```
Quit[];
```

```
SetDirectory[NotebookDirectory[]]
<< HurToolbox.m
```

```
D:\Dropbox\TAMU\Group\Project\Walker\seven_link\AbsAngleJointTorque
```

```
HurToolbox for modeling and analysis of multibody systems 2.0.0.
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.
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Email questions, comments, or concerns to pilwonhur@tamu.edu.
```

```
(*To use n, i,j,k*)
(*HurInitialize[]*)
(*To use user-defined Newtonian RF and i,j,k*)
HurInitialize[rf0]
(*To use user-defined Newtonian RF and its own x,y,z*)
(*HurInitialize[rf0,"xyz"]*)
```

```
HurLoadData["data1.m"]
```

We have 7 links. If a,b,c,d,e,f,g are used, we have problems with g which is the gravitational acceleration. So, let's use rf1..

```
HurDefineRF[rf1, rf2, rf3, rf4, rf5, rf6, rf7]
HurDefineGeneralizedCoordinates[q1[t],
 q2[t], q3[t], q4[t], q5[t], q6[t], q7[t], q8[t], q9[t]]
HurDefineDCM[rf1, q1[t], {0, 0, 1}]
HurDefineDCM[rf2, q2[t], {0, 0, 1}]
HurDefineDCM[rf3, q3[t], {0, 0, 1}]
HurDefineDCM[rf4, q4[t], {0, 0, 1}]
HurDefineDCM[rf5, q5[t], {0, 0, 1}]
HurDefineDCM[rf6, q6[t], {0, 0, 1}]
HurDefineDCM[rf7, q7[t], {0, 0, 1}]
```

```
ToeST = q8[t] i0 + q9[t] j0;
HeelST = ToeST - (lfa + lfb) i1;
FootSTCOM = ToeST - lfa i1 + lfc j1;
AnkleST = ToeST - lfe i1 + (lfc + lfd) j1;
ShankSTCOM = AnkleST + lsa j2;
KneeST = AnkleST + (lsa + lsb) j2;
ThighSTCOM = KneeST + lta j3;
Hip = KneeST + (lta + ltb) j3;
TorsoCOM = Hip + lba j4;
ThighSWCOM = Hip - ltb j5;
KneeSW = Hip - (ltb + lta) j5;
ShankSWCOM = KneeSW - lsb j6;
AnkleSW = KneeSW - (lsb + lsa) j6;
ToeSW = AnkleSW + lfe i7 - (lfc + lfd) j7;
HeelSW = ToeSW - (lfa + lfb) i7;
FootSWCOM = ToeSW - lfa i7 + lfc j7;
```

```
HurDefineCOMPos[rf1, FootSTCOM]
HurDefineCOMPos[rf2, ShankSTCOM]
HurDefineCOMPos[rf3, ThighSTCOM]
HurDefineCOMPos[rf4, TorsoCOM]
HurDefineCOMPos[rf5, ThighSWCOM]
HurDefineCOMPos[rf6, ShankSWCOM]
HurDefineCOMPos[rf7, FootSWCOM]
```

```
HurKinematics[]
```

```
HurDefineMass[rf1, mf]
HurDefineMass[rf2, ms]
HurDefineMass[rf3, mt]
HurDefineMass[rf4, mb]
HurDefineMass[rf5, mt]
HurDefineMass[rf6, ms]
HurDefineMass[rf7, mf]
HurDefineInertia[rf1, {0, 0, 0, 0, 0, Ifz}]
HurDefineInertia[rf2, {0, 0, 0, 0, 0, Isz}]
HurDefineInertia[rf3, {0, 0, 0, 0, 0, Itz}]
HurDefineInertia[rf4, {0, 0, 0, 0, 0, Ibz}]
HurDefineInertia[rf5, {0, 0, 0, 0, 0, Itz}]
HurDefineInertia[rf6, {0, 0, 0, 0, 0, Isz}]
HurDefineInertia[rf7, {0, 0, 0, 0, 0, Ifz}]
```

```
HurDefineVertical[j0]
```

```
HolonomicConst = Flatten[List[HurUnifyTriadsCoord[ToeST, rf0][[1 ;; 2]],
   HurUnifyTriadsCoord[HeelST, rf0][[2]], HurUnifyTriadsCoord[HeelSW, rf0][[1 ;; 2]]]]
HolonomicConstDot = D[HolonomicConst, t]
gcd = D[HurGlobalGeneralizedCoordinates, t];
AConstr = Grad[HolonomicConstDot, gcd];
AConstr // MatrixForm
```

$$\begin{Bmatrix} q8[t],\ q9[t],\ q9[t] - (lfa + lfb)\ Sin[q1[t]], \\ -lfe\ Cos[q1[t]] - (lfa + lfb)\ Cos[q7[t]] + lfe\ Cos[q7[t]] + q8[t] - \\ (lfc + lfd)\ Sin[q1[t]] - (lsa + lsb)\ Sin[q2[t]] - (lta + ltb)\ Sin[q3[t]] + \\ (lta + ltb)\ Sin[q5[t]] + (lsa + lsb)\ Sin[q6[t]] + (lfc + lfd)\ Sin[q7[t]], \\ (lfc + lfd)\ Cos[q1[t]] + (lsa + lsb)\ Cos[q2[t]] + (lta + ltb)\ Cos[q3[t]] - \\ (lta + ltb)\ Cos[q5[t]] - (lsa + lsb)\ Cos[q6[t]] - (lfc + lfd)\ Cos[q7[t]] + \\ q9[t] - lfe\ Sin[q1[t]] - (lfa + lfb)\ Sin[q7[t]] + lfe\ Sin[q7[t]] \end{Bmatrix}$$

$$\begin{Bmatrix} q8'[t],\ q9'[t],\ -(lfa + lfb)\ Cos[q1[t]]\ q1'[t] + q9'[t], \\ -(lfc + lfd)\ Cos[q1[t]]\ q1'[t] + lfe\ Sin[q1[t]]\ q1'[t] - (lsa + lsb)\ Cos[q2[t]]\ q2'[t] - \\ (lta + ltb)\ Cos[q3[t]]\ q3'[t] + (lta + ltb)\ Cos[q5[t]]\ q5'[t] + \\ (lsa + lsb)\ Cos[q6[t]]\ q6'[t] + (lfc + lfd)\ Cos[q7[t]]\ q7'[t] + \\ (lfa + lfb)\ Sin[q7[t]]\ q7'[t] - lfe\ Sin[q7[t]]\ q7'[t] + q8'[t], \\ -lfe\ Cos[q1[t]]\ q1'[t] - (lfc + lfd)\ Sin[q1[t]]\ q1'[t] - (lsa + lsb)\ Sin[q2[t]]\ q2'[t] - \\ (lta + ltb)\ Sin[q3[t]]\ q3'[t] + (lta + ltb)\ Sin[q5[t]]\ q5'[t] + \\ (lsa + lsb)\ Sin[q6[t]]\ q6'[t] - (lfa + lfb)\ Cos[q7[t]]\ q7'[t] + \\ lfe\ Cos[q7[t]]\ q7'[t] + (lfc + lfd)\ Sin[q7[t]]\ q7'[t] + q9'[t] \end{Bmatrix}$$

$$\begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ -(lfa + lfb)\ Cos[q1[t]] & 0 & 0 \\ -(lfc + lfd)\ Cos[q1[t]] + lfe\ Sin[q1[t]] & -(lsa + lsb)\ Cos[q2[t]] & -(lta + ltb)\ Cos[q3[t]] \\ -lfe\ Cos[q1[t]] - (lfc + lfd)\ Sin[q1[t]] & -(lsa + lsb)\ Sin[q2[t]] & -(lta + ltb)\ Sin[q3[t]] \end{pmatrix}$$

```
HurSaveData["data1.m", "HolonomicConst", "AConstr", "ToeST", "HeelST",
 "FootSTCOM", "AnkleST", "ShankSTCOM", "KneeST", "ThighSTCOM", "Hip", "TorsoCOM",
 "ThighSWCOM", "KneeSW", "ShankSWCOM", "AnkleSW", "ToeSW", "HeelSW", "FootSWCOM"]
```

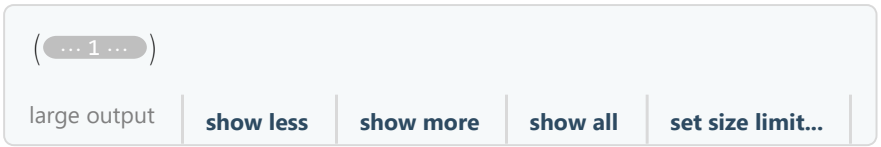
```
Transpose[HurGetJacobian[AnkleST, rf1, rf0]].HurList2Column[{0, 0, 0, 0, 0, -tau1}] +
 Transpose[HurGetJacobian[AnkleST, rf2, rf0]].HurList2Column[{0, 0, 0, 0, 0, tau1}] +
 Transpose[HurGetJacobian[KneeST, rf2, rf0]].HurList2Column[{0, 0, 0, 0, 0, -tau2}] +
 Transpose[HurGetJacobian[KneeST, rf3, rf0]].HurList2Column[{0, 0, 0, 0, 0, tau2}] +
 Transpose[HurGetJacobian[Hip, rf3, rf0]].HurList2Column[{0, 0, 0, 0, 0, -tau3}] +
 Transpose[HurGetJacobian[Hip, rf4, rf0]].HurList2Column[{0, 0, 0, 0, 0, tau3}] +
 Transpose[HurGetJacobian[Hip, rf4, rf0]].HurList2Column[{0, 0, 0, 0, 0, -tau4}] +
 Transpose[HurGetJacobian[Hip, rf5, rf0]].HurList2Column[{0, 0, 0, 0, 0, tau4}] +
 Transpose[HurGetJacobian[KneeSW, rf5, rf0]].HurList2Column[{0, 0, 0, 0, 0, -tau5}] +
 Transpose[HurGetJacobian[KneeSW, rf6, rf0]].HurList2Column[{0, 0, 0, 0, 0, tau5}] +
 Transpose[HurGetJacobian[AnkleSW, rf6, rf0]].HurList2Column[{0, 0, 0, 0, 0, -tau6}] +
 Transpose[HurGetJacobian[AnkleSW, rf7, rf0]].HurList2Column[{0, 0, 0, 0, 0, tau6}] +
 Transpose[AConstr].HurList2Column[{lambda1, lambda2, lambda3, lambda4, lambda5}]
HurDefineNonConservativeForces[Flatten[%]]
```

```
{{-tau1 - lambda3 (lfa + lfb) Cos[q1[t]] +
    lambda5 (-lfe Cos[q1[t]] - (lfc + lfd) Sin[q1[t]]) +
    lambda4 (-(lfc + lfd) Cos[q1[t]] + lfe Sin[q1[t]])},
 {tau1 - tau2 - lambda4 (lsa + lsb) Cos[q2[t]] - lambda5 (lsa + lsb) Sin[q2[t]]},
 {tau2 - tau3 - lambda4 (lta + ltb) Cos[q3[t]] - lambda5 (lta + ltb) Sin[q3[t]]},
 {tau3 - tau4},
 {tau4 - tau5 + lambda4 (lta + ltb) Cos[q5[t]] + lambda5 (lta + ltb) Sin[q5[t]]},
 {tau5 - tau6 + lambda4 (lsa + lsb) Cos[q6[t]] + lambda5 (lsa + lsb) Sin[q6[t]]},
 {tau6 + lambda5 (-(lfa + lfb) Cos[q7[t]] + lfe Cos[q7[t]] + (lfc + lfd) Sin[q7[t]]) +
    lambda4 ((lfc + lfd) Cos[q7[t]] + (lfa + lfb) Sin[q7[t]] - lfe Sin[q7[t]])},
 {lambda1 + lambda4}, {lambda2 + lambda3 + lambda5}}
```

```
{-tau1 - lambda3 (lfa + lfb) Cos[q1[t]] +
  lambda5 (-lfe Cos[q1[t]] - (lfc + lfd) Sin[q1[t]]) +
  lambda4 (-(lfc + lfd) Cos[q1[t]] + lfe Sin[q1[t]]),
 tau1 - tau2 - lambda4 (lsa + lsb) Cos[q2[t]] - lambda5 (lsa + lsb) Sin[q2[t]],
 tau2 - tau3 - lambda4 (lta + ltb) Cos[q3[t]] - lambda5 (lta + ltb) Sin[q3[t]], tau3 - tau4,
 tau4 - tau5 + lambda4 (lta + ltb) Cos[q5[t]] + lambda5 (lta + ltb) Sin[q5[t]],
 tau5 - tau6 + lambda4 (lsa + lsb) Cos[q6[t]] + lambda5 (lsa + lsb) Sin[q6[t]],
 tau6 + lambda5 (-(lfa + lfb) Cos[q7[t]] + lfe Cos[q7[t]] + (lfc + lfd) Sin[q7[t]]) +
  lambda4 ((lfc + lfd) Cos[q7[t]] + (lfa + lfb) Sin[q7[t]] - lfe Sin[q7[t]]),
 lambda1 + lambda4, lambda2 + lambda3 + lambda5}
```

```
HurELEquation[];
```

```
HurGlobalELEquation // MatrixForm
```



