```
In[63]:= Quit[];
In[1]:= SetDirectory[NotebookDirectory[]];
     << HurToolbox.m
     HurToolbox for modeling and analysis of multibody systems 1.0.0.
     HurToolbox mainly uses vector manipulation (vectors, dyadics).
     Coordinates and matrix representation of the dyadics are also available.
     Available methods: Newton-Euler
        Method, Euler-Lagrange Method, Hamiltonian Method, Kane's Method.
     Copyright 2019 Pilwon Hur
     Department of Mechanical Engineering
     Texas A&M University
     All rights reserved.
     Email questions, comments, or concerns to pilwonhur@tamu.edu.
In[3]:= HurInitialize[]
     HurLoadData["data_impactA_abs.m"]
In[4]:= HurDefineRF[a, b, c, d]
     HurDefineGeneralizedCoordinates[q1[t], q2[t], q3[t], q4[t]]
     (*q3, q4 are the x, y position of stance foot*)
     HurDefineDCM[a, q1[t], {0, 0, 1}]
     HurDefineDCM[b, q2[t], {0, 0, 1}]
     HurDefineDCM[d, -gamma, {0, 0, 1}]
ln[9]:= FOOTST = q3[t] n1 + q4[t] n2;
     COMA = FOOTST + la a2; (*COM of stance leg*)
     COMB = FOOTST + (1a + 1b) a2 - 1b b2; (*COM of swing leg*)
     COMC = FOOTST + (la + lb) a2; (*Hip*)
     HIP = COMC;
     FOOTSW = FOOTST + (1a + 1b) a2 - (1a + 1b) b2; (*Swing foot position*)
In[13]:= HurDefineCOMPos[a, COMA];
     HurDefineCOMPos[b, COMB];
     HurDefineCOMPos[c, COMC];
In[16]:= HurKinematics[]
```

```
In[17]:= HurGlobalCOMVel
        HurGlobalCOMAcc
        HurGlobalAngularVel
        HurGlobalAngularAcc
 Out[17]= \{0,
          -a1 la q1'[t] + (a1 Cos[q1[t]] - a2 Sin[q1[t]]) q3'[t] + (a2 Cos[q1[t]] + a1 Sin[q1[t]]) q4'[t],
          -(1a+1b)(b1\cos[q1[t]-q2[t]]+b2\sin[q1[t]-q2[t]])q1'[t]+b1lbq2'[t]+
           b1 \cos[q2[t]] q3'[t] - b2 \sin[q2[t]] q3'[t] + b2 \cos[q2[t]] q4'[t] + b1 \sin[q2[t]] q4'[t],
          -(la+lb)(c1Cos[q1[t]]+c2Sin[q1[t]])q1'[t]+c1q3'[t]+c2q4'[t],0
 Out[18]= \{0, -a2 \mid aq1' \mid t \mid^2 -a1 \mid aq1'' \mid t \mid +a1 \mid cos \mid q1 \mid t \mid \} \mid q3'' \mid t \mid -a1 \mid cos \mid q1 \mid t \mid \} \mid q3'' \mid t \mid -a1 \mid cos \mid q1 \mid t \mid \} \mid q3'' \mid t \mid -a1 \mid cos \mid q1 \mid t \mid \} \mid q3'' \mid t \mid -a1 \mid cos \mid q1 \mid t \mid \} \mid q3'' \mid t \mid -a1 \mid cos \mid q1 \mid t \mid \} \mid q3'' \mid t \mid -a1 \mid cos \mid q1 \mid t \mid \} \mid q3'' \mid t \mid -a1 \mid cos \mid q1 \mid t \mid 
            a2 Sin[q1[t]] q3"[t] + a2 Cos[q1[t]] q4"[t] + a1 Sin[q1[t]] q4"[t],
          b2 (-(la+lb) \cos[q1[t]-q2[t]] q1'[t]^2 + lb q2'[t]^2 - la \sin[q1[t]-q2[t]] q1''[t] -
                lb \, Sin[q1[t] - q2[t]] \, q1''[t] - Sin[q2[t]] \, q3''[t] + Cos[q2[t]] \, q4''[t]) + \\
            b1 ((la + lb) Sin[q1[t] - q2[t]) q1'[t]^2 - (la + lb) Cos[q1[t] - q2[t]) q1''[t] +
                1b q2''[t] + Cos[q2[t]] q3''[t] + Sin[q2[t]] q4''[t]),
          -(la+lb)(c2Cos[q1[t]]-c1Sin[q1[t]])q1'[t]^2-
            (la + lb) (c1 Cos[q1[t]] + c2 Sin[q1[t]]) q1''[t] + c1 q3''[t] + c2 q4''[t], 0
 Out[19]= \{0, n3 q1'[t], n3 q2'[t], 0, 0\}
 Out[20]= \{0, a3 q1''[t], b3 q2''[t], 0, 0\}
  In[21]:= HurDefineMass[a, m];
        HurDefineMass[b, m];
        HurDefineMass[c, mh];
        HurDefineInertia[a, {0, 0, 0, 0, 0, Iz}];
        HurDefineInertia[b, {0, 0, 0, 0, 0, Iz}];
  In[26]:= HurDefineVertical[n2];
  In[27]:= Jaf = HurGetJacobian[F00TST, a, n]
         Jah = HurGetJacobian[HIP, a, n]
         Jbh = HurGetJacobian[HIP, b, n]
 \text{Out}_{[27]} = \{\{0,0,1,0\},\{0,0,0,1\},\{0,0,0,0,0\},\{0,0,0,0\},\{0,0,0,0\},\{1,0,0,0\}\}
 Out[28]= \{ \{ -(la+lb) \cos[q1[t]], 0, 1, 0 \}, \{ -(la+lb) \sin[q1[t]], 0, 0, 1 \}, \}
           \{0, 0, 0, 0\}, \{0, 0, 0, 0\}, \{0, 0, 0, 0\}, \{1, 0, 0, 0\}\}
 Out[29]= \{ \{ -(la+lb) \cos[q1[t]], 0, 1, 0 \}, \{ -(la+lb) \sin[q1[t]], 0, 0, 1 \}, \}
          \{0, 0, 0, 0\}, \{0, 0, 0, 0\}, \{0, 0, 0, 0\}, \{0, 1, 0, 0\}\}
  In[30]:= Transpose[Jaf].HurList2Column[{0, 0, 0, 0, 0, tau1}] +
            Transpose[Jah].HurList2Column[{0, 0, 0, 0, 0, -tau2}] +
           Transpose[Jbh].HurList2Column[{0, 0, 0, 0, 0, tau2}] // MatrixForm
Out[30]//MatrixForm=
           tau1 – tau2
               tau2
                 0
```

In[31]:= HurDefineNonConservativeForces[tau1 - tau2, tau2, 0, 0] Out[31]= {tau1 - tau2, tau2, 0, 0} In[32]:= HurELEquation[] Out[32]= $\left\{-\tan 1 + \tan 2 - 2g \ln m \sin [q1[t]] - g \ln m \sin [q1[t]] - g \right\}$ $(Iz + 2 la lb (m + mh) + lb^{2} (m + mh) + la^{2} (2 m + mh)) q1''[t] - la lb m Cos[q1[t] - q2[t]] q2''[t] - la lb m Cos[t] q1''[t] - la lb m C$ $1b^2 \, m \, Cos[q1[t] - q2[t]] \, q2''[t] - 2 \, la \, m \, Cos[q1[t]] \, q3''[t] - 1b \, m \, Cos[q$ la mh Cos [q1[t]] q3"[t] - lb mh Cos [q1[t]] q3"[t] - 2 la m Sin [q1[t]] q4"[t] - $1b \, m \, Sin[q1[t]] \, q4''[t] - 1a \, mh \, Sin[q1[t]] \, q4''[t] - 1b \, mh \, Sin[q1[t]] \, q4''[t]$ -tau2+glbmSin[q2[t]]+lb(la+lb)mSin[q1[t]-q2[t]]q1′[t]²-1b (1a + 1b) m Cos[q1[t] - q2[t]] q1''[t] + Iz q2''[t] + $1b^2 m q2''[t] + 1b m Cos[q2[t]] q3''[t] + 1b m Sin[q2[t]] q4''[t]$, $(lb (m + mh) + la (2 m + mh)) Sin[q1[t]] q1'[t]^2 - lb m Sin[q2[t]] q2'[t]^2 2 \ln M \cos[q1[t]] q1''[t] - 1b m \cos[q1[t]] q1''[t] - 1a mh \cos[q1[t]] q1''[$ $1b \, mh \, Cos[q1[t]] \, q1''[t] + 1b \, m \, Cos[q2[t]] \, q2''[t] + 2 \, m \, q3''[t] + mh \, q3''[t]$, $2\,g\,m + g\,mh - \left(1b\,\left(m + mh\right) + 1a\,\left(2\,m + mh\right)\right)\,Cos\left[q1[t]\right]\,q1'[t]^2 + 1b\,m\,Cos\left[q2[t]\right]\,q2'[t]^2 - 1a^2\left[q2[t]\right]\,q2'[t]^2 + 1a^2\left[q2[t]\right]^2 + 1a^2\left[$ $2 \ln M \sin[q1[t]] q1''[t] - \ln M \sin[q1[t]] q1''[t] - \ln M \sin[q1[t]] q1''[t] - \ln M \sin[q1[t]] q1''[t]$ $1b \, mh \, Sin[q1[t]] \, q1''[t] + 1b \, m \, Sin[q2[t]] \, q2''[t] + 2 \, m \, q4''[t] + mh \, q4''[t] \, \Big\}$ In[33]:= HurGlobalMMatrix // MatrixForm Out[33]//MatrixForm $Iz + 2 la lb (m + mh) + lb^{2} (m + mh) + la^{2} (2 m + mh) - lb (la + lb) m Cos [q1[t] - q2[t]] - (lb (m + mh)) + la^{2} (2 m + mh) - lb (la + lb) m Cos [q1[t] - q2[t]] - (lb (m + mh)) + la^{2} (2 m + mh) + la^{2} (2 m + mh) - lb (la + lb) m Cos [q1[t] - q2[t]] - (lb (m + mh)) + la^{2} (2 m + mh) + la^$ -1b (1a + 1b) m Cos [q1[t] - q2[t]] $Iz + 1b^2 m$ $- \left(\texttt{lb} \, \left(\texttt{m} + \texttt{mh} \right) \, + \, \texttt{la} \, \left(\texttt{2} \, \texttt{m} + \texttt{mh} \right) \, \right) \, \, \texttt{Cos} \, [\, \texttt{q1} \, [\, \texttt{t} \,] \, \,]$ lb m Cos[q2[t]] -(1b(m+mh)+1a(2m+mh))Sin[q1[t]]lb m Sin [q2[t]] In[34]:= HurGlobalCMatrix // MatrixForm -1b(1a+1b) m Sin[q1[t] - q2[t]] q2'[t] 0 0

Out[34]//MatrixForm=

$$\begin{pmatrix} 0 & -1b \left(1a + 1b \right) \text{ m Sin}[q1[t] - q2[t]] \text{ q2'}[t] & 0 & 0 \\ 1b \left(1a + 1b \right) \text{ m Sin}[q1[t] - q2[t]] \text{ q1'}[t] & 0 & 0 \\ \left(1b \left(m + mh \right) + 1a \left(2m + mh \right) \right) \text{Sin}[q1[t]] \text{ q1'}[t] & -1b \text{ m Sin}[q2[t]] \text{ q2'}[t] & 0 & 0 \\ - \left(1b \left(m + mh \right) + 1a \left(2m + mh \right) \right) \text{Cos}[q1[t]] \text{ q1'}[t] & 1b \text{ m Cos}[q2[t]] \text{ q2'}[t] & 0 & 0 \\ \end{pmatrix}$$

In[35]:= HurGlobalGVector // MatrixForm

Out[35]//MatrixForm=

In[36]:= FOOTSW

Out[36]= a2
$$(la + lb) - b2 (la + lb) + n1 q3 [t] + n2 q4 [t]$$

$$\begin{array}{ll} \text{Out} \mbox{[37]=} & \left\{ \left\{ -\left(\mbox{1a+b} \right) \, \mbox{$Cos\,[q1[t]\,]$, $\left(\mbox{$1$a+$b$} \right) \, \mbox{$Cos\,[q2[t]\,]$, $1,0$} \right\}, \\ & \left\{ -\left(\mbox{1a+b} \right) \, \mbox{$Sin\,[q1[t]\,]$, $\left(\mbox{$1$a+$b$} \right) \, \mbox{$Sin\,[q2[t]\,]$, $0,1$} \right\} \end{array} \right\}$$

```
In[38]:= ImpactLHS = ArrayFlatten[
                                             {{HurGlobalMMatrix, -Transpose[Jbfoot]}, {Jbfoot, Table[0, {i, 2}, {j, 2}]}}];
                              ImpactLHS // MatrixForm
                             ArrayFlatten[{{HurGlobalMMatrix, -Transpose[Jbfoot]}}] // MatrixForm
                              Jbfoot // MatrixForm
Out[39]//MatrixForm=
                                    Iz + 2 la lb (m + mh) + lb^{2} (m + mh) + la^{2} (2 m + mh) - lb (la + lb) m Cos [q1[t] - q2[t]] - (lb (m + mh)) + la^{2} (2 m + mh) - lb (la + lb) m Cos [q1[t] - q2[t]] - (lb (m + mh)) + la^{2} (2 m + mh) + la^{2} (2 m + mh
                                                                -1b(1a+1b) m Cos[q1[t] - q2[t]]
                                                                                                                                                                                                                                                                                                    Iz + 1b^2 m
                                                   -(1b(m+mh) + 1a(2m+mh)) Cos[q1[t]]
                                                                                                                                                                                                                                                                                      1b m Cos [q2[t]]
                                                  -(lb(m+mh)+la(2m+mh))Sin[q1[t]]
                                                                                                                                                                                                                                                                                      lb m Sin [q2[t]]
                                                                                        - (la + lb) Cos [q1[t]]
                                                                                                                                                                                                                                                                            (la + lb) Cos[q2[t]]
                                                                                         - (la + lb) Sin[q1[t]]
                                                                                                                                                                                                                                                                             (la + lb) Sin[q2[t]]
Out[40]//MatrixForm=
                                    Iz + 2 la lb (m + mh) + lb^{2} (m + mh) + la^{2} (2 m + mh) - lb (la + lb) m Cos [q1[t] - q2[t]] - (lb (m + mh))
                                                               -1b (1a + 1b) m Cos [q1[t] - q2[t]]
                                                                                                                                                                                                                                                                                                    Iz + 1b^2 m
                                                  -(1b(m+mh)+1a(2m+mh))Cos[q1[t]]
                                                                                                                                                                                                                                                                              1b m Cos[q2[t]]
                                                    -(1b(m+mh)+1a(2m+mh))Sin[q1[t]]
                                                                                                                                                                                                                                                                                    1b m Sin [q2[t]]
Out[41]//MatrixForm=
                                   - (la + lb) Cos [q1[t]] (la + lb) Cos [q2[t]] 1 0 )
                                | - (la + lb) Sin[q1[t]] (la + lb) Sin[q2[t]] 0 1 |
       In[42]:= HurToJulia[ImpactLHS]
     Out[42] = [(Iz + (2*la*lb*(m+mh) + ((lb)^(2)*(m+mh) + (la)^(2)*(2*m+mh))))
                                        -1*lb*(la+lb)*m*cos((q1+-1*q2)) -1*(lb*(m+mh)+la*(2*m+mh))*cos(q1)
                                        -1*(lb*(m+mh)+la*(2*m+mh))*sin(q1) (la+lb)*cos(q1)
                                        (la+lb)*sin(q1);-1*lb*(la+lb)*m*cos((q1+-1*q2))
                                        (Iz+(1b)^{(2)}*m) 1b*m*cos(q2) 1b*m*sin(q2) -1*(1a+1b)*cos(q2)
                                        -1*(la+lb)*sin(q2);-1*(lb*(m+mh)+la*(2*m+mh))*cos(q1)
                                        1b*m*cos(q2) (2*m+mh) 0 -1 0; -1*(1b*(m+mh))+1a*(2*m+mh))*sin(q1)
                                        1b*m*sin(q2) 0 (2*m+mh) 0 -1;-1*(1a+1b)*cos(q1) (1a+1b)*cos(q2)
                                        1 0 0 0; -1*(la+lb)*sin(q1) (la+lb)*sin(q2) 0 1 0 0
       In[43]:= HurGlobalMMatrix.HurList2Column[{q1'[t], q2'[t], 0, 0}]
                             HurToJulia[%]
     Out[43]= \{\{(Iz + 2 la lb (m + mh) + lb^2 (m + mh) + la^2 (2 m + mh))\} q1'[t] -
                                             1b (1a + 1b) m Cos [q1[t] - q2[t]] q2'[t] 
                                    \{-1b (la + 1b) m Cos[q1[t] - q2[t]] q1'[t] + (Iz + 1b^2 m) q2'[t]\},
                                    \{-(1b(m+mh)+1a(2m+mh)) Cos[q1[t]] q1'[t]+1b m Cos[q2[t]] q2'[t]\},
                                    {-(lb(m+mh)+la(2m+mh))Sin[q1[t]]q1'[t]+lbmSin[q2[t]]q2'[t]}}
      \text{Out}[44] = \left[ \; \left( \; \left( \; \mathsf{Iz} + \; \left( \; 2 \star \; \mathsf{Ia} \star \; \mathsf{Ib} \star \; \left( \; \mathsf{m} + \mathsf{mh} \right) \; + \; \left( \; \mathsf{Ib} \right) \; ^{\wedge} \left( \; 2 \right) \star \; \left( \; \mathsf{m} + \mathsf{mh} \right) \; + \; \left( \; \mathsf{Ia} \right) \; ^{\wedge} \left( \; 2 \; \star \; \mathsf{m} + \mathsf{mh} \right) \; \right) \; \right) \\ \times \; \mathsf{q1d} + \; -1 \star \; \mathsf{Ib} \star \; \left( \; \mathsf{Ia} + \; \mathsf{Ib} \right) \; \star \; \mathsf{m} \star \; \mathsf{cos} \; \left( \; \left( \; \mathsf{Ia} + \; \mathsf{Ib} \right) \; \right) \; \right) \\ \times \; \mathsf{q1d} + \; -1 \star \; \mathsf{Ib} \star \; \left( \; \mathsf{Ia} + \; \mathsf{Ib} \right) \; \star \; \mathsf{m} \star \; \mathsf{cos} \; \left( \; \mathsf{Ia} + \; \mathsf{Ib} \right) \; \right) \\ \times \; \mathsf{q1d} + \; -1 \star \; \mathsf{Ib} \star \; \left( \; \mathsf{Ia} + \; \mathsf{Ib} \right) \; \star \; \mathsf{m} \star \; \mathsf{cos} \; \left( \; \mathsf{Ia} + \; \mathsf{Ib} \right) \; \right) \\ \times \; \mathsf{q1d} + \; \mathsf{q1d} + \; \mathsf{q1d} \; \mathsf{q1d
                                        q1+-1*q2))*q2d); (-1*lb*(la+lb)*m*cos((q1+-1*q2))*q1d+(Iz+(lb)^{(2)}*m)*q2d); (-1*(lb*(la+lb))*m*cos((q1+-1*q2)))*q2d+(Iz+(lb)^{(2)}*m)*q2d); (-1*(lb*(la+lb))*m*cos((q1+-1*q2)))*q1d+(Iz+(lb)^{(2)}*m)*q2d); (-1*(lb*(la+lb))*m*cos((q1+-1*q2)))*q1d+(Iz+(lb)^{(2)}*m)*q2d); (-1*(lb*(la+lb))*m*cos((q1+-1*q2)))*q1d+(Iz+(lb)^{(2)}*m)*q2d); (-1*(lb*(la+lb))*m*cos((q1+-1*q2)))*q1d+(Iz+(lb)^{(2)}*m)*q2d); (-1*(lb*(la+lb))*m*cos((q1+-1*q2)))*q1d+(Iz+(lb)^{(2)}*m)*q2d); (-1*(lb*(la+lb)))*m*cos((q1+-1*q2)))*q1d+(Iz+(lb)^{(2)}*m)*q2d); (-1*(lb*(la+lb)))*m*cos((q1+-1*q2)))*q1d+(Iz+(lb*(la+lb)))*m*cos((q1+-1*q2)))*q1d+(Iz+(lb*(la+lb)))*q1d+(Iz+(lb*(la+lb)))*q1d+(Iz+(lb*(la+lb)))*q1d+(Iz+(lb*(la+lb)))*q1d+(Iz+(lb*(la+lb)))*q1d+(Iz+(lb*(la+lb)))*q1d+(Iz+(lb*(la+lb)))*q1d+(Iz+(lb*(la+lb)))*q1d+(Iz+(lb*(la+lb)))*q1d+(Iz+(lb*(la+lb)))*q1d+(Iz+(lb*(la+lb)))*q1d+(Iz+(lb*(la+lb)))*q1d+(Iz+(lb*(la+lb)))*q1d+(Iz+(lb*(la+lb)))*q1d+(Iz+(lb*(la+lb)))*q1d+(Iz+(lb*(la+lb)))*q1d+(Iz+(lb*(la+lb)))*q1d+(Iz+(lb*(la+lb)))*q1d+(Iz+(lb*(la+lb)))*q1d+(Iz+(lb*(la+lb)))*q1d+(Iz+(lb*(la+lb)))*q1d+(Iz+(lb*(la+lb)))*q1d+(Iz+(lb*(la+lb)))*q1d+(Iz+(lb*(la+lb)))*q1d+(Iz+(lb*(la+lb)))*q1d+(Iz+(lb*(la+lb)))*q1d+(Iz+(lb*(la+lb)))*q1d+(Iz+(lb*(la+lb)))*q1d+(Iz+(lb*(la+lb)))*q1d+(Iz+(lb*(la+lb)))*q1d+(Iz+(lb*(la+lb)))*q1d+(Iz+(lb*(la+lb)))*q1d+(Iz+(lb*(la+lb))
                                        m+mh) + la*(2*m+mh)) * cos(q1) * q1d + lb*m*cos(q2)*q2d); (-1*(lb*(m+mh)+ la*(2*m+mh)) * sin(q1)
                                        *q1d+lb*m*sin(q2)*q2d)
```

