text{ m3} \text{ Cos}[2 \text{ (q2} + \text{q3})] + 6 \text{ a3}^2 \text{ m4} \text{ Cos}[2 \text{ (q2} + \text{q3})] + 6 \text{ a2 a3} \text{ m3} \text{ Cos}[2 \text{ q2} + \text{q3}] + 6 \text{ a3 a4} \text{ m4} \text{ c}_{4} + 6 \text{ a2 a4} \text{ m4} \text{ c}_{34} + 2 \text{ a4}^2 \text{ m4} \text{ Cos}[2 \text{ (q2} + \text{q3} + \text{q4})] + 6 \text{ a2 a4} \text{ m4} \text{ Cos}[2 \text{ (q2} + \text{q3} + \text{q4})] + 6 \text{ a2 a4} \text{ m4} \text{ Cos}[2 \text{ (q2} + \text{q3} + \text{q4})] + 6 \text{ a2 a4} \text{ m4} \text{ Cos}[2 \text{ (q2} + \text{q3} + \text{q4})] + 6 \text{ a3} \text{ a4} \text{ m4} \text{ Cos}[2 \text{ (q2} + 2 \text{ q3} + \text{q4})] + 0 \text{ o, 0, 0} \right\}, \left\{ 0, \text{ a2 a3} \left(\text{m3} + 2 \text{ m4} \right) \text{ c}_3 + 3 \text{ a2}^2 \text{ m4} + 3 \text{ a2}^2 \text{ m4} + 3 \text{ a3}^2 \text{ m4} + 3 \text{ a2}^2 \text{ m4} + 3 \text{ a3} \text{ a4} \text{ m4} \text{ c}_4 + 3 \text{ a2} \text{ a4} \text{ m4} \text{ c}_{34} \right), \\ \frac{1}{6} \left(2 \text{ a3}^2 \text{ m3} + 6 \text{ a3}^2 \text{ m4} + 2 \text{ a4}^2 \text{ m4} + 3 \text{ a2} \text{ a3} \left(\text{m3} + 2 \text{ m4} \right) \text{ c}_3 + 6 \text{ a3} \text{ a4} \text{ m4} \text{ c}_4 + 3 \text{ a2} \text{ a4} \text{ m4} \text{ c}_{34} \right), \\ \frac{1}{6} \text{ a4} \text{ m4} \left(2 \text{ a4} + 3 \text{ a3} \text{ c}_4 + 3 \text{ a2} \text{ c3} \right) \right\}, \\ \left\{ 0, \frac{1}{6} \left(2 \text{ a3}^2 \text{ m3} + 6 \text{ a3}^2 \text{ m4} + 2 \text{ a4}^2 \text{ m4} + 3 \text{ a2} \text{ a3} \left(\text{m3} + 2 \text{ m4} \right) \text{ c}_3 + 6 \text{ a3} \text{ a4} \text{ m4} \text{ c}_4 + 3 \text{ a2} \text{ a4} \text{ m4} \text{ c}_{34} \right), \\ \left\{ 0, \frac{1}{6} \left(2 \text{ a3}^2 \text{ m3} + 6 \text{ a3}^2 \text{ m4} + 2 \text{ a4}^2 \text{ m4} + 3 \text{ a2} \text{ a3} \left(\text{m3} + 2 \text{ m4} \right) \text{ c}_3 + 6 \text{ a3} \text{ a4} \text{ m4} \text{ c}_4 + 3 \text{ a2} \text{ a4} \text{ m4} \text{ c}_{34} \right), \\ \left\{ 0, \frac{1}{6} \left(2 \text{ a3}^2 \text{ m3} + 6 \text{ a3}^2 \text{ m4} + 2 \text{ a4}^2 \text{ m4} + 3 \text{ a2} \text{ a3} \left(\text{m3} + 2 \text{ m4} \right) \text{ c}_3 + 6 \text{ a3} \text{ a4} \text{ m4} \text{ c}_4 + 3 \text{ a2} \text{ a4} \text{ m4} \text{ c}_{34} \right), \\ \left\{ 0, \frac{1}{6} \text{ a4} \text{ m4} \left(2 \text{ a4} + 3 \text{ a3} \text{ c}_4 + 3 \text{ a3} \text{ c}_4 + 3 \text{ a2} \text{ a2} \text{ c34} \right), \frac{1}{6} \text{ a4} \text{ m4} \left(2 \text{ a4} + 3 \text{ a3} \text{ c4} \right)$$

In[*]:= Grid[MU]

$\frac{d1^2 m1}{12} +$	m3 $\left(-\left(\left(-\frac{1}{2} \text{ a3 Cos}[q1]\right)\right)\right)$	$m3\left(-\frac{1}{2} \ a3\left(-\frac{1}{2} \ a3 \ \text{Cos[q1]}\right)\right)$	$m4\left(-\frac{1}{2} a4\right)$
$\frac{1}{12}$ a2 ² m2 Cos[q2] ² +	Cos[q2 + q3] +	Cos[q2 + q3] +	$\left(-\frac{1}{2} \text{ a4 Cos[q1] Cos[}\right)$
$\frac{1}{12}$ a3 ² m3 Cos[q2 + q3] ² +	Cos[q1] (a2	Cos[q1] (a2	q2 + q3 + q4] +
$\frac{1}{12}$ a4 ² m4	Cos[q2] + a3	Cos[q2] + a3	Cos[q1]
$Cos[q2 + q3 + q4]^2 +$	Cos[q2 + q3])	Cos[q2 + q3]))	(a2 Cos[q2] + a3
$m2\left(\frac{1}{4} a2^2 Cos[q1]^2\right)$	Sin[q1]	Sin[q1] Sin[Cos[q2 + q3] +
Cos[q2] ² +	(a2 Sin[q2] +	q2 + q3] -	a4 Cos[
$\frac{1}{4} a2^2 \cos[q2]^2$	$\frac{1}{2}$ a3 Sin[$\frac{1}{2}$ a3 Cos[q1]	q2 + q3 + q4]))
Sin[q1] ²) + m3	q2 + q3])) -	$(\frac{1}{2} \text{ a3 Cos}[q2 + q3]$	Sin[q1] Sin[
,	$Cos[q1](\frac{1}{2} a3)$	Sin[q1] -	q2 + q3 + q4] -
$\left(-\frac{1}{2} \text{ a3 Cos[q1] Cos[q2 +}\right)$	Cos[q2 + q3]	(a2 Cos[q2] + a3	$\frac{1}{2}$ a4 Cos[q1]
q3] + Cos[q1]	Sin[q1] -	Cos[q2 + q3])	$(\frac{1}{2} a4$
(a2 Cos[q2] +	(a2 Cos[q2] + a3	Sin[q1])	Cos[q2 + q3 + q4]
a3 Cos[Cos[q2 + q3])	Sin[q2 + q3]) +	Sin[q1] -
q2 + q3])) ² +	Sin[q1])	m4 $\left(-\left(\left(-\frac{1}{2} \text{ a4 Cos[q1] Cos[}\right)\right)\right)$	(a2 Cos[q2] + a3
$(\frac{1}{2} \text{ a3 Cos}[q2 + q3]$	(a2 Sin[q2] +	q2 + q3 + q4] +	Cos[q2 + q3] +
Sin[q1] - (a2	$\frac{1}{2}$ a3	Cos[q1]	a4 Cos[
Cos[q2] + a3	Sin[q2 + q3])) +	(a2 Cos[q2] +	q2 + q3 + q4])
Cos[q2 + q3])		a3 Cos[q2 +	Sin[q1])
Sin[q1]) ²)+	m4 $\left(-\left(\left(-\frac{1}{2} \text{ a4 Cos[q1] Cos[}\right)\right)\right)$	q3] + a4 Cos[Sin[q2 + q3 + q4])
m4 ll_{-} a4 Cosia1i Cosi	q2 + q3 + q4] +	q2 + q3 + q4]))	

```
Cos[dT]
                                                                                                     Sin[q1]
                   q2 + q3 + q4] +
                                                              (a2 Cos[q2] +
                                                                                                     (a3 Sin[q2 + q3] +
               Cos[q1] (a2
                                                               a3 Cos[q2 +
                                                                                                         \frac{1}{2} a4 Sin[q2 +
                   Cos[q2] + a3
                                                               q3] + a4 Cos[
                                                                                                         q3 + q4])) -
                   Cos[q2 + q3] +
                                                               q2 + q3 + q4)
                                                                                              Cos[q1](\frac{1}{2} a4 Cos[
                   a4 Cos[q2 +
                                                          Sin[q1]
                   q3 + q4]))<sup>2</sup> +
                                                          (a2 Sin[q2] + a3)
                                                                                                         q2 + q3 + q4]
        (\frac{1}{2} \text{ a4 Cos}[q2 + q3 +
                                                               Sin[q2 + q3] +
                                                                                                       Sin[q1] -
                                                              \frac{1}{2} a4 Sin[q2 +
                                                                                                     (a2 \cos[q2] + a3)
                   q4] Sin[q1] -
                                                                                                         Cos[q2 + q3] +
               (a2 Cos[q2] +
                                                               q3 + q4])) -
                                                                                                         a4 Cos[
                   a3 Cos[q2 +
                                                    Cos[q1] \left(\frac{1}{2} \text{ a4 Cos}\right)
                                                                                                         q2 + q3 + q4
                   q3] + a4 Cos[
                                                               q2 + q3 + q4]
                                                                                                       Sin[q1]
                   q2 + q3 + q4
                                                            Sin[q1] -
                                                                                                (a3 Sin[q2 + q3] +
                 Sin[q1]^2
                                                          (a2 \cos[q2] + a3)
                                                                                                     \frac{1}{2} a4 Sin[
                                                               Cos[q2 + q3] +
                                                                                                         q2 + q3 + q4]))
                                                               a4 Cos[
                                                               q2 + q3 + q4
                                                            Sin[q1]
                                                      (a2 Sin[q2] +
                                                          a3 Sin[q2 + q3] +
                                                          \frac{1}{2} a4 Sin[
                                                              q2 + q3 + q4)
m3 \left(-\left(\left(-\frac{1}{2} \text{ a3 Cos[q1]}\right)\right)\right)
                                           \frac{1}{12} a2<sup>2</sup> m2 Cos[q1]<sup>2</sup>
                                                                                      \frac{1}{12} a3<sup>2</sup> m3 Cos[q1]<sup>2</sup>
                                                                                                                                 \frac{1}{12} a4<sup>2</sup> m4 Cos[q1]<sup>2</sup>
                                               (\cos[q1]^2 + \sin[q1]^2) +
                                                                                          (\cos[q1]^2 + \sin[q1]^2) +
                                                                                                                                     (\cos[q1]^2 + \sin[q1]^2) +
                   Cos[q2 + q3] +
                                            \frac{1}{12} a3<sup>2</sup> m3 Cos[q1]<sup>2</sup>
                                                                                        \frac{1}{12} a4<sup>2</sup> m4 Cos[q1]<sup>2</sup>
                                                                                                                                   \frac{1}{12} a4<sup>2</sup> m4 Sin[q1]<sup>2</sup>
                   Cos[q1] (a2
                   Cos[q2] + a3
                                              (\cos[q1]^2 + \sin[q1]^2) +
                                                                                          (\cos[q1]^2 + \sin[q1]^2) +
                                                                                                                                     (Cos[q1]^2 + Sin[q1]^2) +
                                                                                        \frac{1}{12} a3<sup>2</sup> m3 Sin[q1]<sup>2</sup>
                                             \frac{1}{12} a4^2 m4 Cos[q1]^2
                   Cos[q2 + q3]
                                                                                                                                     \left( \left( \cos[q1] \left( -\frac{1}{2} \text{ a4 Cos}[q1] \right) \right) \right)
               Sin[q1]
                                               (\cos[q1]^2 + \sin[q1]^2) +
                                                                                         (\cos[q1]^2 + \sin[q1]^2) +
                                             \frac{1}{12} a2<sup>2</sup> m2 Sin[q1]<sup>2</sup>
                                                                                        \frac{1}{12} a4<sup>2</sup> m4 Sin[q1]<sup>2</sup>
               (a2 Sin[q2] +
                                                                                                                                                    Cos[q2 + q3 +
                   \frac{1}{2} a3 Sin[
                                                                                          (\cos[q1]^2 + \sin[q1]^2) +
                                                                                                                                                    q4] + Cos[q1]
                                               (\cos[q1]^2 + \sin[q1]^2) +
                                             \frac{1}{12} a3^2 m3 Sin[q1]^2
                                                                                                                                                    (a2 Cos[q2] +
                   q2 + q3])) -
                                                                                          \left(\left(\cos[q1]\left(-\frac{1}{2}\right)\right)\right) a3 Cos[q1]
                                                                                                                                                    a3 Cos[
         Cos[q1](\frac{1}{2} a3)
                                               (\cos[q1]^2 + \sin[q1]^2) +
                                                                                                                                                    q2 + q3] +
                                             \frac{1}{12} a4<sup>2</sup> m4 Sin[q1]<sup>2</sup>
                                                                                                         Cos[q2 + q3] +
                 Cos[q2 + q3]
                                                                                                                                                    a4 Cos[q2 +
                                                                                                         Cos[q1]
                                              (\cos[q1]^2 + \sin[q1]^2) +
                 Sin[q1] -
                                                                                                                                                    q3 + q4])) +
                                                                                                         (a2 Cos[q2] +
               (a2 \cos[q2] + a3)
                                             m2 \left( \left( \frac{1}{2} \text{ a2 Cos}[q1]^2 \right) \right)
                                                                                                                                                Sin[q1](-\frac{1}{2}a4)
                                                                                                         a3 Cos[q2 +
                   Cos[q2 + q3]
                                                         Cos[q2] + \frac{1}{2} a2 Cos[q2]
                                                                                                                                                    Cos[q2 + q3 +
                                                                                                         q3])) + Sin[q1]
                 Sin[q1]
                                                                                                                                                    q4] Sin[q1] +
                                                                                                      \left(-\frac{1}{2} \text{ a3 Cos[q2 + ]}\right)
           (a2 Sin[q2] +
                                                            Sin[q1]^{2})^{2} +
                                                                                                                                                    (a2 Cos[q2] +
                                                                                                         q3] Sin[q1] +
               \frac{1}{2} a3
                                                    \frac{1}{4} a2^2 Cos[q1]^2
                                                                                                                                                    a3 Cos[q2 +
                                                                                                         (a2 Cos[q2] +
                 Sin[q2 + q3]) +
                                                      Sin[q2]^2 +
                                                                                                                                                    q3] + a4 Cos[
                                                                                                         a3 Cos[q2 +
  m4 \left(-\left(\left(-\frac{1}{2} \text{ a4 Cos[q1] Cos[}\right)\right)\right)
                                                    \frac{1}{4} a2<sup>2</sup> Sin[q1]<sup>2</sup>
                                                                                                                                                    q2 + q3 + q4
                                                                                                         q3]) Sin[q1]))
```

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] + \frac{1}{2} a4 Sin[q2 + q3 + q4])) - Cos[q1] (\frac{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] + \frac{1}{2} a4 Sin[q2 + q3 + q4])	$Sin[q2]^2$) + m3 $((Cos[q1](-\frac{1}{2} a3 Cos[q1] Cos[q2 + q3] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3]))$ + $Sin[q1](-\frac{1}{2} a3 Cos[q2 + q3] Sin[q1] + (a2 Cos[q2] + a3 Cos[q2 + q3]) Sin[q1]))^2 + Cos[q2] + a3 Cos[q2 + q3]) Sin[q1]))^2 + Cos[q1]^2 (a2 Sin[q2] + \frac{1}{2} a3 Sin[q2]$	(Cos[q1] (-a2 Cos[q1] Cos[q2] - \frac{1}{2} a3 Cos[q1] Cos[q2 + q3] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3])) + Sin[q1] (-a2 Cos[q2] Sin[q1] - \frac{1}{2} a3 Cos[q2 + q3] Sin[q1] + (a2 Cos[q2] + a3 Cos[q2] + a3 Cos[q2] + a3 Cos[q1] ² Sin[q2 + q3] (a2 Sin[q2] + \frac{1}{2} a3 Sin[q2 + q3]) + \frac{1}{2} a3 Sin[q1] ² Sin[Sin[q1])) (Cos[q1] (-Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3]) - \frac{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]) - \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4] Sin[q1] + (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4] Sin[q1])) +
	Cos[q1] Cos[q2 + q3 + q4] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4])) + Sin[q1] $\left(-\frac{1}{2}\right)$ 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] + $\frac{1}{2}$ 34 Sin[q2] .	$\begin{array}{c} 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\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 + q3] + \\ a4 \text{Cos}[q2 + q3] + \\ q3 + q4]\right)\right) + \\ \text{Sin}[q1] \left(-\frac{1}{2} a4\right) \\ \text{Cos}[q2 + q3 + q4] \text{Sin}[q1] + \\ \left(a2 \text{Cos}[q2] + \\ a3 \text{Cos}[q2 + q3] + \\ a4 \text{Cos}[q3 + q3] + \\ a4 \text{Cos}[q3 + q3] + \\ a4 \text{Cos}[q3 + q3] + \\ a5 \text{Cos}[q3 + $	$\frac{1}{2} \text{ a4 } \text{Cos}[q1]^2$ $\text{Sin}[$ $q2 + $ $q3 + $ $q4]$ $(a2 \text{Sin}[q2] + $ $a3 $ $\text{Sin}[q2 + q3] + $ $\frac{1}{2} \text{ a4} $ $\text{Sin}[$ $q2 + q3 + q4]) + $ $\frac{1}{2} \text{ a4 } \text{Sin}[q1]^2$ $\text{Sin}[$ $q2 + $ $q3 + $ $q4]$ $(a2 \text{Sin}[q2] + $ $a3 $ $\text{Sin}[q2] + $ $a3 $

```
- a - 3 111142 +
                                          q2 + q3 + q4]
                                                                          3 111[42 + 43] +
                                                                        \frac{1}{2} a4 Sin[
        q3 + q4]<sup>2</sup> +
                                          Sin[q1]
                                                                           q2 + q3 + q4)
Sin[q1]^2
                                   (Cos[q1] (-a2 Cos[
 (a2 Sin[q2] + a3
                                          q1] Cos[q2] -
                                          \frac{1}{2} a4 Cos[q1]
        Sin[q2 + q3] +
      \frac{1}{2} a4 Sin[q2 +
                                          Cos
        q3 + q4])^2
                                          q2 + q3 + q4] +
                                          Cos[q1] (a2
                                          Cos[q2] + a3
                                          Cos[q2 + q3] +
                                          a4 Cos[q2 +
                                          q3 + q4])) +
                                      Sin[q1]
                                        (-a2 Cos[q2]
                                          Sin[q1] -
                                          \frac{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] +
                                      \frac{1}{2} a4
                                        Sin[
                                         q2 + q3 + q4])
                                   (a2 Sin[q2] +
                                      а3
                                        Sin[q2 + q3] +
                                      \frac{1}{2} a4 Sin[
                                         q2 + q3 + q4] +
                                 Sin[q1]<sup>2</sup>
                                  (a3 Sin[q2 + q3] +
                                      \frac{1}{2} a4 Sin[
                                         q2 + q3 + q4])
                                   (a2 Sin[q2] +
                                      a3 Sin[q2 + q3] +
                                      \frac{1}{2} a4 Sin[
                                          q2 + q3 + q4]))
```