HurGlobalMMatrix // MatrixForm

$$\begin{pmatrix} \text{Ifz} + \text{lfd}^2\,\text{mb} + \text{lfe}^2\,\text{mb} + \text{lfa}^2\,\text{mf} + \text{lfd}^2\,\text{mf} + \text{lfe}^2\,\text{mf} + 2\,\text{lfd}^2\,\text{ms} + 2\,\text{lfe}^2\,\text{ms} + 2\,\text{lfd}^2\,\text{mt} + 2\,\text{lfe}^2\,\text{mt} + 2\,\text{l} \\ \left(\text{lsb}\left(\text{mb}+\text{mf}+\text{ms}+2\,\text{mt}\right)+\text{lsa}\left(\text{mb}+\text{mf}+2\left(\text{ms}+\text{mt}\right)\right)\right)\left(\left(\text{lfc}+\text{lfd}\right)\text{Cos}[\text{q1}[\text{t}] \\ \left(\text{ltb}\left(\text{mb}+\text{mf}+\text{ms}+\text{mt}\right)+\text{lta}\left(\text{mb}+\text{mf}+\text{ms}+2\,\text{mt}\right)\right)\left(\left(\text{lfc}+\text{lfd}\right)\text{Cos}[\text{q1}[\text{t}]-\right. \\ \text{lba}\,\text{mb}\left(\left(\text{lfc}+\text{lfd}\right)\text{Cos}[\text{q1}[\text{t}]-\text{q4}[\text{t}]]-\text{lfe}\,\text{Sin}[\text{q1}[\right. \\ -\left(\text{lta}\left(\text{mf}+\text{ms}\right)+\text{ltb}\left(\text{mf}+\text{ms}+\text{mt}\right)\right)\left(\left(\text{lfc}+\text{lfd}\right)\text{Cos}[\text{q1}[\text{t}]-\text{q5}[\text{t}]\right. \\ -\left(\text{lsa}\,\text{mf}+\text{lsb}\left(\text{mf}+\text{ms}\right)\right)\left(\left(\text{lfc}+\text{lfd}\right)\text{Cos}[\text{q1}[\text{t}]-\text{q6}[\text{t}]]-\text{lf}\right. \\ -\text{mf}\left(\left(\text{lfc}\,\text{lfd}+\text{lfd}^2-\text{lfa}\,\text{lfe}+\text{lfe}^2\right)\text{Cos}[\text{q1}[\text{t}]-\text{q7}[\text{t}]]-\left(\text{lfa}\left(\text{lfc}+\text{lf}\right.\right. \\ -\left(\text{lfd}\left(\text{mb}+\text{mf}+2\left(\text{ms}+\text{mt}\right)\right)+\text{lfc}\left(\text{mb}+2\left(\text{mf}+\text{ms}+\text{mt}\right)\right)\right)\text{Cos}[\text{q1}[\text{t}]]+\left(\text{lfa}\,\text{mf}+\right. \\ \left.-\left(\text{lfa}\,\text{mf}+\text{lfe}\left(\text{mb}+\text{mf}+2\left(\text{ms}+\text{mt}\right)\right)\right)\text{Cos}[\text{q1}[\text{t}]]-\left(\text{lfd}\left(\text{mb}+\text{mf}+2\left(\text{ms}+\text{mt}\right)\right)+\right.\right. \end{pmatrix}$$

HurGlobalCMatrix // MatrixForm

$$\begin{pmatrix} 0 \\ \left(\text{lsb}\left(\text{mb}+\text{mf}+\text{ms}+2\,\text{mt}\right)+\text{lsa}\left(\text{mb}+\text{mf}+2\left(\text{ms}+\text{mt}\right)\right)\right)\left(-\text{lfe}\,\text{Cos}[\text{q1}[\text{t}]-\text{q2}[\text{t}]]-\left(\text{lfc}+\text{l}\right.\right. \\ \left(\text{ltb}\left(\text{mb}+\text{mf}+\text{ms}+\text{mt}\right)+\text{lta}\left(\text{mb}+\text{mf}+\text{ms}+2\,\text{mt}\right)\right)\left(-\text{lfe}\,\text{Cos}[\text{q1}[\text{t}]-\text{q3}[\text{t}]]-\left(\text{lfc}+\text{lfd}\right.\right. \\ \text{lba}\,\text{mb}\left(-\text{lfe}\,\text{Cos}[\text{q1}[\text{t}]-\text{q4}[\text{t}]]-\left(\text{lfc}+\text{lfd}\right)\text{Sin}[\text{q1}[\text{t}]-\text{q4}[\text{t}]]\right. \\ -\left(\text{lta}\left(\text{mf}+\text{ms}\right)+\text{ltb}\left(\text{mf}+\text{ms}+\text{mt}\right)\right)\left(-\text{lfe}\,\text{Cos}[\text{q1}[\text{t}]-\text{q5}[\text{t}]]-\left(\text{lfc}+\text{lfd}\right)\text{Sin}[\right. \\ -\left(\text{lsa}\,\text{mf}+\text{lsb}\left(\text{mf}+\text{ms}\right)\right)\left(-\text{lfe}\,\text{Cos}[\text{q1}[\text{t}]-\text{q6}[\text{t}]]-\left(\text{lfc}+\text{lfd}\right)\text{Sin}[\text{q1}[\text{t}]\right. \\ -\text{mf}\left(-\left(\text{lfa}\left(\text{lfc}+\text{lfd}\right)-\text{lfc}\,\text{lfe}\right)\text{Cos}[\text{q1}[\text{t}]-\text{q7}[\text{t}]]-\left(\text{lfc}\,\text{lfd}+\text{lfd}^2-\text{lfa}\,\text{lfe}+\text{lfe}^2\right)\right. \\ \frac{1}{2}\left(2\left(\text{lfa}\,\text{mf}+\text{lfe}\left(\text{mb}+\text{mf}+2\left(\text{ms}+\text{mt}\right)\right)\right)\text{Cos}[\text{q1}[\text{t}]]+2\left(\text{lfd}\left(\text{mb}+\text{mf}+2\left(\text{ms}+\text{mt}\right)\right)+\text{lfc}\left(\text{mb}+2\right.\right. \\ \frac{1}{2}\left(-2\left(\text{lfd}\left(\text{mb}+\text{mf}+2\left(\text{ms}+\text{mt}\right)\right)+\text{lfc}\left(\text{mb}+2\left(\text{mf}+\text{ms}+\text{mt}\right)\right)\right)\text{Cos}[\text{q1}[\text{t}]]+2\left(\text{lfa}\,\text{mf}+\text{lfe}\left(\text{mb}+\right.\right. \end{pmatrix}$$

HurGlobalGVector // MatrixForm

$$\begin{pmatrix} -\text{g}\left(\left(\text{lfa}\,\text{mf}+\text{lfe}\left(\text{mb}+\text{mf}+2\left(\text{ms}+\text{mt}\right)\right)\right)\text{Cos}[\text{q1}[\text{t}]]+\left(\text{lfd}\left(\text{mb}+\text{mf}+2\left(\text{ms}+\text{mt}\right)\right)+\text{lfc}\left(\text{mb}+2\left(\text{m}\right.\right.\right. \\ -\text{g}\left(\text{lsb}\left(\text{mb}+\text{mf}+\text{ms}+2\,\text{mt}\right)+\text{lsa}\left(\text{mb}+\text{mf}+2\left(\text{ms}+\text{mt}\right)\right)\right)\text{Sin}[\text{q2}[\text{t}]] \\ -\text{g}\left(\text{ltb}\left(\text{mb}+\text{mf}+\text{ms}+\text{mt}\right)+\text{lta}\left(\text{mb}+\text{mf}+\text{ms}+2\,\text{mt}\right)\right)\text{Sin}[\text{q3}[\text{t}]] \\ -\text{g}\,\text{lba}\,\text{mb}\,\text{Sin}[\text{q4}[\text{t}]] \\ \text{g}\left(\text{lta}\left(\text{mf}+\text{ms}\right)+\text{ltb}\left(\text{mf}+\text{ms}+\text{mt}\right)\right)\text{Sin}[\text{q5}[\text{t}]] \\ \text{g}\left(\text{lsa}\,\text{mf}+\text{lsb}\left(\text{mf}+\text{ms}\right)\right)\text{Sin}[\text{q6}[\text{t}]] \\ \text{g}\,\text{mf}\left(\left(-\text{lfa}+\text{lfe}\right)\text{Cos}[\text{q7}[\text{t}]]+\text{lfd}\,\text{Sin}[\text{q7}[\text{t}]]\right) \\ 0 \\ \text{g}\left(\text{mb}+2\left(\text{mf}+\text{ms}+\text{mt}\right)\right) \end{pmatrix}$$

dyn1 = HurGlobalELEquation[[1]];
HurToJulia[dyn1]

```
(tau1+(lambda3*lfa*cos(q1)+(lambda3*lfb*cos(q1)+(lambda4*lfc*cos(q1)+(lambda4*lfd*
  cos(q1)+(lambda5*lfe*cos(q1)+(-1*g*lfe*mb*cos(q1)+(-1*g*lfa*mf*cos(q1)+(-1*g*lfe*
  mf*cos(q1)+(-2*g*lfe*ms*cos(q1)+(-2*g*lfe*mt*cos(q1)+(lambda5*lfc*sin(q1)+(
  lambda5*lfd*sin(q1)+(-1*lambda4*lfe*sin(q1)+(-1*g*lfc*mb*sin(q1)+(-1*g*lfd*mb*sin
  (q1)+(-2*g*lfc*mf*sin(q1)+(-1*g*lfd*mf*sin(q1)+(-2*g*lfc*ms*sin(q1)+(-2*g*lfd*ms*
  sin(q1)+(-2*g*lfc*mt*sin(q1)+(-2*g*lfd*mt*sin(q1)+((lsb*(mb+(mf+(ms+2*mt))))+lsa*(
  mb+(mf+2*(ms+mt))))*(lfe*cos((q1+-1*q2))+(lfc+lfd)*sin((q1+-1*q2)))*(q2d)^(2)+((
  ltb*(mb+(mf+(ms+mt))))+lta*(mb+(mf+(ms+2*mt))))*(lfe*cos((q1+-1*q3))+(lfc+lfd)*
  sin((q1+-1*q3)))*(q3d)^(2)+(lba*lfe*mb*cos((q1+-1*q4))*(q4d)^(2)+(lba*lfc*mb*sin(
  (q1+-1*q4))*(q4d)^(2)+(lba*lfd*mb*sin((q1+-1*q4))*(q4d)^(2)+(-1*lfe*lta*mf*cos((
  q1+-1*q5))*(q5d)^(2)+(-1*lfe*ltb*mf*cos((q1+-1*q5))*(q5d)^(2)+(-1*lfe*lta*ms*cos(
  (q1+-1*q5))*(q5d)^(2)+(-1*lfe*ltb*ms*cos((q1+-1*q5))*(q5d)^(2)+(-1*lfe*ltb*mt*cos
  ((q1+-1*q5))*(q5d)^(2)+(-1*lfc*lta*mf*sin((q1+-1*q5))*(q5d)^(2)+(-1*lfd*lta*mf*
  sin((q1+-1*q5))*(q5d)^(2)+(-1*lfc*ltb*mf*sin((q1+-1*q5))*(q5d)^(2)+(-1*lfd*ltb*mf
  *sin((q1+-1*q5))*(q5d)^(2)+(-1*lfc*lta*ms*sin((q1+-1*q5))*(q5d)^(2)+(-1*lfd*lta*
  ms*sin((q1+-1*q5))*(q5d)^(2)+(-1*lfc*ltb*ms*sin((q1+-1*q5))*(q5d)^(2)+(-1*lfd*ltb
```