Expressions for impact dynamics constraints

```
In[45]:= HurGlobalMMatrix // MatrixForm
Out[45]//MatrixForm=
                                                                Iz + 2 la lb (m + mh) + lb^{2} (m + mh) + la^{2} (2 m + mh) - lb (la + lb) m Cos [q1[t] - q2[t]] - (lb (m + mh)) + la^{2} (2 m + mh) - lb (la + lb) m Cos [q1[t] - q2[t]] - (lb (m + mh)) + la^{2} (2 m + mh) + la^{2} (2 m + mh
                                                                                                              -1b (1a + 1b) m Cos [q1[t] - q2[t]]
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       Iz + 1b^2 m
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     11
                                                                                          -(1b(m+mh)+1a(2m+mh))Cos[q1[t]] lb m Cos[q2[t]]
                                                                                          In[46]:= HurGlobalMMatrix
          Out[46] = \{ \{ Iz + 2 la lb (m + mh) + lb^2 (m + mh) + la^2 (2 m + mh), -lb (la + lb) m Cos [q1[t] - q2[t]] \}
                                                                       -(1b(m+mh)+1a(2m+mh))Cos[q1[t]], -(1b(m+mh)+1a(2m+mh))Sin[q1[t]]
                                                                \{-1b (la + lb) m Cos[q1[t] - q2[t]], Iz + lb^2 m, lb m Cos[q2[t]], lb m Sin[q2[t]]\},
                                                                \{-(1b(m+mh)+1a(2m+mh)) Cos[q1[t]], 1b m Cos[q2[t]], 2m+mh, 0\},
                                                                {- (1b (m + mh) + la (2 m + mh)) Sin[q1[t]], 1b m Sin[q2[t]], 0, 2 m + mh}}
             In[47]:= impDynConst1 = ArrayFlatten[{{HurGlobalMMatrix, -Transpose[Jbfoot]}}].
                                                                                      HurList2Column[{q1dp, q2dp, q3dp, q4dp, F1, F2}] -
                                                                               HurGlobalMMatrix.HurList2Column[{q1'[t], q2'[t], 0, 0}] // Simplify
           \text{Out} [47] = \ \left\{ \ \left( \ \text{Iz} + 2 \ \text{la} \ \text{lb} \ \left( \text{m} + \text{mh} \right) \ + \ \text{lb}^2 \ \left( \text{m} + \text{mh} \right) \ + \ \text{la}^2 \ \left( 2 \ \text{m} + \text{mh} \right) \ \right) \ \text{q1dp} \ + \ \text{F1} \ \left( \text{la} + \ \text{lb} \right) \ \text{Cos} \ \left[ \ \text{q1} \ \left[ \ \text{t} \ \right] \ \right] \ - \ \text{cos} \ \left[ \ \text{q1} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2} \ \text{mh} \right] \ + \ \text{cos} \ \left[ \ \text{q2}
                                                                                 (1b (m+mh) + la (2m+mh)) q3dp Cos[q1[t]] - lb (la+lb) m q2dp Cos[q1[t] - q2[t]] +
                                                                               F2 (la + lb) Sin[q1[t]] - (lb (m + mh) + la (2 m + mh)) q4dp Sin[q1[t]] -
                                                                                (Iz + 2 la lb (m + mh) + lb^{2} (m + mh) + la^{2} (2 m + mh)) q1'[t] +
                                                                               1b (1a + 1b) m Cos [q1[t] - q2[t]] q2'[t],
                                                                \{(Iz + 1b^2 m) q2dp - 1b(1a + 1b) m q1dp Cos[q1[t] - q2[t]] - F1(1a + 1b) Cos[q2[t]] + \{(Iz + 1b^2 m) q2dp - 1b(1a + 1b) m q1dp Cos[q1[t]] + (Iz + 1b^2 m) q2dp - 1b(1a + 1b) m q1dp Cos[q1[t]] + (Iz + 1b^2 m) q2dp - 1b(1a + 1b) m q1dp Cos[q1[t]] + (Iz + 1b^2 m) q2dp - 1b(1a + 1b) m q1dp Cos[q1[t]] + (Iz 
                                                                               1b \, m \, q3dp \, Cos[q2[t]] - F2(1a + 1b) \, Sin[q2[t]] + 1b \, m \, q4dp \, Sin[q2[t]] +
                                                                               1b (la + lb) m Cos[q1[t] - q2[t]] q1'[t] - (Iz + lb^2 m) q2'[t],
                                                                \{-F1 + (2m + mh) \ q3dp - (1b(m + mh) + 1a(2m + mh)) \ q1dp \ Cos[q1[t]] + 1b \ m \ q2dp \ Cos[q2[t]] + (2m + mh) \ q1dp \ Cos[q1[t]] + (2m + mh) \ q2dp \ Cos[q2[t]] + (2m + mh) \ q2dp \ C
                                                                                 (1b (m + mh) + 1a (2 m + mh)) Cos[q1[t]] q1'[t] - 1b m Cos[q2[t]] q2'[t] 
                                                               \{-F2 + (2m + mh) + (2m + mh)
                                                                                 (lb (m + mh) + la (2 m + mh)) Sin[q1[t]] q1'[t] - lb m Sin[q2[t]] q2'[t]}}
              In[48]:= impDynConst2 = Jbfoot.HurList2Column[{q1dp, q2dp, q3dp, q4dp}]
          Out[48]= \{ \{q3dp - (1a + 1b) \ q1dp \ Cos \ [q1[t]] + (1a + 1b) \ q2dp \ Cos \ [q2[t]] \} \}
                                                                {q4dp - (la + lb) q1dp Sin[q1[t]] + (la + lb) q2dp Sin[q2[t]]}}
              In[49]:= impDynConst1[[1]][[1]]
                                                   HurToJulia[%]
          Out[49]= (Iz + 2 la lb (m + mh) + lb^2 (m + mh) + la^2 (2 m + mh)) q1dp + F1 (la + lb) Cos [q1[t]] -
                                                               (1b (m + mh) + 1a (2m + mh)) q3dp Cos[q1[t]] - 1b (1a + 1b) m q2dp Cos[q1[t] - q2[t]] +
                                                            F2 (la + lb) Sin[q1[t]] - (lb (m + mh) + la (2 m + mh)) q4dp Sin[q1[t]] -
                                                                (Iz + 2 la lb (m + mh) + lb^{2} (m + mh) + la^{2} (2 m + mh)) q1'[t] +
                                                            1b (1a + 1b) m Cos [q1[t] - q2[t]] q2'[t]
           \text{Out} \\ \text{Solitor} = \left( \left( \text{Iz} + \left( 2 \star 1 \text{a} \star 1 \text{b} \star \left( \text{m} + \text{mh} \right) + \left( \left( 1 \text{b} \right) \wedge \left( 2 \right) \star \left( \text{m} + \text{mh} \right) + \left( 1 \text{a} \right) \wedge \left( 2 \right) \star \left( 2 \star \text{m} + \text{mh} \right) \right) \right) \right) \\ \text{$\star$ q1dp+ (F1 \star (1a+1b) \star \cos (q1) + \left( 1 \text{b} \right) \wedge \left( 2 \text{b} \right) + \left( 1 \text{b} \right) \wedge \left( 2 \text{b} \right) } \\ \text{$\star$ p1 dp+ (F1 \star (1a+1b) \star \cos (q1) + \left( 1 \text{b} \right) \wedge \left( 2 \text{b} \right) + \left( 1 \text{b} \right) \wedge \left( 2 \text{b} \right) } \\ \text{$\star$ p2 dp+ (F1 \star (1a+1b) \star \cos (q1) + \left( 1 \text{b} \right) \wedge \left( 2 \text{b} \right) + \left( 1 \text{b} \right) \wedge \left( 2 \text{b} \right) } \\ \text{$\star$ p3 dp+ (F1 \star (1a+1b) \star \cos (q1) + \left( 1 \text{b} \right) \wedge \left( 2 \text{b} \right) + \left( 1 \text{b} \right) \wedge \left( 2 \text{b} \right) } \\ \text{$\star$ p3 dp+ (F1 \star (1a+1b) \star \cos (q1) + \left( 1 \text{b} \right) \wedge \left( 2 \text{b} \right) + \left( 1 \text{b} \right) \wedge \left( 2 \text{b} \right) } \\ \text{$\star$ p3 dp+ (F1 \star (1a+1b) \star \cos (q1) + \left( 1 \text{b} \right) \wedge \left( 2 \text{b} \right) } \\ \text{$\star$ p3 dp+ (F1 \star (1a+1b) \star \cos (q1) + \left( 1 \text{b} \right) \wedge \left( 2 \text{b} \right) } \\ \text{$\star$ p3 dp+ (F1 \star (1a+1b) \star \cos (q1) + \left( 1 \text{b} \right) \wedge \left( 2 \text{b} \right) } \\ \text{$\star$ p4 dp+ (F1 \star (1a+1b) \star \cos (q1) + \left( 1 \text{b} \right) \wedge \left( 2 \text{b} \right) } \\ \text{$\star$ p4 dp+ (F1 \star (1a+1b) \star \cos (q1) + \left( 1 \text{b} \right) \wedge \left( 2 \text{b} \right) } \\ \text{$\star$ p4 dp+ (F1 \star (1a+1b) \star \cos (q1) + \left( 1 \text{b} \right) \wedge \left( 2 \text{b} \right) } \\ \text{$\star$ p4 dp+ (F1 \star (1a+1b) \star \cos (q1) + \left( 1 \text{b} \right) \wedge \left( 2 \text{b} \right) } \\ \text{$\star$ p4 dp+ (F1 \star (1a+1b) \star \cos (q1) + \left( 1 \text{b} \right) \wedge \left( 2 \text{b} \right) } \\ \text{$\star$ p4 dp+ (F1 \star (1a+1b) \star \cos (q1) + \left( 1 \text{b} \right) \wedge \left( 2 \text{b} \right) } \\ \text{$\star$ p4 dp+ (F1 \star (1a+1b) \star \cos (q1) + \left( 1 \text{b} \right) \wedge \left( 2 \text{b} \right) } \\ \text{$\star$ p4 dp+ (F1 \star (1a+1b) \star \cos (q1) + \left( 1 \text{b} \right) \wedge \left( 2 \text{b} \right) } \\ \text{$\star$ p4 dp+ (F1 \star (1a+1b) \star \cos (q1) + \left( 1 \text{b} \right) \wedge \left( 2 \text{b} \right) } \\ \text{$\star$ p4 dp+ (F1 \star (1a+1b) \star \cos (q1) + \left( 1 \text{b} \right) \wedge \left( 2 \text{b} \right) } \\ \text{$\star$ p4 dp+ (F1 \star (1a+1b) \star (1a+1b) + \left( 1 \text{b} \right) \wedge \left( 2 \text{b} \right) } \\ \text{$\star$ p4 dp+ (F1 \star (1a+1b) \star (1a+1b) + \left( 1 \text{b} \right) } \\ \text{$\star$ p4 dp+ (F1 \star (1a+1b) \star (1a+1b) + \left( 1 \text{b} \right) } \\ \text{$\star$ p4 dp+ (F1 \star (1a+1b) + \left( 1 \text{b} \right) \wedge \left( 1 \text{b} \right) } \\ \text{$\star$ p4 dp+ (F1 \star (1a+1b) \star (1a+1b) + \left( 1 \text{b} \right) \wedge \left( 1 \text{b} \right) } \\ \text{$\star$ p4 dp+ (F1 \star (1a+1b) \star (1a+1b) + \left( 1 \text{b} \right) \wedge \left( 1 \text{b} \right) } \\ \text{$\star$ p4 dp+ (F1 \star (1a+1b) \star (1a+1b) + \left( 1 \text{b} \right) \wedge \left( 1
                                                                    -1*(1b*(m+mh)+la*(2*m+mh))*q3dp*cos(q1)+(-1*lb*(la+lb)*m*q2dp*cos((q1+-1*q2))+(F2*(la+lb)*m*q2dp*cos((q1+-1*q2))+(F2*(la+lb)*m*q2dp*cos((q1+-1*q2))+(F2*(la+lb)*m*q2dp*cos((q1+-1*q2))+(F2*(la+lb)*m*q2dp*cos((q1+-1*q2))+(F2*(la+lb)*m*q2dp*cos((q1+-1*q2))+(F2*(la+lb)*m*q2dp*cos((q1+-1*q2))+(F2*(la+lb)*m*q2dp*cos((q1+-1*q2))+(F2*(la+lb)*m*q2dp*cos((q1+-1*q2))+(F2*(la+lb)*m*q2dp*cos((q1+-1*q2))+(F2*(la+lb)*m*q2dp*cos((q1+-1*q2))+(F2*(la+lb)*m*q2dp*cos((q1+-1*q2))+(F2*(la+lb)*m*q2dp*cos((q1+-1*q2))+(F2*(la+lb)*m*q2dp*cos((q1+-1*q2))+(F2*(la+lb)*m*q2dp*cos((q1+-1*q2))+(F2*(la+lb)*m*q2dp*cos((q1+-1*q2))+(F2*(la+lb)*m*q2dp*cos((q1+-1*q2))+(F2*(la+lb)*m*q2dp*cos((q1+-1*q2))+(F2*(la+lb)*m*q2dp*cos((q1+-1*q2))+(F2*(la+lb)*m*q2dp*cos((q1+-1*q2))+(F2*(la+lb)*m*q2dp*cos((q1+-1*q2))+(F2*(la+lb)*m*q2dp*cos((q1+-1*q2))+(F2*(la+lb)*m*q2dp*cos((q1+1+1*q2))+(F2*(la+lb)*m*q2dp*cos((q1+1+1*q2))+(F2*(la+lb)*m*q2dp*cos((q1+1+1*q2))+(F2*(la+lb)*m*q2dp*cos((q1+1+1*q2))+(F2*(la+lb)*m*q2dp*cos((q1+1+1*q2))+(F2*(la+lb)*m*q2dp*cos((q1+1+1*q2))+(F2*(la+lb)*m*q2dp*cos((q1+1+1*q2))+(F2*(la+lb)*m*q2dp*cos((q1+1+1*q2))+(F2*(la+lb)*m*q2dp*cos((q1+1+1*q2))+(F2*(la+lb)*m*q2dp*cos((q1+1+1*q2))+(F2*(la+lb)*m*q2dp*cos((q1+1+1*q2))+(F2*(la+lb)*m*q2dp*cos((q1+1+1*q2))+(F2*(la+lb)*m*q2dp*cos((q1+1+1*q2))+(F2*(la+lb)*m*q2dp*cos((q1+1+1*q2))+(F2*(la+lb)*m*q2dp*cos((q1+1+1*q2))+(F2*(la+lb)*m*q2dp*cos((q1+1+1*q2))+(F2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(la+lb)*m*q2*(
```