 $m3/-\frac{1}{2} a3/-\frac{1}{2} a3 (osig1) \frac{1}{2} a3^2 m3 (osig1)^2$

 $\frac{1}{2}$ a32 m3 Cos(a1)2

 $\frac{1}{2}$ a4² m4 Cos(a1)²

	2 2	12	12	12
	Cos[q2 + q3] +	$(\cos[q1]^2 + \sin[q1]^2) +$	$(\cos[q1]^2 + \sin[q1]^2) +$	$(\cos[q1]^2 + \sin[q1]^2) +$
	Cos[q1] (a2	$\frac{1}{12}$ a4 ² m4 Cos[q1] ²	$\frac{1}{12}$ a4 ² m4 Cos[q1] ²	$\frac{1}{12}$ a4 ² m4 Sin[q1] ²
	Cos[q2] + a3	$(Cos[q1]^2 + Sin[q1]^2) +$	$(\cos[q1]^2 + \sin[q1]^2) +$	$(\cos[q1]^2 + \sin[q1]^2) +$
	Cos[q2 + q3])	$\frac{1}{12}$ a3 ² m3 Sin[q1] ²	$\frac{1}{12}$ a3 ² m3 Sin[q1] ²	m4 ((Cos[q1] (-a2 Cos[q1]
	Sin[q1] Sin[$(\cos[q1]^2 + \sin[q1]^2) +$	$(\cos[q1]^2 + \sin[q1]^2) +$	(\) Cos[q2] -
	q2 + q3] -	$\frac{1}{12}$ a4 ² m4 Sin[q1] ²	$\frac{1}{12}$ a4 ² m4 Sin[q1] ²	$\frac{1}{2}$ a4
	$\frac{1}{2}$ a3 Cos[q1]	$(Cos[q1]^2 + Sin[q1]^2) +$	$(\cos[q1]^2 + \sin[q1]^2) +$	Cos[q1] Cos[
	$(\frac{1}{2} \text{ a3 Cos}[q2 + q3]$	m3	m3 ((Cos[q1] (-a2 Cos[q1]	q2 + q3 + q4] +
	Sin[q1] -	$((\cos[q1](-\frac{1}{2} \text{ a3 Cos}[q1])$	Cos[q2] -	Cos[q1] (a2
	(a2 Cos[q2] + a3	Cos[q2 + q3] +	$\frac{1}{2} \text{ a3 Cos[q1]}$	Cos[q2] + a3
	Cos[q2 + q3])	Cos[q1]	-	Cos[q2 + q3] +
Out[0]=	Sin[q1])	(a2 Cos[q2] +	Cos[q2 + q3] + Cos[q1]	a4 Cos[q2 +
	Sin[q2 + q3])+	a3 Cos[q2 +	(a2 Cos[q2] +	q3 + q4])) +
	m4 $\left(-\left(\left(-\frac{1}{2} \text{ a4 Cos[q1] Cos[}\right)\right)\right)$	q3])) + Sin[q1]	a3 Cos[Sin[q1]
	· · · · <u>Z</u>	$\left(-\frac{1}{2} \text{ a3 Cos[q2 +}\right)$	q2 + q3])) +	(-a2 Cos[q2]
	q2 + q3 + q4] + Cos[q1]	q3] Sin[q1] +	Sin[q1] (-a2	Sin[q1] -
	(a2 Cos[q2] +	(a2 Cos[q2] +	Cos[q2] Sin[$\frac{1}{2}$ a4 Cos[
	a3 Cos[q2 +	a3 Cos[q2 +	q1] - $\frac{1}{2}$ a3	q2 + q3 + q4]
	q3] + a4 Cos[q3]) Sin[q1]))	Cos[q2 + q3]	Sin[q1] +
	q2 + q3 + q4]))	(Cos[q1] (-a2 Cos[Sin[q1] + (a2	(a2 Cos[q2] +
	Sin[q1]	q1] Cos[q2] -	Cos[q2] + a3	a3 Cos[q2 +
	(a3 Sin[q2 + q3] +	$\frac{1}{2}$ a3 Cos[q1]	Cos[q2 + q3])	q3] + a4 Cos[
	$\frac{1}{2}$ a4 Sin[q2 +	Cos[q2 + q3] +	Sin[q1])) ² +	q2 + q3 + q4]
	2 q3 + q4])) -	Cos[q1]	"	Sin[q1]))
	$Cos[q1]\left(\frac{1}{2} \text{ a4 Cos}\right)$	(a2 Cos[q2] +	$\frac{1}{4}$ a3 ² Cos[q1] ²	(Cos[q1] (-Cos[q1]
	q2 + q3 + q4	a3 Cos[q2 +	Sin[q2 + q3] ² +	(a2 Cos[q2] +
	۲۵۰۹۶ (۱۳۵۶) Sin[q1] -	q3])) + Sin[q1]	$\frac{1}{4}$ a3 ²	a3 Cos[q2 +
	(a2 Cos[q2] + a3	(-a2 Cos[q2]	a3- Sin[q1] ²	$q3]$) - $\frac{1}{2}$ a4
	Cos[q2 + q3] +	Sin[q1] -	Sin[q2 + q3] ²)+	Cos[q1] Cos[
	a4 Cos[$\frac{1}{2}$ a3 Cos[q2 +		q2 + q3 + q4] +
	q2 + q3 + q4])	q3] Sin[q1] +	m4 ((Cos[q1] (-a2 Cos[q1]	Cos[q1] (a2
	Sin[q1])	(a2 Cos[q2] +	Cos[q2] -	Cos[q2] + a3
	(a3 Sin[q2 + q3] +	a3 Cos[q2 +	$\frac{1}{2}$ a4	Cos[q2 + q3] + a4 Cos[q2 +
	$\frac{1}{2}$ a4 Sin[q3]) Sin[q1])) +	Cos[q1] Cos[q3 + q4])) +
	q2 + q3 + q4]))	$\frac{1}{2}$ a3 Cos[q1] ²	q2 + q3 + q4] +	Sin[q1]
		Sin[Cos[q1] (a2	(-((a2 Cos[q2] +
		q2 + q3]	Cos[q2] + a3 Cos[q2 + q3] +	a3 Cos[q2 +
		(a2 Sin[q2] +	a4 Cos[q2 +	q3]) Sin[q1]) -
		$\frac{1}{2}$ a3	q3 + q4])) +	$\frac{1}{2}$ a4 Cos[
		Sin[q2 + q3]) +	Sin[q1]	2 q2 + q3 + q4]
		$\frac{1}{2}$ a3 Sin[q1] ²	/-a2 Cos[a2]	Sin[a1]+

_	/	* 1 4
Sin[\ Sin[q1] -	(a2 Cos[q2] +
q2 + q3]	$\frac{1}{2}$ a4 Cos[a3 Cos[q2 +
(a2 Sin[q2] +	q2 + q3 + q4]	q3] + a4 Cos[
$\frac{1}{2}$ a3	q2 + q3 + q4; Sin[q1] +	q2 + q3 + q4])
Sin[q2 + q3])) +	(a2 Cos[q2] +	Sin[q1]))+
- "		. "
m4 $((\cos[q1](-\frac{1}{2})a4)$	a3 Cos[q2 +	$\frac{1}{2}$ a4 Cos[q1] ²
Cos[q1] Cos[q3] + a4 Cos[Sin[
q2 + q3 + q4] +	q2 + q3 + q4])	q2 +
Cos[q1] (a2	Sin[q1])) ² +	q3 +
Cos[q2] + a3	Cos[q1] ²	q4]
Cos[q2 + q3] +	(a3 Sin[q2 + q3] +	(a3 Sin[q2 + q3] +
a4 Cos[q2 +	$\frac{1}{2}$ a4 Sin[q2 +	$\frac{1}{2}$
q3 + q4])) +	q3 + q4]) ² +	a4
Sin[q1] $\left(-\frac{1}{2}\right)$ a4	Sin[q1] ²	Sin[
Cos[q2 + q3 +	(a3 Sin[q2 + q3] +	q2 + q3 + q4]) +
q4] Sin[q1] +	$\frac{1}{2}$ a4 Sin[q2 +	$\frac{1}{2}$ a4 Sin[q1] ²
(a2 Cos[q2] +	- 2.	Sin[
a3 Cos[q2 +	$(q3 + q4)^2$	q2 +
q3] + a4 Cos[q3 +
q2 + q3 + q4])		q4]
Sin[q1]))		(a3 Sin[q2 + q3] +
(Cos[q1] (-a2 Cos[$\frac{1}{2}$
q1] Cos[q2] -		a4
$\frac{1}{2}$ a4 Cos[q1]		Sin[
Cos		q2 + q3 + q4]))
q2 + q3 + q4] +		
Cos[q1] (a2		
Cos[q2] + a3		
Cos[q2 + q3] +		
a4 Cos[q2 +		
q3 + q4])) +		
Sin[q1]		
(-a2 Cos[q2]		
Sin[q1] -		
$\frac{1}{2}$ a4 Cos[
q2 + q3 + q4]		
Sin[q1] +		
(a2 Cos[q2] +		
a3 Cos[q2 +		
q3] + a4 Cos[
q2 + q3 + q4])		
Sin[q1]))+		
- 1 -1//		

```
Cos[q1]<sup>2</sup>
                                               (a3 Sin[q2 + q3] +
                                                   \frac{1}{2} a4
                                                     Sin
                                                       q2 + q3 + q4
                                               (a2 Sin[q2] +
                                                   а3
                                                    Sin[q2 + q3] +
                                                   \frac{1}{2} a4 Sin[
                                                       q2 + q3 + q4] +
                                             Sin[q1]2
                                               (a3 Sin[q2 + q3] +
                                                   \frac{1}{2} a4 Sin[
                                                       q2 + q3 + q4])
                                               (a2 Sin[q2] +
                                                   a3 Sin[q2 + q3] +
                                                   \frac{1}{2} a4 Sin[
                                                       q2 + q3 + q4]))
                                                                                                                 \frac{1}{12} a4^2 m4 Cos[q1]^2
                                      \frac{1}{12} a4<sup>2</sup> m4 Cos[q1]<sup>2</sup>
                                                                           \frac{1}{12} a4<sup>2</sup> m4 Cos[q1]<sup>2</sup>
m4\left(-\frac{1}{2} a4\right)
                                         (\cos[q1]^2 + \sin[q1]^2) +
      \left(-\frac{1}{2} \text{ a4 Cos[q1] Cos[}\right)
                                                                              (\cos[q1]^2 + \sin[q1]^2) +
                                                                                                                     (\cos[q1]^2 + \sin[q1]^2) +
                                                                             \frac{1}{12} a4<sup>2</sup> m4 Sin[q1]<sup>2</sup>
                                       \frac{1}{12} a4<sup>2</sup> m4 Sin[q1]<sup>2</sup>
                                                                                                                   \frac{1}{12} a4<sup>2</sup> m4 Sin[q1]<sup>2</sup>
               q2 + q3 + q4] +
                                         (Cos[q1]^2 + Sin[q1]^2) +
                                                                              (\cos[q1]^2 + \sin[q1]^2) +
                                                                                                                    (\cos[q1]^2 + \sin[q1]^2) +
           Cos[q1]
             (a2 \cos[q2] + a3)
                                                                             m4 ((Cos[q1] (-a2 Cos[q1]
                                                                                                                   m4 ((Cos[q1] (-Cos[q1]
                                         \left( \left( \cos[q1] \left( -\frac{1}{2} \text{ a4 Cos}[q1] \right) \right) \right)
                 Cos[q2 + q3] +
                                                                                             Cos[q2] -
                                                                                                                                   (a2 Cos[q2] +
                                                                                             \frac{1}{2} a4
                 a4 Cos[
                                                       Cos[q2 + q3 +
                                                                                                                                   a3 Cos[q2 +
                 q2 + q3 + q4)
                                                       q4] + Cos[q1]
                                                                                             Cos[q1] Cos[
                                                                                                                                   q3]) - \frac{1}{2} a4
       Sin[q1] Sin[
                                                       (a2 Cos[q2] +
                                                                                             q2 + q3 + q4] +
                                                                                                                                   Cos[q1] Cos[
         q2 + q3 + q4] -
                                                       a3 Cos[
                                                                                             Cos[q1] (a2
                                                                                                                                   q2 + q3 + q4] +
      \frac{1}{2} a4 Cos[q1]
                                                       q2 + q3] +
                                                                                             Cos[q2] + a3
                                                                                                                                   Cos[q1] (a2
       \left(\frac{1}{2}\right) a4
                                                       a4 Cos[q2 +
                                                                                             Cos[q2 + q3] +
                                                                                                                                   Cos[q2] + a3
                                                       q3 + q4])) +
                                                                                             a4 Cos[q2 +
             Cos[q2 + q3 + q4]
                                                                                                                                   Cos[q2 + q3] +
                                                   Sin[q1](-\frac{1}{2}a4)
                                                                                             q3 + q4])) +
             Sin[q1] -
                                                                                                                                   a4 Cos[q2 +
           (a2 \cos[q2] + a3)
                                                       Cos[q2 + q3 +
                                                                                         Sin[q1]
                                                                                                                                   q3 + q4])) +
                                                       q4] Sin[q1] +
                                                                                          (-a2 Cos[q2]
                 Cos[q2 + q3] +
                                                                                                                               Sin[q1] (-((a2
                                                       (a2 Cos[q2] +
                 a4 Cos[
                                                                                             Sin[q1] -
                                                                                                                                   Cos[q2] + a3
                                                                                             \frac{1}{2} a4 Cos[
                 q2 + q3 + q4
                                                       a3 Cos[q2 +
                                                                                                                                   Cos[q2 + q3]
                                                       q3] + a4 Cos[
                                                                                             q2 + q3 + q4]
             Sin[q1])
                                                                                                                                   Sin[q1]) -
                                                       q2 + q3 + q4
                                                                                             Sin[q1] +
       Sin[q2 + q3 + q4]
                                                                                                                                   \frac{1}{2} a4 Cos[
                                                       Sin[q1]))
                                                                                            (a2 Cos[q2] +
                                                                                                                                   q2 + q3 + q4
                                               (Cos[q1](-Cos[q1]
                                                                                             a3 Cos[q2 +
                                                                                                                                   Sin[q1] +
                                                                                             q3] + a4 Cos[
                                                       (a2 Cos[q2] +
                                                                                                                                   (a2 Cos[q2] +
```

a3 Cos[q2 +

q3] + a4 Cos[

q2 + q3 + q4

 $Sin[q1])^2 +$

In[*]:= Grid[CM]

2 24

$$\frac{1}{6} \left(\left(-a2^2 \, m2 - 3 \, a2^2 \, m3 - 3 \, a2^2 \, m4 \right) \right.$$

$$Sin[2 \, q2] + \left(-3 \, a2 \, a3 \, m3 - 6 \, a2 \, a3 \, m4 \right)$$

$$Sin[2 \, q2 + q3] + \left(-a3^2 \, m3 - 3 \, a3^2 \, m4 \right)$$

$$Sin[2 \, q2 + 2 \, q3] - 3 \, a2 \, a4 \, m4$$

$$Sin[2 \, q2 + q3 + q4] - 3 \, a3 \, a4 \, m4 \, Sin[$$

$$2 \, q2 + 2 \, q3 + q4] - a4^2 \, m4 \, Sin[2 \, q2 + 2 \, q3 + q4] - a4^2 \, m4 \, Sin[2 \, q2 + 2 \, q3 + q4] \right]$$