*ms*sin((q1+-1*q5))*(q5d)^(2)+(-1*lfc*ltb*mt*sin((q1+-1*q5))*(q5d)^(2)+(-1*lfd*ltb*mt*sin((q1+-1*q5))*(q5d)^(2)+(-1*lfe*lsa*mf*cos((q1+-1*q6))*(q6d)^(2)+(-1*lfe*lsb*mf*cos((q1+-1*q6))*(q6d)^(2)+(-1*lfe*lsb*ms*cos((q1+-1*q6))*(q6d)^(2)+(-1*lfc*lsa*mf*sin((q1+-1*q6))*(q6d)^(2)+(-1*lfd*lsa*mf*sin((q1+-1*q6))*(q6d)^(2)+(-1*lfc*lsb*mf*sin((q1+-1*q6))*(q6d)^(2)+(-1*lfd*lsb*mf*sin((q1+-1*q6))*(q6d)^(2)+(-1*lfc*lsb*ms*sin((q1+-1*q6))*(q6d)^(2)+(-1*lfd*lsb*ms*sin((q1+-1*q6))*(q6d)^(2)+(-1*lfa*lfc*mf*cos((q1+-1*q7))*(q7d)^(2)+(-1*lfa*lfd*mf*cos((q1+-1*q7))*(q7d)^(2)+(lfc*lfe*mf*cos((q1+-1*q7))*(q7d)^(2)+(-1*lfc*lfd*mf*sin((q1+-1*q7))*(q7d)^(2)+(-1*(lfd)^(2)*mf*sin((q1+-1*q7))*(q7d)^(2)+(lfa*lfe*mf*sin((q1+-1*q7))*(q7d)^(2)+(-1*(lfe)^(2)*mf*sin((q1+-1*q7))*(q7d)^(2)+(Ifz*q1dd+((lfc)^(2)*mb*q1dd+(2*lfc*lfd*mb*q1dd+((lfd)^(2)*mb*q1dd+((lfe)^(2)*mb*q1dd+((lfa)^(2)*mf*q1dd+(2*(lfc)^(2)*mf*q1dd+(2*lfc*lfd*mf*q1dd+((lfd)^(2)*mf*q1dd+((lfe)^(2)*mf*q1dd+(2*(lfc)^(2)*ms*q1dd+(4*lfc*lfd*ms*q1dd+(2*(lfd)^(2)*ms*q1dd+(2*(lfe)^(2)*ms*q1dd+(2*(lfc)^(2)*mt*q1dd+(4*lfc*lfd*mt*q1dd+(2*(lfd)^(2)*mt*q1dd+(2*(lfe)^(2)*mt*q1dd+(lfc*lsa*mb*cos((q1+-1*q2))*q2dd+(lfd*lsa*mb*cos((q1+-1*q2))*q2dd+(lfc*lsb*mb*cos((q1+-1*q2))*q2dd+(lfd*lsb*mb*cos((q1+-1*q2))*q2dd+(lfc*lsa*mf*cos((q1+-1*q2))*q2dd+(lfd*lsa*mf*cos((q1+-1*q2))*q2dd+(lfc*lsb*mf*cos((q1+-1*q2))*q2dd+(lfd*lsb*mf*cos((q1+-1*q2))*q2dd+(2*lfc*lsa*ms*cos((q1+-1*q2))*q2dd+(2*lfd*lsa*ms*cos((q1+-1*q2))*q2dd+(lfc*lsb*ms*cos((q1+-1*q2))*q2dd+(lfd*lsb*ms*cos((q1+-1*q2))*q2dd+(2*lfc*lsa*mt*cos((q1+-1*q2))*q2dd+(2*lfd*lsa*mt*cos((q1+-1*q2))*q2dd+(2*lfc*lsb*mt*cos((q1+-1*q2))*q2dd+(2*lfd*lsb*mt*cos((q1+-1*q2))*q2dd+(-1*lfe*lsa*mb*sin((q1+-1*q2))*q2dd+(-1*lfe*lsb*mb*sin((q1+-1*q2))*q2dd+(-1*lfe*lsa*mf*sin((q1+-1*q2))*q2dd+(-1*lfe*lsb*mf*sin((q1+-1*q2))*q2dd+(-2*lfe*lsa*ms*sin((q1+-1*q2))*q2dd+(-1*lfe*lsb*ms*sin((q1+-1*q2))*q2dd+(-2*lfe*lsa*mt*sin((q1+-1*q2))*q2dd+(-2*lfe*lsb*mt*sin((q1+-1*q2))*q2dd+(lfc*lta*mb*cos((q1+-1*q3))*q3dd+(lfd*lta*mb*cos((q1+-1*q3))*q3dd+(lfc*ltb*mb*cos((q1+-1*q3))*q3dd+(lfd*ltb*mb*cos((q1+-1*q3))*q3dd+(lfc*lta*mf*cos((q1+-1*q3))*q3dd+(lfd*lta*mf*cos((q1+-1*q3))*q3dd+(lfc*ltb*mf*cos((q1+-1*q3))*q3dd+(lfd*ltb*mf*cos((q1+-1*q3))*q3dd+(lfc*lta*ms*cos((q1+-1*q3))*q3dd+(lfd*lta*ms*cos((q1+-1*q3))*q3dd+(lfc*ltb*ms*cos((q1+-1*q3))*q3dd+(lfd*ltb*ms*cos((q1+-1*q3))*q3dd+(2*lfc*lta*mt*cos((q1+-1*q3))*q3dd+(2*lfd*lta*mt*cos((q1+-1*q3))*q3dd+(lfc*ltb*mt*cos((q1+-1*q3))*q3dd+(lfd*ltb*mt*cos((q1+-1*q3))*q3dd+(-1*lfe*lta*mb*sin((q1+-1*q3))*q3dd+(-1*lfe*ltb*mb*sin((q1+-1*q3))*q3dd+(-1*lfe*lta*mf*sin((q1+-1*q3))*q3dd+(-1*lfe*ltb*mf*sin((q1+-1*q3))*q3dd+(-1*lfe*lta*ms*sin((q1+-1*q3))*q3dd+(-1*lfe*ltb*ms*sin((q1+-1*q3))*q3dd+(-2*lfe*lta*mt*sin((q1+-1*q3))*q3dd+(-1*lfe*ltb*mt*sin((q1+-1*q3))*q3dd+(lba*lfc*mb*cos((q1+-1*q4))*q4dd+(lba*lfd*mb*cos((q1+-1*q4))*q4dd+(-1*lba*lfe*mb*sin((q1+-1*q4))*q4dd+(-1*lfc*lta*mf*cos((q1+-1*q5))*q5dd+(-1*lfd*lta*mf*cos((q1+-1*q5))*q5dd+(-1*lfc*ltb*mf*cos((q1+-1*q5))*q5dd+(-1*lfd*ltb*mf*cos((q1+-1*q5))*q5dd+(-1*lfc*lta*ms*cos((q1+-1*q5))*q5dd+(-1*lfd*lta*ms*cos((q1+-1*q5))*q5dd+(-1*lfc*ltb*ms*cos((q1+-1*q5))*q5dd+(-1*lfd*ltb*ms*cos((q1+-1*q5))*q5dd+(-1*lfc*ltb*mt*cos((q1+-1*q5))*q5dd+(-1*lfd*ltb*mt*cos((q1+-1*q5))*q5dd+(lfe*lta*mf*sin((q1+-1*q5))*q5dd+(lfe*ltb*mf*sin((q1+-1*q5))*q5dd+(lfe*lta*ms*sin((q1+-1*q5))*q5dd+(lfe*ltb*ms*sin((q1+-1*q5))*q5dd+(lfe*ltb*mt*sin((q1+-1*q5))*q5dd+(-1*lfc*lsa*mf*cos((q1+-1*q6))*q6dd+(-1*lfd*lsa*mf*cos((q1+-1*q6))*q6dd+(-1*lfc*lsb*mf*cos((q1+-1*q6))*q6dd+(-1*lfd*lsb*mf*cos((q1+-1*q6))*q6dd+(-1*lfc*lsb*ms*cos((q1+-1*q6))*q6dd+(-1*lfd*lsb*ms*cos((q1+-1*q6))*q6dd+(lfe*lsa*mf*sin((q1+-1*q6))*q6dd+(lfe*lsb*mf*sin((q1+-1*q6))*q6dd+(lfe*lsb*ms*sin((q1+-1*q6))*q6dd+(-1*lfc*lfd*mf*cos((q1+-1*q7))*q7dd+(-1*(lfd)^(2)*mf*cos((q1+-1*q7))*q7dd+(lfa*lfe*mf*cos((q1+-1*q7))*q7dd+(-1*(lfe)^(2)*mf*cos((q1+-1*q7))*q7dd+(lfa*lfc*mf*sin((q1+-1*q7))*q7dd+(lfa*lfd*mf*sin((q1+-1*q7))*q7dd+(-1*lfc*lfe*mf*sin((q1+-1*q7))*q7dd+(-1*lfc*mb*cos(q1)*q8dd+(-1*lfd*mb*cos(q1)*q8dd+(-2*lfc*mf*cos(q1)*q8dd+(-1*lfd*mf*cos(q1)*q8dd+(-2*lfc*ms*cos(q1)*q8dd+(-2*lfd*ms*cos(q1)*q8dd+(-2*lfc*mt*cos(q1)*q8dd+(-2*lfd*mt*cos(q1)*q8dd+(lfe*mb*sin(q1)*q8dd+(lfa*mf*sin(q1)*q8dd+(lfe*mf*sin(q1)*q8dd+(2*lfe*ms*sin(q1)*q8dd+(2*lfe*mt*sin(q1)*q8dd+(-1*lfe*mb*cos(q1)*q9dd+(-1*lfa*mf*cos(q1)*q9dd+(-1*lfe*mf*cos(q1)*q9dd+(-2*lfe*ms*cos(q1)*q9dd+(-2*lfe*mt*cos(q1)*q9dd+(-1*lfc*mb*sin(q1)*q9dd+(-1*lfd*mb*sin(q1)*q9dd+

```
(-2*lfc*mf*sin(q1)*q9dd+(-1*lfd*mf*sin(q1)*q9dd+(-2*lfc*ms*sin(q1)*q9dd+(-2*lfd*
ms*sin(q1)*q9dd+(-2*lfc*mt*sin(q1)*q9dd+-2*lfd*mt*sin(q1)*q9dd)))))))))))))))))
))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))
))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))
))))))))))
```

```
dyn2 = HurGlobalELEquation[[2]];
HurToJulia[dyn2]
```

```
(-1*tau1+(tau2+(lambda4*lsa*cos(q2)+(lambda4*lsb*cos(q2)+(lambda5*lsa*sin(q2)+(
lambda5*lsb*sin(q2)+(-1*g*lsa*mb*sin(q2)+(-1*g*lsb*mb*sin(q2)+(-1*g*lsa*mf*sin(q2
)+(-1*g*lsb*mf*sin(q2)+(-2*g*lsa*ms*sin(q2)+(-1*g*lsb*ms*sin(q2)+(-2*g*lsa*mt*sin
(q2)+(-2*g*lsb*mt*sin(q2)+(-1*(lsb*(mb+(mf+(ms+2*mt)))+lsa*(mb+(mf+2*(ms+mt))))*
(lfe*cos((q1+-1*q2))+(lfc+lfd)*sin((q1+-1*q2)))*(q1d)^(2)+((lsa+lsb)*(ltb*(mb+(
mf+(ms+mt)))+lta*(mb+(mf+(ms+2*mt))))*sin((q2+-1*q3))*(q3d)^(2)+(lba*lsa*mb*sin(
(q2+-1*q4))*(q4d)^(2)+(lba*lsb*mb*sin((q2+-1*q4))*(q4d)^(2)+(-1*lsa*lta*mf*sin((
q2+-1*q5))*(q5d)^(2)+(-1*lsb*lta*mf*sin((q2+-1*q5))*(q5d)^(2)+(-1*lsa*ltb*mf*sin(
(q2+-1*q5))*(q5d)^(2)+(-1*lsb*ltb*mf*sin((q2+-1*q5))*(q5d)^(2)+(-1*lsa*lta*ms*sin
((q2+-1*q5))*(q5d)^(2)+(-1*lsb*lta*ms*sin((q2+-1*q5))*(q5d)^(2)+(-1*lsa*ltb*ms*
sin((q2+-1*q5))*(q5d)^(2)+(-1*lsb*ltb*ms*sin((q2+-1*q5))*(q5d)^(2)+(-1*lsa*ltb*mt
*sin((q2+-1*q5))*(q5d)^(2)+(-1*lsb*ltb*mt*sin((q2+-1*q5))*(q5d)^(2)+(-1*(lsa)^(2
)*mf*sin((q2+-1*q6))*(q6d)^(2)+(-2*lsa*lsb*mf*sin((q2+-1*q6))*(q6d)^(2)+(-1*(lsb
)^(2)*mf*sin((q2+-1*q6))*(q6d)^(2)+(-1*lsa*lsb*ms*sin((q2+-1*q6))*(q6d)^(2)+(-1*
(lsb)^(2)*ms*sin((q2+-1*q6))*(q6d)^(2)+(-1*lfa*lsa*mf*cos((q2+-1*q7))*(q7d)^(2)+
(lfe*lsa*mf*cos((q2+-1*q7))*(q7d)^(2)+(-1*lfa*lsb*mf*cos((q2+-1*q7))*(q7d)^(2)+(
lfe*lsb*mf*cos((q2+-1*q7))*(q7d)^(2)+(-1*lfd*lsa*mf*sin((q2+-1*q7))*(q7d)^(2)+(-1
*lfd*lsb*mf*sin((q2+-1*q7))*(q7d)^(2)+(lfc*lsa*mb*cos((q1+-1*q2))*q1dd+(lfd*lsa*
mb*cos((q1+-1*q2))*q1dd+(lfc*lsb*mb*cos((q1+-1*q2))*q1dd+(lfd*lsb*mb*cos((q1+-1*
q2))*q1dd+(lfc*lsa*mf*cos((q1+-1*q2))*q1dd+(lfd*lsa*mf*cos((q1+-1*q2))*q1dd+(lfc*
lsb*mf*cos((q1+-1*q2))*q1dd+(lfd*lsb*mf*cos((q1+-1*q2))*q1dd+(2*lfc*lsa*ms*cos((
q1+-1*q2))*q1dd+(2*lfd*lsa*ms*cos((q1+-1*q2))*q1dd+(lfc*lsb*ms*cos((q1+-1*q2))*
q1dd+(lfd*lsb*ms*cos((q1+-1*q2))*q1dd+(2*lfc*lsa*mt*cos((q1+-1*q2))*q1dd+(2*lfd*
lsa*mt*cos((q1+-1*q2))*q1dd+(2*lfc*lsb*mt*cos((q1+-1*q2))*q1dd+(2*lfd*lsb*mt*cos(