1a + 1b) * sin(q1) + (-1*(1b*(m+mh) + 1a*(2*m+mh)) * q4dp*sin(q1) + (-1*(Iz + (2*la*1b*(m+mh) + ((1a*(1b*(m+mh) + 1a*(2*m+mh)) + ((1a*(1b*(m+mh) + 1a*(2*m+mh))) + ((1a*(1b*(m+mh) + 1a*(2*m+mh)) + ((1a*(1b*(m+m+mh) + 1a*(2*m+mh)) + ((1a*(1b*(m+mh) + 1a*(2*m+mh)) + ((1a*(1b*(m+mh) + 1a*(2*m+mh)) + ((1a*(1b*(m+mh) + 1a*(2*m+mh))) + ((1a*(1b*(m+mh) + 1a* $1b)^{(2)} * (m+mh) + (1a)^{(2)} * (2*m+mh))) * q1d + 1b * (1a+1b) * m * cos ((q1+-1*q2)) * q2d))))))$

```
In[51]:= impDynConst1[[2]][[1]]
                                                   HurToJulia[%]
Out[51]= (Iz + 1b^2 m) q2dp - 1b (la + lb) m q1dp Cos[q1[t] - q2[t]] -
                                                              F1 (la + lb) Cos[q2[t]] + lb m q3dp Cos[q2[t]] - F2 (la + lb) Sin[q2[t]] +
                                                             1b \text{ m q4dp Sin}[q2[t]] + 1b (1a + 1b) \text{ m Cos}[q1[t] - q2[t]] q1'[t] - (Iz + 1b^2 \text{ m}) q2'[t]
 \text{Out} \text{[52]= } \left( \left( \text{Iz} + \left( 1b \right) ^{\wedge} \left( 2 \right) \star \text{m} \right) \star \text{q2dp} + \left( -1 \star 1b \star \left( 1a + 1b \right) \star \text{m} \star \text{q1dp} \star \text{cos} \left( \left( \text{q1} + -1 \star \text{q2} \right) \right) + \left( -1 \star \text{F1} \star \left( 1a + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star \text{cos} \left( \text{q2} \right) + \left( 1b + 1b \right) \star 
                                                                        *m*q3dp*cos(q2) + (-1*F2*(1a+1b)*sin(q2) + (1b*m*q4dp*sin(q2) + (1b*(1a+1b)*m*cos((q1+-1*(1b*(1a+1b)*m*cos((q1+-1*(1a+1b)*m*cos((q1+-1*(1a+1b)*m*cos((q1+-1*(1a+1b)*m*cos((q1+-1*(1a+1b)*m*q3dp*cos((q1+-1*(1a+1b)*m*cos((q1+-1*(1a+1b)*m*cos((q1+-1*(1a+1b)*m*cos((q1+-1*(1a+1b)*m*cos((q1+-1*(1a+1b)*m*cos((q1+-1*(1a+1b)*m*cos((q1+-1*(1a+1b)*m*cos((q1+-1*(1a+1b)*m*cos((q1+-1*(1a+1b)*m*cos((q1+-1*(1a+1b)*m*cos((q1+-1*(1a+1b)*m*cos((q1+-1*(1a+1b)*m*cos((q1+-1*(1a+1b)*m*cos((q1+-1*(1a+1b)*m*cos((q1+-1*(1a+1b)*m*cos((q1+-1*(1a+1b)*m*cos((q1+-1*(1a+1b)*m*cos((q1+-1*(1a+1b)*m*cos((q1+-1*(1a+1b)*m*cos((q1+-1*(1a+1b)*m*cos((q1+-1*(1a+1b)*m*cos((q1+-1*(1a+1b)*m*cos((q1+-1*(1a+1b)*m*cos((q1+-1*(1a+1b)*m*cos((q1+-1*(1a+1b)*m*cos((q1+-1*(1a+1b)*m*cos((q1+-1*(1a+1b)*m*cos((q1+-1*(1a+1b)*m*cos((q1+-1*(1a+1b)*m*cos((q1+-1*(1a+1b)*m*cos((q1+-1*(1a+1b)*m*cos((q1+-1*(1a+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos((q1+1b)*m*cos(
                                                                        q2))*q1d+-1*(Iz+(1b)^{(2)*m)*q2d)))))))
     In[53]:= impDynConst1[[3]][[1]]
                                                  HurToJulia[%]
Out[53] = -F1 + (2 m + mh) q3dp - (1b (m + mh) + 1a (2 m + mh)) q1dp Cos[q1[t]] + 1b m q2dp Cos[q2[t]] + 1b m q2
                                                                 (1b (m + mh) + 1a (2 m + mh)) Cos[q1[t]] q1'[t] - 1b m Cos[q2[t]] q2'[t]
 \text{Out}_{[54]} = (-1 \times \text{F1+} ((2 \times \text{m+mh}) \times \text{q3dp} + (-1 \times (1b \times (\text{m+mh}) + 1a \times (2 \times \text{m+mh})) \times \text{q1dp} \times \cos(\text{q1}) + (1b \times \text{m} \times \text{q2dp} \times \cos(\text{q2}) + ((1b \times \text{m+mh}) \times \text{q3dp} \times (1b \times \text{m+mh})) \times \text{q1dp} \times \cos(\text{q1}) + (1b \times \text{m+q2dp} \times \cos(\text{q2}) + (1b \times \text{m+mh}) \times \text{q3dp} \times (1b \times \text{m+mh})) \times \text{q1dp} \times \cos(\text{q1}) + (1b \times \text{m+q2dp} \times \cos(\text{q2}) + (1b \times \text{m+mh}) \times \text{q3dp} \times (1b \times \text{m+mh})) \times \text{q3dp} \times (1b \times \text{m+mh}) \times \text{q3dp} \times (1b \times \text{m+mh}) \times \text{q3dp} \times (1b \times \text{m+mh})) \times \text{q3dp} \times (1b \times \text{m+mh}) \times \text{q3dp} \times (1b \times \text{m+mh}) \times (
                                                                         *(m+mh)+la*(2*m+mh))*cos(q1)*q1d+-1*lb*m*cos(q2)*q2d)))))
    In[55]:= impDynConst1[[4]][[1]]
                                                  HurToJulia[%]
Out[55] = -F2 + (2 m + mh) q4dp - (1b (m + mh) + 1a (2 m + mh)) q1dp Sin[q1[t]] + 1b m q2dp Sin[q2[t]] +
                                                                 (1b (m + mh) + 1a (2 m + mh)) Sin[q1[t]] q1'[t] - 1b m Sin[q2[t]] q2'[t]
Out[56] = (-1 * F2 + ((2 * m + mh) * q4dp + (-1 * (1b * (m + mh) + 1a * (2 * m + mh)) * q1dp * sin(q1) + (1b * m * q2dp * sin(q2) + ((1b * m * q2dp * sin(q2) + (1b * m * q2dp * sin(
                                                                        *(m+mh)+la*(2*m+mh))*sin(q1)*q1d+-1*lb*m*sin(q2)*q2d)))))
    In[57]:= impDynConst2[[1]][[1]]
                                                  HurToJulia[%]
Out[57]= q3dp - (la + lb) q1dp Cos[q1[t]] + (la + lb) q2dp Cos[q2[t]]
Out[58]= (q3dp + (-1*(la+lb)*q1dp*cos(q1) + (la+lb)*q2dp*cos(q2)))
    In[59]:= impDynConst2[[2]][[1]]
                                                  HurToJulia[%]
Out[59]= q4dp - (la + lb) q1dp Sin[q1[t]] + (la + lb) q2dp Sin[q2[t]]
Out[60] = (q4dp + (-1*(la+lb)*q1dp*sin(q1) + (la+lb)*q2dp*sin(q2)))
    In[61]:= temp = Inverse[HurGlobalMMatrix].Transpose[Jbfoot] // Simplify
```

```
Out[61]= \left\{ -\left( (1b m (-(2 Iz (2 m + mh)) + 1b m (1b (m + mh)) - 1a (2 m + mh)) \right) Cos[q1[t]] + \right\}
                                                                                                                                                                                                                             lb m (lb (m + mh) + la (2 m + mh)) Cos [q1[t] - 2 q2[t]])) / (-2 Iz^2 (2 m + mh)^2 -
                                                                                                                                                                                               4 \text{ Iz } 1b^2 \text{ m } (2 \text{ m}^2 + 3 \text{ m mh} + \text{mh}^2) - 1b^4 \text{ m}^2 (\text{m}^2 + 4 \text{ m mh} + 2 \text{ mh}^2) + 1b^4 \text{ m}^4 \text{ Cos} [2 (q1[t] - q2[t])])
                                                                                                                  (1b \, m \, ((2 \, Iz \, (2 \, m + mh) + 1b \, m \, (1b \, (m + mh) - 1a \, (2 \, m + mh)))) \, Sin[q1[t]] +
                                                                                                                                                                                               1b m (1b (m + mh) + 1a (2 m + mh)) Sin[q1[t] - 2 q2[t]]))
                                                                                                                               \left(-2\,\text{Iz}^2\,\left(2\,\text{m}+\text{mh}\right)^2-4\,\text{Iz}\,1b^2\,\text{m}\,\left(2\,\text{m}^2+3\,\text{m}\,\text{mh}+\text{mh}^2\right)\,-1b^4\,\text{m}^2\,\left(\text{m}^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{m}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{m}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{m}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{m}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{m}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{m}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{m}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{m}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{m}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{m}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{m}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{m}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{m}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{m}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{
                                                                                                                                                             1b^4 m^4 Cos[2(q1[t] - q2[t])]),
                                                                                               \{(-1b^3 m^3 \cos[2 q1[t] - q2[t]] + (2 Iz (2 m + mh) (1b (m + mh) + 1a (2 m + mh)) + (2 Iz (2 m + mh)) + (2
                                                                                                                                                                                                              1b^2 \; m \; \left(2 \; 1a \; \left(2 \; m^2 \; + \; 3 \; m \; mh \; + \; mh^2\right) \; + \; 1b \; \left(m^2 \; + \; 4 \; m \; mh \; + \; 2 \; mh^2\right) \right) \right) \; Cos \left[\; q2 \; [\; t\; ]\; \right] \; \right) \; / \; (2 \; 1a \; \left(2 \; m^2 \; + \; 3 \; m \; mh \; + \; mh^2\right) \; + \; 1b \; \left(m^2 \; + \; 4 \; m \; mh \; + \; 2 \; mh^2\right) \right) \; ) \; Cos \left[\; q2 \; [\; t\; ]\; \right] \; / \; (2 \; m^2 \; + \; 3 \; m \; mh \; + \; mh^2) \; + \; 1b \; \left(m^2 \; + \; 4 \; m \; mh \; + \; 2 \; mh^2\right) \; ) \; ) \; (2 \; m^2 \; + \; 3 \; m \; mh \; + \; mh^2) \; + \; 1b \; \left(m^2 \; + \; 4 \; m \; mh \; + \; 2 \; mh^2\right) \; ) \; ) \; (2 \; m^2 \; + \; 3 \; m \; mh \; + \; mh^2) \; + \; 1b \; \left(m^2 \; + \; 4 \; m \; mh \; + \; 2 \; mh^2\right) \; ) \; ) \; (2 \; m^2 \; + \; 3 \; m \; mh \; + \; mh^2) \; + \; 1b \; \left(m^2 \; + \; 4 \; m \; mh \; + \; 2 \; mh^2\right) \; ) \; ) \; (2 \; m^2 \; + \; 3 \; m \; mh \; + \; mh^2) \; + \; 1b \; \left(m^2 \; + \; 4 \; m \; mh \; + \; 2 \; mh^2\right) \; ) \; ) \; (2 \; m^2 \; + \; 3 \; m \; mh \; + \; mh^2) \; + \; 1b \; \left(m^2 \; + \; 4 \; m \; mh \; + \; 2 \; mh^2\right) \; ) \; ) \; (2 \; m^2 \; + \; 3 \; m \; mh \; + \; mh^2) \; + \; 1b \; \left(m^2 \; + \; 4 \; m \; mh \; + \; 2 \; mh^2\right) \; ) \; (2 \; m^2 \; + \; 3 \; m \; mh \; + \; mh^2) \; + \; 1b \; \left(m^2 \; + \; 4 \; m \; mh \; + \; 2 \; mh^2\right) \; ) \; ) \; (2 \; m^2 \; + \; 3 \; m \; mh \; + \; mh^2) \; + \; 1b \; \left(m^2 \; + \; 4 \; m \; mh \; + \; 2 \; mh^2\right) \; ) \; ) \; (2 \; m^2 \; + \; 3 \; m \; mh \; + \; mh^2) \; + \; 1b \; \left(m^2 \; + \; 4 \; m \; mh \; + \; 2 \; mh^2\right) \; ) \; (2 \; m^2 \; + \; 3 \; m \; mh \; + \; mh^2) \; ) \; (2 \; m^2 \; + \; 3 \; m \; mh \; + \; mh^2) \; ) \; (2 \; m^2 \; + \; 3 \; m \; mh \; + \; mh^2) \; ) \; (2 \; m^2 \; + \; 3 \; m \; mh \; + \; mh^2) \; (2 \; m^2 \; + \; 3 \; m \; mh^2) \; (2 \; m^2 \; + \; 3 \; m \; mh^2) \; (2 \; m^2 \; + \; 3 \; m \; mh^2) \; (2 \; m^2 \; + \; 3 \; m \; mh^2) \; (2 \; m^2 \; + \; 3 \; m \; mh^2) \; (2 \; m^2 \; + \; 3 \; m \; mh^2) \; (2 \; m^2 \; + \; 3 \; m^2) \; (2 \; m^2 \; + \; 3 \; m^2) \; (2 \; m^2 \; + \; 3 \; m^2) \; (2 \; m^2) \; (2 \; m^2 \; + \; 3 \; m^2) \; (2 \; m^2) \; (2
                                                                                                                                   (2 Iz^{2} (2 m + mh)^{2} + 4 Iz 1b^{2} m (2 m^{2} + 3 m mh + mh^{2}) + 1b^{4} m^{2} (m^{2} + 4 m mh + 2 mh^{2}) -
                                                                                                                                                             1b^4 m^4 Cos[2(q1[t] - q2[t])]),
                                                                                                                     (-1b^3 m^3 Sin[2q1[t] - q2[t]] + (2 Iz (2m + mh) (1b (m + mh) + 1a (2m + mh)) +
                                                                                                                                                                                                              1b^2 \; m \; \left(2 \; 1a \; \left(2 \; m^2 \; + \; 3 \; m \; mh \; + \; mh^2\right) \; + \; 1b \; \left(m^2 \; + \; 4 \; m \; mh \; + \; 2 \; mh^2\right) \right) \right) \; Sin \left[\; q2 \; [\; t \; ] \; \right) \; / \; (1b^2 \; m) \; / \; (1b
                                                                                                                                      (2 \text{ Iz}^2 (2 \text{ m} + \text{mh})^2 + 4 \text{ Iz} 1b^2 \text{ m} (2 \text{ m}^2 + 3 \text{ m} \text{ mh} + \text{mh}^2) + 1b^4 \text{ m}^2 (\text{m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2) -
                                                                                                                                                               1b^4 m^4 Cos[2(q1[t] - q2[t])]),
                                                                                                 \left\{\,\left(8\,\,\text{Iz}^{2}\,\text{m} - 8\,\,\text{Iz}\,\,\text{la}\,\,\text{lb}\,\,\text{m}^{2} + 4\,\,\text{Iz}\,\,\text{lb}^{2}\,\,\text{m}^{2} + 2\,\,\text{la}^{2}\,\,\text{lb}^{2}\,\,\text{m}^{3} - 2\,\,\text{la}\,\,\text{lb}^{3}\,\,\text{m}^{3} + 4\,\,\text{Iz}^{2}\,\,\text{mh} - 2\,\,\text{la}^{2}\,\,\text{lb}^{2}\,\,\text{m}^{2} + 2\,\,\text{la}^{2}\,\,\text{lb}^{2}\,\,\text{m}^{3} + 2\,\,\text{la}^{2}\,\,\text{lb}^{2}\,\,\text{m}^{3} + 4\,\,\text{lz}^{2}\,\,\text{mh} - 2\,\,\text{la}^{2}\,\,\text{lb}^{2}\,\,\text{m}^{2} + 2\,\,\text{la}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{m}^{2} + 2\,\,\text{la}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,\text{lb}^{2}\,\,
                                                                                                                                                               1b \, m \, (2 \, Iz \, (1b \, (m + mh) + 1a \, (2 \, m + mh)) + 1b \, m \, (1b^2 \, mh - 1a^2 \, (2 \, m + mh))) \, Cos [2 \, q1[t]] + 1b \, m \, (2 \, Iz \, (1b \, (m + mh))) \, cos [2 \, q1[t]] + 1b \, m \, (1b^2 \, mh - 1a^2 \, (2 \, m + mh)))
                                                                                                                                                               1b^2 (1a + 1b) m^2 (2 1a m + 1a mh + 1b mh) Cos [2 (q1[t] - q2[t])] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2 q2[t]] - 4 Iz 1a 1b m^2 Cos [2
                                                                                                                                                               2 Iz 1b^2 m mh Cos [2 q2[t]] + 1a^2 1b^2 m² mh Cos [2 q2[t]] - 1b^4 m² mh Cos [2 q2[t]]) /
                                                                                                                                   \left(2 \left(2 \text{ Iz}^2 \left(2 \text{ m} + \text{mh}\right)^2 + 4 \text{ Iz } 1b^2 \text{ m} \left(2 \text{ m}^2 + 3 \text{ m} \text{ mh} + \text{mh}^2\right) + 1b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) - 10b^4 \text{ m}^2 \left(1 \text{ m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(1 \text{ m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(1 \text{ m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(1 \text{ m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(1 \text{ m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(1 \text{ m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(1 \text{ m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(1 \text{ m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(1 \text{ m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(1 \text{ m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(1 \text{ m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(1 \text{ m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(1 \text{ m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(1 \text{ m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(1 \text{ m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(1 \text{ m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(1 \text{ m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(1 \text{ m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(1 \text{ m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(1 \text{ m}^2 + 4 \text{ m}^2\right) + 10b^4 \text{ m}^2 \left(1 \text{ m}^2 + 4 \text{ m}^2\right) + 10b^4 \text{ m}^2 \left(1 \text{ m}^2 + 4 \text{ m}^2\right) + 10b^4 \text{ m}^2 \left(1 \text{ m}^2 + 4 \text{ m}^2\right) + 10b^4 \text{ m}^2 \left(1 \text{ m}^2 + 4 \text{ m}^2\right) + 10b^4 \text{ m}^2 \left(1 \text{ m}^2 + 4 \text{ m}^2\right) + 10b^4 \text{ m}^2 \left(1 \text{ m}^2 + 4 \text{ m}^2\right) + 10b^4 \text{ m}^2 \left(1 \text{ m}^2 + 4 \text{ m}^2\right) + 10b^4 \text{ m}^2 \left(1 \text{ m}^2 + 4 \text{ m}^2\right) + 10b^4 \text{ m}^2 \left(1 \text{ m}^2 + 4 \text{ m}^2\right) + 10b^4 \text{ m}^2 \left(1 \text{ m}^2 + 4 \text{ m}^2\right) + 10b^4 \text{ m}^2 \left(1 \text{ m}^2 + 4 \text{ m}^2\right) + 10b^4 \text{ m}^2 \left(1 \text{ m}^2 + 4 \text{ m}^2\right) + 10b^4 \text{ m}^2 \left(1 \text{ m}^2 + 4 \text{ m}^2\right) + 10b^4 \text{ m}^2 \left(1 \text{ m}^2 + 4 \text{ m}^2\right) + 10b^4 \text{ m}^2 \left(1 \text{ m}^2 + 4 \text{ m}^2\right) + 10b^4 \text{ m}^2 \left(1 \text{ m}^2\right) + 10b^4 \text{ m}^2 \left(1 \text{ m}^2 + 4 \text{ m}^2\right) +
                                                                                                                                                                                               1b^4 m^4 Cos[2(q1[t] - q2[t])]),
                                                                                                                     (lb \, m \, Cos[q1[t] - q2[t]] \, (lb \, (la + lb) \, m \, (lb \, mh + la \, (2 \, m + mh)) \, Sin[q1[t] - q2[t]] + (lb \, m \, Cos[q1[t] - q2[t]]) + (lb \, m \, Cos[q1[t] - q2[t]])
                                                                                                                                                                                                   (2 \text{ Iz } (1b (m+mh) + 1a (2 m+mh)) + 1b m (1b^2 mh - 1a^2 (2 m+mh))) \text{ Sin } [q1[t] + q2[t]]))
                                                                                                                                 \left(-2\,\text{Iz}^2\,\left(2\,\text{m}+\text{mh}\right)^2-4\,\text{Iz}\,1b^2\,\text{m}\,\left(2\,\text{m}^2+3\,\text{m}\,\text{mh}+\text{mh}^2\right)\,-1b^4\,\text{m}^2\,\left(\text{m}^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{mh}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{m}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{m}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{m}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{m}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{m}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{m}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{m}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{m}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{m}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{m}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{m}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{m}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{m}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}\,\text{mh}+2\,\text{m}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{1}{2}\,m^2+4\,\text{m}^2\right)\,+1b^4\,\text{m}^2\,\left(\frac{
                                                                                                                                                               1b^4 m^4 Cos[2(q1[t] - q2[t])]),
                                                                                                 -( (lb \, m \, Cos \, [q1[t] - q2[t]) \, (lb \, (la + lb) \, m \, (lb \, mh + la \, (2 \, m + mh)) \, Sin \, [q1[t] - q2[t]] - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t] - q2[t]) \, - (lb \, m \, cos \, [q1[t
                                                                                                                                                                                                                                   (2 \text{ Iz } (1b (m+mh) + 1a (2 m+mh)) + 1b m (1b^2 mh - 1a^2 (2 m+mh))) \text{ Sin } [q1[t] + q2[t]]))
                                                                                                                                                                 \left(-2 \text{ Iz}^2 \left(2 \text{ m}+\text{mh}\right)^2-4 \text{ Iz } 1b^2 \text{ m} \left(2 \text{ m}^2+3 \text{ m} \text{ mh}+\text{mh}^2\right)\right.\\ \left.-1b^4 \text{ m}^2 \left(\text{m}^2+4 \text{ m} \text{ mh}+2 \text{ mh}^2\right)\right.\\ \left.+12 \text{ m}^2 \left(-12 \text{ m}^2+1 \text{ m}^2 \text{ mh}^2\right)\right.\\ \left.+12 \text{ m}^2 \left(-12 \text{ m}^2+1 \text{ m}^2 \text{ mh}^2\right)\right.\\ \left.+12 \text{ m}^2 \left(-12 \text{ m}^2+1 \text{ m}^2 \text{ mh}^2\right)\right.\\ \left.+12 \text{ m}^2 \left(-12 \text{ m}^2+1 \text{ m}^2\right)\right.\\ \left.+12 \text{ m}^2 \left(-12 \text{ m}^2\right)\right.\\ \left.+12
                                                                                                                                                                                               1b^4 m^4 Cos[2(q1[t] - q2[t])]),
                                                                                                                     (8\,\text{Iz}^2\,\text{m} - 8\,\text{Iz}\,\text{la}\,\text{lb}\,\text{m}^2 + 4\,\text{Iz}\,\text{lb}^2\,\text{m}^2 + 2\,\text{la}^2\,\text{lb}^2\,\text{m}^3 - 2\,\text{la}\,\text{lb}^3\,\text{m}^3 + 4\,\text{Iz}^2\,\text{mh} - 4\,\text{Iz}\,\text{la}\,\text{lb}\,\text{m}\,\text{mh} + 4\,\text{lz}^2\,\text{mh}^2 + 4\,\text{lz}^2\,\text{mh}^2 + 2\,\text{la}^2\,\text{lb}^2\,\text{m}^3 - 2\,\text{la}\,\text{lb}^3\,\text{m}^3 + 4\,\text{Iz}^2\,\text{mh}^2 - 4\,\text{Iz}\,\text{la}\,\text{lb}\,\text{m}\,\text{mh}^2 + 4\,\text{lz}^2\,\text{mh}^2 + 4\,\text{lz}^2\,\text{mh}^2 + 2\,\text{la}^2\,\text{lb}^2\,\text{m}^3 - 2\,\text{la}\,\text{lb}^3\,\text{m}^3 + 4\,\text{lz}^2\,\text{mh}^2 - 4\,\text{lz}^2\,\text{la}^2\,\text{mh}^2 + 4\,\text{lz}^2\,\text{mh}^2 + 2\,\text{la}^2\,\text{mh}^2 + 2\,
                                                                                                                                                               4 \text{ Iz } 1b^2 \text{ m mh} + 1a^2 1b^2 \text{ m}^2 \text{ mh} - 2 1a 1b^3 \text{ m}^2 \text{ mh} + 1b^4 \text{ m}^2 \text{ mh} +
                                                                                                                                                               1b \, m \, (2 \, Iz \, (1b \, (m + mh) + 1a \, (2 \, m + mh)) + 1b \, m \, (1b^2 \, mh - 1a^2 \, (2 \, m + mh))) \, Cos [2 \, q1[t]] + 1b \, m \, (2 \, Iz \, (1b \, (m + mh))) \, cos [2 \, q1[t]] + 1b \, m \, (1b^2 \, mh - 1a^2 \, (2 \, m + mh)))
                                                                                                                                                               1b^2 (1a + 1b) m^2 (2 1a m + 1a mh + 1b mh) Cos [2 (q1[t] - q2[t])] + 4 Iz 1a 1b m^2 Cos [2 q2[t]] +
                                                                                                                                                               2 \text{ Iz } 1b^2 \text{ m mh Cos} [2 \text{ q2}[t]] - 1a^2 1b^2 \text{ m}^2 \text{ mh Cos} [2 \text{ q2}[t]] + 1b^4 \text{ m}^2 \text{ mh Cos} [2 \text{ q2}[t]]) /
                                                                                                                                      (2(2Iz^2(2m+mh)^2+4Iz1b^2m(2m^2+3mmh+mh^2)+1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2mh^2)-1b^4m^2(m^2+4mmh+2m^2)-1b^4m^2(m^2+4mmh+2m^2)-1b^4m^2(m^2+4mmh+2m^2)-1b^4m^2(m^2+4mmh+2m^2)-1b^4m^2(m^2+4mm^2)-1b^4m^2(m^2+4mm^2)
                                                                                                                                                                                               1b^4 m^4 Cos[2(q1[t] - q2[t])]))}
```

```
In[62]:= coef = temp.Inverse[Jbfoot.temp].Jbfoot // Simplify
 \text{Out} [62] = \ \left\{ \ \left( \ \mbox{lb} \ \left( \ \mbox{la} + \ \mbox{lb} \right) \ \mbox{m} \ \left( \ - \ \mbox{2} \ \mbox{Iz} \ - \ \mbox{2} \ \mbox{la}^2 \ \mbox{m} \ - \ \mbox{la} \ \mbox{lb} \ \mbox{m} \ - \ \mbox{la}^2 \ \mbox{mh} \ - \ \mbox{2} \ \mbox{la} \ \mbox{lb} \ \mbox{mh} \ - \ \mbox{2} \ \mbox{la} \ \mbox{lb} \ \mbox{mh} \ - \ \mbox{2} \ \mbox{la} \ \mbox{lb} \ \mbox{mh} \ - \ \mbox{la} \ \mbox{lb} \ \mbox{mh} \ \mbox{mh} \ - \ \mbox{la} \ \mbox{lb} \ \mbox{mh} \ \mbox{mh} \ - \ \mbox{la} \ \mbox{lb} \ \mbox{mh} \ \mbox{mh} \ - \ \mbox{la} \ \mbox{lb} \ \mbox{mh} \ \mbox{lb} \ \mbox{mh} \ \mbox{mh} \ \mbox{lb} \ \mbox{mh} \ \mbox{mh} \ \mbox{lb} \ \mbox{mh} \ \mbox{mh} \ \mbox{mh} \ \mbox{mh} \ \mbox{mh} \ \mbox{lb} \ \mbox{mh} \ \mbox{mh} \ \mbox{mh} \ \mbox{mh} \ \mbox{mh} \ \mbox{lb} \ \mbox{mh} \mbox{mh} \ \mbox{mh} \mbox{mh
                                              1b^2 mh + (1a + 1b) (1b (m + mh) + 1a (2 m + mh)) Cos[2 (q1[t] - q2[t])]))
                               (-2 Iz^2 - 2 Iz (2 Ia 1b (m + mh) + 1a^2 (2 m + mh) + 1b^2 (2 m + mh)) -
                                     1b^2 m (2 la lb (m + 2 mh) + lb^2 (m + 2 mh) + la^2 (3 m + 2 mh)) +
                                     1b^{2} (1a + 1b)^{2} m^{2} Cos[2 (q1[t] - q2[t])]),
                          -((2 lb (la + lb) m (-Iz + la lb m) Cos[q1[t] - q2[t]))
                                       \left(-2\,\text{Iz}^2-2\,\text{Iz}\,\left(2\,\text{la}\,\text{lb}\,\left(\text{m}+\text{mh}\right)\,+\,\text{la}^2\,\left(2\,\text{m}+\text{mh}\right)\,+\,\text{lb}^2\,\left(2\,\text{m}+\text{mh}\right)\right)\,-\,
                                              1b^2 \, m \, (2 \, 1a \, 1b \, (m + 2 \, mh) \, + 1b^2 \, (m + 2 \, mh) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)) \, + 1a^2 \, (3 \, m + 2 \, mh)
                                              1b^{2} (1a + 1b)^{2} m^{2} Cos[2(q1[t] - q2[t])]),
                            (lb m ((2 Iz + lb^2 (m + mh) + la^2 (2 m + mh) + la lb (m + 2 mh)) Cos[q1[t]] -
                                               (la + lb) (lb (m + mh) + la (2 m + mh)) Cos[q1[t] - 2 q2[t]]))