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

 $\cos\left[\frac{q^4}{2}\right] \sin\left[\frac{q^4}{2}\right] q3'[t]$

 $Sin\left[\frac{q4}{2}\right]q3'[t]$

In[*]:= EPrint[MU, "Mass matrix"]

Sin[q2 + q3 + q4] q1'[t]

```
In[*]:= EPrint[CM, "C matrix"]
    In[.]:= Mprint[G, "Gravity Vector g ="]
Out[-]= Mprint[\{0, \frac{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]\},
                                                           \frac{1}{2} g ((a3 m3 + 2 a3 m4) Cos[q2 + q3] + a4 m4 Cos[q2 + q3 + q4]),
                                                          \frac{1}{2} \text{ a4 g m4 Cos}[q2 + q3 + q4], \text{ Gravity Vector g =}]
    In[.]:= c[1, 1, 1]
 Out[-]= 0
    In[.]:= c[1, 1, 2]
Out[-]= \frac{1}{6} ((a2<sup>2</sup> m2 + 3 a2<sup>2</sup> m3 + 3 a2<sup>2</sup> 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])
     <code>ln[₀]:= (*loads the package - after installation*)</code>
                                           Get@FileNameJoin[{NotebookDirectory[], "ToPython.wl"}]
   log_{-1} = ToPython \left[ \frac{1}{6} \left( (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] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 a3 a3 a3 a3 a3 a3 a
                                                                              (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 \rightarrow "np"]
 + (3 * a2 * a3 * m3 + 6 * a2 * a3 * m4) * np.sin(2 * q2 + q3) + ((a3 ** 2) * m3 + 3 * (a3 ** 2) * (a
                                                            a4 * m4 * np.sin(2 * q2 + 2 * q3 + q4) + (a4 ** 2) * m4 * np.sin(2 * q2 + 2 * q3 + 2 * q4))
    ln[\cdot]:= c[1, 1, 3]
Out[-] = \frac{1}{12} \left( (3 \text{ a2 a3 m3} + 6 \text{ a2 a3 m4}) \text{Sin}[q3] + (3 \text{ a2 a3 m3} + 6 \text{ a2 a3 m4}) \text{Sin}[2 \text{ q2} + \text{q3}] + (3 \text{ a2 a3 m3} + 6 \text{ a2 a3 m4}) \text{Sin}[2 \text{ q2} + \text{q3}] + (3 \text{ a2 a3 m3} + 6 \text{ a2 a3 m4}) \text{Sin}[2 \text{ q2} + \text{q3}] + (3 \text{ a2 a3 m3} + 6 \text{ a2 a3 m4}) \text{Sin}[2 \text{ q2} + \text{q3}] + (3 \text{ a2 a3 m3} + 6 \text{ a2 a3 m4}) \text{Sin}[2 \text{ q2} + \text{q3}] + (3 \text{ a3 a3 m3} + 6 \text{ a3 a3 m3}) \text{Sin}[2 \text{ q2} + \text{q3}] + (3 \text{ a3 a3 m3} + 6 \text{ a3 a3 m3}) \text{Sin}[2 \text{ q3} + \text{q3}] + (3 \text{ a3 a3 m3}) \text{Sin}[2 \text{ q3} + \text{q3}] + (3 \text{ a3 a3 m3}) \text{Sin}[2 \text{ q3} + \text{q3}] + (3 \text{ a3 a3 m3}) \text{Sin}[2 \text{ q3} + \text{q3}] + (3 \text{ a3 a3 m3}) \text{Sin}[2 \text{ q3} + \text{q3}] + (3 \text{ a3 a3 m3}) \text{Sin}[2 \text{ q3} + \text{q3}] + (3 \text{ a3 a3 m3}) \text{Sin}[2 \text{ q3} + \text{q3}] + (3 \text{ a3 a3 m3}) \text{Sin}[2 \text{ q3} + \text{q3}] + (3 \text{ a3 a3 m3}) \text{Sin}[2 \text{ q3} + \text{q3}] + (3 \text{ a3 a3 m3}) \text{Sin}[2 \text{ q3} + \text{q3}] + (3 \text{ a3 a3 m3}) \text{Sin}[2 \text{ q3} + \text{q3}] + (3 \text{ a3 a3 m3}) \text{Sin}[2 \text{ q3} + \text{q3}] + (3 \text{ a3 a3 m3}) \text{Sin}[2 \text{ q3} + \text{q3}] + (3 \text{ a3 a3 m3}) \text{Sin}[2 \text{ q3} + \text{q3}] + (3 \text{ a3 a3 m3}) \text{Sin}[2 \text{ q3} + \text{q3}] + (3 \text{ a3 a3 m3}) + (3
                                                                     (2 \text{ a3}^2 \text{ m3} + 6 \text{ a3}^2 \text{ m4}) \sin[2 \text{ q2} + 2 \text{ q3}] + 3 \text{ a2} \text{ a4} \text{ m4} \sin[q3 + q4] + 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] + 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] + 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] + 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] + 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] + 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] + 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] + 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] + 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] + 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] + 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] + 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] + 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] + 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] + 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] + 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] + 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] + 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] + 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] + 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] + 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] + 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] + 3 \text{ a2} \text{ a4} \text{ a
                                                                     6 a3 a4 m4 Sin[2 q2 + 2 q3 + q4] + 2 a4<sup>2</sup> m4 Sin[2 q2 + 2 q3 + 2 q4]
```

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log_{-1} = ToPython \left[ \frac{1}{12} \left( (3 a2 a3 m3 + 6 a2 a3 m4) Sin[q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m3 + 6 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2 q2 + q3] + (3 a2 a3 m4) Sin[2
                                   (2 a3<sup>2</sup> m3 + 6 a3<sup>2</sup> 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<sup>2</sup> m4 Sin[2 q2 + 2 q3 + 2 q4]), NumpyPrefix \rightarrow "np"]
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))
  ln[\cdot]:= c[1, 1, 4]
Out[-]= \frac{1}{2} a4 m4 (3 a2 Cos[q2] + 3 a3 Cos[q2 + q3] + 2 a4 Cos[q2 + q3 + q4]) Sin[q2 + q3 + q4]
 lo[-]:= ToPython \begin{bmatrix} 1 \\ -6 \end{bmatrix} a4 m4 (3 a2 Cos[q2] + 3 a3 Cos[q2 + q3] + 2 a4 Cos[q2 + q3 + q4]) Sin[q2 + q3 + q4],
                       NumpyPrefix → "np"]
* 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} ((-a2<sup>2</sup> m2 - 3 a2<sup>2</sup> m3 - 3 a2<sup>2</sup> m4) Sin[2 q2] +
                              (-3 \text{ a2 a3 m3} - 6 \text{ a2 a3 m4}) \sin[2 \text{ q2} + \text{q3}] + (-a3^2 \text{ m3} - 3 a3^2 \text{ m4}) \sin[2 \text{ q2} + 2 \text{ q3}] - (-a3^2 \text{ m3} - 3 a3^2 \text{ m4}) \sin[2 \text{ q2} + 2 \text{ q3}] - (-a3^2 \text{ m3} - 3 a3^2 \text{ m4}) \sin[2 \text{ q2} + 2 \text{ q3}] - (-a3^2 \text{ m3} - 3 a3^2 \text{ m4}) \sin[2 \text{ q2} + 2 \text{ q3}] - (-a3^2 \text{ m3} - 3 a3^2 \text{ m4}) \sin[2 \text{ q2} + 2 \text{ q3}] - (-a3^2 \text{ m3} - 3 a3^2 \text{ m4}) \sin[2 \text{ q2} + 2 \text{ q3}] - (-a3^2 \text{ m3} - 3 a3^2 \text{ m4}) \sin[2 \text{ q2} + 2 \text{ q3}] - (-a3^2 \text{ m3} - 3 a3^2 \text{ m4}) \sin[2 \text{ q2} + 2 \text{ q3}] - (-a3^2 \text{ m3} - 3 a3^2 \text{ m4}) \sin[2 \text{ q2} + 2 \text{ q3}] - (-a3^2 \text{ m3} - 3 a3^2 \text{ m4}) \sin[2 \text{ q2} + 2 \text{ q3}] - (-a3^2 \text{ m3} - 3 a3^2 \text{ m4}) \sin[2 \text{ q2} + 2 \text{ q3}] - (-a3^2 \text{ m3} - 3 a3^2 \text{ m4}) \sin[2 \text{ q2} + 2 \text{ q3}] - (-a3^2 \text{ m3} - 3 a3^2 \text{ m4}) \sin[2 \text{ q2} + 2 \text{ q3}] - (-a3^2 \text{ m3} - 3 a3^2 \text{ m4}) \sin[2 \text{ q2} + 2 \text{ q3}] - (-a3^2 \text{ m3} - 3 a3^2 \text{ m4}) \sin[2 \text{ q2} + 2 \text{ q3}] - (-a3^2 \text{ m3} - 3 a3^2 \text{ m4}) \sin[2 \text{ q2} + 2 \text{ q3}] - (-a3^2 \text{ m3} - 3 a3^2 \text{ m4}) \sin[2 \text{ q2} + 2 \text{ q3}] - (-a3^2 \text{ m3} - 3 a3^2 \text{ m4}) \sin[2 \text{ q2} + 2 \text{ q3}] - (-a3^2 \text{ m3} - 3 a3^2 \text{ m4}) \sin[2 \text{ q2} + 2 \text{ q3}] - (-a3^2 \text{ m3} - 3 a3^2 \text{ m4}) \sin[2 \text{ q2} + 2 \text{ q3}] - (-a3^2 \text{ m3} - 3 a3^2 \text{ m4}) \sin[2 \text{ q2} + 2 \text{ q3}] - (-a3^2 \text{ m3} - 3 a3^2 \text{ m4}) \sin[2 \text{ q2} + 2 \text{ q3}] - (-a3^2 \text{ m3} - 3 a3^2 \text{ m4}) \sin[2 \text{ q2} + 2 \text{ q3}] - (-a3^2 \text{ m3} - 3 a3^2 \text{ m4}) \sin[2 \text{ q2} + 2 \text{ q3}] - (-a3^2 \text{ m3} - 3 a3^2 \text{ m4}) \sin[2 \text{ q2} + 2 \text{ q3}] - (-a3^2 \text{ m3} - 3 a3^2 \text{ m4}) \sin[2 \text{ q2} + 2 \text{ q3}] - (-a3^2 \text{ m3} - 3 a3^2 \text{ m4}) \sin[2 \text{ q2} + 2 \text{ q3}] - (-a3^2 \text{ m3} - 3 a3^2 \text{ m3}) \cos[2 \text{ q3} + 2 \text{ q3}] - (-a3^2 \text{ m3} - 3 a3^2 \text{ m4}) \cos[2 \text{ q3} + 2 \text{ q3}] - (-a3^2 \text{ m3} - 3 a3^2 \text{ m4}) \cos[2 \text{ q3} + 2 \text{ q3}] - (-a3^2 \text{ m3} - 3 a3^2 \text{ m4}) \cos[2 \text{ q3} + 2 \text{ q3}] - (-a3^2 \text{ m3} - 3 a3^2 \text{ m4}) \cos[2 \text{ q3} + 2 \text{ q3}] - (-a3^2 \text{ m3} - 3 a3^2 \text{ m4}) \cos[2 \text{ q3} + 2 \text{ q3}] - (-a3^2 \text{ m3} - 3 a3^2 \text{ m4}) \cos[2 \text{ q3} + 2 \text{ q3}] - (-a3^2 \text{ m3} - 3 a3^2 \text{ m4}) \cos[2 \text{ q3} + 2 \text{ q3}] - (-a3^2 \text{ m3} - 3 a3^2 \text{ m
                              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]
 (-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 \rightarrow "np"]
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]= 0
  ln[\cdot]:= c[1, 2, 3]
Out[0]= 0
  ln[\cdot]:= c[1, 2, 4]
Out[-]= 0
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In[.]:= c[1, 3, 1]
(-2 \text{ a3}^2 \text{ m3} - 6 \text{ a3}^2 \text{ m4}) \sin[2 \text{ q2} + 2 \text{ q3}] - 3 \text{ a2} \text{ a4} \text{ m4} \sin[q3 + q4] - 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] - 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] - 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] - 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] - 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] - 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] - 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] - 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] - 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] - 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] - 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] - 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] - 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] - 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] - 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] - 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] - 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] - 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] - 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] - 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] - 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] - 3 \text{ a2} \text{ a4} \text{ m4} \sin[2 \text{ q2} + q3 + q4] - 3 \text{ a2} \text{ a4} \text{ a4} \text{ a4} - 3 \text{ a2} \text{ a4} - 3 \text{ a2} \text{ a4} + 3 \text{ a3} - 3 \text{ a4} + 3 \text{ a4} 3 \text{
                                        6 a3 a4 m4 Sin[2 q2 + 2 q3 + q4] - 2 a4^2 m4 <math>Sin[2 q2 + 2 q3 + 2 q4]
 log[-1] = ToPython[\frac{1}{13}] ((-3 a2 a3 m3 - 6 a2 a3 m4) Sin[q3] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m3 - 6 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m4) Sin[2 q2 + q3] + (-3 a2 a3 m4) Si
                                             (-2 \text{ a3}^2 \text{ m3} - 6 \text{ a3}^2 \text{ m4}) \sin[2 \text{ q2} + 2 \text{ q3}] - 3 \text{ a2} a4 m4 \sin[\text{q3} + \text{q4}] - 3 \text{ a2} a4 m4 \sin[2 \text{ q2} + \text{q3} + \text{q4}] - 3 \text{ a2}
                                             6 a3 a4 m4 Sin[2 q2 + 2 q3 + q4] - 2 a4^2 m4 <math>Sin[2 q2 + 2 q3 + 2 q4], NumpyPrefix \rightarrow "np"]
* a2 * a3 * m3 -6 * a2 * a3 * m4) * np.sin(2 * q2 + q3) + (-2 * (a3 ** 2) * m3)
                                  * q2 + 2 * q3 + q4) -2 * (a4 ** 2) * m4 * np.sin(2 * q2 + 2 * q3 + 2 * q4))
  ln[\cdot]:= c[1, 3, 2]
Out[0]= 0
  In[.]:= c[1, 3, 3]
Out[•]= 0
  ln[\cdot]:= c[1, 3, 4]
Out[o]= 0
  In[.]:= c[1, 4, 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]
  log_{-} = ToPython[-\frac{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"]
* np.cos(q2 + q3) + 2 * a4 * np.cos(q2 + q3 + q4)) * np.sin(q2 + q3 + q4)
  ln[\cdot]:= c[1, 4, 2]
Out[-]= 0
  ln[-]:= c[1, 4, 3]
Out[-]= 0
  In[.]:= c[1, 4, 4]
```

Out[•]= **0**