(q1+-1*q2))*q1dd+(-1*lfe*lsa*mb*sin((q1+-1*q2))*q1dd+(-1*lfe*lsb*mb*sin((q1+-1*q2
))*q1dd+(-1*lfe*lsa*mf*sin((q1+-1*q2))*q1dd+(-1*lfe*lsb*mf*sin((q1+-1*q2))*q1dd+(
-2*lfe*lsa*ms*sin((q1+-1*q2))*q1dd+(-1*lfe*lsb*ms*sin((q1+-1*q2))*q1dd+(-2*lfe*
lsa*mt*sin((q1+-1*q2))*q1dd+(-2*lfe*lsb*mt*sin((q1+-1*q2))*q1dd+(Isz*q2dd+((lsa)^
(2)*mb*q2dd+(2*lsa*lsb*mb*q2dd+((lsb)^(2)*mb*q2dd+((lsa)^(2)*mf*q2dd+(2*lsa*lsb*
mf*q2dd+((lsb)^(2)*mf*q2dd+(2*(lsa)^(2)*ms*q2dd+(2*lsa*lsb*ms*q2dd+((lsb)^(2)*ms*
q2dd+(2*(lsa)^(2)*mt*q2dd+(4*lsa*lsb*mt*q2dd+(2*(lsb)^(2)*mt*q2dd+(lsa*lta*mb*cos
((q2+-1*q3))*q3dd+(lsb*lta*mb*cos((q2+-1*q3))*q3dd+(lsa*ltb*mb*cos((q2+-1*q3))*
q3dd+(lsb*ltb*mb*cos((q2+-1*q3))*q3dd+(lsa*lta*mf*cos((q2+-1*q3))*q3dd+(lsb*lta*
mf*cos((q2+-1*q3))*q3dd+(lsa*ltb*mf*cos((q2+-1*q3))*q3dd+(lsb*ltb*mf*cos((q2+-1*
q3))*q3dd+(lsa*lta*ms*cos((q2+-1*q3))*q3dd+(lsb*lta*ms*cos((q2+-1*q3))*q3dd+(lsa*
ltb*ms*cos((q2+-1*q3))*q3dd+(lsb*ltb*ms*cos((q2+-1*q3))*q3dd+(2*lsa*lta*mt*cos((
q2+-1*q3))*q3dd+(2*lsb*lta*mt*cos((q2+-1*q3))*q3dd+(lsa*ltb*mt*cos((q2+-1*q3))*
q3dd+(lsb*ltb*mt*cos((q2+-1*q3))*q3dd+(lba*lsa*mb*cos((q2+-1*q4))*q4dd+(lba*lsb*
mb*cos((q2+-1*q4))*q4dd+(-1*lsa*lta*mf*cos((q2+-1*q5))*q5dd+(-1*lsb*lta*mf*cos((
q2+-1*q5))*q5dd+(-1*lsa*ltb*mf*cos((q2+-1*q5))*q5dd+(-1*lsb*ltb*mf*cos((q2+-1*q5)
)*q5dd+(-1*lsa*lta*ms*cos((q2+-1*q5))*q5dd+(-1*lsb*lta*ms*cos((q2+-1*q5))*q5dd+(-
1*lsa*ltb*ms*cos((q2+-1*q5))*q5dd+(-1*lsb*ltb*ms*cos((q2+-1*q5))*q5dd+(-1*lsa*ltb
*mt*cos((q2+-1*q5))*q5dd+(-1*lsb*ltb*mt*cos((q2+-1*q5))*q5dd+(-1*(lsa)^(2)*mf*cos
((q2+-1*q6))*q6dd+(-2*lsa*lsb*mf*cos((q2+-1*q6))*q6dd+(-1*(lsb)^(2)*mf*cos((q2+-1
*q6))*q6dd+(-1*lsa*lsb*ms*cos((q2+-1*q6))*q6dd+(-1*(lsb)^(2)*ms*cos((q2+-1*q6))*
q6dd+(-1*lfd*lsa*mf*cos((q2+-1*q7))*q7dd+(-1*lfd*lsb*mf*cos((q2+-1*q7))*q7dd+(lfa
*lsa*mf*sin((q2+-1*q7))*q7dd+(-1*lfe*lsa*mf*sin((q2+-1*q7))*q7dd+(lfa*lsb*mf*sin(
(q2+-1*q7))*q7dd+(-1*lfe*lsb*mf*sin((q2+-1*q7))*q7dd+(-1*lsa*mb*cos(q2)*q8dd+(-1*
lsb*mb*cos(q2)*q8dd+(-1*lsa*mf*cos(q2)*q8dd+(-1*lsb*mf*cos(q2)*q8dd+(-2*lsa*ms*
cos(q2)*q8dd+(-1*lsb*ms*cos(q2)*q8dd+(-2*lsa*mt*cos(q2)*q8dd+(-2*lsb*mt*cos(q2)*
q8dd+(-1*lsa*mb*sin(q2)*q9dd+(-1*lsb*mb*sin(q2)*q9dd+(-1*lsa*mf*sin(q2)*q9dd+(-1*
lsb*mf*sin(q2)*q9dd+(-2*lsa*ms*sin(q2)*q9dd+(-1*lsb*ms*sin(q2)*q9dd+(-2*lsa*mt*
sin(q2)*q9dd+-2*lsb*mt*sin(q2)*q9dd)))))))))))))))))))))))))))))))))))))))))))))
)))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))
)))))))))
```

```
dyn3 = HurGlobalELEquation[[3]];
HurToJulia[dyn3]
```

```
(-1*tau2+(tau3+(lambda4*lta*cos(q3)+(lambda4*ltb*cos(q3)+(lambda5*lta*sin(q3)+(
lambda5*ltb*sin(q3)+(-1*g*lta*mb*sin(q3)+(-1*g*ltb*mb*sin(q3)+(-1*g*lta*mf*sin(q3
)+(-1*g*ltb*mf*sin(q3)+(-1*g*lta*ms*sin(q3)+(-1*g*ltb*ms*sin(q3)+(-2*g*lta*mt*sin
(q3)+(-1*g*ltb*mt*sin(q3)+(-1*(ltb*(mb+(mf+(ms+mt)))+lta*(mb+(mf+(ms+2*mt))))))*(
lfe*cos((q1+-1*q3))+(lfc+lfd)*sin((q1+-1*q3)))*(q1d)^(2)+(-1*(lsa+lsb)*(ltb*(mb+
(mf+(ms+mt)))+lta*(mb+(mf+(ms+2*mt))))*sin((q2+-1*q3))*(q2d)^(2)+(lba*lta*mb*sin
((q3+-1*q4))*(q4d)^(2)+(lba*ltb*mb*sin((q3+-1*q4))*(q4d)^(2)+(-1*(lta)^(2)*mf*
sin((q3+-1*q5))*(q5d)^(2)+(-2*lta*ltb*mf*sin((q3+-1*q5))*(q5d)^(2)+(-1*(ltb)^(2)
*mf*sin((q3+-1*q5))*(q5d)^(2)+(-1*(lta)^(2)*ms*sin((q3+-1*q5))*(q5d)^(2)+(-2*lta
*ltb*ms*sin((q3+-1*q5))*(q5d)^(2)+(-1*(ltb)^(2)*ms*sin((q3+-1*q5))*(q5d)^(2)+(-1
*lta*ltb*mt*sin((q3+-1*q5))*(q5d)^(2)+(-1*(ltb)^(2)*mt*sin((q3+-1*q5))*(q5d)^(2)
+(-1*lsa*lta*mf*sin((q3+-1*q6))*(q6d)^(2)+(-1*lsb*lta*mf*sin((q3+-1*q6))*(q6d)^(2
)+(-1*lsa*ltb*mf*sin((q3+-1*q6))*(q6d)^(2)+(-1*lsb*ltb*mf*sin((q3+-1*q6))*(q6d)^
(2)+(-1*lsb*lta*ms*sin((q3+-1*q6))*(q6d)^(2)+(-1*lsb*ltb*ms*sin((q3+-1*q6))*(q6d
)^(2)+(-1*lfa*lta*mf*cos((q3+-1*q7))*(q7d)^(2)+(lfe*lta*mf*cos((q3+-1*q7))*(q7d)^
(2)+(-1*lfa*ltb*mf*cos((q3+-1*q7))*(q7d)^(2)+(lfe*ltb*mf*cos((q3+-1*q7))*(q7d)^(2
)+(-1*lfd*lta*mf*sin((q3+-1*q7))*(q7d)^(2)+(-1*lfd*ltb*mf*sin((q3+-1*q7))*(q7d)^
(2)+(lfc*lta*mb*cos((q1+-1*q3))*q1dd+(lfd*lta*mb*cos((q1+-1*q3))*q1dd+(lfc*ltb*mb
*cos((q1+-1*q3))*q1dd+(lfd*ltb*mb*cos((q1+-1*q3))*q1dd+(lfc*lta*mf*cos((q1+-1*q3)
)*q1dd+(lfd*lta*mf*cos((q1+-1*q3))*q1dd+(lfc*ltb*mf*cos((q1+-1*q3))*q1dd+(lfd*ltb
*mf*cos((q1+-1*q3))*q1dd+(lfc*lta*ms*cos((q1+-1*q3))*q1dd+(lfd*lta*ms*cos((q1+-1*
q3))*q1dd+(lfc*ltb*ms*cos((q1+-1*q3))*q1dd+(lfd*ltb*ms*cos((q1+-1*q3))*q1dd+(2*
lfc*lta*mt*cos((q1+-1*q3))*q1dd+(2*lfd*lta*mt*cos((q1+-1*q3))*q1dd+(lfc*ltb*mt*
cos((q1+-1*q3))*q1dd+(lfd*ltb*mt*cos((q1+-1*q3))*q1dd+(-1*lfe*lta*mb*sin((q1+-1*
q3))*q1dd+(-1*lfe*ltb*mb*sin((q1+-1*q3))*q1dd+(-1*lfe*lta*mf*sin((q1+-1*q3))*q1dd
+(-1*lfe*ltb*mf*sin((q1+-1*q3))*q1dd+(-1*lfe*lta*ms*sin((q1+-1*q3))*q1dd+(-1*lfe*
ltb*ms*sin((q1+-1*q3))*q1dd+(-2*lfe*lta*mt*sin((q1+-1*q3))*q1dd+(-1*lfe*ltb*mt*
sin((q1+-1*q3))*q1dd+(lsa*lta*mb*cos((q2+-1*q3))*q2dd+(lsb*lta*mb*cos((q2+-1*q3))
*q2dd+(lsa*ltb*mb*cos((q2+-1*q3))*q2dd+(lsb*ltb*mb*cos((q2+-1*q3))*q2dd+(lsa*lta*
mf*cos((q2+-1*q3))*q2dd+(lsb*lta*mf*cos((q2+-1*q3))*q2dd+(lsa*ltb*mf*cos((q2+-1*
q3))*q2dd+(lsb*ltb*mf*cos((q2+-1*q3))*q2dd+(lsa*lta*ms*cos((q2+-1*q3))*q2dd+(lsb*
lta*ms*cos((q2+-1*q3))*q2dd+(lsa*ltb*ms*cos((q2+-1*q3))*q2dd+(lsb*ltb*ms*cos((q2+
-1*q3))*q2dd+(2*lsa*lta*mt*cos((q2+-1*q3))*q2dd+(2*lsb*lta*mt*cos((q2+-1*q3))*
q2dd+(lsa*ltb*mt*cos((q2+-1*q3))*q2dd+(lsb*ltb*mt*cos((q2+-1*q3))*q2dd+(Itz*q3dd+
((lta)^(2)*mb*q3dd+(2*lta*ltb*mb*q3dd+((ltb)^(2)*mb*q3dd+((lta)^(2)*mf*q3dd+(2*
lta*ltb*mf*q3dd+((ltb)^(2)*mf*q3dd+((lta)^(2)*ms*q3dd+(2*lta*ltb*ms*q3dd+((ltb)^(
2)*ms*q3dd+(2*(lta)^(2)*mt*q3dd+(2*lta*ltb*mt*q3dd+((ltb)^(2)*mt*q3dd+(lba*lta*mb
*cos((q3+-1*q4))*q4dd+(lba*ltb*mb*cos((q3+-1*q4))*q4dd+(-1*(lta)^(2)*mf*cos((q3+-
1*q5))*q5dd+(-2*lta*ltb*mf*cos((q3+-1*q5))*q5dd+(-1*(ltb)^(2)*mf*cos((q3+-1*q5))*
q5dd+(-1*(lta)^(2)*ms*cos((q3+-1*q5))*q5dd+(-2*lta*ltb*ms*cos((q3+-1*q5))*q5dd+(-
1*(ltb)^(2)*ms*cos((q3+-1*q5))*q5dd+(-1*lta*ltb*mt*cos((q3+-1*q5))*q5dd+(-1*(ltb)
^(2)*mt*cos((q3+-1*q5))*q5dd+(-1*lsa*lta*mf*cos((q3+-1*q6))*q6dd+(-1*lsb*lta*mf*
cos((q3+-1*q6))*q6dd+(-1*lsa*ltb*mf*cos((q3+-1*q6))*q6dd+(-1*lsb*ltb*mf*cos((q3+-
1*q6))*q6dd+(-1*lsb*lta*ms*cos((q3+-1*q6))*q6dd+(-1*lsb*ltb*ms*cos((q3+-1*q6))*
q6dd+(-1*lfd*lta*mf*cos((q3+-1*q7))*q7dd+(-1*lfd*ltb*mf*cos((q3+-1*q7))*q7dd+(lfa
*lta*mf*sin((q3+-1*q7))*q7dd+(-1*lfe*lta*mf*sin((q3+-1*q7))*q7dd+(lfa*ltb*mf*sin(
(q3+-1*q7))*q7dd+(-1*lfe*ltb*mf*sin((q3+-1*q7))*q7dd+(-1*lta*mb*cos(q3)*q8dd+(-1*
ltb*mb*cos(q3)*q8dd+(-1*lta*mf*cos(q3)*q8dd+(-1*ltb*mf*cos(q3)*q8dd+(-1*lta*ms*
cos(q3)*q8dd+(-1*ltb*ms*cos(q3)*q8dd+(-2*lta*mt*cos(q3)*q8dd+(-1*ltb*mt*cos(q3)*
q8dd+(-1*lta*mb*sin(q3)*q9dd+(-1*ltb*mb*sin(q3)*q9dd+(-1*lta*mf*sin(q3)*q9dd+(-1*
ltb*mf*sin(q3)*q9dd+(-1*lta*ms*sin(q3)*q9dd+(-1*ltb*ms*sin(q3)*q9dd+(-2*lta*mt*
sin(q3)*q9dd+-1*ltb*mt*sin(q3)*q9dd))))))))))))))))))))))))))))))))))))))))))))))
))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))