                              \left(-2 \text{ Iz}^2 - 2 \text{ Iz} \left(2 \text{ la lb } (m+mh) + \text{la}^2 \left(2 \text{ m} + \text{mh}\right) + \text{lb}^2 \left(2 \text{ m} + \text{mh}\right)\right) - \left(-2 \text{ Iz}^2 - 2 \text{ Iz} \left(2 \text{ la lb } (m+mh) + \text{la}^2 \left(2 \text{ m} + \text{mh}\right) + \text{lb}^2 \left(2 \text{ m} + \text{mh}\right)\right)\right)
                                      1b^2 m (2 la lb (m + 2 mh) + lb^2 (m + 2 mh) + la^2 (3 m + 2 mh)) +
                                     1b^{2} (1a + 1b)^{2} m^{2} Cos [2 (q1[t] - q2[t])]),
                            (lb m ((2 Iz + lb^2 (m + mh) + la^2 (2 m + mh) + la lb (m + 2 mh)) Sin[q1[t]] +
                                               (la + lb) (lb (m + mh) + la (2 m + mh)) Sin[q1[t] - 2 q2[t]])) /
                               \left(-2\,\text{Iz}^2-2\,\text{Iz}\,\left(2\,\text{la}\,\text{lb}\,\left(\text{m}+\text{mh}\right)\,+\,\text{la}^2\,\left(2\,\text{m}+\text{mh}\right)\,+\,\text{lb}^2\,\left(2\,\text{m}+\text{mh}\right)\right)\,-\,
                                      1b^2 m (2 la lb (m + 2 mh) + 1b^2 (m + 2 mh) + 1a^2 (3 m + 2 mh)) +
                                     1b^{2} (1a + 1b)^{2} m^{2} Cos [2 (q1[t] - q2[t])])
                       \{(2(la+lb)(lb^2m(lbmh+la(m+mh))+lz(lb(m+mh)+la(2m+mh))) Cos[q1[t]-q2[t]])/
                               \left(-2\,\text{Iz}^2-2\,\text{Iz}\,\left(2\,\text{la}\,\text{lb}\,\left(\text{m}+\text{mh}\right)\,+\,\text{la}^2\,\left(2\,\text{m}+\text{mh}\right)\,+\,\text{lb}^2\,\left(2\,\text{m}+\text{mh}\right)\right)\,-\,
                                      1b^2 m (2 la lb (m + 2 mh) + lb^2 (m + 2 mh) + la^2 (3 m + 2 mh)) +
                                      1b^{2} (1a + 1b)^{2} m^{2} Cos[2 (q1[t] - q2[t])]),
                            ((la + lb) (-lb^2 m (3 la m + lb m + 2 la mh + 2 lb mh) - 2 Iz (lb (m + mh) + la (2 m + mh)) + la (2 m + mh))
                                              1b^{2} (la + 1b) m^{2} Cos [2 (q1[t] - q2[t])]))
                               \left(-2\,\text{Iz}^2-2\,\text{Iz}\,\left(2\,\text{la}\,\text{lb}\,\left(\text{m}+\text{mh}\right)\,+\,\text{la}^2\,\left(2\,\text{m}+\text{mh}\right)\,+\,\text{lb}^2\,\left(2\,\text{m}+\text{mh}\right)\right)\,-\,
                                      1b^2 m (2 la lb (m + 2 mh) + lb^2 (m + 2 mh) + la^2 (3 m + 2 mh)) +
                                      1b^{2} (1a + 1b)^{2} m^{2} Cos [2 (q1[t] - q2[t])]), (-1b^{2} (1a + 1b) m^{2} Cos [2 q1[t] - q2[t]] +
                                       (1b^2 m (3 la m + 1b m + 2 la mh + 2 lb mh) + 2 Iz (1b (m + mh) + 1a (2 m + mh))) Cos[q2[t]])
                                (2 \text{ Iz}^2 + 2 \text{ Iz} (2 \text{ la lb} (m + mh) + \text{la}^2 (2 m + mh) + \text{lb}^2 (2 m + mh)) +
                                     1b^2 m (2 la lb (m + 2 mh) + 1b^2 (m + 2 mh) + 1a^2 (3 m + 2 mh)) -
                                      1b^{2} (1a + 1b)^{2} m^{2} Cos[2 (q1[t] - q2[t])]), (-1b^{2} (1a + 1b) m^{2} Sin[2 q1[t] - q2[t]] +
                                       (1b^2 \text{ m } (3 \text{ la m} + 1 \text{ b m} + 2 \text{ la mh} + 2 \text{ lb mh}) + 2 \text{ Iz } (1b (m + mh) + 1a (2 m + mh))) \sin[q2[t]])
                                (2 \text{ Iz}^2 + 2 \text{ Iz} (2 \text{ la lb} (m + mh) + \text{la}^2 (2 m + mh) + \text{lb}^2 (2 m + mh)) +
                                     1b^2 m (2 la lb (m + 2 mh) + 1b^2 (m + 2 mh) + 1a^2 (3 m + 2 mh)) -
                                     1b^{2} (1a + 1b)^{2} m^{2} Cos [2 (q1[t] - q2[t])])
                       \left\{-\left(\left(1a+1b\right)\left(2\left(1z-1a1bm\right)\left(2Iz+1b^{2}\left(m+mh\right)+1a^{2}\left(2m+mh\right)+1a1b\left(m+2mh\right)\right)\cos\left[q1[t]\right]+1a^{2}\left(2m+mh\right)\right\}
                                                      (1a + 1b) (-(2 Iz (1b (m + mh) + 1a (2 m + mh)) + 1b m (1b^2 mh - 1a^2 (2 m + mh))) Cos [
```

```
q1[t] - 2q2[t] + lb(la + lb) m(lbmh + la(2m + mh)) Cos[3q1[t] - 2q2[t])))
                    (4 \text{ Iz}^2 + 4 \text{ Iz} (2 \text{ la lb} (m + mh) + \text{la}^2 (2 m + mh) + \text{lb}^2 (2 m + mh)) +
                            2 lb^{2} (la + lb)^{2} m^{2} Cos [2 (q1[t] - q2[t])]), -((la + lb) (-Iz + la lb m))
                              (1b (1a+1b) m Cos[2q1[t]-q2[t]] + (-2 Iz + (1a-1b) 1b m) Cos[q2[t]]))
                    \left(-2\,\text{Iz}^2-2\,\text{Iz}\,\left(2\,\text{la}\,\text{lb}\,\left(\text{m}+\text{mh}\right)\,+\,\text{la}^2\,\left(2\,\text{m}+\text{mh}\right)\,+\,\text{lb}^2\,\left(2\,\text{m}+\text{mh}\right)\,\right)\,-\,\text{lb}^2\,\text{m}\,\left(2\,\text{la}\,\text{lb}\,\left(\text{m}+2\,\text{mh}\right)\,+\,\text{lb}^2\,\left(2\,\text{m}+\text{mh}\right)\,\right)
                                          4 \text{ Iz}^2 + 4 \text{ Iz } 1a^2 \text{ m} + 4 \text{ Iz } 1b^2 \text{ m} - 2 1a^3 1b \text{ m}^2 - 2 1a 1b^3 \text{ m}^2 + 2 \text{ Iz } 1a^2 \text{ mh} + 4 \text{ Iz } 1a 1b \text{ mh} + 4 \text{ Iz } 1a^2 \text{ mh} + 
                   2 \text{ Iz } 1b^2 \text{ mh} - 1a^3 1b \text{ m mh} - 1a^2 1b^2 \text{ m mh} + 1a 1b^3 \text{ m mh} + 1b^4 \text{ m mh} -
                   1b (1a + 1b) m (2 Iz + 2 1a 1b mh + 1b^2 mh + 1a^2 (2 m + mh)) Cos [2 q1[t]] +
                   1b (1a + 1b)^2 m (1b mh + 1a (2 m + mh)) Cos [2 (q1[t] - q2[t])] -
                   4 \text{ Iz } 1a^2 \text{ m } \cos[2 \text{ q2}[t]] - 6 \text{ Iz } 1a \text{ 1b m } \cos[2 \text{ q2}[t]] - 2 \text{ Iz } 1b^2 \text{ m } \cos[2 \text{ q2}[t]] +
                   2 la^3 lb m^2 Cos [2 q2[t]] + 2 la^2 lb^2 m^2 Cos [2 q2[t]] - 2 Iz la^2 mh Cos [2 q2[t]] -
                   4 \text{ Iz } 1a \text{ 1b mh Cos} [2 \text{ q2}[t]] - 2 \text{ Iz } 1b^2 \text{ mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] + 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] 
                   1a^2 1b^2 m mh Cos[2 q2[t]] - 1a 1b^3 m mh Cos[2 q2[t]] - 1b^4 m mh Cos[2 q2[t]] /
          (4 Iz^2 + 4 Iz (2 la lb (m + mh) + la^2 (2 m + mh) + lb^2 (2 m + mh)) +
                   2 lb^2 m (2 la lb (m + 2 mh) + lb^2 (m + 2 mh) + la^2 (3 m + 2 mh)) -
                   2 lb^{2} (la + lb)^{2} m^{2} Cos [2 (q1[t] - q2[t])]),
    -(((1a+1b)(1bm(2Iz+2lalbmh+1b^2mh+la^2(2m+mh))Sin[2q1[t]]+
                                     1b (1a + 1b) m (1b mh + 1a (2 m + mh)) Sin[2 (q1[t] - q2[t])] +
                                       (2 \text{ Iz } (1b (m+mh) + 1a (2 m+mh)) + 1b m (1b^2 mh - 1a^2 (2 m+mh))) \text{ Sin } [2 q2[t]]))
                   (4 \text{ Iz}^2 + 4 \text{ Iz} (2 \text{ la lb } (m + mh) + \text{ la}^2 (2 \text{ m} + mh) + \text{ lb}^2 (2 \text{ m} + mh)) + 2 \text{ lb}^2 \text{ m} (2 \text{ la lb } (m + 2 \text{ mh}) + \text{ lb}^2 (2 \text{ m} + mh)))
                                          1b^{2}(m+2mh)+1a^{2}(3m+2mh))-21b^{2}(1a+1b)^{2}m^{2}Cos[2(q1[t]-q2[t])])
\left\{-\left(\left(1a+1b\right)\left(2\left(1z-1a1b\,m\right)\left(2\,Iz+1b^2\left(m+mh\right)+1a^2\left(2\,m+mh\right)+1a\,1b\left(m+2\,mh\right)\right)\right\}\right\}
                                       (la + lb) ((2 Iz (lb (m + mh) + la (2 m + mh)) + lb m (lb^2 mh - la^2 (2 m + mh))) Sin[
                                                              q1[t] - 2q2[t] + lb(la + lb) m(lbmh + la(2m + mh)) Sin[3q1[t] - 2q2[t]])))
                    (4 \text{ Iz}^2 + 4 \text{ Iz} (2 \text{ la lb} (m + mh) + \text{la}^2 (2 m + mh) + \text{lb}^2 (2 m + mh)) +
                            2 lb^2 m (2 la lb (m + 2 mh) + lb^2 (m + 2 mh) + la^2 (3 m + 2 mh)) -
                            2 lb^{2} (la + lb)^{2} m^{2} Cos [2 (q1[t] - q2[t])]), -((la + lb) (-Iz + la lb m))
                              (1b (1a+1b) m Sin[2q1[t]-q2[t]] + (-2 Iz + (1a-1b) 1b m) Sin[q2[t]]))
                    \left(-2\,\text{Iz}^2-2\,\text{Iz}\,\left(2\,\text{la}\,\text{lb}\,\left(\text{m}+\text{mh}\right)\,+\,\text{la}^2\,\left(2\,\text{m}+\text{mh}\right)\,+\,\text{lb}^2\,\left(2\,\text{m}+\text{mh}\right)\,\right)\,-\,\text{lb}^2\,\text{m}\,\left(2\,\text{la}\,\text{lb}\,\left(\text{m}+2\,\text{mh}\right)\,+\,\text{lb}^2\,\left(2\,\text{m}+\text{mh}\right)\,\right)
                                          1b^{2}\,\left(\text{m}+2\,\text{mh}\right)\,+\,1a^{2}\,\left(3\,\text{m}+2\,\text{mh}\right)\,\right)\,+\,1b^{2}\,\left(1a+1b\right)^{2}\,\text{m}^{2}\,\text{Cos}\left[\,2\,\left(\text{q1}\,\text{[t]}\,-\,\text{q2}\,\text{[t]}\,\right)\,\right]\,\right)\,\text{,}
    -(((1a+1b)(1bm(2Iz+2la1bmh+1b^2mh+1a^2(2m+mh))Sin[2q1[t]]-
                                     1b (1a + 1b) m (1b mh + 1a (2 m + mh)) Sin[2 (q1[t] - q2[t])] +
                                       (2 \text{ Iz } (1b (m+mh) + 1a (2 m+mh)) + 1b m (1b^2 mh - 1a^2 (2 m+mh))) \sin[2 q2[t]]))
                    (4 \text{ Iz}^2 + 4 \text{ Iz} (2 \text{ la lb} (m + mh) + \text{la}^2 (2 m + mh) + \text{lb}^2 (2 m + mh)) +
                            2 \ 1b^2 \ m \ (2 \ 1a \ 1b \ (m+2 \ mh) \ + \ 1b^2 \ (m+2 \ mh) \ + \ 1a^2 \ (3 \ m+2 \ mh)) \ -
                            2 lb^{2} (la + lb)^{2} m^{2} Cos [2 (q1[t] - q2[t])]),
      4 Iz^2 + 4 Iz Ia^2 m + 4 Iz Ib^2 m - 2 Ia^3 Ib m^2 - 2 Ia Ib^3 m^2 + 2 Iz Ia^2 mh + 4 Iz Ia Ib mh + 4 Iz Ib mh + 4 I
```

```
2 \text{ Iz } 1b^2 \text{ mh} - 1a^3 \text{ 1b m mh} - 1a^2 \text{ 1b}^2 \text{ m mh} + 1a \text{ 1b}^3 \text{ m mh} + 1b^4 \text{ m mh} +
                                             1b (1a + 1b) m (2 Iz + 2 1a 1b mh + 1b^2 mh + 1a^2 (2 m + mh)) Cos [2 q1 [t]] +
                                             1b (1a + 1b)^2 m (1b mh + 1a (2 m + mh)) Cos [2 (q1[t] - q2[t])] +
                                             4 \text{ Iz } 1a^2 \text{ m } \cos[2 \text{ q2}[t]] + 6 \text{ Iz } 1a \text{ 1b m } \cos[2 \text{ q2}[t]] + 2 \text{ Iz } 1b^2 \text{ m } \cos[2 \text{ q2}[t]] -
                                             2 la^3 lb m^2 Cos [2 q2[t]] - 2 la^2 lb^2 m^2 Cos [2 q2[t]] + 2 Iz la^2 mh Cos [2 q2[t]] +
                                             4 \text{ Iz } 1a \text{ 1b mh Cos} [2 \text{ q2}[t]] + 2 \text{ Iz } 1b^2 \text{ mh Cos} [2 \text{ q2}[t]] - 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]] - 1a^3 \text{ 1b m mh Cos} [2 \text{ q2}[t]]
                                             1a^2 1b^2 m mh Cos[2 q2[t]] + 1a 1b^3 m mh Cos[2 q2[t]] + 1b^4 m mh Cos[2 q2[t]] /
                                      (4 \text{ Iz}^2 + 4 \text{ Iz} (2 \text{ la lb} (m + mh) + \text{la}^2 (2 m + mh) + \text{lb}^2 (2 m + mh)) +
                                             2 lb^2 m (2 la lb (m + 2 mh) + lb^2 (m + 2 mh) + la^2 (3 m + 2 mh)) -
                                            2\, 1b^2\, \left( \text{la} + 1b \right)^2\, \text{m}^2\, \text{Cos} \left[ \, 2\, \left( \text{q1[t]} \, - \text{q2[t]} \, \right) \, \right] \, \right) \, \right\} \, \right\}
 In[63]:= Dimensions [coef]
Out[63]= \{4, 4\}
 In[64]:= LinOp = IdentityMatrix[4] - coef // Simplify
Out[64]= \{\{1 - (1b (1a + 1b) m (-2 Iz - 2 1a^2 m - 1a 1b m - 1b^2 m - 1a^2 mh - 2 1a 1b mh - 2
                                                           1b^2 mh + (1a + 1b) (1b (m + mh) + 1a (2 m + mh)) Cos[2 (q1[t] - q2[t])]))
                                         \left(-2\,\text{Iz}^2-2\,\text{Iz}\,\left(2\,\text{la}\,\text{lb}\,\left(\text{m}+\text{mh}\right)\,+\,\text{la}^2\,\left(2\,\text{m}+\text{mh}\right)\,+\,\text{lb}^2\,\left(2\,\text{m}+\text{mh}\right)\right)\,-\,
                                                 1b^2 m (2 la lb (m + 2 mh) + lb^2 (m + 2 mh) + la^2 (3 m + 2 mh)) +
                                                 1b^{2} (1a + 1b)^{2} m^{2} Cos [2 (q1[t] - q2[t])]),
                                 (2 lb (la + lb) m (-Iz + la lb m) Cos[q1[t] - q2[t]]) /
                                    \left(-2\,\text{Iz}^2-2\,\text{Iz}\,\left(2\,\text{la}\,\text{lb}\,\left(\text{m}+\text{mh}\right)\,+\,\text{la}^2\,\left(2\,\text{m}+\text{mh}\right)\,+\,\text{lb}^2\,\left(2\,\text{m}+\text{mh}\right)\right)\,-\,
                                             1b^2 m (2 la lb (m + 2 mh) + lb^2 (m + 2 mh) + la^2 (3 m + 2 mh)) +
                                            1b^{2} (1a + 1b)^{2} m^{2} Cos [2 (q1[t] - q2[t])]),
                                 (1b m (-(2 Iz + 1b^2 (m + mh) + 1a^2 (2 m + mh) + 1a 1b (m + 2 mh)) Cos[q1[t]] +
                                                       (la + lb) (lb (m + mh) + la (2 m + mh)) Cos[q1[t] - 2 q2[t]]))
                                     \left(-2\,\text{Iz}^2-2\,\text{Iz}\,\left(2\,\text{la}\,\text{lb}\,\left(\text{m}+\text{mh}\right)\,+\,\text{la}^2\,\left(2\,\text{m}+\text{mh}\right)\,+\,\text{lb}^2\,\left(2\,\text{m}+\text{mh}\right)\right)\,-\,
                                             1b^2 \ m \ \left( \ 2 \ 1a \ 1b \ \left( \ m + 2 \ mh \right) \right) \ + 1b^2 \ \left( \ m + 2 \ mh \right) \ + 1a^2 \ \left( \ 3 \ m + 2 \ mh \right) \right) \ +
                                            1b^{2} (1a + 1b)^{2} m^{2} Cos[2 (q1[t] - q2[t])]),
                                -((1b m ((2 Iz + 1b^2 (m + mh) + 1a^2 (2 m + mh) + 1a 1b (m + 2 mh)) Sin[q1[t]] +
                                                                (la + lb) (lb (m + mh) + la (2 m + mh)) Sin[q1[t] - 2 q2[t]]))
                                              \left(-2\,\text{Iz}^2-2\,\text{Iz}\,\left(2\,\text{la}\,\text{lb}\,\left(\text{m}+\text{mh}\right)\,+\,\text{la}^2\,\left(2\,\text{m}+\text{mh}\right)\,+\,\text{lb}^2\,\left(2\,\text{m}+\text{mh}\right)\,\right)\,-\,\text{lb}^2\,\text{m}\,\left(2\,\text{la}\,\text{lb}\,\left(\text{m}+2\,\text{mh}\right)\,+\,\text{lb}^2\,\left(2\,\text{m}+\text{mh}\right)\,\right)
                                                                   1b^{2}(m+2mh)+1a^{2}(3m+2mh))+1b^{2}(1a+1b)^{2}m^{2}Cos[2(q1[t]-q2[t])])},
                           \left(-2\,\text{Iz}^2-2\,\text{Iz}\,\left(2\,\text{la}\,\text{lb}\,\left(\text{m}+\text{mh}\right)\,+\,\text{la}^2\,\left(2\,\text{m}+\text{mh}\right)\,+\,\text{lb}^2\,\left(2\,\text{m}+\text{mh}\right)\right)\,-\,
                                                      1b^2 m (2 la lb (m + 2 mh) + 1b^2 (m + 2 mh) + la^2 (3 m + 2 mh)) +
                                                      1b^{2} (la + 1b)^{2} m^{2} Cos[2(q1[t] - q2[t])]),
                                (2 (Iz - la lb m) (Iz + lb^2 m)) / (2 Iz^2 + 2 Iz (2 la lb (m + mh) + la^2 (2 m + mh) + lb^2 (2 m + mh)) + lb^2 (2 m + mh)) + lb^2 (2 m + mh)) + lb^2 (2 m + mh))
                                            1b^2 m (2 1a 1b (m + 2 mh) + 1b^2 (m + 2 mh) + 1a^2 (3 m + 2 mh)) -
                                            1b^{2} \, \left(1a+1b\right)^{2} \, m^{2} \, Cos\left[2 \, \left(q1[t]-q2[t]\right)\right]\right) \, \text{, } \, \left(1b^{2} \, \left(1a+1b\right) \, m^{2} \, Cos\left[2 \, q1[t]-q2[t]\right]\right. - \left. q^{2}[t]\right] \, dt + \left[1b^{2} \, \left(1a+1b\right) \, m^{2} \, Cos\left[2 \, q1[t]-q2[t]\right]\right] \, dt + \left[1b^{2} \, \left(1a+1b\right) \, m^{2} \, Cos\left[2 \, q1[t]-q2[t]\right]\right] \, dt + \left[1b^{2} \, \left(1a+1b\right) \, m^{2} \, Cos\left[2 \, q1[t]-q2[t]\right]\right] \, dt + \left[1b^{2} \, \left(1a+1b\right) \, m^{2} \, Cos\left[2 \, q1[t]-q2[t]\right]\right] \, dt + \left[1b^{2} \, \left(1a+1b\right) \, m^{2} \, Cos\left[2 \, q1[t]-q2[t]\right]\right] \, dt + \left[1b^{2} \, \left(1a+1b\right) \, m^{2} \, Cos\left[2 \, q1[t]-q2[t]\right]\right] \, dt + \left[1b^{2} \, \left(1a+1b\right) \, m^{2} \, Cos\left[2 \, q1[t]-q2[t]\right]\right] \, dt + \left[1b^{2} \, \left(1a+1b\right) \, m^{2} \, Cos\left[2 \, q1[t]-q2[t]\right]\right] \, dt + \left[1b^{2} \, \left(1a+1b\right) \, m^{2} \, Cos\left[2 \, q1[t]-q2[t]\right]\right] \, dt + \left[1b^{2} \, \left(1a+1b\right) \, m^{2} \, Cos\left[2 \, q1[t]-q2[t]\right]\right] \, dt + \left[1b^{2} \, \left(1a+1b\right) \, m^{2} \, Cos\left[2 \, q1[t]-q2[t]\right]\right] \, dt + \left[1b^{2} \, \left(1a+1b\right) \, m^{2} \, Cos\left[2 \, q1[t]-q2[t]\right]\right] \, dt + \left[1b^{2} \, \left(1a+1b\right) \, m^{2} \, Cos\left[2 \, q1[t]-q2[t]\right]\right] \, dt + \left[1b^{2} \, \left(1a+1b\right) \, m^{2} \, Cos\left[2 \, q1[t]-q2[t]\right]\right] \, dt + \left[1b^{2} \, \left(1a+1b\right) \, m^{2} \, Cos\left[2 \, q1[t]-q2[t]\right]\right] \, dt + \left[1b^{2} \, \left(1a+1b\right) \, m^{2} \, Cos\left[2 \, q1[t]-q2[t]\right]\right] \, dt + \left[1b^{2} \, \left(1a+1b\right) \, m^{2} \, Cos\left[2 \, q1[t]-q2[t]\right]\right] \, dt + \left[1b^{2} \, \left(1a+1b\right) \, m^{2} \, Cos\left[2 \, q1[t]-q2[t]\right]\right] \, dt + \left[1b^{2} \, \left(1a+1b\right) \, m^{2} \, Cos\left[2 \, q1[t]-q2[t]\right]\right] \, dt + \left[1b^{2} \, \left(1a+1b\right) \, m^{2} \, Cos\left[2 \, q1[t]-q2[t]\right]\right] \, dt + \left[1b^{2} \, \left(1a+1b\right) \, m^{2} \, Cos\left[2 \, q1[t]-q2[t]\right]\right] \, dt + \left[1b^{2} \, \left(1a+1b\right) \, m^{2} \, Cos\left[2 \, q1[t]-q2[t]\right] \, dt + \left[1b^{2} \, \left(1a+1b\right) \, m^{2} \, Cos\left[2 \, q1[t]-q2[t]\right] \, dt + \left[1b^{2} \, \left(1a+1b\right) \, m^{2} \, Cos\left[2 \, q1[t]-q2[t]\right] \, dt + \left[1b^{2} \, \left(1a+1b\right) \, m^{2} \, Cos\left[2 \, q1[t]-q2[t]\right] \, dt + \left[1b^{2} \, \left(1a+1b\right) \, m^{2} \, Cos\left[2 \, q1[t]-q2[t]\right] \, dt + \left[1b^{2} \, \left(1a+1b\right) \, m^{2} \, Cos\left[2 \, q1[t]-q2[t]\right] \, dt + \left[1b^{2} \, \left(1a+1b\right) \, m^{2} \, Cos\left[2 \, q1[t]-q2[t]\right] \, dt + \left[1b^{2} \, \left(1a+1b\right) \, m^{2} \, Cos\left[2 \, q1[t]-q2[t]\right] \, dt + \left[1b^{2} \, \left(1a+1b\right) \, m^{2} \, Cos\left[2 \, q1[t]-q2[t]\right] \, dt + \left[1b^{2} \, \left(1a+1b\right)
```

```
(1b^2 m (3 la m + 1b m + 2 la mh + 2 lb mh) + 2 Iz (1b (m + mh) + 1a (2 m + mh))) Cos[q2[t]])
     (2 Iz^2 + 2 Iz (2 Ia 1b (m + mh) + 1a^2 (2 m + mh) + 1b^2 (2 m + mh)) +
         1b^2 m (2 la lb (m + 2 mh) + lb^2 (m + 2 mh) + la^2 (3 m + 2 mh)) -
         1b^2 (1a + 1b)^2 m^2 Cos[2 (q1[t] - q2[t])]), (1b^2 (1a + 1b) m^2 Sin[2 q1[t] - q2[t]) - q2[t])
         (1b^2 m (3 la m + 1b m + 2 la mh + 2 lb mh) + 2 Iz (1b (m + mh) + 1a (2 m + mh))) Sin[q2[t]])
     (2 Iz^2 + 2 Iz (2 la lb (m + mh) + la^2 (2 m + mh) + lb^2 (2 m + mh)) +
         1b^2 m (2 la lb (m + 2 mh) + lb^2 (m + 2 mh) + la^2 (3 m + 2 mh)) -
         1b^{2} (1a + 1b)^{2} m^{2} Cos[2 (q1[t] - q2[t])])
\{((1a+1b)(2(Iz-1a1bm)(2Iz+1b^2(m+mh)+1a^2(2m+mh)+1a1b(m+2mh))Cos[q1[t]]+1a^2(2m+mh)+1a1b(m+2mh))Cos[q1[t]]+1a^2(2m+mh)+1a1b(m+2mh))Cos[q1[t]]+1a^2(2m+mh)+1a1b(m+2mh))Cos[q1[t]]+1a^2(2m+mh)+1a1b(m+2mh))Cos[q1[t]]+1a^2(2m+mh)+1a1b(m+2mh))Cos[q1[t]]+1a^2(2m+mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2mh)+1a1b(m+2m
              (la + lb) (-(2 Iz (lb (m + mh) + la (2 m + mh)) + lb m (lb^2 mh - la^2 (2 m + mh))) Cos [
                          q1[t] - 2q2[t]] + 1b(1a + 1b) m(1bmh + 1a(2m + mh)) Cos[3q1[t] - 2q2[t]])))/
     (4 \text{ Iz}^2 + 4 \text{ Iz} (2 \text{ la lb} (m + mh) + \text{la}^2 (2 m + mh) + \text{lb}^2 (2 m + mh)) +
        2 lb^2 m (2 la lb (m + 2 mh) + lb^2 (m + 2 mh) + la^2 (3 m + 2 mh)) -
         2 lb^{2} (la + lb)^{2} m^{2} Cos [2 (q1[t] - q2[t])]), ((la + lb) (-Iz + la lb m))
         (1b (1a + 1b) m Cos[2 q1[t] - q2[t]] + (-2 Iz + (1a - 1b) 1b m) Cos[q2[t]]))
     (-2 Iz^2 - 2 Iz (2 Ia 1b (m + mh) + 1a^2 (2 m + mh) + 1b^2 (2 m + mh)) -
         1b^2 m (2 la lb (m + 2 mh) + lb^2 (m + 2 mh) + la^2 (3 m + 2 mh)) +
        1b^{2} (1a + 1b)^{2} m^{2} Cos [2 (q1[t] - q2[t])]),
   ((1a + 1b)) (4 Iz la m + 4 Iz lb m + 2 la<sup>2</sup> lb m<sup>2</sup> + 4 la lb<sup>2</sup> m<sup>2</sup> + 2 lb<sup>3</sup> m<sup>2</sup> + 2 Iz la mh + 2 Iz lb mh +
             1a^{2} 1b m mh + 4 1a 1b<sup>2</sup> m mh + 3 1b^{3} m mh + 1b m (2 Iz + 2 1a 1b mh + 1b^{2} mh + 1a^{2} (2 m + mh))
               \cos[2 q1[t]] - 1b(1a + 1b)^{2} m(2 m + mh) \cos[2 (q1[t] - q2[t])] + 4 Iz 1a m \cos[2 q2[t]] +
             2 \text{ Iz } 1b \text{ m Cos } [2 \text{ q2}[t]] - 2 1a^2 1b \text{ m}^2 \text{ Cos } [2 \text{ q2}[t]] + 2 \text{ Iz } 1a \text{ mh Cos } [2 \text{ q2}[t]] +
             2 Iz lb mh Cos [2 q2[t]] - la<sup>2</sup> lb m mh Cos [2 q2[t]] + lb<sup>3</sup> m mh Cos [2 q2[t]]) /
     (4 \text{ Iz}^2 + 4 \text{ Iz} (2 \text{ la lb} (m + mh) + \text{la}^2 (2 m + mh) + \text{lb}^2 (2 m + mh)) +
         2 lb^2 m (2 la lb (m + 2 mh) + lb^2 (m + 2 mh) + la^2 (3 m + 2 mh)) -
         2 lb^{2} (la + lb)^{2} m^{2} Cos [2 (q1[t] - q2[t])]),
  ((la + lb) (lb m (2 Iz + 2 la lb mh + lb^2 mh + la^2 (2 m + mh)) Sin[2 q1[t]] +
             1b (1a + 1b) m (1b mh + 1a (2 m + mh)) Sin[2 (q1[t] - q2[t])] +
              (2 \text{ Iz } (1b (m+mh) + 1a (2 m+mh)) + 1b m (1b^2 mh - 1a^2 (2 m+mh))) \text{ Sin } [2 q2[t]]))
     (4 Iz^2 + 4 Iz (2 Ia Ib (m + mh) + Ia^2 (2 m + mh) + Ib^2 (2 m + mh)) +
         2 lb^2 m (2 la lb (m + 2 mh) + lb^2 (m + 2 mh) + la^2 (3 m + 2 mh)) -
         2 lb^{2} (la + lb)^{2} m^{2} Cos [2 (q1[t] - q2[t])])
\{((1a+1b)(2(Iz-1a1bm)(2Iz+1b^2(m+mh)+1a^2(2m+mh)+1a1b(m+2mh))Sin[q1[t]]+1a^2(2m+mh)+1a1b(m+2mh))\}
              (la + lb) ((2 Iz (lb (m + mh) + la (2 m + mh)) + lb m (lb^2 mh - la^2 (2 m + mh))) Sin [
                          q1[t] - 2q2[t] + 1b(1a + 1b) m(1bmh + 1a(2m + mh)) Sin[3q1[t] - 2q2[t])))
     (4 \text{ Iz}^2 + 4 \text{ Iz} (2 \text{ la lb} (m + mh) + \text{la}^2 (2 m + mh) + \text{lb}^2 (2 m + mh)) +
         2 lb^2 m (2 la lb (m + 2 mh) + lb^2 (m + 2 mh) + la^2 (3 m + 2 mh)) -
         2 lb^{2} (la + lb)^{2} m^{2} Cos [2 (q1[t] - q2[t])], ((la + lb) (-Iz + la lb m))
         (1b (1a + 1b) m Sin[2 q1[t] - q2[t]] + (-2 Iz + (1a - 1b) 1b m) Sin[q2[t]]))
```

```
\left(-2\,\text{Iz}^2-2\,\text{Iz}\,\left(2\,\text{la}\,\text{lb}\,\left(\text{m}+\text{mh}\right)\right) + \text{la}^2\,\left(2\,\text{m}+\text{mh}\right) + \text{lb}^2\,\left(2\,\text{m}+\text{mh}\right)\right) -
                               1b^2 m (2 la lb (m + 2 mh) + 1b^2 (m + 2 mh) + 1a^2 (3 m + 2 mh)) +
                                1b^{2} (1a + 1b)^{2} m^{2} Cos[2 (q1[t] - q2[t])]),
    ((la + lb) (lb m (2 Iz + 2 la lb mh + lb^2 mh + la^2 (2 m + mh)) Sin[2 q1[t]] -
                                                       1b (la + 1b) m (lb mh + la (2 m + mh)) Sin[2 (q1[t] - q2[t])] +
                                                        (2 \text{ Iz } (1b (m + mh) + 1a (2 m + mh)) + 1b m (1b^2 mh - 1a^2 (2 m + mh))) \sin[2 q2[t]]))
            (4 Iz^2 + 4 Iz (2 Ia Ib (m + mh) + Ia^2 (2 m + mh) + Ib^2 (2 m + mh)) +
                                2 lb^2 m (2 la lb (m + 2 mh) + lb^2 (m + 2 mh) + la^2 (3 m + 2 mh)) -
                                 2 lb^{2} (la + lb)^{2} m^{2} Cos [2 (q1[t] - q2[t])]),
-\left( \left( \left( 1a + 1b \right) \right. \left( -4 \, \text{Iz} \, 1a \, \text{m} - 4 \, \text{Iz} \, 1b \, \text{m} - 2 \, 1a^2 \, 1b \, \text{m}^2 - 4 \, 1a \, 1b^2 \, \text{m}^2 - 2 \, 1b^3 \, \text{m}^2 - 2 \, \text{Iz} \, 1a \, \text{mh} - 2 \, \text{Iz} \, 1b \, \text{mh} - 2 \, 1b \, \text{m
                                                                           1a^{2} 1b \ m \ mh \ - \ 4 \ 1a \ 1b^{2} \ m \ mh \ - \ 3 \ 1b^{3} \ m \ mh \ + \ 1b \ m \ \left(2 \ Iz \ + \ 2 \ 1a \ 1b \ mh \ + \ 1b^{2} \ mh \ + \ 1a^{2} \ \left(2 \ m \ + \ mh \right) \right) \ Cos \ [mathematical limits of the content of the
                                                                                                 2 q1[t] + 1b (1a + 1b)^{2} m (2 m + mh) Cos[2 (q1[t] - q2[t])] + 4 Iz la m Cos[2 q2[t]] +
                                                                           2\;Iz\;lb\;m\;Cos\;[\;2\;q\;2\;[\;t\;]\;]\;-\;2\;la^2\;lb\;m^2\;Cos\;[\;2\;q\;2\;[\;t\;]\;]\;+\;2\;Iz\;la\;mh\;Cos\;[\;2\;q\;2\;[\;t\;]\;]\;+\;2\;Iz\;la\;mh\;Cos\;[\;2\;q\;2\;[\;t\;]\;]\;+\;2\;Iz\;la\;mh\;Cos\;[\;2\;q\;2\;[\;t\;]\;]\;+\;2\;Iz\;la\;mh\;Cos\;[\;2\;q\;2\;[\;t\;]\;]\;+\;2\;Iz\;la\;mh\;Cos\;[\;2\;q\;2\;[\;t\;]\;]\;+\;2\;Iz\;la\;mh\;Cos\;[\;2\;q\;2\;[\;t\;]\;]\;+\;2\;Iz\;la\;mh\;Cos\;[\;2\;q\;2\;[\;t\;]\;]\;+\;2\;Iz\;la\;mh\;Cos\;[\;2\;q\;2\;[\;t\;]\;]\;+\;2\;Iz\;la\;mh\;Cos\;[\;2\;q\;2\;[\;t\;]\;]\;+\;2\;Iz\;la\;mh\;Cos\;[\;2\;q\;2\;[\;t\;]\;]\;+\;2\;Iz\;la\;mh\;Cos\;[\;2\;q\;2\;[\;t\;]\;]\;+\;2\;Iz\;la\;mh\;Cos\;[\;2\;q\;2\;[\;t\;]\;]\;+\;2\;Iz\;la\;mh\;Cos\;[\;2\;q\;2\;[\;t\;]\;]\;+\;2\;Iz\;la\;mh\;Cos\;[\;2\;q\;2\;[\;t\;]\;]\;+\;2\;Iz\;la\;mh\;Cos\;[\;2\;q\;2\;[\;t\;]\;]\;+\;2\;Iz\;la\;mh\;Cos\;[\;2\;q\;2\;[\;t\;]\;]\;+\;2\;Iz\;la\;mh\;Cos\;[\;2\;q\;2\;[\;t\;]\;]\;+\;2\;Iz\;la\;mh\;Cos\;[\;2\;q\;2\;[\;t\;]\;]\;+\;2\;Iz\;la\;mh\;Cos\;[\;2\;q\;2\;[\;t\;]\;]\;+\;2\;Iz\;la\;mh\;Cos\;[\;2\;q\;2\;[\;t\;]\;]\;+\;2\;Iz\;la\;mh\;Cos\;[\;2\;q\;2\;[\;t\;]\;]\;+\;2\;Iz\;la\;mh\;Cos\;[\;2\;q\;2\;[\;t\;]\;]\;+\;2\;Iz\;la\;mh\;Cos\;[\;2\;q\;2\;[\;t\;]\;]\;+\;2\;Iz\;la\;mh\;Cos\;[\;2\;q\;2\;[\;t\;]\;]\;+\;2\;Iz\;la\;mh\;Cos\;[\;2\;q\;2\;[\;t\;]\;]\;
                                                                           2 Iz lb mh Cos [2 q2[t]] - la<sup>2</sup> lb m mh Cos [2 q2[t]] + lb<sup>3</sup> m mh Cos [2 q2[t]]) /
                                   \left(4\,\text{Iz}^2 + 4\,\text{Iz}\,\left(2\,\text{la}\,\text{lb}\,\left(\text{m} + \text{mh}\right) + \text{la}^2\,\left(2\,\text{m} + \text{mh}\right) + \text{lb}^2\,\left(2\,\text{m} + \text{mh}\right)\right) + 2\,\text{lb}^2\,\text{m}\,\left(2\,\text{la}\,\text{lb}\,\left(\text{m} + 2\,\text{mh}\right) + \text{lb}^2\,\left(2\,\text{m} + 2\,\text{mh}\right)\right) + 2\,\text{lb}^2\,\left(2\,\text{m} + 2\,\text{mh}\right)
                                                                                    1b^{2}(m+2mh)+1a^{2}(3m+2mh))-21b^{2}(1a+1b)^{2}m^{2}Cos[2(q1[t]-q2[t])]))
```