```
In[.]:= c[2, 1, 1]
\textit{Out[*]} = \frac{1}{6} \left( \left( -a2^2 \, m2 - 3 \, a2^2 \, m3 - 3 \, a2^2 \, m4 \right) \, Sin[2 \, q2] + \right.
                       (-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<sup>2</sup> m4 Sin[2 q2 + 2 q3 + 2 q4]
 (-a3<sup>2</sup> m3 - 3 a3<sup>2</sup> 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 \rightarrow "np"]
+ (-3 * a2 * a3 * m3 - 6 * a2 * a3 * m4) * np.sin(2 * q2 + q3) + (-((a3 ** 2) * m3) - 3 * (a3 ** 2) * m3) + (-((a3 ** 2) * m3) + (-((
                    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]= 0
 ln[\cdot]:= c[2, 1, 3]
Out[=]= 0
 ln[\cdot]:= c[2, 1, 4]
Out[-]= 0
 In[.] = c[2, 2, 1]
Out[0]= 0
 ln[\cdot]:= c[2, 2, 2]
Out[-]= 0
 In[0]:= c[2, 2, 3]
Out[-]= \frac{1}{2} a2 ((a3 m3 + 2 a3 m4) Sin[q3] + a4 m4 Sin[q3 + q4])
 In[-]:= ToPython \begin{bmatrix} \frac{1}{2} & 2 & ((a3 m3 + 2 a3 m4) Sin[q3] + a4 m4 Sin[q3 + q4]), NumpyPrefix <math>\rightarrow "np"]
Out[\cdot]=0.5 * a2 * ((a3 * m3 + 2 * a3 * m4) * np.sin(q3) + a4 * m4 * np.sin(q3 + q4))
 ln[\cdot]:= c[2, 2, 4]
Out[*]= \frac{1}{2} a4 m4 (a3 Sin[q4] + a2 Sin[q3 + q4])
 lo[-]:= ToPython\begin{bmatrix} 1\\2 \end{bmatrix} a4 m4 (a3 Sin[q4] + a2 Sin[q3 + q4]), NumpyPrefix \rightarrow "np"
Out[\cdot]= 0.5 * a4 * m4 * (a3 * np.sin(q4) + a2 * np.sin(q3 + q4))
```

$$ln[\cdot]:= c[2, 3, 1]$$

Out[0]= 0

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

$$lo[\cdot]:= \text{ ToPython}\Big[-\frac{1}{2} \text{ a2 ((a3 m3 + 2 a3 m4) Sin[q3] + a4 m4 Sin[q3 + q4]), NumpyPrefix} \rightarrow "np"\Big]$$

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

$$ln[\cdot]:= c[2, 3, 3]$$

Out[•]= **0**

$$ln[\cdot]:= c[2, 3, 4]$$

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

$$ln[-]:=$$
 ToPython[a3 a4 m4 Cos[$\frac{q4}{2}$] Sin[$\frac{q4}{2}$], NumpyPrefix \rightarrow "np"]

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

Out[0]= 0

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

$$lo[\cdot]:=$$
 ToPython $\left[-\frac{1}{2} \text{ a4 m4 (a3 Sin[q4] + a2 Sin[q3 + q4]), NumpyPrefix} \rightarrow "np"\right]$

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

Out[*]= -a3 a4 m4
$$\cos\left[\frac{q4}{2}\right] \sin\left[\frac{q4}{2}\right]$$

$$ln[\cdot]:=$$
 ToPython[-a3 a4 m4 Cos[$\frac{q4}{2}$] Sin[$\frac{q4}{2}$], NumpyPrefix \rightarrow "np"]

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

$$ln[\cdot]:= c[2, 4, 4]$$

Out[•]= 0

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

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

$$lo[\cdot]:= \text{ ToPython}\Big[-\frac{1}{2} \text{ a2 ((a3 m3 + 2 a3 m4) Sin[q3] + a4 m4 Sin[q3 + q4]), NumpyPrefix} \rightarrow "np"\Big]$$

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

$$ln[\cdot]:= c[3, 3, 4]$$

$$\mathit{Out[\@agray belowder]{\circ}} \ a3\ a4\ m4\ Cos\Big[\frac{q4}{2}\Big] Sin\Big[\frac{q4}{2}\Big]$$

$$ln[\cdot]:=$$
 ToPython[a3 a4 m4 Cos[$\frac{q4}{2}$] Sin[$\frac{q4}{2}$], NumpyPrefix \rightarrow "np"]

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

$$ln[\cdot]:= c[3, 4, 2]$$

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

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

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

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

$$ln[-]:=$$
 ToPython[-a3 a4 m4 Cos[$\frac{q4}{2}$] Sin[$\frac{q4}{2}$], NumpyPrefix \rightarrow "np"]

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

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

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

$$ln[\cdot]:= c[4, 3, 3]$$

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

$$ln[\cdot]:=$$
 ToPython[-a3 a4 m4 Cos[$\frac{q4}{2}$] Sin[$\frac{q4}{2}$], NumpyPrefix \rightarrow "np"]

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

$$ln[\cdot]:= c[4, 3, 4]$$

$$ln[.] = c[4, 4, 2]$$

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

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

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

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

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

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

$$\begin{aligned} & \textit{Out}[\cdot] = & \frac{\text{d}1^2 \, \text{m1}}{12} + \frac{1}{12} \, \text{a2}^2 \, \text{m2} \, \text{Cos}[\text{q2}]^2 + \frac{1}{12} \, \text{a3}^2 \, \text{m3} \, \text{Cos}[\text{q2} + \text{q3}]^2 + \\ & \frac{1}{12} \, \text{a4}^2 \, \text{m4} \, \text{Cos}[\text{q2} + \text{q3} + \text{q4}]^2 + \text{m2} \left(\frac{1}{4} \, \text{a2}^2 \, \text{Cos}[\text{q1}]^2 \, \text{Cos}[\text{q2}]^2 + \frac{1}{4} \, \text{a2}^2 \, \text{Cos}[\text{q2}]^2 \, \text{Sin}[\text{q1}]^2 \right) + \\ & \text{m3} \left(\left(-\frac{1}{2} \, \text{a3} \, \text{Cos}[\text{q1}] \, \text{Cos}[\text{q2} + \text{q3}] + \text{Cos}[\text{q1}] \, \left(\text{a2} \, \text{Cos}[\text{q2}] + \text{a3} \, \text{Cos}[\text{q2} + \text{q3}] \right) \right)^2 + \\ & \left(\frac{1}{2} \, \text{a3} \, \text{Cos}[\text{q2} + \text{q3}] \, \text{Sin}[\text{q1}] - \left(\text{a2} \, \text{Cos}[\text{q2}] + \text{a3} \, \text{Cos}[\text{q2} + \text{q3}] \right) \, \text{Sin}[\text{q1}] \right)^2 \right) + \\ & \text{m4} \left(\left(-\frac{1}{2} \, \text{a4} \, \text{Cos}[\text{q1}] \, \text{Cos}[\text{q2} + \text{q3} + \text{q4}] + \text{Cos}[\text{q1}] \, \left(\text{a2} \, \text{Cos}[\text{q2}] + \text{a3} \, \text{Cos}[\text{q2} + \text{q3}] + \text{a4} \, \text{Cos}[\text{q2} + \text{q3} + \text{q4}] \right) \right)^2 + \\ & \left(\frac{1}{2} \, \text{a4} \, \text{Cos}[\text{q2} + \text{q3} + \text{q4}] \, \text{Sin}[\text{q1}] - \left(\text{a2} \, \text{Cos}[\text{q2}] + \text{a3} \, \text{Cos}[\text{q2} + \text{q3}] + \text{a4} \, \text{Cos}[\text{q2} + \text{q3} + \text{q4}] \right) \, \text{Sin}[\text{q1}] \right)^2 \right) \end{aligned}$$

$$\begin{aligned} & \text{mi}[-] & \text{ToPython} \left(\frac{\text{d}^2 \, \text{m1}}{12} + \frac{1}{12} \, \text{a} \, \text{2}^2 \, \text{m2} \, \text{Cos}[q2]^2 + \frac{1}{12} \, \text{a} \, \text{a}^2 \, \text{m3} \, \text{Cos}[q2 + q3]^2 + \\ & \frac{1}{12} \, \text{a} \, \text{d}^2 \, \text{m4} \, \text{Cos}[q2 + q3 + q4]^2 + \text{m2} \left(\frac{1}{4} \, \text{a} \, \text{a}^2 \, \text{Cos}[q1]^2 \, \text{Cos}[q2]^2 + \frac{1}{4} \, \text{a} \, \text{a}^2 \, \text{Cos}[q2]^2 \, \text{Sin}[q1]^2 \right) + \\ & \text{m3} \left(\left(-\frac{1}{2} \, \text{a3} \, \text{Cos}[q2 + q3] \, \text{Fin}[q1] - \left(\text{a2} \, \text{Cos}[q2] + \text{a3} \, \text{Cos}[q2 + q3] \, \text{Sin}[q1] \right)^2 \right) + \\ & \text{m4} \left(\left(-\frac{1}{2} \, \text{a4} \, \text{Cos}[q1] \, \text{Cos}[q2 + q3 + q4] + \text{Cos}[q1] \, \left(\text{a2} \, \text{Cos}[q2] + \text{a3} \, \text{Cos}[q2 + q3] + \text{a4} \, \text{Cos}[q2 + q3 + q4] \right) \right)^2 + \\ & \left(\frac{1}{2} \, \text{a4} \, \text{Cos}[q2] + \text{a3} \, \text{Cos}[q2 + q3] + \text{a4} \, \text{Cos}[q2] + \text{a3} \, \text{Cos}[q2 + q3] + \text{a4} \, \text{Cos}[q2 + q3 + q4] \right) \right)^2 + \\ & \left(\frac{1}{2} \, \text{a4} \, \text{Cos}[q2] + \text{a3} \, \text{Cos}[q2 + q3] + \text{a4} \, \text{Cos}[q2] + \text{a3} \, \text{Cos}[q2 + q3] + \text{a4} \, \text{Cos}[q2 + q3 + q4] \right) \right)^2 + \\ & \left(\frac{1}{2} \, \text{a4} \, \text{Cos}[q2] + \text{a3} \, \text{Cos}[q2 + q3] + \text{a4} \, \text{Cos}[q2] + \text{a3} \, \text{Cos}[q2 + q3] + \text{a4} \, \text{Cos}[q2 + q3] + \text{a4} \, \text{Cos}[q2 + q3] + \text{a4} \, \text{Cos}[q2 + q3] \right)^2 \right) \right) \\ & \text{cut}[-]^2 & \left(\frac{1}{2} \, \text{a4} \, \text{Cos}[q2] + \text{a3} \, \text{Cos}[q2 + q3] + \text{a4} \, \text{Cos}[q2 + q3] + \text{a4} \, \text{Cos}[q2 + q3] \right) \right) \right) \\ & \left(\frac{1}{2} \, \text{a4} \, \text{Cos}[q2] + \text{a3} \, \text{Cos}[q2 + q3] + \text{a4} \, \text{Cos}[q2] + \text{a3} \, \text{Cos}[q2] + \text{a3} \, \text{Cos}[q2] \right) \right) \\ & \left(\frac{1}{2} \, \text{a4} \, \text{Cos}[q2] + \text{a3} \, \text{Cos}[q2] + \text{a3} \, \text{A4} \, \text{Cos}[q2] + \text{a3} \, \text{Cos}[q2] + \text{a3} \, \text{A3} \right) \right) \\ & \left(\frac{1}{2} \, \text{(np.cos}[q2] + \text{a3} \, \text{(np.cos}[q2] + \text{a3} \, \text{a4} + \text{a2} \right) \right) \right) \\ & \left(\frac{1}{2} \, \text{(np.cos}[q2] + \text{a3} \, \text{np.cos}[q2] + \text{a3} \, \text{np.cos}[q2] + \text{a3} \, \text{np.cos}[q2] \right) \\ & \left(\frac{1}{2} \, \text{a3} \, \text{(np.cos}[q2] + \text{a3} \, \text{np.cos}[q2] + \text{a3} \, \text{np.cos}[q2] + \text{a3} \, \text{np.cos}[q2] \right) \\ & \left(\frac{1}{2} \, \text{a3} \, \text{(np.cos}[q2] + \text{a3} \, \text{np.cos}[q2] + \text{a3} \, \text{np.cos}[q2] + \text{a3} \, \text{np.cos}[q2] + \text{a3} \, \text{np.cos}[q2] \right) \\ & \left(\frac{1}{2} \, \text{a3} \, \text{Cos}[q2] + \text{$$

ToPython[
$$m3\left(-\frac{1}{2} \ a3\left(-\frac{1}{2} \ a3 \cos[q_1] \cos[q_2+q_3] + \cos[q_1] \left(a2 \cos[q_2] + a3 \cos[q_2+q_3]\right) \sin[q_1] \sin[q_2+q_3] - \frac{1}{2} \ a3 \cos[q_1] \left(\frac{1}{2} \ a3 \cos[q_2+q_3] \sin[q_1] - \left(a2 \cos[q_2] + a3 \cos[q_2+q_3]\right) \sin[q_1]\right) \sin[q_2+q_3] + m4\left(-\left(-\frac{1}{2} \ a4 \cos[q_2+q_3+q_4] + \cos[q_1] \left(a2 \cos[q_2] + a3 \cos[q_2+q_3] + a4 \cos[q_2+q_3+q_4]\right)\right) \sin[q_1] \left(a3 \sin[q_2+q_3] + \frac{1}{2} \ a4 \sin[q_2+q_3+q_4]\right) - \cos[q_1] \left(\frac{1}{2} \ a4 \cos[q_2+q_3+q_4] + \frac{1}{2} \ a4 \sin[q_2+q_3+q_4]\right), \ \text{NumpyPrefix} + \text{"np"}$$

$$\left(a3 \sin[q_2+q_3] + \frac{1}{2} \ a4 \sin[q_2+q_3+q_4]\right), \ \text{NumpyPrefix} + \text{"np"}$$

$$\left(a3 \sin[q_2+q_3] + \frac{1}{2} \ a4 \sin[q_2+q_3+q_4]\right), \ \text{NumpyPrefix} + \text{"np"}$$

$$\left(a3 \sin[q_2+q_3] + \frac{1}{2} \ a4 \sin[q_2+q_3+q_4]\right), \ \text{NumpyPrefix} + \text{"np"}$$

$$\left(a3 \sin[q_2+q_3] + \frac{1}{2} \ a4 \sin[q_2+q_3+q_4]\right), \ \text{np.} \cos[q_2+q_3] + \text{np.} \cos[q_1+q_3] + \text{np.} \sin[q_1+q_3] + \text{np.} \cos[q_1+q_3] + \text{np.} \cos[q_1+q_3+q_4] + \text{np.} \cos[q_1+q_3+q_$$

```
In[.]:= MU[2, 1]
Out[-]= m3 \left(-\left(\left(-\frac{1}{2} \text{ a3 Cos}[q1] \text{ Cos}[q2+q3] + \text{Cos}[q1] \left(\text{a2 Cos}[q2] + \text{a3 Cos}[q2+q3]\right)\right)\right)
                                                                                                 Sin[q1] \left(a2 Sin[q2] + \frac{1}{2} a3 Sin[q2 + q3]\right) - Cos[q1]
                                                                              \left(\frac{1}{2} \text{ a3 Cos}[q2+q3] \text{ Sin}[q1] - \left(\text{a2 Cos}[q2]+\text{a3 Cos}[q2+q3]\right) \text{ Sin}[q1]\right) \left(\text{a2 Sin}[q2] + \frac{1}{2} \text{ a3 Sin}[q2+q3]\right) + \frac{1}{2} \text{ a3 Sin}[q2+q3]\right)
                                            m4\left(-\left(\left(-\frac{1}{2} \text{ a4 Cos[q1] Cos[q2+q3+q4]+ Cos[q1] (a2 Cos[q2]+a3 Cos[q2+q3]+a4 Cos[q2+q3+q4])\right)\right)
                                                                                                 Sin[q1] \left(a2 Sin[q2] + a3 Sin[q2 + q3] + \frac{1}{2} a4 Sin[q2 + q3 + q4]\right)
                                                                       \cos[q_1] \left( \frac{1}{2} \text{ a4 } \cos[q_2 + q_3 + q_4] \sin[q_1] - \left( \text{a2 } \cos[q_2] + \text{a3 } \cos[q_2 + q_3] + \text{a4 } \cos[q_2 + q_3 + q_4] \right) \sin[q_1] \right)
                                                                               \left(a2 \sin[q2] + a3 \sin[q2 + q3] + \frac{1}{2} a4 \sin[q2 + q3 + q4]\right)
    I_{n[\cdot]} = \text{ToPython}[m3 \left(-\left(-\frac{1}{2} \text{ a3 Cos[q1] Cos[q2 + q3] + Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3])}\right)]
                                                                                                         Sin[q1] \left(a2 Sin[q2] + \frac{1}{2} a3 Sin[q2 + q3]\right) - Cos[q1]
                                                                                      \left(\frac{1}{2} \text{ a3 Cos}[q2+q3] \text{ Sin}[q1] - \left(\text{a2 Cos}[q2] + \text{a3 Cos}[q2+q3]\right) \text{ Sin}[q1]\right) \left(\text{a2 Sin}[q2] + \frac{1}{2} \text{ a3 Sin}[q2+q3]\right)\right) +
                                                     m4\left(-\left(\left(-\frac{1}{2}\right)^{2}\right)^{2} + a^{2} + a^{2
                                                                                                          Sin[q1] \left(a2 Sin[q2] + a3 Sin[q2 + q3] + \frac{1}{2} a4 Sin[q2 + q3 + q4]\right)
                                                                               Cos[q1] \left(\frac{1}{2} \text{ a4 } Cos[q2+q3+q4] \, Sin[q1] - \left(\text{a2 } Cos[q2]+\text{a3 } Cos[q2+q3]+\text{a4 } Cos[q2+q3+q4]\right) \, Sin[q1]\right)
                                                                                        \left(a2 \operatorname{Sin}[q2] + a3 \operatorname{Sin}[q2 + q3] + \frac{1}{2} a4 \operatorname{Sin}[q2 + q3 + q4]\right), NumpyPrefix \rightarrow "np"
 out = m3 * (-((-0.5 * a3 * np.cos(q1) * np.cos(q2 + q3) + np.cos(q1) * (a2 * np.cos(q2) + a3 * np.co
                                                       np.cos(q2 + q3))) * np.sin(q1) * (a2 * np.sin(q2) + 0.5 * a3 * np.sin(q2 + q3))) -(np.cos(q1)) + (np.cos(q1)) + (np.cos(q1))
                                                      * (0.5 * a3 * np.cos(q2 + q3) * np.sin(q1) - ((a2 * np.cos(q2) + a3 * np.cos(q2 + q3))
                                                       np.cos(q1) * np.cos(q2 + q3 + q4) + np.cos(q1) * (a2 * np.cos(q2) + a3 * np.cos(q2 + q3) + np.cos(q2) + a3 * np.cos(q3) + a3 * np.cos(q3
                                                       q3) + a4 * np.cos(q2 + q3 + q4))) * np.sin(q1) * (a2 * np.sin(q2) + a3 * np.sin(q2 + q3)) + a4 * np.cos(q2 + q3 + q4))) * np.sin(q1) * (a2 * np.sin(q2) + a3 * np.sin(q2) + a3 * np.sin(q2) + a4 * np.cos(q2 + q3) + a4 * np.cos(q3) + a4 * np.cos(q
                                                       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 * <math>np.sin(q2 + q3 + q4)))
```

$$\begin{aligned} & \frac{1}{12} \ \ \, \text{a2}^2 \ \, \text{m2} \ \, \text{Cos}[\text{q1}]^2 \left(\text{Cos}[\text{q1}]^2 + \text{Sin}[\text{q1}]^2 \right) + \frac{1}{12} \ \, \text{a3}^2 \ \, \text{m3} \ \, \text{Cos}[\text{q1}]^2 \left(\text{Cos}[\text{q1}]^2 + \text{Sin}[\text{q1}]^2 \right) + \frac{1}{12} \ \, \text{a2}^2 \ \, \text{m2} \ \, \text{Sin}[\text{q1}]^2 \left(\text{Cos}[\text{q1}]^2 + \text{Sin}[\text{q1}]^2 \right) + \frac{1}{12} \ \, \text{a2}^2 \ \, \text{m2} \ \, \text{Sin}[\text{q1}]^2 \left(\text{Cos}[\text{q1}]^2 + \text{Sin}[\text{q1}]^2 \right) + \frac{1}{12} \ \, \text{a2}^2 \ \, \text{m3} \ \, \text{Sin}[\text{q1}]^2 \left(\text{Cos}[\text{q1}]^2 + \text{Sin}[\text{q1}]^2 \right) + \frac{1}{12} \ \, \text{a4}^2 \ \, \text{m4} \ \, \text{Sin}[\text{q1}]^2 \left(\text{Cos}[\text{q1}]^2 + \text{Sin}[\text{q1}]^2 \right) + \frac{1}{4} \ \, \text{a2}^2 \ \, \text{Cos}[\text{q1}]^2 + \frac{1}{4} \ \, \text{a2}^2 \ \, \text{Sin}[\text{q1}]^2 \right) + \frac{1}{4} \ \, \text{a2}^2 \ \, \text{Cos}[\text{q1}]^2 \ \, \text{Sin}[\text{q2}]^2 + \frac{1}{4} \ \, \text{a2}^2 \ \, \text{Sin}[\text{q1}]^2 \ \, \text{Sin}[\text{q2}]^2 + \frac{1}{4} \ \, \text{a2}^2 \ \, \text{Sin}[\text{q1}]^2 \ \, \text{Sin}[\text{q2}]^2 + \frac{1}{4} \ \, \text{a2}^2 \ \, \text{Sin}[\text{q1}]^2 \ \, \text{Sin}[\text{q2}]^2 + \frac{1}{4} \ \, \text{a2}^2 \ \, \text{Sin}[\text{q1}]^2 \ \, \text{Sin}[\text{q2}]^2 + \frac{1}{4} \ \, \text{a2}^2 \ \, \text{Sin}[\text{q1}]^2 \ \, \text{Sin}[\text{q2}]^2 + \frac{1}{4} \ \, \text{a2}^2 \ \, \text{Sin}[\text{q1}]^2 \ \, \text{Sin}[\text{q2}]^2 + \frac{1}{4} \ \, \text{a2}^2 \ \, \text{Sin}[\text{q1}]^2 \ \, \text{Sin}[\text{q2}]^2 + \frac{1}{4} \ \, \text{a2}^2 \ \, \text{Sin}[\text{q2}]^2 + \frac{1}{4} \ \, \text{a2}^2 \ \, \text{Sin}[\text{q2}]^2 + \frac{1}{4} \ \, \text{a2}^2 \ \, \text{Sin}[\text{q1}]^2 \ \, \text{Sin}[\text{q2}]^2 + \frac{1}{4} \ \, \text{a2}^2 \ \, \text{Sin}[\text{q1}]^2 \ \, \text{Sin}[\text{q2}]^2 + \frac{1}{4} \ \, \text{a2}^2 \ \, \text{Sin}[\text{q1}]^2 \ \, \text{Sin}[\text{q2}]^2 + \frac{1}{4} \ \, \text{a2}^2 \ \, \text{Sin}[\text{q2}]^2 + \frac{1}{4} \ \, \text{a2}^2 \ \, \text{Sin}[\text{q2}]^2 + \frac{1}{4} \ \, \text{a2}^2 \ \, \text{Sin}[\text{q1}]^2 \ \, \text{Sin}[\text{q1}]^2 \ \, \text{Sin}[\text{q2}]^2 + \frac{1}{4} \ \, \text{a2}^2 \ \, \text{Sin}[\text{q2}]^2 + \frac{1}{4} \ \, \text{a2}^2 \ \, \text{Sin}[\text{q1}]^2 \ \, \text{Sin}[$$