))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))
)))))))
```

```
dyn4 = HurGlobalELEquation[[4]];
HurToJulia[dyn4]
```

```
(-1*tau3+(tau4+(-1*g*lba*mb*sin(q4)+(-1*lba*mb*(lfe*cos((q1+-1*q4))+(lfc+lfd)*sin((
  q1+-1*q4))))*(q1d)^(2)+(-1*lba*(lsa+lsb)*mb*sin((q2+-1*q4))*(q2d)^(2)+(-1*lba*lta
  *mb*sin((q3+-1*q4))*(q3d)^(2)+(-1*lba*ltb*mb*sin((q3+-1*q4))*(q3d)^(2)+(lba*lfc*
  mb*cos((q1+-1*q4))*q1dd+(lba*lfd*mb*cos((q1+-1*q4))*q1dd+(-1*lba*lfe*mb*sin((q1+-
  1*q4))*q1dd+(lba*lsa*mb*cos((q2+-1*q4))*q2dd+(lba*lsb*mb*cos((q2+-1*q4))*q2dd+(
  lba*lta*mb*cos((q3+-1*q4))*q3dd+(lba*ltb*mb*cos((q3+-1*q4))*q3dd+(Ibz*q4dd+((lba)
  ^(2)*mb*q4dd+(-1*lba*mb*cos(q4)*q8dd+-1*lba*mb*sin(q4)*q9dd)))))))))))))))))))
```

```
dyn5 = HurGlobalELEquation[[5]];
HurToJulia[dyn5]
```

```
(-1*tau4+(tau5+(-1*lambda4*lta*cos(q5)+(-1*lambda4*ltb*cos(q5)+(-1*lambda5*lta*sin(
  q5)+(-1*lambda5*ltb*sin(q5)+(g*lta*mf*sin(q5)+(g*ltb*mf*sin(q5)+(g*lta*ms*sin(q5)
  +(g*ltb*ms*sin(q5)+(g*ltb*mt*sin(q5)+((lta*(mf+ms)+ltb*(mf+(ms+mt)))*(lfe*cos((q1
  +-1*q5))+(lfc+lfd)*sin((q1+-1*q5))))*(q1d)^(2)+((lsa+lsb)*(lta*(mf+ms)+ltb*(mf+(
  ms+mt))))*sin((q2+-1*q5))*(q2d)^(2)+((lta)^(2)*mf*sin((q3+-1*q5))*(q3d)^(2)+(2*
  lta*ltb*mf*sin((q3+-1*q5))*(q3d)^(2)+((ltb)^(2)*mf*sin((q3+-1*q5))*(q3d)^(2)+((
  lta)^(2)*ms*sin((q3+-1*q5))*(q3d)^(2)+(2*lta*ltb*ms*sin((q3+-1*q5))*(q3d)^(2)+((
  ltb)^(2)*ms*sin((q3+-1*q5))*(q3d)^(2)+(lta*ltb*mt*sin((q3+-1*q5))*(q3d)^(2)+((ltb
  )^(2)*mt*sin((q3+-1*q5))*(q3d)^(2)+(lsa*lta*mf*sin((q5+-1*q6))*(q6d)^(2)+(lsb*lta
  *mf*sin((q5+-1*q6))*(q6d)^(2)+(lsa*ltb*mf*sin((q5+-1*q6))*(q6d)^(2)+(lsb*ltb*mf*
  sin((q5+-1*q6))*(q6d)^(2)+(lsb*lta*ms*sin((q5+-1*q6))*(q6d)^(2)+(lsb*ltb*ms*sin((
  q5+-1*q6))*(q6d)^(2)+(lfa*lta*mf*cos((q5+-1*q7))*(q7d)^(2)+(-1*lfe*lta*mf*cos((q5
  +-1*q7))*(q7d)^(2)+(lfa*ltb*mf*cos((q5+-1*q7))*(q7d)^(2)+(-1*lfe*ltb*mf*cos((q5+
  -1*q7))*(q7d)^(2)+(lfd*lta*mf*sin((q5+-1*q7))*(q7d)^(2)+(lfd*ltb*mf*sin((q5+-1*q7
  ))*(q7d)^(2)+(-1*lfc*lta*mf*cos((q1+-1*q5))*q1dd+(-1*lfd*lta*mf*cos((q1+-1*q5))*
  q1dd+(-1*lfc*ltb*mf*cos((q1+-1*q5))*q1dd+(-1*lfd*ltb*mf*cos((q1+-1*q5))*q1dd+(-1*
  lfc*lta*ms*cos((q1+-1*q5))*q1dd+(-1*lfd*lta*ms*cos((q1+-1*q5))*q1dd+(-1*lfc*ltb*
  ms*cos((q1+-1*q5))*q1dd+(-1*lfd*ltb*ms*cos((q1+-1*q5))*q1dd+(-1*lfc*ltb*mt*cos((
  q1+-1*q5))*q1dd+(-1*lfd*ltb*mt*cos((q1+-1*q5))*q1dd+(lfe*lta*mf*sin((q1+-1*q5))*
  q1dd+(lfe*ltb*mf*sin((q1+-1*q5))*q1dd+(lfe*lta*ms*sin((q1+-1*q5))*q1dd+(lfe*ltb*
  ms*sin((q1+-1*q5))*q1dd+(lfe*ltb*mt*sin((q1+-1*q5))*q1dd+(-1*lsa*lta*mf*cos((q2+-
  1*q5))*q2dd+(-1*lsb*lta*mf*cos((q2+-1*q5))*q2dd+(-1*lsa*ltb*mf*cos((q2+-1*q5))*
  q2dd+(-1*lsb*ltb*mf*cos((q2+-1*q5))*q2dd+(-1*lsa*lta*ms*cos((q2+-1*q5))*q2dd+(-1*
  lsb*lta*ms*cos((q2+-1*q5))*q2dd+(-1*lsa*ltb*ms*cos((q2+-1*q5))*q2dd+(-1*lsb*ltb*
  ms*cos((q2+-1*q5))*q2dd+(-1*lsa*ltb*mt*cos((q2+-1*q5))*q2dd+(-1*lsb*ltb*mt*cos((
  q2+-1*q5))*q2dd+(-1*(lta)^(2)*mf*cos((q3+-1*q5))*q3dd+(-2*lta*ltb*mf*cos((q3+-1*
  q5))*q3dd+(-1*(ltb)^(2)*mf*cos((q3+-1*q5))*q3dd+(-1*(lta)^(2)*ms*cos((q3+-1*q5))
  *q3dd+(-2*lta*ltb*ms*cos((q3+-1*q5))*q3dd+(-1*(ltb)^(2)*ms*cos((q3+-1*q5))*q3dd+(
  -1*lta*ltb*mt*cos((q3+-1*q5))*q3dd+(-1*(ltb)^(2)*mt*cos((q3+-1*q5))*q3dd+(Itz*
  q5dd+((lta)^(2)*mf*q5dd+(2*lta*ltb*mf*q5dd+((ltb)^(2)*mf*q5dd+((lta)^(2)*ms*q5dd+
  (2*lta*ltb*ms*q5dd+((ltb)^(2)*ms*q5dd+((ltb)^(2)*mt*q5dd+(lsa*lta*mf*cos((q5+-1*
  q6))*q6dd+(lsb*lta*mf*cos((q5+-1*q6))*q6dd+(lsa*ltb*mf*cos((q5+-1*q6))*q6dd+(lsb*
  ltb*mf*cos((q5+-1*q6))*q6dd+(lsb*lta*ms*cos((q5+-1*q6))*q6dd+(lsb*ltb*ms*cos((q5+
  -1*q6))*q6dd+(lfd*lta*mf*cos((q5+-1*q7))*q7dd+(lfd*ltb*mf*cos((q5+-1*q7))*q7dd+(-
  1*lfa*lta*mf*sin((q5+-1*q7))*q7dd+(lfe*lta*mf*sin((q5+-1*q7))*q7dd+(-1*lfa*ltb*mf
  *sin((q5+-1*q7))*q7dd+(lfe*ltb*mf*sin((q5+-1*q7))*q7dd+(lta*mf*cos(q5)*q8dd+(ltb*
  mf*cos(q5)*q8dd+(lta*ms*cos(q5)*q8dd+(ltb*ms*cos(q5)*q8dd+(ltb*mt*cos(q5)*q8dd+(
  lta*mf*sin(q5)*q9dd+(ltb*mf*sin(q5)*q9dd+(lta*ms*sin(q5)*q9dd+(ltb*ms*sin(q5)*q9dd
  +ltb*mt*sin(q5)*q9dd)))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))
  )))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))
```

```
dyn6 = HurGlobalELEquation[[6]];
HurToJulia[dyn6]
```

```
(-1*tau5+(tau6+(-1*lambda4*lsa*cos(q6)+(-1*lambda4*lsb*cos(q6)+(-1*lambda5*lsa*sin(
  q6)+(-1*lambda5*lsb*sin(q6)+(g*lsa*mf*sin(q6)+(g*lsb*mf*sin(q6)+(g*lsb*ms*sin(q6)
  +((lsa*mf+lsb*(mf+ms))*(lfe*cos((q1+-1*q6)))+(lfc+lfd)*sin((q1+-1*q6))))*(q1d)^(2)
  +((lsa+lsb)*(lsa*mf+lsb*(mf+ms))*sin((q2+-1*q6)))*(q2d)^(2)+(lsa*lta*mf*sin((q3+-1
  *q6)))*(q3d)^(2)+(lsb*lta*mf*sin((q3+-1*q6)))*(q3d)^(2)+(lsa*ltb*mf*sin((q3+-1*q6))
  *(q3d)^(2)+(lsb*ltb*mf*sin((q3+-1*q6)))*(q3d)^(2)+(lsb*lta*ms*sin((q3+-1*q6)))*(q3d
  )^(2)+(lsb*ltb*ms*sin((q3+-1*q6)))*(q3d)^(2)+(-1*lsa*lta*mf*sin((q5+-1*q6)))*(q5d)^
  (2)+(-1*lsb*lta*mf*sin((q5+-1*q6)))*(q5d)^(2)+(-1*lsa*ltb*mf*sin((q5+-1*q6)))*(q5d
  )^(2)+(-1*lsb*ltb*mf*sin((q5+-1*q6)))*(q5d)^(2)+(-1*lsb*lta*ms*sin((q5+-1*q6)))*(
  q5d)^(2)+(-1*lsb*ltb*ms*sin((q5+-1*q6)))*(q5d)^(2)+(lfa*lsa*mf*cos((q6+-1*q7)))*(
  q7d)^(2)+(-1*lfe*lsa*mf*cos((q6+-1*q7)))*(q7d)^(2)+(lfa*lsb*mf*cos((q6+-1*q7)))*(
  q7d)^(2)+(-1*lfe*lsb*mf*cos((q6+-1*q7)))*(q7d)^(2)+(lfd*lsa*mf*sin((q6+-1*q7)))*(
  q7d)^(2)+(lfd*lsb*mf*sin((q6+-1*q7)))*(q7d)^(2)+(-1*lfc*lsa*mf*cos((q1+-1*q6)))*
  q1dd+(-1*lfd*lsa*mf*cos((q1+-1*q6)))*q1dd+(-1*lfc*lsb*mf*cos((q1+-1*q6)))*q1dd+(-1*
  lfd*lsb*mf*cos((q1+-1*q6)))*q1dd+(-1*lfc*lsb*ms*cos((q1+-1*q6)))*q1dd+(-1*lfd*lsb*
  ms*cos((q1+-1*q6)))*q1dd+(lfe*lsa*mf*sin((q1+-1*q6)))*q1dd+(lfe*lsb*mf*sin((q1+-1*
  q6)))*q1dd+(lfe*lsb*ms*sin((q1+-1*q6)))*q1dd+(-1*(lsa)^(2)*mf*cos((q2+-1*q6)))*q2dd+
  (-2*lsa*lsb*mf*cos((q2+-1*q6)))*q2dd+(-1*(lsb)^(2)*mf*cos((q2+-1*q6)))*q2dd+(-1*lsa
  *lsb*ms*cos((q2+-1*q6)))*q2dd+(-1*(lsb)^(2)*ms*cos((q2+-1*q6)))*q2dd+(-1*lsa*lta*mf
  *cos((q3+-1*q6)))*q3dd+(-1*lsb*lta*mf*cos((q3+-1*q6)))*q3dd+(-1*lsa*ltb*mf*cos((q3+
  -1*q6)))*q3dd+(-1*lsb*ltb*mf*cos((q3+-1*q6)))*q3dd+(-1*lsb*lta*ms*cos((q3+-1*q6)))*
  q3dd+(-1*lsb*ltb*ms*cos((q3+-1*q6)))*q3dd+(lsa*lta*mf*cos((q5+-1*q6)))*q5dd+(lsb*
  lta*mf*cos((q5+-1*q6)))*q5dd+(lsa*ltb*mf*cos((q5+-1*q6)))*q5dd+(lsb*ltb*mf*cos((q5+
  -1*q6)))*q5dd+(lsb*lta*ms*cos((q5+-1*q6)))*q5dd+(lsb*ltb*ms*cos((q5+-1*q6)))*q5dd+(
  Isz*q6dd+((lsa)^(2)*mf*q6dd+(2*lsa*lsb*mf*q6dd+((lsb)^(2)*mf*q6dd+((lsb)^(2)*ms*
  q6dd+(lfd*lsa*mf*cos((q6+-1*q7)))*q7dd+(lfd*lsb*mf*cos((q6+-1*q7)))*q7dd+(-1*lfa*
  lsa*mf*sin((q6+-1*q7)))*q7dd+(lfe*lsa*mf*sin((q6+-1*q7)))*q7dd+(-1*lfa*lsb*mf*sin((
  q6+-1*q7)))*q7dd+(lfe*lsb*mf*sin((q6+-1*q7)))*q7dd+(lsa*mf*cos(q6)*q8dd+(lsb*mf*cos
  (q6)*q8dd+(lsb*ms*cos(q6)*q8dd+(lsa*mf*sin(q6)*q9dd+(lsb*mf*sin(q6)*q9dd+lsb*ms*
  sin(q6)*q9dd)))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))
  )))))
```

```
dyn7 = HurGlobalELEquation[[7]];