In[65]:= qdotplus = LinOp.HurList2Column[{q1dminus, q2dminus, 0, 0}] // Simplify

```
Out[65]= \left\{ \left\{ \left(2 \text{ lb } \left(\text{la} + \text{lb}\right) \text{ m } \left(-\text{Iz} + \text{la lb m}\right) \text{ q2dminus Cos} \left[\text{q1}\left[\text{t}\right] - \text{q2}\left[\text{t}\right]\right] - \right\} \right\} \right\}
                                                                                      \texttt{q1dminus} \left( \texttt{2} \, \texttt{Iz}^2 + \texttt{lb} \, \texttt{m} \, \left( -\, \texttt{la}^2 \, \texttt{lb} \, \texttt{mh} + \, \texttt{la} \, \texttt{lb}^2 \, \texttt{mh} + \, \texttt{lb}^3 \, \texttt{mh} - \, \texttt{la}^3 \, \left( \texttt{2} \, \texttt{m} + \, \texttt{mh} \right) \right) \, + \, \texttt{matrix} \right) \, + \, \texttt{matrix} \left( \texttt{matrix} \, \texttt{mh} + \, \texttt{mh} + \, \texttt{matrix} \, \texttt{mh} + \, \, \, \, \texttt{mh} + \, \, \, \, \texttt{mh} + \, \, \, \, \, \texttt{mh}
                                                                                                                 2 \text{ Iz } (1b^2 (m + mh) + 1a^2 (2 m + mh) + 1a 1b (m + 2 mh)) +
                                                                                                                lb (la + lb)^2 m (lb mh + la (2 m + mh)) Cos [2 (q1[t] - q2[t])])
                                                                     \left(-2\,\text{Iz}^2-2\,\text{Iz}\,\left(2\,\text{la}\,\text{lb}\,\left(\text{m}+\text{mh}\right)\,+\,\text{la}^2\,\left(2\,\text{m}+\text{mh}\right)\,+\,\text{lb}^2\,\left(2\,\text{m}+\text{mh}\right)\right)\,-\,
                                                                                     1b^2 \ m \ \left( 2 \ la \ lb \ \left( m + 2 \ mh \right) \ + \ lb^2 \ \left( m + 2 \ mh \right) \ + \ la^2 \ \left( 3 \ m + 2 \ mh \right) \right) \ + \\
                                                                                     1b^{2} (1a + 1b)^{2} m^{2} Cos [2 (q1[t] - q2[t])])
                                                     \left\{\,\left(2\,\left(\,\left(\text{Iz}-\text{la}\,\text{lb}\,\text{m}\right)\,\left(\text{Iz}+\text{lb}^2\,\text{m}\right)\,\,\text{q2dminus}\,+\,\left(\text{la}+\text{lb}\right)\,\left(\text{lb}^2\,\text{m}\,\left(\text{lb}\,\text{mh}\,+\,\text{la}\,\left(\text{m}\,+\,\text{mh}\right)\,\right)\,+\,\right.\right.\right.
                                                                                                                                  Iz (lb(m+mh) + la(2m+mh)) q1dminus Cos[q1[t] - q2[t]])
                                                                       (2 \text{ Iz}^2 + 2 \text{ Iz } (2 \text{ la lb } (m + mh) + \text{la}^2 (2 \text{ m} + mh) + \text{lb}^2 (2 \text{ m} + mh)) + \text{lb}^2 (2 \text{ m} + mh))
                                                                                     1b^2 m (2 la lb (m + 2 mh) + 1b^2 (m + 2 mh) + la^2 (3 m + 2 mh)) -
                                                                                     1b^{2} (1a + 1b)^{2} m^{2} Cos [2 (q1[t] - q2[t])]), { (1a + 1b)
                                                                       (q1dminus (2 (Iz - la lb m) (2 Iz + lb^2 (m + mh) + la^2 (2 m + mh) + la lb (m + 2 mh)) Cos[q1[t]] +
                                                                                                                                     (la + lb) (-(2 Iz (lb (m + mh) + la (2 m + mh)) + lb m (lb^2 mh - la^2 (2 m + mh))) Cos[q1[]
                                                                                                                                                                                              t] - 2q2[t]] + 1b(1a + 1b) m(1b mh + 1a(2 m + mh)) Cos[3q1[t] - 2q2[t]]))) /
                                                                                                  (4 \text{ Iz}^2 + 4 \text{ Iz} (2 \text{ la lb} (m + mh) + \text{la}^2 (2 m + mh) + \text{lb}^2 (2 m + mh)) +
                                                                                                                 2 lb^2 m (2 la lb (m + 2 mh) + lb^2 (m + 2 mh) + la^2 (3 m + 2 mh)) -
                                                                                                               2 lb^{2} (la + lb)^{2} m^{2} Cos [2 (q1[t] - q2[t])] + ((-Iz + la lb m) q2dminus)
                                                                                                                  (1b (1a + 1b) m Cos[2 q1[t] - q2[t]] + (-2 Iz + (1a - 1b) 1b m) Cos[q2[t]]))
                                                                                                  (-2 Iz^2 - 2 Iz (2 la lb (m + mh) + la^2 (2 m + mh) + lb^2 (2 m + mh)) -
                                                                                                                1b^2 m (2 la lb (m + 2 mh) + 1b^2 (m + 2 mh) + la^2 (3 m + 2 mh)) +
                                                                                                               1b^{2} (la + 1b)^{2} m^{2} Cos[2(q1[t] - q2[t])]), { (la + 1b)
                                                                       \left( \left( \texttt{q1dminus} \left( 2 \left( \texttt{Iz} - \texttt{la} \, \texttt{lb} \, \texttt{m} \right) \right. \left( 2 \, \texttt{Iz} + \texttt{lb}^2 \left( \texttt{m} + \texttt{mh} \right) + \texttt{la}^2 \left( 2 \, \texttt{m} + \texttt{mh} \right) + \texttt{la} \, \texttt{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) \right) \, \\ \left. \mathsf{Sin} \left[ \texttt{q1} \left[ \texttt{t} \right] \right] + \mathsf{mh} \right) + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) \right) \, \\ \left. \mathsf{Sin} \left[ \texttt{q1} \left[ \texttt{t} \right] \right] + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) \right) \, \\ \mathsf{Sin} \left[ \texttt{q1} \left[ \texttt{t} \right] \right] + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) \right) \, \\ \mathsf{Sin} \left[ \mathsf{q1} \left[ \texttt{t} \right] \right] + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) \right) \, \\ \mathsf{Sin} \left[ \mathsf{q1} \left[ \texttt{t} \right] \right] + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) \right) \, \\ \mathsf{Sin} \left[ \mathsf{q1} \left[ \texttt{m} \right] \right] + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) \right) \, \\ \mathsf{la} \left[ \mathsf{la} \left[ \texttt{m} + 2 \, \texttt{mh} \right] \right) + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) + \mathsf{la} \, \mathsf{lb} \left( \texttt{m} + 2 \, \texttt{mh} \right) + \mathsf{la} \, \mathsf{lb} \left( \texttt{m
                                                                                                                                    \left( \text{la} + \text{lb} \right) \; \left( \; \left( \; \text{2 Iz} \; \left( \; \text{lb} \; \left( \; \text{m} + \; \text{mh} \right) \; + \; \text{la} \; \left( \; \text{2 m} + \; \text{mh} \right) \; \right) \; + \; \text{lb m} \; \left( \; \text{lb}^2 \; \text{mh} - \; \text{la}^2 \; \left( \; \text{2 m} + \; \text{mh} \right) \; \right) \; \right) \; \\ \text{Sin} \left[ \; \text{q1} \left[ \; \text{t} \; \right] \; - \; \text{sin} \left[ \; \text{q2} \; \text{t} \; \right] \; + \; \text{lb m} \; \left( \; \text{lb}^2 \; \text{mh} - \; \text{la}^2 \; \left( \; \text{2 m} + \; \text{mh} \right) \; \right) \; \right) \; \\ \text{Sin} \left[ \; \text{q1} \left[ \; \text{t} \; \right] \; - \; \text{sin} \left[ \; \text{q2} \; \text{t} \; \right] \; + \; \text{lb m} \; \left( \; \text{lb}^2 \; \text{mh} - \; \text{la}^2 \; \left( \; \text{2 m} + \; \text{mh} \right) \; \right) \; \right) \; \\ \text{Sin} \left[ \; \text{q2} \; \text{t} \; \right] \; \\ \text{Sin} \left[ \; \text{q2} \; \text{t} \; \right] \; + \; \text{lb} \; \text{m} \; \left( \; \text{lb}^2 \; \text{mh} - \; \text{la}^2 \; \left( \; \text{2 m} + \; \text{mh} \right) \; \right) \; \\ \text{Sin} \left[ \; \text{q2} \; \text{t} \; \right] \; \\ \text{Sin} \left[ \; \text{q2} \; \text{t} \; \right] \; + \; \text{lb} \; \text{m} \; \left( \; \text{lb}^2 \; \text{mh} - \; \text{la}^2 \; \left( \; \text{2 m} + \; \text{mh} \right) \; \right) \; \\ \text{Sin} \left[ \; \text{q2} \; \text{t} \; \right] \; + \; \text{lb} \; \text{m} \; \left( \; \text{lb}^2 \; \text{mh} - \; \text{la}^2 \; \left( \; \text{lb}^2 \; \text{mh} + \; \text{lb}^2 \; \right) \; \\ \text{Sin} \left[ \; \text{q2} \; \text{t} \; \text{lb}^2 \; \text{mh} + \; \text{lb}^2 \; \text{lb}^2 \; \text{mh} + \; \text{lb}^2 \; \text{mh} + \; \text{lb}^2 \; \text
                                                                                                                                                                                      2 q2[t]] + 1b (1a + 1b) m (1b mh + 1a (2 m + mh)) Sin[3 q1[t] - 2 q2[t]]))) /
                                                                                                  (4 \text{ Iz}^2 + 4 \text{ Iz} (2 \text{ la lb} (m + mh) + \text{la}^2 (2 m + mh) + \text{lb}^2 (2 m + mh)) +
                                                                                                                2 lb^2 m (2 la lb (m + 2 mh) + lb^2 (m + 2 mh) + la^2 (3 m + 2 mh)) -
                                                                                                                 2 lb^{2} (la + lb)^{2} m^{2} Cos [2 (q1[t] - q2[t])]) + ((-Iz + la lb m) q2dminus)
                                                                                                                 (lb (la + lb) m Sin[2 q1[t] - q2[t]] + (-2 Iz + (la - lb) lb m) Sin[q2[t]]))
                                                                                                 \left(-2\,\text{Iz}^2-2\,\text{Iz}\,\left(2\,\text{la}\,\text{lb}\,\left(\text{m}+\text{mh}\right)\,+\,\text{la}^2\,\left(2\,\text{m}+\text{mh}\right)\,+\,\text{lb}^2\,\left(2\,\text{m}+\text{mh}\right)\right)\,-\,
                                                                                                                 1b^2 m (2 la lb (m + 2 mh) + lb^2 (m + 2 mh) + la^2 (3 m + 2 mh)) +
                                                                                                                1b^{2} (la + 1b)^{2} m^{2} Cos[2 (q1[t] - q2[t])]))
```