```
lo[-]= ToPython\left[\frac{1}{12} a2^2 m2 \cos[q1]^2 \left(\cos[q1]^2 + \sin[q1]^2\right) + \frac{1}{12} a3^2 m3 \cos[q1]^2 \cos[q1]^2 + \frac{1}{12} a3^2 m3 \cos[q1]^2 \cos[q1]^2 + \frac{1}{12} a3^2 m3 \cos[q1]^2 + \frac{1}{12} a
                                                           \frac{1}{12} \text{ a4}^2 \text{ m4 } \text{Cos}[q1]^2 \left( \text{Cos}[q1]^2 + \text{Sin}[q1]^2 \right) + \frac{1}{12} \text{ a2}^2 \text{ m2 } \text{Sin}[q1]^2 \left( \text{Cos}[q1]^2 + \text{Sin}[q1]^2 \right) + \frac{1}{12} \text{ a2}^2 \text{ m2 } \text{Sin}[q1]^2 \left( \text{Cos}[q1]^2 + \text{Sin}[q1]^2 \right) + \frac{1}{12} \text{ a2}^2 \text{ m2 } \text{Sin}[q1]^2 \right)
                                                           \frac{1}{12} a3<sup>2</sup> m3 Sin[q1]<sup>2</sup> (Cos[q1]<sup>2</sup> + Sin[q1]<sup>2</sup>) + \frac{1}{12} a4<sup>2</sup> m4 Sin[q1]<sup>2</sup> (Cos[q1]<sup>2</sup> + Sin[q1]<sup>2</sup>) + m2
                                                                  \left( \left( \frac{1}{2} \text{ a2 Cos}[q1]^2 \text{ Cos}[q2] + \frac{1}{2} \text{ a2 Cos}[q2] \text{ Sin}[q1]^2 \right)^2 + \frac{1}{4} \text{ a2}^2 \text{ Cos}[q1]^2 \text{ Sin}[q2]^2 + \frac{1}{4} \text{ a2}^2 \text{ Sin}[q1]^2 \text{ Sin}[q2]^2 \right) + \frac{1}{4} \text{ a2}^2 \text{ Cos}[q1]^2 \text{ Sin}[q2]^2 + \frac{1}{4} \text{ a2}^2 \text{ Sin}[q1]^2 \text{ Sin}[q2]^2 + \frac{1}{4} \text{ a2}^2 \text{ Sin}[q1]^2 \text{ Sin}[q2]^2 + \frac{1}{4} \text{ a2}^2 \text{ Sin}[q1]^2 \text{ Sin}[q2]^2 + \frac{1}{4} \text{ a2}^2 + \frac{1}{4} \text{ a2
                                                         m3 \left( \left[ \cos[q1] \left( -\frac{1}{2} \right] \right] + \cos[q1] \left[ \cos[q2] + a3 \cos[q2] + a
                                                                                                                   Sin[q1] \left(-\frac{1}{2} \text{ a3 } Cos[q2+q3] Sin[q1] + \left(a2 Cos[q2]+a3 Cos[q2+q3]\right) Sin[q1]\right)^{2} +
                                                                                      \cos[q_1]^2 \left(a2 \sin[q_2] + \frac{1}{2} a3 \sin[q_2 + q_3]\right)^2 + \sin[q_1]^2 \left(a2 \sin[q_2] + \frac{1}{2} a3 \sin[q_2 + q_3]\right)^2 + \sin[q_1]^2 \left(a2 \sin[q_2] + \frac{1}{2} a3 \sin[q_2 + q_3]\right)^2 + \sin[q_1]^2 \left(a2 \sin[q_2] + \frac{1}{2} a3 \sin[q_2 + q_3]\right)^2 + \sin[q_1]^2 \left(a2 \sin[q_2] + \frac{1}{2} a3 \sin[q_2 + q_3]\right)^2 + \sin[q_1]^2 \left(a2 \sin[q_2] + \frac{1}{2} a3 \sin[q_2 + q_3]\right)^2 + \sin[q_1]^2 \left(a2 \sin[q_2] + \frac{1}{2} a3 \sin[q_2 + q_3]\right)^2 + \sin[q_1]^2 \left(a2 \sin[q_2] + \frac{1}{2} a3 \sin[q_2 + q_3]\right)^2 + \sin[q_1]^2 \left(a2 \sin[q_2] + \frac{1}{2} a3 \sin[q_2 + q_3]\right)^2 + \sin[q_1]^2 \left(a2 \sin[q_2] + \frac{1}{2} a3 \sin[q_2 + q_3]\right)^2 + \sin[q_1]^2 \left(a2 \sin[q_2] + \frac{1}{2} a3 \sin[q_2 + q_3]\right)^2 + \sin[q_1]^2 \cos[q_1]^2 + \sin[q_2] + \sin[q_2]^2 + \sin[
                                                         m4 \left( \left[ \cos[q1] \left( -\frac{1}{2} \right] \right] + \cos[q1] \left[ \cos[q2 + q3 + q4] + \cos[q1] \left[ \cos[q2 + q3] + \cos[q2 + q3]
                                                                                                                   Sin[q1]\left(-\frac{1}{2} \text{ a4 } Cos[q2+q3+q4] Sin[q1]+\left(a2 Cos[q2+q3+q3]+a4 Cos[q2+q3+q4]\right)\right)
                                                                                                                                                         Sin[q1])<sup>2</sup> + Cos[q1]^2 \left(a2 Sin[q2] + a3 Sin[q2 + q3] + \frac{1}{2} a4 Sin[q2 + q3 + q4]\right)^2 +
                                                                                      Sin[q1]^2 \left( a2 Sin[q2] + a3 Sin[q2 + q3] + \frac{1}{2} a4 Sin[q2 + q3 + q4] \right)^2, NumpyPrefix \rightarrow "np"
2 + np.sin(q1) ** 2) + 0.0833333333333333333 * (a4 ** 2) * m4 * (np.cos(q1) ** 2) *
                                                           (np.sin(q1) ** 2) * (np.cos(q1) ** 2 + np.sin(q1) ** 2) + 0.0833333333333333 * (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) * <math>(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.si
                                                            ** 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(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))) ** (a2 * np.sin(q2)) ** (a3 * np.sin(q2)) ** (a4 * np.cos(q1) ** (a5 * 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]

$$\begin{aligned} & \frac{1}{12} \text{ a3}^2 \text{ m3 Cos}[q1]^2 \left(\text{Cos}[q1]^2 + \text{Sin}[q1]^2 \right) + \frac{1}{12} \text{ a4}^2 \text{ m4 Cos}[q1]^2 \left(\text{Cos}[q1]^2 + \text{Sin}[q1]^2 \right) + \\ & \frac{1}{12} \text{ a3}^2 \text{ m3 Sin}[q1]^2 \left(\text{Cos}[q1]^2 + \text{Sin}[q1]^2 \right) + \frac{1}{12} \text{ a4}^2 \text{ m4 Sin}[q1]^2 \left(\text{Cos}[q1]^2 + \text{Sin}[q1]^2 \right) + \\ & \text{m3} \left(\left[\text{Cos}[q1] \left(-\frac{1}{2} \text{ a3 Cos}[q1] \text{Cos}[q2 + q3] + \text{Cos}[q1] \left(\text{a2 Cos}[q2] + \text{a3 Cos}[q2 + q3] \right) \right) + \\ & \text{Sin}[q1] \left(-\frac{1}{2} \text{ a3 Cos}[q2] + \text{q3} \right) + \text{Cos}[q1] \left(\text{a2 Cos}[q2] + \text{a3 Cos}[q2 + q3] \right) + \\ & \text{Sin}[q1] \left(-\text{a2 Cos}[q1] \text{Cos}[q2] - \frac{1}{2} \text{ a3 Cos}[q1] \text{Cos}[q2 + q3] + \text{Cos}[q1] \left(\text{a2 Cos}[q2] + \text{a3 Cos}[q2 + q3] \right) \right) + \\ & \text{Sin}[q1] \left(-\text{a2 Cos}[q2] \text{Sin}[q1] - \frac{1}{2} \text{ a3 Cos}[q2 + q3] \text{Sin}[q2] + \frac{1}{2} \text{ a3 Sin}[q2 + q3] \right) + \\ & \frac{1}{2} \text{ a3 Cos}[q1]^2 \text{Sin}[q2 + q3] \left(\text{a2 Sin}[q2] + \frac{1}{2} \text{ a3 Sin}[q2 + q3] \right) + \\ & \frac{1}{2} \text{ a3 Sin}[q1]^2 \text{Sin}[q2 + q3] \left(\text{a2 Sin}[q2] + \frac{1}{2} \text{ a3 Sin}[q2 + q3] \right) + \\ & \text{m4} \left(\left[\text{Cos}[q1] \left(-\frac{1}{2} \text{ a4 Cos}[q1] \text{Cos}[q2 + q3 + q4] + \text{Cos}[q1] \left(\text{a2 Cos}[q2] + \text{a3 Cos}[q2 + q3] + \text{a4 Cos}[q2 + q3 + q4] \right) \right) + \\ & \text{Sin}[q1] \left(-\frac{1}{2} \text{ a4 Cos}[q1] \text{Cos}[q2 + q3 + q4] \text{Sin}[q1] + \left(\text{a2 Cos}[q2] + \text{a3 Cos}[q2 + q3] + \text{a4 Cos}[q2 + q3 + q4] \right) \right) \\ & \text{Sin}[q1] \left(\text{Cos}[q1] \left(-\text{a2 Cos}[q1] \text{Cos}[q2] - \frac{1}{2} \text{ a4 Cos}[q2] \text{Cos}[q2 + q3 + q4] \right) + \\ & \text{Cos}[q1] \left(\text{a2 Cos}[q2] + \text{a3 Cos}[q2 + q3] + \text{a4 Cos}[q2 + q3 + q4] \right) \right) + \\ & \text{Cos}[q1] \left(\text{a2 Cos}[q2] + \text{a3 Cos}[q2 + q3] + \text{a4 Cos}[q2 + q3] + \text{a4 Cos}[q2 + q3] + \text{a4 Cos}[q2] \text{Sin}[q1] \right) \right) + \\ & \text{Cos}[q1]^2 \left(\text{a3 Sin}[q2 + q3] + \frac{1}{2} \text{ a4 Sin}[q2 + q3 + q4] \right) \left(\text{a2 Sin}[q2] + \text{a3 Sin}[q2 + q3] + \frac{1}{2} \text{ a4 Sin}[q2 + q3 + q4] \right) \right) + \\ & \text{Sin}[q1]^2 \left(\text{a3 Sin}[q2 + q3] + \frac{1}{2} \text{ a4 Sin}[q2 + q3 + q4] \right) \left(\text{a2 Sin}[q2] + \text{a3 Sin}[q2] + \text{a3 Sin}[q2 + q3] + \frac{1}{2} \text{ a4 Sin}[q2 + q3 + q4] \right) \right) + \\ & \text{Sin}[q1]^2 \left(\text{a3 Sin}[q2 + q3] + \frac{1}{2} \text{ a4 Sin}[q2 + q3 + q4] \right) \left(\text{a2 Sin}[q$$