HurToJulia[dyn7]
```

```
(-1*tau6+(lambda5*lfa*cos(q7)+(lambda5*lfb*cos(q7)+(-1*lambda4*lfc*cos(q7)+(-1*
  lambda4*lfd*cos(q7)+(-1*lambda5*lfe*cos(q7)+(-1*g*lfa*mf*cos(q7)+(g*lfe*mf*cos(q7
  )+(-1*lambda4*lfa*sin(q7)+(-1*lambda4*lfb*sin(q7)+(-1*lambda5*lfc*sin(q7)+(-1*
  lambda5*lfd*sin(q7)+(lambda4*lfe*sin(q7)+(g*lfd*mf*sin(q7)+(mf*((lfa*(lfc+lfd)+-1
  *lfc*lfe)*cos((q1+-1*q7)))+(lfc*lfd+((lfd)^(2)+(-1*lfa*lfe+(lfe)^(2))))*sin((q1+-
  1*q7)))*(q1d)^(2)+((lsa+lsb)*mf*((lfa+-1*lfe)*cos((q2+-1*q7))+lfd*sin((q2+-1*q7)
  ))*(q2d)^(2)+(lfa*lta*mf*cos((q3+-1*q7))*(q3d)^(2)+(-1*lfe*lta*mf*cos((q3+-1*q7)
  )*(q3d)^(2)+(lfa*ltb*mf*cos((q3+-1*q7))*(q3d)^(2)+(-1*lfe*ltb*mf*cos((q3+-1*q7))
  *(q3d)^(2)+(lfd*lta*mf*sin((q3+-1*q7))*(q3d)^(2)+(lfd*ltb*mf*sin((q3+-1*q7))*(q3d
  )^(2)+(-1*lfa*lta*mf*cos((q5+-1*q7))*(q5d)^(2)+(lfe*lta*mf*cos((q5+-1*q7))*(q5d)^
  (2)+(-1*lfa*ltb*mf*cos((q5+-1*q7))*(q5d)^(2)+(lfe*ltb*mf*cos((q5+-1*q7))*(q5d)^(2
  )+(-1*lfd*lta*mf*sin((q5+-1*q7))*(q5d)^(2)+(-1*lfd*ltb*mf*sin((q5+-1*q7))*(q5d)^
  (2)+(-1*lfa*lsa*mf*cos((q6+-1*q7))*(q6d)^(2)+(lfe*lsa*mf*cos((q6+-1*q7))*(q6d)^(2
  )+(-1*lfa*lsb*mf*cos((q6+-1*q7))*(q6d)^(2)+(lfe*lsb*mf*cos((q6+-1*q7))*(q6d)^(2)
  +(-1*lfd*lsa*mf*sin((q6+-1*q7))*(q6d)^(2)+(-1*lfd*lsb*mf*sin((q6+-1*q7))*(q6d)^(2
  )+(-1*lfc*lfd*mf*cos((q1+-1*q7))*q1dd+(-1*(lfd)^(2)*mf*cos((q1+-1*q7))*q1dd+(lfa*
  lfe*mf*cos((q1+-1*q7))*q1dd+(-1*(lfe)^(2)*mf*cos((q1+-1*q7))*q1dd+(lfa*lfc*mf*sin
  ((q1+-1*q7))*q1dd+(lfa*lfd*mf*sin((q1+-1*q7))*q1dd+(-1*lfc*lfe*mf*sin((q1+-1*q7))
  *q1dd+(-1*lfd*lsa*mf*cos((q2+-1*q7))*q2dd+(-1*lfd*lsb*mf*cos((q2+-1*q7))*q2dd+(
  lfa*lsa*mf*sin((q2+-1*q7))*q2dd+(-1*lfe*lsa*mf*sin((q2+-1*q7))*q2dd+(lfa*lsb*mf*
  sin((q2+-1*q7))*q2dd+(-1*lfe*lsb*mf*sin((q2+-1*q7))*q2dd+(-1*lfd*lta*mf*cos((q3+-
  1*q7))*q3dd+(-1*lfd*ltb*mf*cos((q3+-1*q7))*q3dd+(lfa*lta*mf*sin((q3+-1*q7))*q3dd+
  (-1*lfe*lta*mf*sin((q3+-1*q7))*q3dd+(lfa*ltb*mf*sin((q3+-1*q7))*q3dd+(-1*lfe*ltb*
  mf*sin((q3+-1*q7))*q3dd+(lfd*lta*mf*cos((q5+-1*q7))*q5dd+(lfd*ltb*mf*cos((q5+-1*
  q7))*q5dd+(-1*lfa*lta*mf*sin((q5+-1*q7))*q5dd+(lfe*lta*mf*sin((q5+-1*q7))*q5dd+(-
  1*lfa*ltb*mf*sin((q5+-1*q7))*q5dd+(lfe*ltb*mf*sin((q5+-1*q7))*q5dd+(lfd*lsa*mf*
  cos((q6+-1*q7))*q6dd+(lfd*lsb*mf*cos((q6+-1*q7))*q6dd+(-1*lfa*lsa*mf*sin((q6+-1*
  q7))*q6dd+(lfe*lsa*mf*sin((q6+-1*q7))*q6dd+(-1*lfa*lsb*mf*sin((q6+-1*q7))*q6dd+(
  lfe*lsb*mf*sin((q6+-1*q7))*q6dd+(Ifz*q7dd+((lfa)^(2)*mf*q7dd+((lfd)^(2)*mf*q7dd+(
  -2*lfa*lfe*mf*q7dd+((lfe)^(2)*mf*q7dd+(lfd*mf*cos(q7)*q8dd+(lfa*mf*sin(q7)*q8dd+(
  -1*lfe*mf*sin(q7)*q8dd+(-1*lfa*mf*cos(q7)*q9dd+(lfe*mf*cos(q7)*q9dd+lfd*mf*sin(q7
  )*q9dd))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))
  ))))
```

```
dyn8 = HurGlobalELEquation[[8]];
HurToJulia[dyn8]
```

```
(-1*lambda1+(-1*lambda4+(((lfa*mf+lfe*(mb+(mf+2*(ms+mt))))*cos(q1)+(lfd*(mb+(mf+2*(
  ms+mt)))+lfc*(mb+2*(mf+(ms+mt))))*sin(q1))*(q1d)^(2)+((lsb*(mb+(mf+(ms+2*mt))))+
  lsa*(mb+(mf+2*(ms+mt))))*sin(q2)*(q2d)^(2)+(lta*mb*sin(q3)*(q3d)^(2)+(ltb*mb*sin(
  q3)*(q3d)^(2)+(lta*mf*sin(q3)*(q3d)^(2)+(ltb*mf*sin(q3)*(q3d)^(2)+(lta*ms*sin(q3)
  *(q3d)^(2)+(ltb*ms*sin(q3)*(q3d)^(2)+(2*lta*mt*sin(q3)*(q3d)^(2)+(ltb*mt*sin(q3)*
  (q3d)^(2)+(lba*mb*sin(q4)*(q4d)^(2)+(-1*lta*mf*sin(q5)*(q5d)^(2)+(-1*ltb*mf*sin(
  q5)*(q5d)^(2)+(-1*lta*ms*sin(q5)*(q5d)^(2)+(-1*ltb*ms*sin(q5)*(q5d)^(2)+(-1*ltb*
  mt*sin(q5)*(q5d)^(2)+(-1*lsa*mf*sin(q6)*(q6d)^(2)+(-1*lsb*mf*sin(q6)*(q6d)^(2)+(-
  1*lsb*ms*sin(q6)*(q6d)^(2)+(lfa*mf*cos(q7)*(q7d)^(2)+(-1*lfe*mf*cos(q7)*(q7d)^(2)
  +(-1*lfd*mf*sin(q7)*(q7d)^(2)+(-1*lfc*mb*cos(q1)*q1dd+(-1*lfd*mb*cos(q1)*q1dd+(-2
  *lfc*mf*cos(q1)*q1dd+(-1*lfd*mf*cos(q1)*q1dd+(-2*lfc*ms*cos(q1)*q1dd+(-2*lfd*ms*
  cos(q1)*q1dd+(-2*lfc*mt*cos(q1)*q1dd+(-2*lfd*mt*cos(q1)*q1dd+(lfe*mb*sin(q1)*q1dd
  +(lfa*mf*sin(q1)*q1dd+(lfe*mf*sin(q1)*q1dd+(2*lfe*ms*sin(q1)*q1dd+(2*lfe*mt*sin(
  q1)*q1dd+(-1*lsa*mb*cos(q2)*q2dd+(-1*lsb*mb*cos(q2)*q2dd+(-1*lsa*mf*cos(q2)*q2dd+
  (-1*lsb*mf*cos(q2)*q2dd+(-2*lsa*ms*cos(q2)*q2dd+(-1*lsb*ms*cos(q2)*q2dd+(-2*lsa*
  mt*cos(q2)*q2dd+(-2*lsb*mt*cos(q2)*q2dd+(-1*lta*mb*cos(q3)*q3dd+(-1*ltb*mb*cos(q3
  )*q3dd+(-1*lta*mf*cos(q3)*q3dd+(-1*ltb*mf*cos(q3)*q3dd+(-1*lta*ms*cos(q3)*q3dd+(-
  1*ltb*ms*cos(q3)*q3dd+(-2*lta*mt*cos(q3)*q3dd+(-1*ltb*mt*cos(q3)*q3dd+(-1*lba*mb*
  cos(q4)*q4dd+(lta*mf*cos(q5)*q5dd+(ltb*mf*cos(q5)*q5dd+(lta*ms*cos(q5)*q5dd+(ltb*
  ms*cos(q5)*q5dd+(ltb*mt*cos(q5)*q5dd+(lsa*mf*cos(q6)*q6dd+(lsb*mf*cos(q6)*q6dd+(
  lsb*ms*cos(q6)*q6dd+(lfd*mf*cos(q7)*q7dd+(lfa*mf*sin(q7)*q7dd+(-1*lfe*mf*sin(q7)*
  q7dd+(mb*q8dd+(2*mf*q8dd+(2*ms*q8dd+2*mt*q8dd))))))))))))))))))))))))))))))))))))
  ))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))
```

```
dyn9 = HurGlobalELEquation[[9]];
HurToJulia[dyn9]
```

```
(-1*lambda2+(-1*lambda3+(-1*lambda5+(g*mb+(2*g*mf+(2*g*ms+(2*g*mt+(-1*((lfd*(mb+(mf
  +2*(ms+mt)))+lfc*(mb+2*(mf+(ms+mt))))*cos(q1)+-1*(lfa*mf+lfe*(mb+(mf+2*(ms+mt))))
  )*sin(q1))*(q1d)^(2)+(-1*(lsb*(mb+(mf+(ms+2*mt))))+lsa*(mb+(mf+2*(ms+mt))))*cos(
  q2)*(q2d)^(2)+(-1*lta*mb*cos(q3)*(q3d)^(2)+(-1*ltb*mb*cos(q3)*(q3d)^(2)+(-1*lta*
  mf*cos(q3)*(q3d)^(2)+(-1*ltb*mf*cos(q3)*(q3d)^(2)+(-1*lta*ms*cos(q3)*(q3d)^(2)+(-
  1*ltb*ms*cos(q3)*(q3d)^(2)+(-2*lta*mt*cos(q3)*(q3d)^(2)+(-1*ltb*mt*cos(q3)*(q3d)^
  (2)+(-1*lba*mb*cos(q4)*(q4d)^(2)+(lta*mf*cos(q5)*(q5d)^(2)+(ltb*mf*cos(q5)*(q5d)^
  (2)+(lta*ms*cos(q5)*(q5d)^(2)+(ltb*ms*cos(q5)*(q5d)^(2)+(ltb*mt*cos(q5)*(q5d)^(2)
  +(lsa*mf*cos(q6)*(q6d)^(2)+(lsb*mf*cos(q6)*(q6d)^(2)+(lsb*ms*cos(q6)*(q6d)^(2)+(
  lfd*mf*cos(q7)*(q7d)^(2)+(lfa*mf*sin(q7)*(q7d)^(2)+(-1*lfe*mf*sin(q7)*(q7d)^(2)+(
  -1*lfe*mb*cos(q1)*q1dd+(-1*lfa*mf*cos(q1)*q1dd+(-1*lfe*mf*cos(q1)*q1dd+(-2*lfe*ms
  *cos(q1)*q1dd+(-2*lfe*mt*cos(q1)*q1dd+(-1*lfc*mb*sin(q1)*q1dd+(-1*lfd*mb*sin(q1)*
  q1dd+(-2*lfc*mf*sin(q1)*q1dd+(-1*lfd*mf*sin(q1)*q1dd+(-2*lfc*ms*sin(q1)*q1dd+(-2*
  lfd*ms*sin(q1)*q1dd+(-2*lfc*mt*sin(q1)*q1dd+(-2*lfd*mt*sin(q1)*q1dd+(-1*lsa*mb*
  sin(q2)*q2dd+(-1*lsb*mb*sin(q2)*q2dd+(-1*lsa*mf*sin(q2)*q2dd+(-1*lsb*mf*sin(q2)*
  q2dd+(-2*lsa*ms*sin(q2)*q2dd+(-1*lsb*ms*sin(q2)*q2dd+(-2*lsa*mt*sin(q2)*q2dd+(-2*
  lsb*mt*sin(q2)*q2dd+(-1*lta*mb*sin(q3)*q3dd+(-1*ltb*mb*sin(q3)*q3dd+(-1*lta*mf*
  sin(q3)*q3dd+(-1*ltb*mf*sin(q3)*q3dd+(-1*lta*ms*sin(q3)*q3dd+(-1*ltb*ms*sin(q3)*
  q3dd+(-2*lta*mt*sin(q3)*q3dd+(-1*ltb*mt*sin(q3)*q3dd+(-1*lba*mb*sin(q4)*q4dd+(lta
  *mf*sin(q5)*q5dd+(ltb*mf*sin(q5)*q5dd+(lta*ms*sin(q5)*q5dd+(ltb*ms*sin(q5)*q5dd+(
  ltb*mt*sin(q5)*q5dd+(lsa*mf*sin(q6)*q6dd+(lsb*mf*sin(q6)*q6dd+(lsb*ms*sin(q6)*q6dd
  +(-1*lfa*mf*cos(q7)*q7dd+(lfe*mf*cos(q7)*q7dd+(lfd*mf*sin(q7)*q7dd+(mb*q9dd+(2*mf
  *q9dd+(2*ms*q9dd+2*mt*q9dd))))))))))))))))))))))))))))))))))))))))))))))))))))))))
  ))))))))))))))))))))
```

```
HurUnifyTriadsCoord[ToeST, rf0] // MatrixForm
D[%[[2]], t]
```