Julia Expression for Constraints Dynamics at collocation points

```
Flatten[qdotplus][[1]]
HurToJulia[%]
```

```
2 lb (la + lb) m (-Iz + la lb m) q2dminus Cos [q2[t]] +
                                 q1dminus \left(2 Iz^{2} + 2 Iz \left(2 Ia Ib (m + mh) + Ia^{2} (2 m + mh) + Ib^{2} (2 m + mh)\right) + Ia^{2} \left(2 m + mh\right)\right) + Ia^{2} \left(2 m + mh\right)\right) + Ia^{2} \left(2 m + mh\right)
                                                                      1b^2 \ m \ \left( 2 \ la \ lb \ \left( m + 2 \ mh \right) \ + \ lb^2 \ \left( m + 2 \ mh \right) \ + \ la^2 \ \left( 3 \ m + 2 \ mh \right) \right) \ -
                                                                     4 lb (la + lb) m Cos \left[\frac{q2[t]}{2}\right]^2 (Iz + 2 la^2 m + 2 la lb m + lb^2 m + la^2 mh + 2 la lb mh + lb^2 mh - lb^2 mh + lb
                                                                                                                 \left(\texttt{la}+\texttt{lb}\right)\;\left(\texttt{lb}\;\left(\texttt{m}+\texttt{mh}\right)\;+\;\texttt{la}\;\left(\texttt{2}\;\texttt{m}+\texttt{mh}\right)\right)\;\mathsf{Cos}\left[\texttt{q2}\left[\texttt{t}\right]\right]\right)\;-\;\texttt{lb}^2\;\left(\texttt{la}+\texttt{lb}\right)^2\;\texttt{m}^2\;\mathsf{Cos}\left[\texttt{2}\;\texttt{q2}\left[\texttt{t}\right]\right]\right)\left/\;\right.
             (2 \text{ Iz}^2 + 2 \text{ Iz} (2 \text{ la lb} (m + mh) + \text{la}^2 (2 m + mh) + \text{lb}^2 (2 m + mh)) +
                                 1b^2 m (2 la lb (m + 2 mh) + 1b^2 (m + 2 mh) + 1a^2 (3 m + 2 mh)) -
                                1b^{2} (1a + 1b)^{2} m^{2} Cos [2 q2 [t]]
(\ (2\star (1z)^{(2)} + (2\star 1z\star (2\star 1a\star 1b\star (m+mh) + (\ (1a)^{(2)}\star (2\star m+mh) + (1b)^{(2)}\star (2\star m+mh)\ )) + (\ (1b)^{(2)}\star m+mh)) + (\ (1b)^{(2)}\star m+mh)) + (\ (1b)^{(2)}\star m+mh)) + (\ (1b)^{(2)}\star m+mh)) + (\ (1b)^{(2)}\star m+mh) 
                     * (2*1a*1b*(m+2*mh) + ((1b)^{(2)}*(m+2*mh) + (1a)^{(2)}*(3*m+2*mh))) + -1*(1b)^{(2)}*((1a+1b))^{(1a+1b)})
                     (2) * (m)^{(2)} * (cos(2*q2)))))^{(-1)} * (2*lb*(la+lb)*m*(-1*Iz+la*lb*m)*q2dminus*cos(q2)+
                      \texttt{q1dminus} \star (2 \star (1z) \, ^{\land}(2) + (2 \star 1z \star (2 \star 1a \star 1b \star (m + mh) + ((1a) \, ^{\land}(2) \star (2 \star m + mh) + (1b) \, ^{\land}(2) \star (2 \star m + mh))) + (1b) \, ^{\land}(2) \star (2 \star m + mh))) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\land}(2) \star (2 \star m + mh)) + (1b) \, ^{\backprime}(2) \, ^{\backprime}(2) \, ^{\backprime}(2) \, ^{\backprime}(2) \, ^{\backprime}(2) 
                       (1b) ^ (2) *m* (2*1a*1b* (m+2*mh) + ( (1b) ^ (2) * (m+2*mh) + (1a) ^ (2) * (3*m+2*mh) )) + (-4*1b* (1a+1b* (
                       ) *m* (\cos(1/2*q^2))^{(2)} *(1z+(2*(1a)^(2)*m+(2*1a*1b*m+((1b)^(2)*m+((1a)^(2)*mh+(2*1a*1b*m+((1b)^(2)*m+((1a)^(2)*mh+(2*1a*1b*m+((1b)^(2)*m+((1a)^(2)*mh+(2*1a*1b*m+((1b)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)*m+((1a)^(2)
                     1a+1b))^{(2)}*(m)^{(2)}*cos(2*q2))))))
```