$$\begin{array}{l} I_{\text{pd}} = \text{ToPython} \Big[\frac{1}{12} \text{ a3}^2 \text{ m3 Cos}[q1]^2 \left(\text{Cos}[q1]^2 + \text{Sin}[q1]^2 \right) + \frac{1}{12} \text{ a4}^2 \text{ m4 Cos}[q1]^2 \left(\text{Cos}[q1]^2 + \text{Sin}[q1]^2 \right) + \\ \frac{1}{12} \text{ a3}^2 \text{ m3 Sin}[q1]^2 \left(\text{Cos}[q1]^2 + \text{Sin}[q1]^2 \right) + \frac{1}{12} \text{ a4}^2 \text{ m4 Sin}[q1]^2 \left(\text{Cos}[q1]^2 + \text{Sin}[q1]^2 \right) + \\ \text{m3} \left(\Big[\text{Cos}[q1] \left(-\frac{1}{2} \text{ a3 Cos}[q1] \text{ Cos}[q2 + q3] + \text{Cos}[q1] \left(\text{a2 Cos}[q2] + \text{a3 Cos}[q2 + q3] \right) \right) + \\ \text{Sin}[q1] \left(-\frac{1}{2} \text{ a3 Cos}[q2] + \text{a3] Sin}[q1] + \left(\text{a2 Cos}[q2] + \text{a3 Cos}[q2 + q3] \right) \text{Sin}[q1] \Big) \Big) \\ \left(\text{Cos}[q1] \left(-\text{a2 Cos}[q1] \text{ Cos}[q2] - \frac{1}{2} \text{ a3 Cos}[q1] \text{ Cos}[q2 + q3] + \text{Cos}[q1] \left(\text{a2 Cos}[q2] + \text{a3 Cos}[q2 + q3] \right) \right) + \\ \text{Sin}[q1] \left(-\text{a2 Cos}[q2] \text{ Sin}[q1] - \frac{1}{2} \text{ a3 Cos}[q2 + q3] \text{ Sin}[q1] + \left(\text{a2 Cos}[q2] + \text{a3 Cos}[q2 + q3] \right) \right) + \\ \frac{1}{2} \text{ a3 Cos}[q1]^2 \text{ Sin}[q2 + q3] \left(\text{a2 Sin}[q2] + \frac{1}{2} \text{ a3 Sin}[q2 + q3] \right) + \\ \frac{1}{2} \text{ a3 Sin}[q1]^2 \text{ Sin}[q2 + q3] \left(\text{a2 Sin}[q2] + \frac{1}{2} \text{ a3 Sin}[q2 + q3] \right) \right) + \\ \text{m4} \left(\Big[\text{Cos}[q1] \left(-\frac{1}{2} \text{ a4 Cos}[q1] \text{ Cos}[q2 + q3 + q4] + \text{Cos}[q1] \text{ (a2 Cos}[q2] + \text{a3 Cos}[q2 + q3] + \text{a4 Cos}[q2 + q3 + q4] \right) \right) + \\ \text{Sin}[q1] \left(-\frac{1}{2} \text{ a4 Cos}[q2 + q3 + q4] \text{ Sin}[q1] + \left(\text{a2 Cos}[q2] + \text{a3 Cos}[q2 + q3] + \text{a4 Cos}[q2 + q3 + q4] \right) \\ \text{Sin}[q1] \left(-\text{a2 Cos}[q1] \left(\text{cos}[q2 + q3 + q4] + \text{Cos}[q2] + \text{a3 Cos}[q2 + q3 + q4] \right) \right) + \\ \text{Cos}[q1] \left(\text{a2 Cos}[q2] + \text{a3 Cos}[q2 + q3] + \text{a4 Cos}[q2 + q3 + q4] \right) + \\ \text{Cos}[q1] \left(\text{a2 Sin}[q2 + q3] + \frac{1}{2} \text{ a4 Sin}[q2 + q3 + q4] \right) + \text{Sin}[q1] \right) + \\ \frac{1}{2} \text{ a4 Sin}[q2 + q3 + q4] + \text{Sin}[q1] \left(\text{a3 Sin}[q2 + q3 + q4] \right) \right) + \\ \text{Cos}[q1]^2 \left(\text{a3 Sin}[q2 + q3] + \frac{1}{2} \text{ a4 Sin}[q2 + q3 + q4] \right) \right) + \\ \text{Sin}[q2] + \text{a3 Sin}[q2 + q3] + \frac{1}{2} \text{ a4 Sin}[q2 + q3 + q4] \right) \right) + \\ \text{Cos}[q1]^2 \left(\text{a3 Sin}[q2 + q3] + \frac{1}{2} \text{ a4 Sin}[q2 + q3 + q4] \right) \right) + \\ \text{Sin}[q1]^2 \left(\text{a3 Sin}[q2 + q3] + \frac{1}{2} \text{ a4 Sin}[q2 + q3 + q4] \right) \right) + \\ \text{Cos}[q1]^2 \left(\text{a3 Sin}[q2 + q3] + \frac{$$

** 2) + 0.08333333333333333333 * (a3 ** 2) * m3 * (np.sin(q1) ** 2) * (np.cos(q1) ** 2 + ** 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 * q2)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 * q3))) + np.sin(q2) * (-(a2 * q3))) + np.sin(q2) * (-(a2 * q3))) + np.sin(q2) * (-(a2 * q3))) + (-(a2 * q3))) * (-(a2 * q3)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)) * np.sin(q3 + q3)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)) + np.sin(q1) * (-0.5 * a4 * np.cos(q+ 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) + np.cos(q2) + a3 * np.cos(q3) + a3 * np.cos(q3q3) + 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 * <math>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)))

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

$$\begin{array}{l} \inf_{(-)^2} \quad \text{ToPython} \Big[\frac{1}{12} \; \text{a3}^2 \; \text{m3} \; \text{Cos}[q1]^2 \left(\text{Cos}[q1]^2 + \text{Sin}[q1]^2 \right) + \frac{1}{12} \; \text{a4}^2 \; \text{m4} \; \text{Cos}[q1]^2 \left(\text{Cos}[q1]^2 + \text{Sin}[q1]^2 \right) + \frac{1}{12} \; \text{a4}^2 \; \text{m4} \; \text{Sin}[q1]^2 \left(\text{Cos}[q1]^2 + \text{Sin}[q1]^2 \right) + \frac{1}{12} \; \text{a4}^2 \; \text{m4} \; \text{Sin}[q1]^2 \left(\text{Cos}[q1]^2 + \text{Sin}[q1]^2 \right) + \frac{1}{2} \; \text{a3} \; \text{Cos}[q1] \left(-\frac{1}{2} \; \text{a3} \; \text{Cos}[q1] \; \text{Cos}[q2] + \text{q3}] + \text{Cos}[q1] \left(\text{a2} \; \text{Cos}[q2] + \text{a3} \; \text{Cos}[q2] + \text{q3}] \right) \right) + \frac{1}{2} \; \text{m3} \left(\left[\left(-\frac{1}{2} \; \text{a3} \; \text{Cos}[q2] + \text{q3} \right) \; \text{Sin}[q1] + \left(\text{a2} \; \text{Cos}[q2] + \text{a3} \; \text{Cos}[q2] + \text{q3} \right) \; \text{Sin}[q1] \right) \right) \right) \\ \quad \left(\text{Cos}[q1] \left(-\frac{1}{2} \; \text{a3} \; \text{Cos}[q2] + \frac{1}{2} \; \text{a4} \; \text{Cos}[q2] + \frac{1}{2} \; \text{a4} \; \text{Cos}[q2] + \frac{1}{2} \; \text{a3} \; \text{Cos}[q2] + \frac{1}{2} \; \text{a4} \; \text{Cos}[q2] +$$

** 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 * partial + q3)) + np.sin(q1) * (-(a2 * partial + q3))) + (-(a2 * partial + q3)))) + (-(a2 * partial + q3))))) + (-(a2 * partial + q3))))) + (-(a2 * partial + q3))))) + (-(a2 * partial + q3)))))) + (-(a2 * partial + q3)))))))) + (-(a2 * partial + q3)))))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)) * np.sin(q3 + q3)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)) + np.sin(q1) * (-0.5 * a4 * np.cos(q+ 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) + np.cos(q2) + np.cos(q3) + np.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 * <math>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] $Out[*] = \frac{1}{12} a4^2 \text{ m4 } Cos[q1]^2 \left(Cos[q1]^2 + Sin[q1]^2 \right) + \frac{1}{12} a4^2 \text{ m4 } Sin[q1]^2 \left(Cos[q1]^2 + Sin[q1]^2 \right) + \frac{1}{12} a4^2 \text{ m4 } Sin[q1]^2 \left(Cos[q1]^2 + Sin[q1]^2 \right) + \frac{1}{12} a4^2 \text{ m4 } Sin[q1]^2 \left(Cos[q1]^2 + Sin[q1]^2 \right) + \frac{1}{12} a4^2 \text{ m4 } Sin[q1]^2 \left(Cos[q1]^2 + Sin[q1]^2 \right) + \frac{1}{12} a4^2 \text{ m4 } Sin[q1]^2 \left(Cos[q1]^2 + Sin[q1]^2 \right) + \frac{1}{12} a4^2 \text{ m4 } Sin[q1]^2 \left(Cos[q1]^2 + Sin[q1]^2 \right) + \frac{1}{12} a4^2 \text{ m4 } Sin[q1]^2 \left(Cos[q1]^2 + Sin[q1]^2 \right) + \frac{1}{12} a4^2 \text{ m4 } Sin[q1]^2 \left(Cos[q1]^2 + Sin[q1]^2 \right) + \frac{1}{12} a4^2 \text{ m4 } Sin[q1]^2 \left(Cos[q1]^2 + Sin[q1]^2 \right) + \frac{1}{12} a4^2 \text{ m4 } Sin[q1]^2 \left(Cos[q1]^2 + Sin[q1]^2 \right) + \frac{1}{12} a4^2 \text{ m4 } Sin[q1]^2 \left(Cos[q1]^2 + Sin[q1]^2 \right) + \frac{1}{12} a4^2 \text{ m4 } Sin[q1]^2 \right) + \frac{1}{12} a4^2 \text{ m4 } Sin[q1]^2 \left(Cos[q1]^2 + Sin[q1]^2 \right) + \frac{1}{12} a4^2 \text{ m4 } Sin[q1]^2 \right) + \frac{1}{12} a4^2 \text{ m4 } Sin[q1]^2 \left(Cos[q1]^2 + Sin[q1]^2 \right) + \frac{1}{12} a4^2 \text{ m4 } Sin[q1]^2 \right) + \frac{1}{12} a4^2 \text{ m4 } Sin[q1]^2 \right) + \frac{1}{12} a4^2 \text{ m4 } Sin[q1]^2 \left(Cos[q1]^2 + Sin[q1]^2 \right) + \frac{1}{12} a4^2 \text{ m4 } Sin[q1]^2 \right) + \frac{1}{12} a4^2 \text{ m4 } Sin[q1]^2 \right) + \frac{1}{12} a4^2 \text{ m4 } Sin[q1]^2 + \frac{1}{12} a4^2 \text{ m4 } Sin[q1]^2 \right) + \frac{1}{12} a4^2 \text{ m4 } Sin[q1]^2 + \frac{1}{12} a4^2 \text{ m4 } Sin[q1]^2 \right) + \frac{1}{12} a4^2 \text{ m4 } Sin[q1]^2 + \frac{1}{12} a4^2 + \frac{1}{12} a4^2 + \frac{1}{12} a4^2 + \frac{1}{12} a4^2$ $m4 \left(\left[Cos[q1] \left(-\frac{1}{2} a4 Cos[q1] Cos[q2 + q3 + q4] + Cos[q1] \left(a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4] \right) \right) + a4 Cos[q2] + a3 Cos[q2] + a3 Cos[q2] + a4 Cos[q2] + a4$ $\left(-\frac{1}{2} \text{ a4 Cos}[q2+q3+q4] \text{ Sin}[q1] + \left(a2 \text{ Cos}[q2]+a3 \text{ Cos}[q2+q3]+a4 \text{ Cos}[q2+q3+q4]\right) \text{ Sin}[q1]\right)$ $\left(\cos[q1]\left(-\cos[q1]\left(a2\cos[q2] + a3\cos[q2 + q3]\right) - \frac{1}{2}a4\cos[q1]\cos[q2 + q3 + q4] + a3\cos[q2]\right)$ $Cos[q1] \left(a2 \; Cos[q2] + a3 \; Cos[q2+q3] + a4 \; Cos[q2+q3+q4] \right) + \\$ $Sin[q1] \left(-(a2 Cos[q2] + a3 Cos[q2 + q3]) Sin[q1] \right) - \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] + \frac{1}{2} a4 Cos[q3 + q4] + \frac{1}{2} a4 Cos[q3 + q4] + \frac{1}{2} a4 Cos[q3 + q4] + \frac{1}{2}$ (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4]) Sin[q1]) + $\frac{1}{2} \text{ a4 } \cos[q1]^2 \sin[q2 + q3 + q4] \left(\text{a2 } \sin[q2] + \text{a3 } \sin[q2 + q3] + \frac{1}{2} \text{ a4 } \sin[q2 + q3 + q4] \right) + \frac{1}{2} \sin[q2 + q3] + \frac{1}{2} \sin[q2 + q3]$ $\frac{1}{2} \text{ a4 Sin}[q1]^2 \text{ Sin}[q2 + q3 + q4] \left(\text{a2 Sin}[q2] + \text{a3 Sin}[q2 + q3] + \frac{1}{2} \text{ a4 Sin}[q2 + q3 + q4] \right)$

```
lo[-] = ToPython[\frac{1}{12} a4^2 m4 Cos[q1]^2 (Cos[q1]^2 + Sin[q1]^2) + \frac{1}{12} a4^2 m4 Sin[q1]^2 (Cos[q1]^2 + Sin[q1]^2) +
                                                        m4\left(\left(\cos[q1]\left(-\frac{1}{2}\right) + a4\cos[q1]\cos[q2+q3+q4] + \cos[q1]\left(a2\cos[q2+a3\cos[q2+q3] + a4\cos[q2+q3+q4]\right)\right) + a4\cos[q1]\cos[q2+q3+q4]\right)
                                                                                                                Sin[q1]\left(-\frac{1}{2} \text{ a4 } Cos[q2+q3+q4] Sin[q1]+\left(a2 Cos[q2+q3+q4]+a4 Cos[q2+q3+q4]\right)\right)
                                                                                                                                                     Sin[q1] (Cos[q1] (-Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3]) -
                                                                                                                                            \frac{1}{2} \text{ a4 Cos}[q1] \cos[q2 + q3 + q4] + \cos[q1] \left( \text{a2 Cos}[q2] + \text{a3 Cos}[q2 + q3] + \text{a4 Cos}[q2 + q3 + q4] \right) + \frac{1}{2} \left( \text{a4 Cos}[q2] + \text{a4 Cos}[q2]
                                                                                                                 Sin[q1] \left( -(a2 Cos[q2] + a3 Cos[q2 + q3]) Sin[q1] \right) - \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + a3 Cos[q2 + q3] Sin[q1] +
                                                                                                                                           (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4]) Sin[q1]))+
                                                                                     \frac{1}{2} \text{ a4 } \cos[q1]^2 \sin[q2 + q3 + q4] \left( \text{a2 } \sin[q2] + \text{a3 } \sin[q2 + q3] + \frac{1}{2} \text{ a4 } \sin[q2 + q3 + q4] \right) + \frac{1}{2} \sin[q2 + q3] + \frac{1}{2} \sin[q2 + q3]
                                                                                    \frac{1}{2} = \frac{1}
                                                                                                \left(a2 \operatorname{Sin}[q2] + a3 \operatorname{Sin}[q2 + q3] + \frac{1}{2} a4 \operatorname{Sin}[q2 + q3 + q4]\right), NumpyPrefix \rightarrow "np"
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 * <math>np.cos(q2) + a3 * np.cos(q2 + q3) + q3) + q3 * np.cos(q2 + q3) + q3 * np.cos(q2 + q3) + q3 * np.cos(q3) * np.cos(q
                                                          a4 * np.cos(q2 + q3 + q4))) + np.sin(q1) * (-((a2 * np.cos(q2) + a3 * np.cos(q2 + q4)))) + np.sin(q1) * (-((a2 * np.cos(q2) + a3 * np.cos(q2 + q4)))))))
                                                          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)))
```

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

In[.]:= ToPython

$$m3 \left(-\frac{1}{2} \ a3 \left(-\frac{1}{2} \ a3 \ \text{Cos[q1]} \ \text{Cos[q2 + q3] + Cos[q1]} \left(a2 \ \text{Cos[q2] + a3 Cos[q2 + q3]} \right) \right) \ \text{Sin[q1]} \ \text{Sin[q2 + q3] - }$$

$$\frac{1}{2} \ a3 \ \text{Cos[q1]} \left(\frac{1}{2} \ a3 \ \text{Cos[q2 + q3]} \ \text{Sin[q1] - } \left(a2 \ \text{Cos[q2] + a3 Cos[q2 + q3]} \right) \ \text{Sin[q1]} \right) \ \text{Sin[q2 + q3]} \right) +$$

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

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

$$\left(a3 \ \text{Sin[q2 + q3] + } \frac{1}{2} \ a4 \ \text{Sin[q2 + q3 + q4]} \right), \ \text{NumpyPrefix} \rightarrow \text{"np"} \right]$$