$$\begin{pmatrix} (\text{lfa}+\text{lfb})\,\text{Cos}[\text{q1}[t]]+\text{q8}[t] \\ \text{q9}[t]+(\text{lfa}+\text{lfb})\,\text{Sin}[\text{q1}[t]] \\ 0 \\ \text{rf0} \end{pmatrix}$$

$$(\text{lfa}+\text{lfb})\,\text{Cos}[\text{q1}[t]]\,\text{q1}'[t]+\text{q9}'[t]$$

```
ToeSWLength = HurUnifyTriadsCoord[ToeSW, rf0][[1]]
HurToJulia[ToeSWLength]
```

$$-\text{lfe}\,\text{Cos}[\text{q1}[t]]+\text{lfe}\,\text{Cos}[\text{q7}[t]]+\text{q8}[t]-(\text{lfc}+\text{lfd})\,\text{Sin}[\text{q1}[t]]-(\text{lsa}+\text{lsb})\,\text{Sin}[\text{q2}[t]]-(\text{lta}+\text{ltb})\,\text{Sin}[\text{q3}[t]]+(\text{lta}+\text{ltb})\,\text{Sin}[\text{q5}[t]]+(\text{lsa}+\text{lsb})\,\text{Sin}[\text{q6}[t]]+(\text{lfc}+\text{lfd})\,\text{Sin}[\text{q7}[t]]$$

```
(-1*lfe*cos(q1)+(lfe*cos(q7)+(q8+(-1*(lfc+lfd)*sin(q1)+(-1*(lsa+lsb)*sin(q2)+(-1*(lta+ltb)*sin(q3)+((lta+ltb)*sin(q5)+((lsa+lsb)*sin(q6)+(lfc+lfd)*sin(q7)))))))))
```

```
ToeSWHeight = HurUnifyTriadsCoord[ToeSW, rf0][[2]]
HurToJulia[ToeSWHeight]
```