Flatten[qdotplus][[2]] HurToJulia[%]

$$\left(2 \left(-2 \left(1 a+1 b\right) \left(1 b \, m h+1 a \left(2 \, m+m h\right)\right) \right. \\ \left. \left. \left(1 z-1 a \, 1 b \, m\right) +1 b \left(1 a+1 b\right) \, m \, Cos \left[q 2 \left[t\right]\right]\right) + \left(1 z-1 a \, 1 b \, m\right) \, q 2 d m i n u s \left(1 z+1 b^2 \, m+1 b \left(1 a+1 b\right) \, m \, Cos \left[q 2 \left[t\right]\right]\right)\right) \right) \right/ \\ \left(2 \, 1 z^2+2 \, 1 z \, \left(2 \, 1 a \, 1 b \, \left(m+m h\right)+1 a^2 \, \left(2 \, m+m h\right)+1 b^2 \, \left(2 \, m+m h\right)\right) + 1 b^2 \, m \, \left(2 \, 1 a \, 1 b \, \left(m+2 \, m h\right)+1 b^2 \, \left(m+2 \, m h\right)+1 a^2 \, \left(3 \, m+2 \, m h\right)\right)-1 b^2 \, \left(1 a+1 b\right)^2 \, m^2 \, Cos \left[2 \, q 2 \left[t\right]\right]\right) \\ 2 \times \left(-2 \times \left(1 a+1 b\right) \times \left(1 b \times m h+1 a \times \left(2 \times m+m h\right)\right) \times q 1 d m i n u s \times \left(cos \left(1/2 \times q 2\right)\right)^{\wedge} \left(2\right) \times \left(1 z+\left(-1 \times 1 a \times 1 b \times m+1 b \times \left(1 a+1 b\right)\right) \times m \times cos \left(q 2\right)\right)\right) + \left(1 z+-1 \times 1 a \times 1 b \times m\right) \times q 2 d m i n u s \times \left(1 z+\left(1 b\right)^{\wedge} \left(2\right) \times m+1 b \times \left(1 a+1 b\right) \times m \times cos \left(q 2\right)\right)\right)\right) \times \left((2 \times \left(1 z\right)^{\wedge} \left(2\right) + \left(2 \times 1 z \times \left(2 \times 1 a \times 1 b \times \left(m+m h\right)+\left(1 a\right)^{\wedge} \left(2\right) \times \left(2 \times m+m h\right)+\left(1 b\right)^{\wedge} \left(2\right) \times \left(2 \times m+m h\right)\right)\right) + \left(1 b\right)^{\wedge} \left(2\right) \times m \times \left(1 z \times 1 a \times 1 b \times \left(m+2 \times m h\right)+\left(1 a\right)^{\wedge} \left(2\right) \times \left(3 \times m+2 \times m h\right)\right)\right) + -1 \times \left(1 b\right)^{\wedge} \left(2\right) \times \left(\left(1 a+1 b\right)^{\wedge} \left(2\right) \times \left(1 a+1 b\right)^{\wedge} \left(2\right)^{\wedge} \left(2\right)^{$$

```
ln[66]:= A = \{ \{0, 0, 1, 0\}, \{0, 0, 0, 1\} \}
Out[66]= \{\{0, 0, 1, 0\}, \{0, 0, 0, 1\}\}
```

```
In[67]:= tempA = A.Inverse[HurGlobalMMatrix] // Simplify
Out[67]= \{ \{ (2 \text{ Iz } (2 \text{ m} + \text{mh}) (1 \text{ b} (\text{m} + \text{mh}) + 1 \text{ a} (2 \text{ m} + \text{mh}) \} + \} \}
                                                                                                                    1b^2 m (2 la (2 m^2 + 3 m mh + mh^2) + 1b (m^2 + 4 m mh + 2 mh^2))) Cos[q1[t]] -
                                                                                       1b^3 m^3 \cos [q1[t] - 2 q2[t]]) / (2 Iz^2 (2 m + mh)^2 + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) +
                                                                                         1b^4 m^2 (m^2 + 4 m mh + 2 mh^2) - 1b^4 m^4 Cos[2 (q1[t] - q2[t])]),
                                                               -((1b m (1b m (1b (m + mh) + 1a (2 m + mh)) Cos[2 q1[t] - q2[t]] -
                                                                                                                               (2 \text{ Iz } (2 \text{ m} + \text{mh}) + 1 \text{b m} (1 \text{b} (\text{m} + \text{mh}) - 1 \text{a} (2 \text{ m} + \text{mh}))) \cos[q2[t]])) / (-2 \text{ Iz}^2 (2 \text{ m} + \text{mh})^2 - 1 \text{cos}[q2[t]]))
                                                                                                           4 \text{ Iz } 1b^2 \text{ m } \left(2 \text{ m}^2 + 3 \text{ m mh} + \text{mh}^2\right) - 1b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m mh} + 2 \text{ mh}^2\right) + 1b^4 \text{ m}^4 \text{ Cos} \left[2 \left(\text{q1[t]} - \text{q2[t]}\right)\right]\right)
                                                                 (4 \text{ Iz}^2 \text{ m} + 4 \text{ Iz} 1a^2 \text{ m}^2 + 4 \text{ Iz} 1a 1b \text{ m}^2 + 6 \text{ Iz} 1b^2 \text{ m}^2 + 2 1a^2 1b^2 \text{ m}^3 + 1a 1b^3 \text{ m}^3 + 1b^4 \text
                                                                                         2 \text{ Iz}^2 \text{ mh} + 4 \text{ Iz} \text{ la}^2 \text{ m mh} + 6 \text{ Iz} \text{ la} \text{ lb m mh} + 6 \text{ Iz} \text{ lb}^2 \text{ m mh} + 3 \text{ la}^2 \text{ lb}^2 \text{ m}^2 \text{ mh} + 6 \text{ Iz} \text{ la}^2 \text{ lb}^2 \text{ m}^2 \text{ mh} + 6 \text{ Iz} \text{ la}^2 \text{ lb}^2 \text{ m}^2 \text{ mh} + 6 \text{ Iz} \text{ la}^2 \text{ lb}^2 \text{ m}^2 \text{ mh} + 6 \text{ Iz} \text{ la}^2 \text{ lb}^2 \text{ m}^2 \text{ mh} + 6 \text{ Iz} \text{ la}^2 \text{ lb}^2 \text{ mh} + 6 \text{ Iz} \text{ la}^2 \text{ lb}^2 \text{ mh} + 6 \text{ Iz} \text{ la}^2 \text{ lb}^2 \text{ mh} + 6 \text{ Iz} \text{ la}^2 \text{ lb}^2 \text{ mh} + 6 \text{ Iz} \text{ la}^2 \text{ lb}^2 \text{ mh} + 6 \text{ Iz} \text{ la}^2 \text{ lb}^2 \text{ mh} + 6 \text{ Iz} \text{ la}^2 \text{ lb}^2 \text{ mh} + 6 \text{ Iz} \text{ la}^2 \text{ lb}^2 \text{ mh} + 6 \text{ Iz} \text{ la}^2 \text{ lb}^2 \text{ mh} + 6 \text{ Iz} \text{ la}^2 \text{ lb}^2 \text{ l
                                                                                         4 \; la \; lb^3 \; m^2 \; mh \; + \; 3 \; lb^4 \; m^2 \; mh \; + \; Iz \; la^2 \; mh^2 \; + \; 2 \; Iz \; la \; lb \; mh^2 \; + \; Iz \; lb^2 \; mh^2 \; + \; 10 \; mh
                                                                                         1a^2 1b^2 m mh^2 + 2 1a 1b^3 m mh^2 + 1b^4 m mh^2 + (1b (m + mh) + 1a (2 m + mh))
                                                                                                     (1b^2 m (1b mh + 1a (m + mh)) + Iz (1b (m + mh) + 1a (2 m + mh))) Cos[2 q1[t]] -
                                                                                         1b^3 (la + 1b) m^3 Cos[2 (q1[t] - q2[t])] + Iz 1b^2 m^2 Cos[2 q2[t]] - la 1b^3 m^3 Cos[2 q2[t]])
                                                                         (2 Iz^{2} (2 m + mh)^{2} + 4 Iz 1b^{2} m (2 m^{2} + 3 m mh + mh^{2}) + 1b^{4} m^{2} (m^{2} + 4 m mh + 2 mh^{2}) -
                                                                                         1b^4 m^4 Cos [2 (q1[t] - q2[t])]),
                                                                 ((1b (m + mh) + 1a (2 m + mh)) (1b^2 m (1b mh + 1a (m + mh)) + Iz (1b (m + mh) + 1a (2 m + mh)))
                                                                                                  Sin[2q1[t]] + 1b^2 m^2 (Iz - 1a 1b m) Sin[2q2[t]]) /
                                                                           (2 \text{ Iz}^2 (2 \text{ m} + \text{mh})^2 + 4 \text{ Iz} 1b^2 \text{ m} (2 \text{ m}^2 + 3 \text{ m} \text{ mh} + \text{mh}^2) + 1b^4 \text{ m}^2 (\text{m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2) -
                                                                                         1b^4 m^4 Cos[2(q1[t] - q2[t])]),
                                                      \{((2 Iz (2 m + mh) (1b (m + mh) + 1a (2 m + mh)) +
                                                                                                                    1b^2 m (2 la (2 m^2 + 3 m mh + mh^2) + 1b (m^2 + 4 m mh + 2 mh^2))) Sin[q1[t]] +
                                                                                       1b^3 m^3 Sin[q1[t] - 2 q2[t]]) / (2 Iz^2 (2 m + mh)^2 + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m (2 m^2 + 3 m mh + mh^2) + 4 Iz 1b^2 m 
                                                                                         1b^4 \; m^2 \; \left(\, m^2 \, + \, 4 \; m \; mh \, + \, 2 \; mh^2 \,\right) \, - \, 1b^4 \; m^4 \; Cos \left[\, 2 \; \left(\, q1 \, [\, t\,] \, - \, q2 \, [\, t\,] \,\,\right) \,\,\right] \, \right) \, ,
                                                               -((1bm(1bm(1bm(m+mh)+1a(2m+mh))Sin[2q1[t]-q2[t]]-
                                                                                                                              (2 \text{ Iz } (2 \text{ m} + \text{mh}) + 1 \text{b m } (1 \text{b } (\text{m} + \text{mh}) - 1 \text{a } (2 \text{ m} + \text{mh}))) \text{ Sin}[q2[t]])) / (-2 \text{ Iz}^2 (2 \text{ m} + \text{mh})^2 - 1 \text{cm})
                                                                                                          4 \text{ Iz } 1b^2 \text{ m } (2 \text{ m}^2 + 3 \text{ m mh} + \text{mh}^2) - 1b^4 \text{ m}^2 (\text{m}^2 + 4 \text{ m mh} + 2 \text{ mh}^2) + 1b^4 \text{ m}^4 \text{ Cos} [2 (q1[t] - q2[t])]),
                                                                 ((1b(m+mh)+1a(2m+mh))(1b^2m(1bmh+1a(m+mh))+Iz(1b(m+mh)+1a(2m+mh)))
                                                                                                  Sin[2 q1[t]] + 1b^2 m^2 (Iz - 1a 1b m) Sin[2 q2[t]]) /
                                                                           (2 \text{ Iz}^2 (2 \text{ m} + \text{mh})^2 + 4 \text{ Iz} 1b^2 \text{ m} (2 \text{ m}^2 + 3 \text{ m} \text{ mh} + \text{mh}^2) + 1b^4 \text{ m}^2 (\text{m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2) -
                                                                                         1b^4 m^4 Cos[2(q1[t] - q2[t])]),
                                                                 (4 \text{ Iz}^2 \text{ m} + 4 \text{ Iz} \text{ la}^2 \text{ m}^2 + 4 \text{ Iz} \text{ la} \text{ lb} \text{ m}^2 + 6 \text{ Iz} \text{ lb}^2 \text{ m}^2 + 2 \text{ la}^2 \text{ lb}^2 \text{ m}^3 + \text{ la} \text{ lb}^3 \text{ m}^3 + \text{ lb}^4 \text{ m}^4 + \text{ lb}^4 \text{ lb}^4 + 
                                                                                         2 Iz^2 mh + 4 Iz 1a^2 m mh + 6 Iz 1a 1b m mh + 6 Iz 1b^2 m mh + 3 1a^2 1b^2 m^2 mh +
                                                                                         4 la lb^3 m^2 mh + 3 lb^4 m^2 mh + Iz la^2 mh^2 + 2 Iz la lb mh^2 + Iz lb^2 mh^2 +
                                                                                         1a^2 1b^2 m mh^2 + 2 1a 1b^3 m mh^2 + 1b^4 m mh^2 - (1b (m + mh) + 1a (2 m + mh))
                                                                                                    (1b^2 m (1b mh + 1a (m + mh)) + Iz (1b (m + mh) + 1a (2 m + mh))) Cos[2 q1[t]] -
                                                                                         1b^3 (1a + 1b) m^3 Cos[2 (q1[t] - q2[t])] - Iz 1b^2 m^2 Cos[2 q2[t]] + la 1b^3 m^3 Cos[2 q2[t]]) /
                                                                           \left(2 \text{ Iz}^2 \left(2 \text{ m} + \text{mh}\right)^2 + 4 \text{ Iz } 1b^2 \text{ m} \left(2 \text{ m}^2 + 3 \text{ m} \text{ mh} + \text{mh}^2\right) + 1b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) - 10b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m} \text{ mh} + 2 \text{ mh}^2\right) + 10b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m}^2\right) + 10b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m}^2\right) + 10b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m}^2\right) + 10b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m}^2\right) + 10b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m}^2\right) + 10b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m}^2\right) + 10b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m}^2\right) + 10b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m}^2\right) + 10b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m}^2\right) + 10b^4 \text{ m}^2 \left(\text{m}^2 + 4 \text{ m}^2\right) + 10b^4 \text{ m}^2 \left
                                                                                         1b^4 m^4 Cos[2(q1[t] - q2[t])])
```

```
In[68]:= tempB = Inverse[tempA.Transpose[A]].tempA // Simplify
Out[68]= \{\{((b^2 m (3 la m + lb m + 2 la mh + 2 lb mh) + 2 lz (lb (m + mh) + la (2 m + mh))\} Cos [q1 [t]] -
                  1b^{2} (1a + 1b) m^{2} Cos[q1[t] - 2 q2[t]])
               (2 \text{ Iz}^2 + 2 \text{ Iz} (2 \text{ la lb} (m + mh) + \text{la}^2 (2 m + mh) + \text{lb}^2 (2 m + mh)) +
                  1b^2 m (2 la lb (m + 2 mh) + 1b^2 (m + 2 mh) + la^2 (3 m + 2 mh)) -
                  1b^{2} (1a + 1b)^{2} m^{2} Cos[2(q1[t] - q2[t])]),
             -((lb m ((la + lb) (lb (m + mh) + la (2 m + mh)) Cos[2 q1[t] - q2[t]] -
                          (2 \text{ Iz} + 1b^2 (m + mh) + 1a^2 (2 m + mh) + 1a 1b (m + 2 mh)) \cos[q2[t]]))
                  \left(-2 \text{ Iz}^2 - 2 \text{ Iz} \left(2 \text{ la lb } (m+mh) + \text{la}^2 \left(2 \text{ m} + \text{mh}\right) + \text{lb}^2 \left(2 \text{ m} + \text{mh}\right)\right) - \left(-2 \text{ Iz}^2 - 2 \text{ Iz} \left(2 \text{ la lb } (m+mh) + \text{la}^2 \left(2 \text{ m} + \text{mh}\right) + \text{lb}^2 \left(2 \text{ m} + \text{mh}\right)\right)\right)
                      1b^2 m (2 la lb (m + 2 mh) + 1b^2 (m + 2 mh) + la^2 (3 m + 2 mh)) +
                      1b^{2} (1a + 1b)^{2} m^{2} Cos[2 (q1[t] - q2[t])]), 1, 0
           1b^{2} (la + 1b) m^{2} Sin[q1[t] - 2q2[t]]) /
               (2 Iz^2 + 2 Iz (2 Ia 1b (m + mh) + Ia^2 (2 m + mh) + 1b^2 (2 m + mh)) +
                  1b^2 m (2 la lb (m + 2 mh) + 1b^2 (m + 2 mh) + la^2 (3 m + 2 mh)) -
                  1b^{2} (1a + 1b)^{2} m^{2} Cos[2 (q1[t] - q2[t])]),
             (1b m (-(1a+1b) (1b (m+mh) + 1a (2m+mh)) Sin[2q1[t] - q2[t]] +
                       (2 \text{ Iz} + 1b^2 (m + mh) + 1a^2 (2 m + mh) + 1a 1b (m + 2 mh)) \sin[q2[t]]))
               \left(-2 \text{ Iz}^2 - 2 \text{ Iz} \left(2 \text{ la lb } (m+mh) + \text{la}^2 \left(2 \text{ m} + \text{mh}\right) + \text{lb}^2 \left(2 \text{ m} + \text{mh}\right)\right) - \left(-2 \text{ Iz}^2 - 2 \text{ Iz} \left(2 \text{ la lb } (m+mh) + \text{la}^2 \left(2 \text{ m} + \text{mh}\right) + \text{lb}^2 \left(2 \text{ m} + \text{mh}\right)\right)\right)
                  1b^2 m (2 la lb (m + 2 mh) + 1b^2 (m + 2 mh) + la^2 (3 m + 2 mh)) +
                  1b^{2} (1a + 1b)^{2} m^{2} Cos[2 (q1[t] - q2[t])], 0, 1\}
```

```
ln[69]: HurList2Column[HurGlobalELEquation] /. {q1''[t] \rightarrow 0, q2''[t] \rightarrow 0, q3''[t] \rightarrow 0, q4''[t] \rightarrow 0}
                           lambda = tempB.% // Simplify
Out[69]= \{ - \tan 1 + \tan 2 - 2 g \text{ la m Sin}[q1[t]] - g \text{ lb m Sin}[q1[t]] - g \text{ lb m Sin}[q1[t]] \} 
                                           {-tau2+glbmSin[q2[t]]+lb(la+lb)mSin[q1[t]-q2[t]]q1'[t]<sup>2</sup>},
                                       (lb (m + mh) + la (2 m + mh)) Sin[q1[t]] q1'[t]^2 - lb m Sin[q2[t]] q2'[t]^2,
                                  \{2 \text{ g m} + \text{ g mh} - (1b (m + mh) + 1a (2 m + mh)) \cos[q1[t]] q1'[t]^2 + 1b m \cos[q2[t]] q2'[t]^2\}\}
Out[70]= \left\{ \left\{ \left( lb \left( m + mh \right) + la \left( 2m + mh \right) \right) Sin[q1[t]] q1'[t]^2 - \right\} \right\}
                                             (1b m ((1a + 1b) (1b (m + mh) + 1a (2 m + mh)) Cos[2 q1[t] - q2[t]] -
                                                                        (2 \text{ Iz} + 1b^2 (m + mh) + 1a^2 (2 m + mh) + 1a 1b (m + 2 mh)) \cos[q2[t]])
                                                            (-tau2 + g lb m Sin[q2[t]] + lb (la + lb) m Sin[q1[t] - q2[t]] q1'[t]^{2}))
                                                  \left(-2\,\text{Iz}^2-2\,\text{Iz}\,\left(2\,\text{la}\,\text{lb}\,\left(\text{m}+\text{mh}\right)\,+\,\text{la}^2\,\left(2\,\text{m}+\text{mh}\right)\,+\,\text{lb}^2\,\left(2\,\text{m}+\text{mh}\right)\right)\,-\,
                                                           1b^2 m (2 la lb (m + 2 mh) + 1b^2 (m + 2 mh) + la^2 (3 m + 2 mh)) +
                                                           1b^{2} (la + 1b)^{2} m^{2} Cos [2 (q1[t] - q2[t])] - 1b m Sin[q2[t]] q2'[t]^{2} +
                                             ((1b^2 m (3 la m + 1b m + 2 la mh + 2 lb mh) + 2 Iz (1b (m + mh) + la (2 m + mh))) Cos[q1[t]] -
                                                                      1b^{2} (1a + 1b) m^{2} Cos [q1[t] - 2 q2[t]]) (tau1 - tau2 +
                                                                      g\,\left(1b\,\left(m+mh\right)\,+\,1a\,\left(2\,m+mh\right)\right)\,Sin\,[\,q1\,[\,t\,]\,\,]\,\,+\,1b\,\left(1a\,+\,1b\right)\,m\,Sin\,[\,q1\,[\,t\,]\,\,-\,q2\,[\,t\,]\,\,]\,\,q2'\,[\,t\,]^{\,2}\,\right)\,\left/\,\left(1b\,\left(m+mh\right)\,+\,1a\,\left(2\,m+mh\right)\,\right)\,Sin\,[\,q1\,[\,t\,]\,\,]\,+\,1b\,\left(1a\,+\,1b\right)\,m\,Sin\,[\,q1\,[\,t\,]\,\,-\,q2\,[\,t\,]\,\,]\,q\,2'\,[\,t\,]^{\,2}\,\right)\,\right/\,\left(1b\,\left(m+mh\right)\,+\,1a\,\left(2\,m+mh\right)\,\right)\,Sin\,[\,q1\,[\,t\,]\,\,]\,+\,1b\,\left(1a\,+\,1b\right)\,m\,Sin\,[\,q1\,[\,t\,]\,\,]\,q\,2'\,[\,t\,]^{\,2}\,\right)\,\left/\,\left(m+mh\right)\,+\,1a\,\left(2\,m+mh\right)\,\right)\,Sin\,[\,q1\,[\,t\,]\,\,]\,+\,1b\,\left(1a\,+\,1b\right)\,m\,Sin\,[\,q1\,[\,t\,]\,\,]\,q\,2'\,[\,t\,]^{\,2}\,\right)\,\left/\,\left(m+mh\right)\,+\,1a\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m+mh\right)\,\left(m
                                                  \left(-2\,\text{Iz}^2-2\,\text{Iz}\,\left(2\,\text{la}\,\text{lb}\,\left(\text{m}+\text{mh}\right)\,+\,\text{la}^2\,\left(2\,\text{m}+\text{mh}\right)\,+\,\text{lb}^2\,\left(2\,\text{m}+\text{mh}\right)\right)\,-\,
                                                           1b^2 \; m \; \left( \; 2 \; 1a \; 1b \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1a^2 \; \left( \; 3 \; m \; + \; 2 \; mh \; \right) \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + \; 1b^2 \; \left( \; m \; + \; 2 \; mh \; \right) \; + 
                                                           1b^{2} (1a + 1b)^{2} m^{2} Cos [2 (q1[t] - q2[t])]),
                                 \{2gm + gmh - (1b(m+mh) + 1a(2m+mh)) Cos[q1[t]]q1'[t]^2 + (2gm + gmh) \}
                                             (1b m (-(1a+1b) (1b (m+mh) + 1a (2m+mh)) Sin[2q1[t] - q2[t]] +
                                                                        (2 \text{ Iz} + 1b^2 (m + mh) + 1a^2 (2 m + mh) + 1a 1b (m + 2 mh)) \text{ Sin}[q2[t]])
                                                            (-tau2 + g lb m Sin[q2[t]] + lb (la + lb) m Sin[q1[t] - q2[t]] q1'[t]^{2}))
                                                  \left(-2\,\text{Iz}^2-2\,\text{Iz}\,\left(2\,\text{la}\,\text{lb}\,\left(\text{m}+\text{mh}\right)\,+\,\text{la}^2\,\left(2\,\text{m}+\text{mh}\right)\,+\,\text{lb}^2\,\left(2\,\text{m}+\text{mh}\right)\right)\,-\,
                                                           1b^2 m (2 la lb (m + 2 mh) + lb^2 (m + 2 mh) + la^2 (3 m + 2 mh)) +
                                                           1b^{2} (1a + 1b)^{2} m^{2} Cos[2 (q1[t] - q2[t])] + 1b m Cos[q2[t]] q2'[t]^{2} -
                                             ((1b^2 m (3 la m + 1b m + 2 la mh + 2 lb mh) + 2 Iz (1b (m + mh) + la (2 m + mh))) Sin[q1[t]] +
                                                                       1b^{2} (1a + 1b) m^{2} Sin[q1[t] - 2q2[t]]) (tau1 - tau2 + tau2)
                                                                      g(lb(m+mh)+la(2m+mh))Sin[q1[t]]+lb(la+lb)mSin[q1[t]-q2[t]]q2'[t]^2)
                                                  (2 \text{ Iz}^2 + 2 \text{ Iz} (2 \text{ la lb} (m + mh) + \text{la}^2 (2 m + mh) + \text{lb}^2 (2 m + mh)) +
                                                           1b^2 m (2 la lb (m + 2 mh) + lb^2 (m + 2 mh) + la^2 (3 m + 2 mh)) -
                                                           1b^{2} (1a + 1b)^{2} m^{2} Cos [2 (q1[t] - q2[t])])
```

HurToJulia[lambda[[1, 1]]]

```
(((1b*(m+mh)+la*(2*m+mh))*sin(q1)+lb*m*sin((q1+q2)))*(q1d)^(2)+(((2*(Iz)^(2)+(2*Iz*(2)+(2*Iz)^(2)+(2*Iz*(2)+(2*Iz)^(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz*(2)+(2*Iz
                                   *1a*1b*(m+mh) + ((1a)^{(2)}*(2*m+mh) + (1b)^{(2)}*(2*m+mh)) + ((1b)^{(2)}*m*(2*1a*1b*(m+2*mh) + (1b)^{(2)}*m*(2*1a*1b*(m+2*mh)) + ((1b)^{(2)}*m*(2*1a*1b*(m+2*mh)) + ((1b)^{(2)}*m*(2*1a*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b*(m+2*1b
                                   ((1b)^{(2)} * (m+2*mh) + (1a)^{(2)} * (3*m+2*mh)) + -1*(1b)^{(2)} * ((1a+1b))^{(2)} * (m)^{(2)} * (m)^{(2)} * (2*mh)^{(2)} *
                                m+mh)))*cos(q1)+lb*m*(cos(q1)*(2*(Iz+-1*la*lb*m)*cos(q2)+lb*(Ia+lb)*m*cos(2*q2))+-2*
                                   (1z + (2*(1a)^{(2)}*m + (2*1a*1b*m + ((1b)^{(2)}*m + ((1a)^{(2)}*m + (2*1a*1b*m + ((1b)^{(2)}*m + 1b*((1a)^{(2)}*m + (2*1a*1b*m + ((1b)^{(2)}*m + 1b*((1a)^{(2)}*m + (2*1a*1b*m + ((1b)^{(2)}*m + 1b*((1a)^{(2)}*m + ((1a)^{(2)}*m + ((1a)^{
                                1a + 1b) *m*cos(q2)))))))))) *sin(q1) *sin(q2))) * (-1*tau2 + (-1*g*lb*m*sin((q1+q2)) + 1b*(1a+q2))) * (1a+q2))) * (1a+q2)) * (1a+
                                1b) *m*sin(q2) *(q1d)^{(2)}) + (2*1b*m*sin((q1+q2)) *q1d*q2d+(1b*m*sin((q1+q2)) *(q2d)^{(2)}+(2b*m*sin((q1+q2))) *(q2d)^{(2)}+(2b*
                                   -1*\left( (2*(1z)^{(2)} + (2*1z*(2*1a*1b*(m+mh) + ((1a)^{(2)} * (2*m+mh) + (1b)^{(2)} * (2*m+mh)) \right) + ((1b)^{(2)} + ((1a)^{(2)} +
                                   (2) *m * (2*1a*1b*(m+2*mh) + ((1b)^{(2)}*(m+2*mh) + (1a)^{(2)}*(3*m+2*mh))) + -1*(1b)^{(2)}*((1a+2*mh)) + (1a)^{(2)}*(1a+2*mh)) + (1a)^{(2)}*(1a+2*mh) + (1a)^{(2)}*(1a+2*mh)) + (1a)^{(2)}*(1a+2*mh
                                1b)\ )^{(2)} \star (m)^{(2)} \star \cos (2 \star q2)))))^{(-1)} \star (((1b)^{(2)} \star m \star (3 \star 1a \star m + (1b \star m + (2 \star 1a \star mh + 2 \star 1b \star mh))) + (1b \star m + (2 \star 1a \star mh + 2 \star 1b \star mh)))) + (1b \star m + (2 \star 1a \star mh + 2 \star 1b \star mh)))) + (1b \star m + (2 \star 1a \star mh + 2 \star 1b \star mh)))) + (1b \star m + (2 \star 1a \star mh + 2 \star 1b \star mh)))) + (1b \star m + (2 \star 1a \star mh + 2 \star 1b \star mh)))) + (1b \star m + (2 \star 1a \star mh + 2 \star 1b \star mh)))))
                                2*Iz*(lb*(m+mh)+la*(2*m+mh)))*cos(q1)+-1*(lb)^(2)*(la+lb)*(m)^(2)*cos((q1+2*q2)))*(la+lb)*(m)^(2)*cos((q1+2*q2)))*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(la+lb)*(l
                                tau1 + (2*g*la*m*sin(q1) + (g*lb*m*sin(q1) + (g*la*mh*sin(q1) + (g*lb*mh*sin(q1) + (g*lb*m*sin(q1) +
                                     ((q1+q2)) + (2*1b*(1a+1b)*m*sin(q2)*q1d*q2d+1b*(1a+1b)*m*sin(q2)*(q2d)^(2))))))))))
```