Out[*] = M3 * (-0.5 * a3 * (-0.5 * a3 * np.cos(q1) * np.cos(q2 + q3) + np.cos(q1) * (a2 * np.cos(q2) + q3) + np.cos(q3) + np.coa3 * np.cos(q2 + q3))) * np.sin(q1) * np.sin(q2 + q3) -0.5 * a3 * np.cos(q1) * (0.5 * a3) + np* 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) * np.cos(q1) * np.cos(q2 + q3)) + np.cos(q1) * np.cos(q1) * np.cos(q2 + q3)) + np.cos(q1) * np.cos(q1) * np.cos(q2 + q3) + np.cos(q1) * np.cos(q1) * np.cos(q1) * np.cos(q2 + q3) + np.cos(q1) * np.cos(q1(a2 * np.cos(q2) + a3 * np.cos(q2 + q3) + a4 * np.cos(q2 + q3 + q4))) * np.sin(q1) * (a3 * np.cos(q2) + q3) + q4))) * np.sin(q1) * (a3 * np.cos(q2) + q3) + q4))) * np.sin(q1) * (a3 * np.cos(q2) + q3) + q4))) * np.sin(q1) * (a3 * np.cos(q2) + q3) + q4))) * np.sin(q1) * (a3 * np.cos(q2) + q3) + q4))) * np.sin(q1) * (a3 * np.cos(q2) + q3) + q4))) * np.sin(q1) * (a3 * np.cos(q2) + q3) + q4))) * np.sin(q1) * (a3 * np.cos(q2) + q3) + q4))) * np.sin(q1) * (a3 * np.cos(q2) + q3) + q4))) * np.sin(q1) * (a3 * np.cos(q2) + q3) + q4))) * np.sin(q1) * (a3 * np.cos(q2) + q3) + q4))) * np.sin(q1) * (a3 * np.cos(q2) + q3) + q4))) * np.sin(q1) * (a3 * np.cos(q2) + q3) + q4))) * np.sin(q1) * (a3 * np.cos(q2) + q3) + q4))) * np.sin(q1) * (a3 * np.cos(q2) + q3) + q4))) * np.sin(q1) * (a3 * np.cos(q2) + q3) + q4))) * np.sin(q1) * (a3 * np.cos(q2) + q3) + q4))) * np.sin(q2) + q3) + q4)) * np.sin(q2) + q3) + q4) +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) + a3 * np.cos(q2+ q3 + q4)) * np.sin(q1))) * (a3 * np.sin(q2 + q3) + 0.5 * a4 * np.sin(q2 + q3 + q4))))

$$\begin{aligned} & \frac{1}{12} \text{ a3}^2 \text{ m3 Cos}[q1]^2 \left(\text{Cos}[q1]^2 + \text{Sin}[q1]^2 \right) + \frac{1}{12} \text{ a4}^2 \text{ m4 Cos}[q1]^2 \left(\text{Cos}[q1]^2 + \text{Sin}[q1]^2 \right) + \\ & \frac{1}{12} \text{ a3}^2 \text{ m3 Sin}[q1]^2 \left(\text{Cos}[q1]^2 + \text{Sin}[q1]^2 \right) + \frac{1}{12} \text{ a4}^2 \text{ m4 Sin}[q1]^2 \left(\text{Cos}[q1]^2 + \text{Sin}[q1]^2 \right) + \\ & \text{m3} \left(\left(\text{Cos}[q1] \left(-\frac{1}{2} \text{ a3 Cos}[q1] \text{Cos}[q2 + q3] + \text{Cos}[q1] \left(\text{a2 Cos}[q2] + \text{a3 Cos}[q2 + q3] \right) \right) + \\ & \text{Sin}[q1] \left(-\frac{1}{2} \text{ a3 Cos}[q2 + q3] \text{Sin}[q1] + \left(\text{a2 Cos}[q2] + \text{a3 Cos}[q2 + q3] \right) \text{Sin}[q1] \right) \right) \\ & \left(\text{Cos}[q1] \left(-\text{a2 Cos}[q1] \text{Cos}[q2] - \frac{1}{2} \text{ a3 Cos}[q1] \text{Cos}[q2 + q3] + \text{Cos}[q1] \left(\text{a2 Cos}[q2] + \text{a3 Cos}[q2 + q3] \right) \right) + \\ & \text{Sin}[q1] \left(-\text{a2 Cos}[q2] \text{Sin}[q1] - \frac{1}{2} \text{ a3 Cos}[q2 + q3] \text{Sin}[q1] + \left(\text{a2 Cos}[q2] + \text{a3 Cos}[q2 + q3] \right) \text{Sin}[q1] \right) \right) + \\ & \frac{1}{2} \text{ a3 Cos}[q1]^2 \text{Sin}[q2 + q3] \left(\text{a2 Sin}[q2] + \frac{1}{2} \text{ a3 Sin}[q2 + q3] \right) + \\ & \frac{1}{2} \text{ a3 Sin}[q1]^2 \text{Sin}[q2 + q3] \left(\text{a2 Sin}[q2] + \frac{1}{2} \text{ a3 Sin}[q2 + q3] \right) \right) + \\ & \text{m4} \left(\left(\text{Cos}[q1] \left(-\frac{1}{2} \text{ a4 Cos}[q1] \text{Cos}[q2 + q3 + q4] + \text{Cos}[q1] \left(\text{a2 Cos}[q2] + \text{a3 Cos}[q2 + q3] + \text{a4 Cos}[q2 + q3 + q4] \right) \right) \right) + \\ & \text{Sin}[q1] \left(-\frac{1}{2} \text{ a4 Cos}[q1] \text{Cos}[q2 + q3 + q4] + \text{Cos}[q1] \text{Cos}[q2] + \frac{1}{2} \text{a4 Cos}[q2 + q3 + q4] \right) \\ & \text{Sin}[q1] \left(\text{a2 Cos}[q2] + \text{a3 Cos}[q2 + q3] + \text{a4 Cos}[q2 + q3 + q4] \right) + \\ & \text{Cos}[q1] \left(\text{a2 Cos}[q2] + \text{a3 Cos}[q2 + q3] + \text{a4 Cos}[q2 + q3 + q4] \right) \\ & \text{Cos}[q1] \left(\text{a3 Sin}[q2 + q3] + \frac{1}{2} \text{a4 Sin}[q2 + q3 + q4] \right) \left(\text{a2 Sin}[q2] + \text{a3 Sin}[q2 + q3] + \frac{1}{2} \text{a4 Sin}[q2 + q3 + q4] \right) \\ & \text{Sin}[q1]^2 \left(\text{a3 Sin}[q2 + q3] + \frac{1}{2} \text{a4 Sin}[q2 + q3 + q4] \right) \left(\text{a2 Sin}[q2] + \text{a3 Sin}[q2 + q3] + \frac{1}{2} \text{a4 Sin}[q2 + q3 + q4] \right) \right) + \\ & \text{Sin}[q1]^2 \left(\text{a3 Sin}[q2 + q3] + \frac{1}{2} \text{a4 Sin}[q2 + q3 + q4] \right) \left(\text{a2 Sin}[q2] + \text{a3 Sin}[q2 + q3] + \frac{1}{2} \text{a4 Sin}[q2 + q3 + q4] \right) \right) + \\ & \text{Sin}[q1]^2 \left(\text{a3 Sin}[q2 + q3] + \frac{1}{2} \text{a4 Sin}[q2 + q3 + q4] \right) \left(\text{a2 Sin}[q2] + \text{a3$$

$$\begin{aligned} & \text{Ind}(-) = & \text{ToPython} \Big[\frac{1}{12} \text{ a3}^2 \text{ m3 } \text{Cos}[q1]^2 \left(\text{Cos}[q1]^2 + \text{Sin}[q1]^2 \right) + \frac{1}{12} \text{ a4}^2 \text{ m4 } \text{Cos}[q1]^2 \left(\text{Cos}[q1]^2 + \text{Sin}[q1]^2 \right) + \\ & \frac{1}{12} \text{ a3}^2 \text{ m3 } \text{Sin}[q1]^2 \left(\text{Cos}[q1]^2 + \text{Sin}[q1]^2 \right) + \frac{1}{12} \text{ a4}^2 \text{ m4 } \text{Sin}[q1]^2 \left(\text{Cos}[q1]^2 + \text{Sin}[q1]^2 \right) + \\ & \text{m3} \left(\left[\text{Cos}[q1] \left(-\frac{1}{2} \text{ a3 } \text{Cos}[q1] \text{ Cos}[q2] + \text{q3} \right] + \text{Cos}[q1] \left(\text{a2 } \text{Cos}[q2] + \text{a3 } \text{Cos}[q2] + \text{q3} \right) \right) \right) + \\ & \text{Sin}[q1] \left(-\frac{1}{2} \text{ a3 } \text{Cos}[q2] + \text{q3} \right) \text{Sin}[q1] + \left(\text{a2 } \text{Cos}[q2] + \text{a3 } \text{Cos}[q2] + \text{q3} \right) \text{Sin}[q1] \right) \right) \\ & \left(\text{Cos}[q1] \left(-\text{a2 } \text{Cos}[q1] \text{ Cos}[q2] - \frac{1}{2} \text{ a3 } \text{Cos}[q2] + \text{q3} \right) + \text{Cos}[q1] \left(\text{a2 } \text{Cos}[q2] + \text{a3 } \text{Cos}[q2] + \text{q3} \right) \right) \right) + \\ & \frac{1}{2} \text{ a3 } \text{Cos}[q1] \left(-\text{a2 } \text{Cos}[q2] \text{ Sin}[q2] - \frac{1}{2} \text{ a3 } \text{Sin}[q2] + \frac{1}{2} \text{ a3 } \text{Sin}[q1] + \left(\text{a2 } \text{Cos}[q2] + \text{a3 } \text{Cos}[q2] + \text{q3} \right) \right) \right) + \\ & \frac{1}{2} \text{ a3 } \text{Cos}[q1]^2 \text{ Sin}[q2 + \text{q3}] \left(\text{a2 } \text{Sin}[q2] + \frac{1}{2} \text{ a3 } \text{Sin}[q2] + \text{q3} \right) \right) + \\ & \frac{1}{2} \text{ a3 } \text{Sin}[q1]^2 \left(\text{Sin}[q2] + \text{q3} \right) \left(\text{a2 } \text{Sin}[q2] + \frac{1}{2} \text{ a3 } \text{Sin}[q2] + \text{q3} \right) \right) + \\ & \text{Sin}[q1] \left(-\frac{1}{2} \text{ a4 } \text{Cos}[q1] \text{ Cos}[q2] + \text{q3} + \text{q4} \right) + \text{Cos}[q1] \left(\text{a2 } \text{Cos}[q2] + \text{a3 } \text{Cos}[q2] + \text{a3 } \text{Cos}[q2] + \text{q3} \right) + \text{a4 } \text{Cos}[q2] + \text{q3} + \text{q4} \right) \right) \\ & \text{Sin}[q1] \left(-\frac{1}{2} \text{ a4 } \text{Cos}[q2] + \text{q3} + \text{q4} \right) \text{Sin}[q1] + \left(\text{a2 } \text{Cos}[q2] + \text{a3 } \text{Cos}[q2] + \text{q3} \right) + \text{a4 } \text{Cos}[q2] + \text{q3} + \text{q4} \right) \\ & \text{Sin}[q1] \left(-\frac{1}{2} \text{ a4 } \text{Cos}[q2] + \text{a3 } \text{Cos}[q2] + \text{q3} \right) + \text{a4 } \text{Cos}[q2] + \text{q3} + \text{q4} \right) \right) \\ & \text{Cos}[q1] \left(\text{a2 } \text{Cos}[q2] + \text{a3 } \text{Cos}[q2] + \text{q3} \right) + \text{a4 } \text{Cos}[q2] + \text{q3} + \text{q4} \right) \right) \\ & \text{Cos}[q1]^2 \left(\text{a3 } \text{Sin}[q2] + \text{q3} \right) + \frac{1}{2} \text{a4 } \text{Sin}[q2] + \text{q3} + \text{q4} \right) \right) \left(\text{a2 } \text{Sin}[q2] + \text{q3} \right) + \frac{1}{2} \text{a4 } \text{Sin}[q2] + \text{q3} + \text{q4} \right) \right) \\ & \text{(a2 } \text{Sin}[q2] + \text{q3} + \text{q4}$$

** 2) + 0.08333333333333333333 * (a3 ** 2) * m3 * (np.sin(q1) ** 2) * (np.cos(q1) ** 2 + ** 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 * q2)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 * q3))) + np.sin(q2) * (-(a2 * q3)) + np.sin(q2) * (-(a2 * q3np.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)) * np.sin(q3 + q3)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)) + np.sin(q1) * (-0.5 * a4 * np.cos(q+ 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) + np.cos(q2) + a3 * np.cos(q3) + a3 * np.cos(q3q3) + 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 * <math>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)))

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

$$\begin{array}{l} \inf_{\{i,j\}} = \operatorname{ToPython} \Big[\frac{1}{12} \ a3^2 \ m3 \ \operatorname{Cos[q1]^2} \left(\operatorname{Cos[q1]^2} + \operatorname{Sin[q1]^2} \right) + \frac{1}{12} \ a4^2 \ m4 \ \operatorname{Cos[q1]^2} \left(\operatorname{Cos[q1]^2} + \operatorname{Sin[q1]^2} \right) + \\ \frac{1}{12} \ a3^2 \ m3 \ \operatorname{Sin[q1]^2} \left(\operatorname{Cos[q1]^2} + \operatorname{Sin[q1]^2} \right) + \frac{1}{12} \ a4^2 \ m4 \ \operatorname{Sin[q1]^2} \left(\operatorname{Cos[q1]^2} + \operatorname{Sin[q1]^2} \right) + \\ m3 \left(\left[\operatorname{Cos[q1]} \left(-\frac{1}{2} \ a3 \ \operatorname{Cos[q2]} + \operatorname{q3}_1 + \operatorname{Cos[q1]} \left(\operatorname{a2} \ \operatorname{Cos[q2]} + \operatorname{a3} \ \operatorname{Cos[q2]} + \operatorname{q3}_1 \right) \right) \right) + \\ & \operatorname{Sin[q1]} \left(-\frac{1}{2} \ a3 \ \operatorname{Cos[q2]} + \operatorname{q3}_1 \ \operatorname{Sin[q1]} + \left(\operatorname{a2} \ \operatorname{Cos[q2]} + \operatorname{a3} \ \operatorname{Cos[q2]}$$

** 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 * q3))) + np.sin(q2) * (-(a2 * q3)) + np.sin(q2) * (-(a2 * q3np.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)) * np.sin(q3 + q3)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)) + np.sin(q1) * (-0.5 * a4 * np.cos(q+ 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) + np.cos(q2) + np.cos(q3) + np.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 * <math>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] $out[-]=\frac{1}{12} a3^2 m3 \cos[q1]^2 (\cos[q1]^2 + \sin[q1]^2) + \frac{1}{12} a4^2 m4 \cos[q1]^2 (\cos[q1]^2 + \sin[q1]^2) + \frac{1}{12} a3^2 m3 \cos[q1]^2 \cos[q1]^2$ $\frac{1}{12}$ a3² m3 Sin[q1]² (Cos[q1]² + Sin[q1]²) + $\frac{1}{12}$ a4² m4 Sin[q1]² (Cos[q1]² + Sin[q1]²) + m3 $\left(\left[\cos[q1] \left[-a2 \cos[q1] \cos[q2] - \frac{1}{2} \right] \right] + \cos[q1] \cos[q2 + q3] + \cos[q1] \left[a2 \cos[q2] + a3 \cos[q2 + q3] \right] + \cos[q2] + a3 \cos[q2 + q3] \right) + \cos[q2] + a3 \cos[q2$ $Sin[q1] \left(-a2 Cos[q2] Sin[q1] - \frac{1}{2} a3 Cos[q2 + q3] Sin[q1] + \left(a2 Cos[q2] + a3 Cos[q2 + q3]\right) Sin[q1]\right)^{2} + \frac{1}{2} a3 Cos[q2] + a3 Cos[q2]$ $\frac{1}{4} a3^{2} \cos[q1]^{2} \sin[q2 + q3]^{2} + \frac{1}{4} a3^{2} \sin[q1]^{2} \sin[q2 + q3]^{2} + \frac{1}{4} a3^{2} \sin[q1]^{2} \sin[q2 + q3]^{2}$ m4 $\left(\left(\cos[q1] \left(-a2 \cos[q1] \cos[q2] - \frac{1}{2} \right) \right) = a4 \cos[q1] \cos[q2 + q3 + q4] + a4 \cos[q1] \cos[q2] + a4 \cos[q2] + a4$

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

```
lo[-] = ToPython[\frac{1}{12} a3^2 m3 Cos[q1]^2 (Cos[q1]^2 + Sin[q1]^2) + \frac{1}{12} a4^2 m4 Cos[q1]^2 (Cos[q1]^2 + Sin[q1]^2) + \frac{1}{12} a4^2
                                                           \frac{1}{12} \text{ a3}^2 \text{ m3 Sin[q1]}^2 \left( \text{Cos[q1]}^2 + \text{Sin[q1]}^2 \right) + \frac{1}{12} \text{ a4}^2 \text{ m4 Sin[q1]}^2 \left( \text{Cos[q1]}^2 + \text{Sin[q1]}^2 \right) + \frac{1}{12} \text{ a4}^2 \text{ m4 Sin[q1]}^2 \left( \text{Cos[q1]}^2 + \text{Sin[q1]}^2 \right) + \frac{1}{12} \text{ a4}^2 \text{ m4 Sin[q1]}^2 \left( \text{Cos[q1]}^2 + \text{Sin[q1]}^2 \right) + \frac{1}{12} \text{ a4}^2 \text{ m4 Sin[q1]}^2 \left( \text{Cos[q1]}^2 + \text{Sin[q1]}^2 \right) + \frac{1}{12} \text{ a4}^2 \text{ m4 Sin[q1]}^2 \left( \text{Cos[q1]}^2 + \text{Sin[q1]}^2 \right) + \frac{1}{12} \text{ a4}^2 \text{ m4 Sin[q1]}^2 \left( \text{Cos[q1]}^2 + \text{Sin[q1]}^2 \right) + \frac{1}{12} \text{ a4}^2 \text{ m4 Sin[q1]}^2 \left( \text{Cos[q1]}^2 + \text{Sin[q1]}^2 \right) + \frac{1}{12} \text{ a4}^2 \text{ m4 Sin[q1]}^2 \left( \text{Cos[q1]}^2 + \text{Sin[q1]}^2 \right) + \frac{1}{12} \text{ a4}^2 \text{ m4 Sin[q1]}^2 \left( \text{Cos[q1]}^2 + \text{Sin[q1]}^2 \right) + \frac{1}{12} \text{ a4}^2 \text{ m4 Sin[q1]}^2 \left( \text{Cos[q1]}^2 + \text{Sin[q1]}^2 \right) + \frac{1}{12} \text{ a4}^2 \text{ m4 Sin[q1]}^2 \left( \text{Cos[q1]}^2 + \text{Sin[q1]}^2 \right) + \frac{1}{12} \text{ a4}^2 \text{ m4 Sin[q1]}^2 \right) + \frac{1}{12} \text{ a4}^2 \text{ m4 Sin[q1]}^2 \left( \text{Cos[q1]}^2 + \text{Sin[q1]}^2 \right) + \frac{1}{12} \text{ a4}^2 \text{ m4 Sin[q1]}^2 \right) + \frac{1}{12} \text{ a4}^2 \text{ m4 Sin[q1]}^2 + \frac{1}{12} \text{ a4}^2 \text{ m4 Sin[q1]}^2 \right) + \frac{1}{12} \text{ a4}^2 \text{ m4 Sin[q1]}^2 + \frac{1}{12} \text{ a4}^2 \text{ m4 Sin[q1]}^2 \right) + \frac{1}{12} \text{ a4}^2 \text{ m4 Sin[q1]}^2 + \frac{1}{12} \text{ a4}^2 \text{ m4 Sin[q1]}^2 + \frac{1}{12} \text{ a4}^2 \text{ m4 Sin[q1]}^2 \right) + \frac{1}{12} \text{ a4}^2 \text{ m4 Sin[q1]}^2 + \frac{1}{12} \text{ a4}^2 \text{ m4 Sin[q1]}^2 + \frac{1}{12} \text{ a4}^2 \text{ m4 Sin[q1]}^2 \right) + \frac{1}{12} \text{ a4}^2 \text{ m4 Sin[q1]}^2 + \frac{1}{12} \text{ a4}^2 \text{ m4 Sin[q1]}^2 + \frac{1}{12} \text{ a4}^2 \text{ m4 Sin[q1]}^2 + \frac{1}{12} \text{ a4}^2 + \frac{1}{12}
                                                         m3 \left( \left[ \cos[q1] \left( -a2 \cos[q1] \cos[q2] - \frac{1}{2} \right] \right) + \sin[q1] \cos[q2] + a3 \cos[q2] 
                                                                                                                                       q1 \left[-a2 \cos[q2] \sin[q1] - \frac{1}{a} a3 \cos[q2 + q3] \sin[q1] + \left(a2 \cos[q2] + a3 \cos[q2 + q3]\right) \sin[q1]\right]^{2} +
                                                                                    \frac{1}{1} = a3^{2} \cos[q1]^{2} \sin[q2 + q3]^{2} + \frac{1}{4} = a3^{2} \sin[q1]^{2} \sin[q2 + q3]^{2} + \frac{1}{4} = a3^{2} \sin[q1]^{2} \sin[q2 + q3]^{2}
                                                         m4 \left( \left[ \cos[q1] \left( -a2 \cos[q1] \cos[q2] - \frac{1}{2} \right] \right] = \frac{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] \left(-a2 \cos[q2] \sin[q1] - \frac{1}{a4} a4\right)
                                                                                                                                                         \cos[q2 + q3 + q4] \sin[q1] + (a2 \cos[q2] + a3 \cos[q2 + q3] + a4 \cos[q2 + q3 + q4]) \sin[q1]
                                                                                      \cos[q_1]^2 \left( a3 \sin[q_2 + q_3] + \frac{1}{2} a4 \sin[q_2 + q_3 + q_4] \right)^2 + \sin[q_1]^2
                                                                                                \left(a3 \sin[q2 + q3] + \frac{1}{2} a4 \sin[q2 + q3 + q4]\right)^{2}, NumpyPrefix \rightarrow "np"
** 2) * (np.cos(q1) ** 2 + np.sin(q1) ** 2) + m3 * ((np.cos(q1) * (-(a2 * np.cos(q1) * (-(a
                                                            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 * q3 + q4) * np.sin(q1) + (a2 * q4) * np.sin(q1) + (a4 * q4) * np.
                                                            np.cos(q2) + a3 * np.cos(q2 + q3) + a4 * np.cos(q2 + q3 + q4)) * np.sin(q1))) ** 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))

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

```
lo[-] = ToPython[\frac{1}{12} a4^2 m4 Cos[q1]^2 (Cos[q1]^2 + Sin[q1]^2) + \frac{1}{12} a4^2 m4 Sin[q1]^2 (Cos[q1]^2 + Sin[q1]^2) +
                                                        m4\left(\left(\cos[q1]\left(-\frac{1}{2}\right) + a4\cos[q1]\cos[q2+q3+q4] + \cos[q1]\left(a2\cos[q2+a3\cos[q2+q3] + a4\cos[q2+q3+q4]\right)\right) + a4\cos[q1]\cos[q2+q3+q4]\right)
                                                                                                                Sin[q1]\left(-\frac{1}{2} \text{ a4 } Cos[q2+q3+q4] Sin[q1]+\left(a2 Cos[q2+q3+q4]+a4 Cos[q2+q3+q4]\right)\right)
                                                                                                                                                     Sin[q1] (Cos[q1] (-Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3]) -
                                                                                                                                            \frac{1}{2} \text{ a4 Cos}[q1] \cos[q2 + q3 + q4] + \cos[q1] \left( \text{a2 Cos}[q2] + \text{a3 Cos}[q2 + q3] + \text{a4 Cos}[q2 + q3 + q4] \right) + \frac{1}{2} \left( \text{a4 Cos}[q2] + \text{a4 Cos}[q2]
                                                                                                                 Sin[q1] \left( -(a2 Cos[q2] + a3 Cos[q2 + q3]) Sin[q1] \right) - \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + a3 Cos[q2 + q3] Sin[q1] +
                                                                                                                                           (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4]) Sin[q1]))+
                                                                                     \frac{1}{2} \text{ a4 } \cos[q1]^2 \sin[q2 + q3 + q4] \left( \text{a2 } \sin[q2] + \text{a3 } \sin[q2 + q3] + \frac{1}{2} \text{ a4 } \sin[q2 + q3 + q4] \right) + \frac{1}{2} \sin[q2 + q3] + \frac{1}{2} \sin[q2 + q3]
                                                                                    \frac{1}{2} = \frac{1}
                                                                                                \left(a2 \operatorname{Sin}[q2] + a3 \operatorname{Sin}[q2 + q3] + \frac{1}{2} a4 \operatorname{Sin}[q2 + q3 + q4]\right), NumpyPrefix \rightarrow "np"
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 * <math>np.cos(q2) + a3 * np.cos(q2 + q3) + q3) + q3 * np.cos(q2 + q3) + q3 * np.cos(q2 + q3) + q3 * np.cos(q3) * np.cos(q
                                                          a4 * np.cos(q2 + q3 + q4))) + np.sin(q1) * (-((a2 * np.cos(q2) + a3 * np.cos(q2 + q4)))) + np.sin(q1) * (-((a2 * np.cos(q2) + a3 * np.cos(q2 + q4)))))))
                                                          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)))
```

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

```
lo[-] = ToPython[\frac{1}{12} a4^2 m4 Cos[q1]^2 (Cos[q1]^2 + Sin[q1]^2) + \frac{1}{12} a4^2 m4 Sin[q1]^2 (Cos[q1]^2 + Sin[q1]^2) + \frac{1}{12} a4^2
                                                          m4 \left( \left[ \cos[q1] \left[ -a2 \cos[q1] \cos[q2] - \frac{1}{2} \right] \right] = \frac{1}{2}  a4 \cos[q1] \cos[q2 + q3 + q4] + \frac{1}{2} 
                                                                                                                                                   Cos[q1](a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4]) + Sin[q1](-a2 Cos[q2] Sin[q1] - a2 Cos[q2] - a2 Co
                                                                                                                                                   \frac{1}{2} \text{ a4 Cos}[q2+q3+q4] \, \text{Sin}[q1] + \left( \text{a2 Cos}[q2] + \text{a3 Cos}[q2+q3] + \text{a4 Cos}[q2+q3+q4] \right) \, \text{Sin}[q1] \right)
                                                                                                  \left(\cos[q1]\left(-\cos[q1]\left(a2\cos[q2]+a3\cos[q2+q3]\right)-\frac{1}{2}\right) a4 Cos[q1] Cos[q2+q3+q4]+
                                                                                                                                                   Cos[q1] (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4]) +
                                                                                                                       Sin[q1] \left( -((a2 Cos[q2] + a3 Cos[q2 + q3]) Sin[q1]) - \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2 + q3 + q4] + \frac{1}{2} a4 Cos[q3 + q4] + \frac{1}{2} a4 Cos[q3 + q4] + \frac{1}{2} a4 Cos[q3 + q4] + \frac{1}{2} 
                                                                                                                                                  (a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4]) Sin[q1])+
                                                                                        \frac{1}{2} \text{ a4 } \cos[q1]^2 \sin[q2 + q3 + q4] \left( \text{a3 } \sin[q2 + q3] + \frac{1}{2} \text{ a4 } \sin[q2 + q3 + q4] \right) + \frac{1}{2} \sin[q2 + q3] + \frac{1}{2} \sin[q2
                                                                                         \frac{1}{2} \text{ a4 Sin[q1]}^2 \text{ Sin[q2+q3+q4]} \left( \text{a3 Sin[q2+q3]} + \frac{1}{2} \text{ a4 Sin[q2+q3+q4]} \right), \text{ NumpyPrefix} \rightarrow \text{"np"} \right]
** 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) + q3 + q4))) * (np.cos(q2) * (np.cos(q3) * (np.cos(q3)
                                                             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)) * (a2 * np.cos(q2 + q3)) * (a3 * np.cos(q2 + q3)) * (a4 * np.cos(q2 + q3)) * (a4 * np.cos(q3)) * (a4 * np.cos(q3) + a3 * np.cos(q3) + a3 * np.cos(q3) * (a4 * np.cos(q3) + a3 * np.cos(q3) + a3 * np.cos(q3) * (a4 * np.cos(q3) + a3 * np.cos(q3) + a3 * np.cos(q3) * (a4 * np.cos(q3) + a3 * np.cos(q3) + a3 * np.cos(q3) * (a4 * np.cos(q3) + a3 * np.cos(q3) + a3 * np.cos(q3) * (a4 * np.cos(q3) + a3 * np.cos(q3) + a3 * np.cos(q3) * (a4 * np.cos(q3) + a3 * np.cos(q3) + a3 * np.cos(q3) * (a4 * np.cos(q3) + a3 * np.cos(q3) + a3 * np.cos(q3) * (a4 * np.cos(q3) + a3 * np.cos(q3) + a3 * np.cos(q3) * (a4 * np.cos(q3) + a3 * np.cos(q3) + a3 * np.cos(q3) * (a4 * np.cos(q3) + a3 * np.cos(q3) + a3 * np.cos(q3) * (a4 * np.cos(q3) + a3 * np.cos(q3) + a3 * np.cos(q3) * (a4 * np.cos(q3) + a3 * np.cos(q3) + a3 * np.cos(q3) * (a4 * np.cos(q3) + a3 * np.
                                                            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<sup>2</sup> m4 Cos[q1]<sup>2</sup> (Cos[q1]<sup>2</sup> + Sin[q1]<sup>2</sup>) + \frac{1}{12} a4<sup>2</sup> m4 Sin[q1]<sup>2</sup> (Cos[q1]<sup>2</sup> + Sin[q1]<sup>2</sup>) +
                                     m4 \left( \left[ \cos[q1] \left( -\cos[q1] \left( a2\cos[q2] + a3\cos[q2 + q3] \right) - \frac{1}{2} \right] \right) = \frac{1}{2} a4 \cos[q1]\cos[q2 + q3 + q4] + \frac{1}{2}
                                                                                                       Cos[q1](a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4]) + a4 Cos[q2 + q3 + q4])
                                                                                 Sin[q1] \left( -\left( a2 Cos[q2] + a3 Cos[q2 + q3] \right) Sin[q1] \right) - \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + a3 Cos[q2 + q3] Sin[q1] Sin[q1] + a3 Cos[q2 + q3] Sin[q1] S
                                                                                                       (a2 \cos[q2] + a3 \cos[q2 + q3] + a4 \cos[q2 + q3 + q4]) \sin[q1])^{2} +
                                                          \frac{1}{a} a4^{2} \cos[q1]^{2} \sin[q2 + q3 + q4]^{2} + \frac{1}{a} a4^{2} \sin[q1]^{2} \sin[q2 + q3 + q4]^{2}
  lo[-] = ToPython[\frac{1}{12} a4^2 m4 Cos[q1]^2 (Cos[q1]^2 + Sin[q1]^2) + \frac{1}{12} a4^2 m4 Sin[q1]^2 (Cos[q1]^2 + Sin[q1]^2) + \frac{1}{12} a4^2 m4 Sin[q1]^2
                                            m4 \left( \left[ \cos[q1] \left( -\cos[q1] \left( a2 \cos[q2] + a3 \cos[q2 + q3] \right) - \frac{1}{2} \right] \right) = \frac{1}{2} a4 \cos[q1] \cos[q2 + q3 + q4] + \frac{1}{2}
                                                                                                              Cos[q1](a2 Cos[q2] + a3 Cos[q2 + q3] + a4 Cos[q2 + q3 + q4]) + a4 Cos[q2 + q3 + q4])
                                                                                       Sin[q1] \left( -((a2 Cos[q2] + a3 Cos[q2 + q3]) Sin[q1]) - \frac{1}{2} a4 Cos[q2 + q3 + q4] Sin[q1] + \frac{1}{2} a4 Cos[q2] + \frac{1}{2} a4 Cos[q2]
                                                                                                             (a2 \cos[q2] + a3 \cos[q2 + q3] + a4 \cos[q2 + q3 + q4]) \sin[q1])^{2} +
                                                                  \frac{1}{4} a4^{2} \cos[q1]^{2} \sin[q2 + q3 + q4]^{2} + \frac{1}{4} a4^{2} \sin[q1]^{2} \sin[q2 + q3 + q4]^{2}, \text{ NumpyPrefix} \rightarrow "np"]
2 + np.sin(q1) ** 2) + m4 * ((np.cos(q1) * (-(np.cos(q1) * (a2 * np.cos(q2) + a3 * (a2 * np.cos(q2) 
                                              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))
                                              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)) ** (np
                                             + q3 + q4) ** 2) + 0.25 * (a4 ** 2) * (np.sin(q1) ** 2) * (np.sin(q2 + q3 + q4) ** 2))
   In[*]:= Mprint[G, "Gravity Vector g ="]
Out[-]= Mprint[\{0, \frac{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]\}
                                             \frac{1}{2} g ((a3 m3 + 2 a3 m4) Cos[q2 + q3] + a4 m4 Cos[q2 + q3 + q4]),
                                             \frac{1}{2} \text{ a4 g m4 Cos}[q2 + q3 + q4], \text{ Gravity Vector g =}]
```

$$In[\cdot]:= \text{ToPython}\Big[\frac{1}{2}\text{ g}\,\Big(\!(\text{a2}\text{ m2}+2\text{ a2}\text{ m3}+2\text{ a2}\text{ m4}\big)\text{ Cos}[\text{q2}] + \Big(\!(\text{a3}\text{ m3}+2\text{ a3}\text{ m4}\big)\text{ Cos}[\text{q2}+\text{q3}] + \text{a4}\text{ m4}\text{ Cos}[\text{q2}+\text{q3}+\text{q4}]\Big),}$$

$$NumpyPrefix \rightarrow \text{"np"}\Big]$$

$$Out[\cdot]:= 0.5 * \text{ g} * ((\text{a2}*\text{ m2}+2*\text{ a2}*\text{ m3}+2*\text{ a2}*\text{ m4}) * \text{np.cos}(\text{q2}) + \\ (\text{a3}*\text{ m3}+2*\text{ a3}*\text{ m4}) * \text{np.cos}(\text{q2}+\text{q3}) + \text{a4}*\text{ m4}*\text{ np.cos}(\text{q2}+\text{q3}+\text{q4})\Big)$$

$$In[\cdot]:= \text{ToPython}\Big[\frac{1}{2}\text{ g}\,\Big(\!(\text{a3}\text{ m3}+2\text{ a3}\text{ m4}\big)\text{ Cos}[\text{q2}+\text{q3}] + \text{a4}\text{ m4}\text{ Cos}[\text{q2}+\text{q3}+\text{q4}]\Big), \text{ NumpyPrefix} \rightarrow \text{"np"}\Big]$$

$$Out[\cdot]:= 0.5 * \text{ g} * ((\text{a3}*\text{ m3}+2*\text{ a3}*\text{ m4}) * \text{np.cos}(\text{q2}+\text{q3}) + \text{a4}*\text{ m4}*\text{ np.cos}(\text{q2}+\text{q3}+\text{q4})\Big)$$

$$In[\cdot]:= \text{ToPython}\Big[\frac{1}{2}\text{ a4}\text{ g}\text{ m4}\text{ Cos}[\text{q2}+\text{q3}+\text{q4}], \text{ NumpyPrefix} \rightarrow \text{"np"}\Big]$$

$$Out[\cdot]:= 0.5 * \text{a4}*\text{ g} * \text{m4}*\text{ np.cos}(\text{q2}+\text{q3}+\text{q4})$$