HurToJulia[lambda[[2, 1]]]

```
*1a*1b*(m+2*mh)+((1b)^{(2)}*(m+2*mh)+(1a)^{(2)}*(3*m+2*mh))+-1*(1b)^{(2)}*((1a+1b))^{(2)}*
                   (\mathsf{m}) \wedge (2) \star \cos (2 \star \mathsf{q2}))))) \wedge (-1) \star (-1 \star (4 \star \mathsf{Iz} \star \mathsf{la} \star \mathsf{m} + (2 \star \mathsf{Iz} \star \mathsf{lb} \star \mathsf{m} + (3 \star \mathsf{Ia} \star (\mathsf{lb}) \wedge (2) \star (\mathsf{m}) \wedge (2) + ((\mathsf{lb}) \wedge (2) \star (\mathsf{lb}) \wedge (2) + ((\mathsf{lb}) \wedge (2) \star (2) + (\mathsf{lb}) \wedge (2) +
                 3)*(m)^{(2)} + (2*Iz*la*mh + (2*Iz*lb*mh + (2*Ia*(1b)^{(2)}*m*mh + (2*(1b)^{(3)}*m*mh + (2*lb*m*(-1a*(1b)^{(2)}*m*mh + (2*(1b)^{(3)}*m*mh + (2*(1b)^{(3)}*
                 \cos{(q1)}*(Iz+(2*(1a)^{(2)}*m+(2*1a*1b*m+((1b)^{(2)}*m+((1a)^{(2)}*m+((2*1a*1b*m+((1b)^{(2)}*m+((1a)^{(2)}*m+(2*1a*1b*m+((1b)^{(2)}*m+(2*1a*1b*m+((1b)^{(2)}*m+(2*1a*1b*m+((1b)^{(2)}*m+(2*1a*1b*m+((1b)^{(2)}*m+(2*1a*1b*m+((1b)^{(2)}*m+(2*1a*1b*m+((1b)^{(2)}*m+(2*1a*1b*m+((1b)^{(2)}*m+(2*1a*1b*m+((1b)^{(2)}*m+(2*1a*1b*m+((1b)^{(2)}*m+(2*1a*1b*m+((1b)^{(2)}*m+(2*1a*1b*m+((1b)^{(2)}*m+(2*1a*1b*m+((1b)^{(2)}*m+(2*1a*1b*m+((1b)^{(2)}*m+(2*1a*1b*m+((1b)^{(2)}*m+(2*1a*1b*m+((1b)^{(2)}*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+(2*1a*1b*m+
                  )*m*sin(q2)*(q1d)^(2))+(-2*lb*m*cos((q1+q2))*q1d*q2d+(-1*lb*m*cos((q1+q2))*(q2d)^(2))
                 ) ^ (2) *m* (2 *la *lb * (m+2 *mh) + ( (1b) ^ (2) * (m+2 *mh) + (1a) ^ (2) * (3 *m+2 *mh) ) ) + -1 * (1b) ^ (2) * ( (1a) ^ (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (2) * (
                 +1b))^{(2)} \times (m)^{(2)} \times \cos(2*q2)))))^{(-1)} \times (((1b)^{(2)} *m * (3*1a*m + (1b*m + (2*1a*mh + 2*1b*mh))))
                  +2*Iz*(1b*(m+mh)+1a*(2*m+mh)))*sin(q1)+-1*(1b)^(2)*(1a+1b)*(m)^(2)*sin((q1+2*q2)))*
                  (tau1 + (2*g*la*m*sin(q1) + (g*lb*m*sin(q1) + (g*la*mh*sin(q1) + (g*lb*mh*sin(q1) + (g*lb*m) + (g
                 \sin((q1+q2)) + (2*lb*(la+lb)*m*sin(q2)*q1d*q2d+lb*(la+lb)*m*sin(q2)*(q2d)^(2))))))))
                 ))))))
```

HurSaveData["data impactA rel.m", "Jbfoot", "impDynConst1", "impDynConst2", "temp", "coef", "LinOp", "qdotplus", "lambda"]

For impact dynamics constraints without inversion

```
impactLHS = HurGlobalMMatrix.HurList2Column[{q1dp, q2dp, q3dp, q4dp}] -
         Transpose[Jbfoot[[1;; 2, ;;]]].HurList2Column[{Fimp1, Fimp2}] // Simplify
 \{ \{q2dp (Iz + 1b^2 m + 1b (1a + 1b) m Cos [q2[t]) \} \}
         q1dp (2 Iz + 2 Ia^2 m + 2 Ia Ib m + 2 Ib^2 m + Ia^2 mh + 2 Ia Ib mh + 1b^2 mh + 2 Ib (Ia + Ib) m Cos[q2[t]]) +
         Fimp1 (la + lb) (Cos[q1[t]] + Cos[q1[t] + q2[t]]) +
         q3dp(-(1b(m+mh)+1a(2m+mh)))cos[q1[t]]-1bmcos[q1[t]+q2[t]])+
         Fimp2 (la + lb) (Sin[q1[t]] + Sin[q1[t] + q2[t]]) +
         q4dp \left(-(1b (m+mh) + la (2m+mh)) Sin[q1[t]] - lb m Sin[q1[t] + q2[t]]\right)
    \{(Iz + 1b^2 m) q2dp + q1dp (Iz + 1b^2 m + 1b (1a + 1b) m Cos [q2[t]]) + \}
         Fimp1 (la + lb) Cos [q1[t] + q2[t]] - lb m q3dp Cos [q1[t] + q2[t]] + q2[t]
         Fimp2 (la + lb) Sin[q1[t] + q2[t]] - lb m q4dp Sin[q1[t] + q2[t]],
    \{-Fimp1 + 2 m q3dp + mh q3dp - (1b (m + mh) + 1a (2 m + mh)) q1dp Cos[q1[t]] - \}
         lb m (q1dp + q2dp) Cos[q1[t] + q2[t]],
    \{-Fimp2 + 2 m q4dp + mh q4dp - (lb (m + mh) + la (2 m + mh)) q1dp Sin[q1[t]] - \}
         1b m (q1dp + q2dp) Sin[q1[t] + q2[t]] 
impactRHS = HurGlobalMMatrix.HurList2Column[{q1dm, q2dm, 0, 0}] // Simplify
 \{ \{ 2 \text{ la}^2 \text{ m q1dm} + 2 \text{ la lb m q1dm} + 2 \text{ lb}^2 \text{ m q1dm} + \text{ la}^2 \text{ mh q1dm} + 2 \text{ la lb mh q1dm} + \text{ lb}^2 \text{ mh q1dm} + 
         1b^2 m q 2dm + Iz (2 q 1dm + q 2dm) + 1b (1a + 1b) m (2 q 1dm + q 2dm) Cos [q 2 [t]] 
    \{(Iz + 1b^2 m) (q1dm + q2dm) + 1b (1a + 1b) m q1dm Cos[q2[t]]\},
    \{-(1b(m+mh)+1a(2m+mh)) \text{ q1dm Cos}[q1[t]]-1bm(q1dm+q2dm) \text{ Cos}[q1[t]+q2[t]]\},
    \{-(1b(m+mh)+1a(2m+mh)) \text{ q1dm Sin}[q1[t]]-1bm(q1dm+q2dm) \text{Sin}[q1[t]+q2[t]]\}\}
impactVel = Jbfoot[[1;; 2, ;;]].HurList2Column[{q1dp, q2dp, q3dp, q4dp}] // Simplify
 \{ \{q3dp - (1a + 1b) \ q1dp \ Cos[q1[t]] - (1a + 1b) \ (q1dp + q2dp) \ Cos[q1[t] + q2[t]] \} \}
    \{q4dp - (la + lb) \ q1dp \ Sin[q1[t]] - (la + lb) \ (q1dp + q2dp) \ Sin[q1[t] + q2[t]]\}\}
impactLHS[[1, 1]]
HurToJulia[%]
q2dp (Iz + 1b^2 m + 1b (1a + 1b) m Cos[q2[t]]) +
   q1dp (2 Iz + 2 Ia^2 m + 2 Ia Ib m + 2 Ib^2 m + Ia^2 mh + 2 Ia Ib mh + 1b^2 mh + 2 Ib (Ia + Ib) m Cos [q2[t]]) +
   Fimp1 (la + lb) (Cos[q1[t]] + Cos[q1[t] + q2[t]]) +
   q3dp \left(-(1b (m+mh) + 1a (2m+mh)) Cos[q1[t]] - 1b m Cos[q1[t] + q2[t]]\right) +
   Fimp2 (la + lb) (Sin[q1[t]] + Sin[q1[t] + q2[t]]) +
   q4dp \left(-(1b (m+mh) + 1a (2m+mh)) Sin[q1[t]] - 1b m Sin[q1[t] + q2[t]]\right)
 (q2dp*(Iz+((lb)^{(2)}*m+lb*(la+lb)*m*cos(q2)))+(q1dp*(2*Iz+(2*(la)^{(2)}*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*n+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*m+(2*la*lb*n+(2*la*lb*n+(2*la*lb*n+(2*la*lb*n+(2*la*lb*n+(2*la*lb*n+(2*la*lb*n+(2*la*lb*n+(2*la*lb*n+(2*la*lb*n+(2*la*lb*n+(2*la*lb*n+(2*la*lb*n+(2*la*lb*n+(2*la*lb*n+(2*la*lb*n+(2*la*lb*n+(2*la*lb*n+(2*la*lb*n+(2*la*lb*n+(2*la*lb*n+(2*la*lb*n+(2*la*lb*n+(2*la*lb*n+(2*la*lb*n+(2*la*lb*n+(2*la*lb*n+(2*la*lb*n+(2*la*lb*n+(2*la*lb*n+(2*la*lb*n+(2*la*lb*n+(2*la*lb*n+(2*la*lb*n+(2*la*lb*n+(2*la*lb*n+(2*la*lb*n+
       Fimp1 \star (1a + 1b) \star (cos(q1) + cos((q1 + q2))) + (q3dp \star (-1 \star (1b \star (m + mh) + 1a \star (2 \star m + mh)) \star cos(q1) + -1 \star 1b)
      *m*cos((q1+q2)))+(Fimp2*(la+lb)*(sin(q1)+sin((q1+q2)))+q4dp*(-1*(lb*(m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+la*(2*m+mh)+l
      mh)) * sin(q1) + -1*lb*m*sin((q1+q2))))))))
```

```
impactLHS[[2, 1]]
HurToJulia[%]
   (Iz + lb^2 m) q2dp + q1dp (Iz + lb^2 m + lb (la + lb) m Cos[q2[t]]) +
          Fimp1 (la + lb) Cos [q1[t] + q2[t]] - lb m q3dp Cos [q1[t] + q2[t]] +
          Fimp2 (la + lb) Sin[q1[t] + q2[t]] - lb m q4dp Sin[q1[t] + q2[t]]
   (\;(\mathsf{IZ}+(\mathsf{lb})\,\,{}^{^{\diamond}}(2)\,\,\star\mathsf{m})\,\,\star\mathsf{q}2\mathsf{d}\mathsf{p}+(\;\mathsf{q}1\mathsf{d}\mathsf{p}\,\star\,(\;\mathsf{IZ}+(\;(\;\mathsf{lb})\,\,{}^{^{\diamond}}(2)\,\,\star\mathsf{m}+\mathsf{lb}\,\star\,(\;\mathsf{la}+\mathsf{lb})\,\,\star\mathsf{m}\,\star\,\mathsf{cos}\,(\;\mathsf{q}2)\;)\;)\,\,+\,(\;\mathsf{Fimp1}\,\star\,(\;\mathsf{la}+\mathsf{lb})\,\,\star\,\mathsf{cos}\,(\;\mathsf{la}+\mathsf{lb})\,\,\star\,\mathsf{cos}\,(\;\mathsf{la}+\mathsf{lb})\,\,\star\,\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf{la}+\mathsf
                      (q1+q2) + (-1*lb*m*q3dp*cos((q1+q2)) + (Fimp2*(la+lb)*sin((q1+q2)) + -1*lb*m*q4dp*sin((q1+q2)) + (-1*lb*m*q3dp*cos((q1+q2)) + (-1*lb*m*q3dp*sin((q1+q2)) + (-1*
                    +q2))))))))
  impactLHS[[3, 1]]
HurToJulia[%]
 -Fimp1 + 2 m q3dp + mh q3dp -
            (1b (m + mh) + 1a (2 m + mh)) q1dp Cos [q1[t]] - 1b m (q1dp + q2dp) Cos [q1[t] + q2[t]]
   (-1*Fimp1 + (2*m*q3dp + (mh*q3dp + (-1*(1b*(m+mh) + 1a*(2*m+mh)) *q1dp*cos(q1) + -1*1b*m*(q1dp + (-1*(1b*(m+mh) + 1a*(2*m+mh)) *q1dp*cos(q1) + -1*1b*m*(q1dp + (-1*(1b*(m+mh) + 1a*(2*m+mh)) *q1dp*cos(q1) + -1*1b*m*(q1dp + (-1*(1b*(m+mh) + 1a*(2*m+mh))) *q1dp*cos(q1) + -1*1b*m*(q1) + -1*1b*m*(q1)
                    q2dp) *cos((q1+q2))))))
  impactLHS[[4, 1]]
HurToJulia[%]
 -Fimp2 + 2 m q4dp + mh q4dp -
            (1b(m+mh)+1a(2m+mh)) q1dp Sin[q1[t]] - lb m (q1dp + q2dp) Sin[q1[t] + q2[t]]
   (-1*Fimp2+(2*m*q4dp+(mh*q4dp+(-1*(lb*(m+mh)+la*(2*m+mh))*q1dp*sin(q1)+-1*lb*m*(q1dp+mh))
                    q2dp) *sin((q1+q2)))))
  impactRHS[[1, 1]]
HurToJulia[%]
 2 la^2 m q1dm + 2 la lb m q1dm + 2 lb^2 m q1dm + la^2 mh q1dm + 2 la lb mh q1dm +
          1b^2 mh q1dm + 1b^2 m q2dm + Iz (2 q1dm + q2dm) + 1b (1a + 1b) m (2 q1dm + q2dm) Cos [q2[t]]
   (2*(1a)^{(2)}*m*q1dm+(2*1a*1b*m*q1dm+(2*(1b)^{(2)}*m*q1dm+((1a)^{(2)}*mh*q1dm+(2*1a*1b*mh*q1dm+((1a)^{(2)}*mh*q1dm+((2*1a*1b*mh*q1dm+((2*1a*1b*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*mh*q1dm+((1a)^{(2)}*m
                    q1dm + (\ (1b) \ ^{\wedge}(2) \ *mh \ *q1dm + (\ (1b) \ ^{\wedge}(2) \ *m \ *q2dm + (\ Iz \ * (2 \ *q1dm + q2dm) \ + 1b \ * (1a \ + 1b) \ *m \ * (2 \ *q1dm + q2dm) \ + 1b \ * (1a \ + 1b) \ * (1a \ +
                    *cos(q2)))))))))
  impactRHS[[2, 1]]
HurToJulia[%]
   (Iz + 1b^2 m) (q1dm + q2dm) + 1b (1a + 1b) m q1dm Cos [q2[t]]
   ((Iz+(1b)^{(2)}*m)*(q1dm+q2dm)+lb*(la+lb)*m*q1dm*cos(q2))
  impactRHS[[3, 1]]
HurToJulia[%]
  -(1b (m+mh) + 1a (2m+mh)) q1dm Cos[q1[t]] - 1b m (q1dm+q2dm) Cos[q1[t]+q2[t]]
   (-1*(1b*(m+mh)+la*(2*m+mh))*q1dm*cos(q1)+-1*lb*m*(q1dm+q2dm)*cos((q1+q2)))
```

```
impactRHS[[4, 1]]
                           HurToJulia[%]
                            -(1b (m+mh) + 1a (2m+mh)) q1dm Sin[q1[t]] - 1b m (q1dm+q2dm) Sin[q1[t]+q2[t]]
                             (-1*(1b*(m+mh)+la*(2*m+mh))*q1dm*sin(q1)+-1*lb*m*(q1dm+q2dm)*sin((q1+q2)))
                            impactVel[[1, 1]]
                           HurToJulia[%]
                           q3dp - (1a + 1b) q1dp Cos[q1[t]] - (1a + 1b) (q1dp + q2dp) Cos[q1[t] + q2[t]]
                             (q3dp + (-1*(1a+1b)*q1dp*cos(q1) + -1*(1a+1b)*(q1dp+q2dp)*cos((q1+q2))))
                            impactVel[[2, 1]]
                           HurToJulia[%]
                           q4dp - (1a + 1b) q1dp Sin[q1[t]] - (1a + 1b) (q1dp + q2dp) Sin[q1[t] + q2[t]]
                             (q4dp + (-1*(la+lb)*q1dp*sin(q1) + -1*(la+lb)*(q1dp+q2dp)*sin((q1+q2))))
                           HurSaveData["data_impactAAcc_rel.m", "Jbfoot", "impDynConst1", "impDynConst2", "temp",
                                "coef", "LinOp", "qdotplus", "lambda", "impactLHS", "impactRHS", "impactVel"]
      In[71]:= ELforGRF = HurGlobalELEquation /.
                                          \{q3[t] \rightarrow 0, q4[t] \rightarrow 0, q3'[t] \rightarrow 0, q4'[t] \rightarrow 0, q3''[t] \rightarrow 0, q4''[t] \rightarrow 0\}
                           % //
                                MatrixForm
Out[72]//MatrixForm=
                                   -\tan 1 + \tan 2 - 2g \ln m \sin[q1[t]] - g \ln m \sin[q1[t]] - lb
                                                                                                                                                                                                                                                                                          -tau2 + g lb m Sin [q2[t]] + lb (la
                                                                                                                                                             (1b (m + mh) + 1a (2 m + mh)) Sin[q1[t]] q1'[t]^2 - 1b m Sin[q2[t]] q2
                                                                                                                                     2gm + gmh - (1b(m+mh) + 1a(2m+mh)) Cos[q1[t]] q1'[t]^2 + 1bmCos[q2[
      In[73]:= lambda1 = ELforGRF[[3]] // Simplify
                            lambda2 = ELforGRF[[4]] // Simplify
    Out[73]= (lb (m + mh) + la (2 m + mh)) Sin[q1[t]] q1'[t]^2 -
                                lb \, m \, Sin[q2[t]] \, q2'[t]^2 - 2 \, la \, m \, Cos[q1[t]] \, q1''[t] - lb \, m \, Cos[q1[t]] \, q1''[t] -
                                la mh Cos[q1[t]] q1''[t] - lb mh Cos[q1[t]] q1''[t] + lb m Cos[q2[t]] q2''[t]
    Out[74]= 2 g m + g mh - (1b (m + mh) + 1a (2 m + mh)) Cos[q1[t]] q1'[t]^2 +
                                1b \, m \, Cos[q2[t]] \, q2'[t]^2 - 2 \, la \, m \, Sin[q1[t]] \, q1''[t] - 1b \, m \, Sin[q1[t]] \, q1''[t] -
                                la mh Sin[q1[t]] q1''[t] - lb mh Sin[q1[t]] q1''[t] + lb m Sin[q2[t]] q2''[t]
      In[75]:= HurToJulia[lambda1]
    Out[75] = ((1b*(m+mh) + la*(2*m+mh))*sin(q1)*(q1d)^{(2)} + (-1*lb*m*sin(q2)*(q2d)^{(2)} + (-2*la*m*cos(q1))) + (-2*la*m*cos(q1))) + (-2*la*m*cos(q1)) + (-2*la*m*cos
                                     *q1dd + (-1*1b*m*cos(q1)*q1dd + (-1*1a*mh*cos(q1)*q1dd + (-1*1b*mh*cos(q1)*q1dd + lb*m*cos(q1)*q1dd + lb
                                     q2) *q2dd))))))
      In[76]:= HurToJulia[lambda2]
     \text{Out} [76] = \left(2 * g * m + \left(g * m + \left(q * m + \left(1 b * \left(m + m h\right) + 1 a * \left(2 * m + m h\right)\right) * \cos \left(q 1\right) * \left(q 1 d\right) ^{2}\right) + \left(1 b * m * \cos \left(q 2\right) * \left(q 2 d\right) ^{2}\right) + \left(1 b * m * \cos \left(q 2\right) * \left(q 2 d\right) ^{2}\right) \right) \right) 
                                     2*la*m*sin(q1)*q1dd+(-1*lb*m*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*lb*mh*sin(q1)*q1dd+(-1*lb*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1dd+(-1*la*mh*sin(q1)*q1d+(-1*la*mh*sin(q1)*q1d+(-1*la*mh*sin(q1)*q1d+(-1*la*mh*sin(q1)*q1d+(-1*la*mh*sin(q1)*q1d+(-1*la*mh*sin(q1)*q1d+(-1*la*
                                     q1dd+lb*m*sin(q2)*q2dd))))))))
```

```
HurSaveData["data_impactAAcc_abs.m", "Jbfoot", "impDynConst1",
 "impDynConst2", "temp", "coef", "LinOp", "qdotplus", "lambda",
 "lambda1", "lambda2", "impactLHS", "impactRHS", "impactVel"]
```