$$(\text{lfc}+\text{lfd})\,\text{Cos}[\text{q1}[t]]+(\text{lsa}+\text{lsb})\,\text{Cos}[\text{q2}[t]]+(\text{lta}+\text{ltb})\,\text{Cos}[\text{q3}[t]]-(\text{lta}+\text{ltb})\,\text{Cos}[\text{q5}[t]]-(\text{lsa}+\text{lsb})\,\text{Cos}[\text{q6}[t]]-(\text{lfc}+\text{lfd})\,\text{Cos}[\text{q7}[t]]+\text{q9}[t]-\text{lfe}\,\text{Sin}[\text{q1}[t]]+\text{lfe}\,\text{Sin}[\text{q7}[t]]$$

```
((lfc+lfd)*cos(q1)+((lsa+lsb)*cos(q2)+((lta+ltb)*cos(q3)+(-1*(lta+ltb)*cos(q5)+(-1*(lsa+lsb)*cos(q6)+(-1*(lfc+lfd)*cos(q7)+(q9+(-1*lfe*sin(q1)+lfe*sin(q7)))))))))
```

```
HeelSWLength = HurUnifyTriadsCoord[HeelSW, rf0][[1]]
HurToJulia[HeelSWLength]
```

$$-\text{lfe}\,\text{Cos}[\text{q1}[t]]-(\text{lfa}+\text{lfb})\,\text{Cos}[\text{q7}[t]]+\text{lfe}\,\text{Cos}[\text{q7}[t]]+\text{q8}[t]-(\text{lfc}+\text{lfd})\,\text{Sin}[\text{q1}[t]]-(\text{lsa}+\text{lsb})\,\text{Sin}[\text{q2}[t]]-(\text{lta}+\text{ltb})\,\text{Sin}[\text{q3}[t]]+(\text{lta}+\text{ltb})\,\text{Sin}[\text{q5}[t]]+(\text{lsa}+\text{lsb})\,\text{Sin}[\text{q6}[t]]+(\text{lfc}+\text{lfd})\,\text{Sin}[\text{q7}[t]]$$

```
(-1*lfe*cos(q1)+(-1*(lfa+lfb)*cos(q7)+(lfe*cos(q7)+(q8+(-1*(lfc+lfd)*sin(q1)+(-1*(lsa+lsb)*sin(q2)+(-1*(lta+ltb)*sin(q3)+((lta+ltb)*sin(q5)+((lsa+lsb)*sin(q6)+(lfc+lfd)*sin(q7)))))))))))
```

```
HeelSWHeight = HurUnifyTriadsCoord[HeelSW, rf0][[2]]
HurToJulia[HeelSWHeight]
```

$$(\text{lfc}+\text{lfd})\,\text{Cos}[\text{q1}[t]]+(\text{lsa}+\text{lsb})\,\text{Cos}[\text{q2}[t]]+(\text{lta}+\text{ltb})\,\text{Cos}[\text{q3}[t]]-(\text{lta}+\text{ltb})\,\text{Cos}[\text{q5}[t]]-(\text{lsa}+\text{lsb})\,\text{Cos}[\text{q6}[t]]-(\text{lfc}+\text{lfd})\,\text{Cos}[\text{q7}[t]]+\text{q9}[t]-\text{lfe}\,\text{Sin}[\text{q1}[t]]-(\text{lfa}+\text{lfb})\,\text{Sin}[\text{q7}[t]]+\text{lfe}\,\text{Sin}[\text{q7}[t]]$$

```
((lfc+lfd)*cos(q1)+((lsa+lsb)*cos(q2)+((lta+ltb)*cos(q3)+(-1*(lta+ltb)*cos(q5)+(-1*(lsa+lsb)*cos(q6)+(-1*(lfc+lfd)*cos(q7)+(q9+(-1*lfe*sin(q1)+(-1*(lfa+lfb)*sin(q7)+lfe*sin(q7)))))))))))
```

```
HeelSWVelHorizontal = D[HurUnifyTriadsCoord[HeelSW, rf0][[1]], t]
HurToJulia[HeelSWVelHorizontal]
```

$$-\left(\text{lfc}+\text{lfd}\right)\,\text{Cos}[\text{q1}[\text{t}]]\,\text{q1}'[\text{t}]+\text{lfe}\,\text{Sin}[\text{q1}[\text{t}]]\,\text{q1}'[\text{t}]-\left(\text{lsa}+\text{lsb}\right)\,\text{Cos}[\text{q2}[\text{t}]]\,\text{q2}'[\text{t}]-\left(\text{lta}+\text{ltb}\right)\,\text{Cos}[\text{q3}[\text{t}]]\,\text{q3}'[\text{t}]+\left(\text{lta}+\text{ltb}\right)\,\text{Cos}[\text{q5}[\text{t}]]\,\text{q5}'[\text{t}]+\left(\text{lsa}+\text{lsb}\right)\,\text{Cos}[\text{q6}[\text{t}]]\,\text{q6}'[\text{t}]+\left(\text{lfc}+\text{lfd}\right)\,\text{Cos}[\text{q7}[\text{t}]]\,\text{q7}'[\text{t}]+\left(\text{lfa}+\text{lfb}\right)\,\text{Sin}[\text{q7}[\text{t}]]\,\text{q7}'[\text{t}]-\text{lfe}\,\text{Sin}[\text{q7}[\text{t}]]\,\text{q7}'[\text{t}]+\text{q8}'[\text{t}]$$

```
(-1*(lfc+lfd)*cos(q1)*q1d+(lfe*sin(q1)*q1d+(-1*(lsa+lsb)*cos(q2)*q2d+(-1*(lta+ltb)*
  cos(q3)*q3d+((lta+ltb)*cos(q5)*q5d+((lsa+lsb)*cos(q6)*q6d+((lfc+lfd)*cos(q7)*q7d+
  ((lfa+lfb)*sin(q7)*q7d+(-1*lfe*sin(q7)*q7d+q8d)))))))))
```

```
HeelSWVelVertical = D[HurUnifyTriadsCoord[HeelSW, rf0][[2]], t]
HurToJulia[HeelSWVelVertical]
```

$$-\text{lfe}\,\text{Cos}[\text{q1}[\text{t}]]\,\text{q1}'[\text{t}]-\left(\text{lfc}+\text{lfd}\right)\,\text{Sin}[\text{q1}[\text{t}]]\,\text{q1}'[\text{t}]-\left(\text{lsa}+\text{lsb}\right)\,\text{Sin}[\text{q2}[\text{t}]]\,\text{q2}'[\text{t}]-\left(\text{lta}+\text{ltb}\right)\,\text{Sin}[\text{q3}[\text{t}]]\,\text{q3}'[\text{t}]+\left(\text{lta}+\text{ltb}\right)\,\text{Sin}[\text{q5}[\text{t}]]\,\text{q5}'[\text{t}]+\left(\text{lsa}+\text{lsb}\right)\,\text{Sin}[\text{q6}[\text{t}]]\,\text{q6}'[\text{t}]-\left(\text{lfa}+\text{lfb}\right)\,\text{Cos}[\text{q7}[\text{t}]]\,\text{q7}'[\text{t}]+\text{lfe}\,\text{Cos}[\text{q7}[\text{t}]]\,\text{q7}'[\text{t}]+\left(\text{lfc}+\text{lfd}\right)\,\text{Sin}[\text{q7}[\text{t}]]\,\text{q7}'[\text{t}]+\text{q9}'[\text{t}]$$

```
(-1*lfe*cos(q1)*q1d+(-1*(lfc+lfd)*sin(q1)*q1d+(-1*(lsa+lsb)*sin(q2)*q2d+(-1*(lta+
  ltb)*sin(q3)*q3d+((lta+ltb)*sin(q5)*q5d+((lsa+lsb)*sin(q6)*q6d+(-1*(lfa+lfb)*cos(
  q7)*q7d+(lfe*cos(q7)*q7d+((lfc+lfd)*sin(q7)*q7d+q9d)))))))))
```

```
HurSaveData["data1.m", "HolonomicConst", "AConstr", "ToeST", "HeelST", "FootSTCOM",
 "AnkleST", "ShankSTCOM", "KneeST", "ThighSTCOM", "Hip", "TorsoCOM", "ThighSWCOM",
 "KneeSW", "ShankSWCOM", "AnkleSW", "ToeSW", "HeelSW", "FootSWCOM", "dyn1", "dyn2",
 "dyn3", "dyn4", "dyn5", "dyn6", "dyn7", "dyn8", "dyn9", "ToeSWLength", "ToeSWHeight",
 "HeelSWLength", "HeelSWHeight", "HeelSWVelHorizontal", "HeelSWVelVertical", "JacToeSW",
 "JacHeelSW", "impDynConst1", "impDynConst2", "impDynConst3", "impDynConst4"]
```

```
HurGlobalNonConservativeForces // MatrixForm
```

$$\begin{pmatrix}
-\text{tau1}-\text{lambda3}\left(\text{lfa}+\text{lfb}\right)\,\text{Cos}[\text{q1}[\text{t}]]+\text{lambda5}\left(-\text{lfe}\,\text{Cos}[\text{q1}[\text{t}]]-\left(\text{lfc}+\text{lfd}\right)\,\text{Sin}[\text{q1}\right. \\
\text{tau1}-\text{tau2}-\text{lambda4}\left(\text{lsa}+\text{lsb}\right)\,\text{Cos}[\text{q2}[\text{t}]]-\text{lambda} \\
\text{tau2}-\text{tau3}-\text{lambda4}\left(\text{lta}+\text{ltb}\right)\,\text{Cos}[\text{q3}[\text{t}]]-\text{lambda} \\
\text{tau3}-\text{tau4} \\
\text{tau4}-\text{tau5}+\text{lambda4}\left(\text{lta}+\text{ltb}\right)\,\text{Cos}[\text{q5}[\text{t}]]+\text{lambda} \\
\text{tau5}-\text{tau6}+\text{lambda4}\left(\text{lsa}+\text{lsb}\right)\,\text{Cos}[\text{q6}[\text{t}]]+\text{lambda} \\
\text{tau6}+\text{lambda5}\left(-\left(\text{lfa}+\text{lfb}\right)\,\text{Cos}[\text{q7}[\text{t}]]+\text{lfe}\,\text{Cos}[\text{q7}[\text{t}]]+\left(\text{lfc}+\text{lfd}\right)\,\text{Sin}[\text{q7}[\text{t}]]\right)+\text{lambda4}\left(\right. \\
\text{lambda1}+\text{lambda4} \\
\text{lambda2}+\text{lambda3}+\text{lambda5}
\end{pmatrix}$$

```
Transpose[AConstr] // MatrixForm
Transpose[AConstr].
  HurList2Column[{lambda1, lambda2, lambda3, lambda4, lambda5}] // MatrixForm
```

$$\begin{pmatrix} 0 & 0 & -(lfa+lfb)\cos[q1[t]] & -(lfc+lfd)\cos[q1[t]]+lfe\sin[q1[t]] \\ 0 & 0 & 0 & -(lsa+lsb)\cos[q2[t]] \\ 0 & 0 & 0 & -(lta+ltb)\cos[q3[t]] \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & (lta+ltb)\cos[q5[t]] \\ 0 & 0 & 0 & (lsa+lsb)\cos[q6[t]] \\ 0 & 0 & 0 & (lfc+lfd)\cos[q7[t]]+(lfa+lfb)\sin[q7[t]]-lfe\sin[q7[t] \\ 1 & 0 & 0 & 1 \\ 0 & 1 & 1 & 0 \end{pmatrix}$$

$$\begin{pmatrix} -lambda3\,(lfa+lfb)\cos[q1[t]]+lambda5\,(-lfe\cos[q1[t]]-(lfc+lfd)\sin[q1[t]]) \\ -lambda4\,(lsa+lsb)\cos[q2[t]]-lambda5\,(lsa+l \\ -lambda4\,(lta+ltb)\cos[q3[t]]-lambda5\,(lta+l \\ 0 \\ lambda4\,(lta+ltb)\cos[q5[t]]+lambda5\,(lta+l \\ lambda4\,(lsa+lsb)\cos[q6[t]]+lambda5\,(lsa+l \\ lambda5\,(-(lfa+lfb)\cos[q7[t]]+lfe\cos[q7[t]]+(lfc+lfd)\sin[q7[t]])+lambda4\,((lfc+ \\ lambda1+lambda4 \\ lambda2+lambda3+lambda5 \end{pmatrix}$$

```
JacToeSW = HurGetJacobian[ToeSW, rf7, rf0][[1 ;; 2, ;;]];
JacHeelSW = HurGetJacobian[HeelSW, rf7, rf0][[1 ;; 2, ;;]];
JacToeSW // MatrixForm
JacHeelSW // MatrixForm
```

$$\begin{pmatrix} -(lfc+lfd)\cos[q1[t]]+lfe\sin[q1[t]] & -(lsa+lsb)\cos[q2[t]] & -(lta+ltb)\cos[q3[t]] \\ -lfe\cos[q1[t]]-(lfc+lfd)\sin[q1[t]] & -(lsa+lsb)\sin[q2[t]] & -(lta+ltb)\sin[q3[t]] \end{pmatrix}$$

$$\begin{pmatrix} -(lfc+lfd)\cos[q1[t]]+lfe\sin[q1[t]] & -(lsa+lsb)\cos[q2[t]] & -(lta+ltb)\cos[q3[t]] \\ -lfe\cos[q1[t]]-(lfc+lfd)\sin[q1[t]] & -(lsa+lsb)\sin[q2[t]] & -(lta+ltb)\sin[q3[t]] \end{pmatrix}$$

```
impDynConst1 =
  ArrayFlatten[{{HurGlobalMMatrix, -Transpose[JacToeSW]}}].HurList2Column[
     {q1dp, q2dp, q3dp, q4dp, q5dp, q6dp, q7dp, q8dp, q9dp, FimpToeX, FimpToeY}] -
   HurGlobalMMatrix.HurList2Column[{q1'[t], q2'[t], q3'[t],
      q4'[t], q5'[t], q6'[t], q7'[t], q8'[t], q9'[t]}];

impDynConst2 =
  JacToeSW.HurList2Column[{q1dp, q2dp, q3dp, q4dp, q5dp, q6dp, q7dp, q8dp, q9dp}];

impDynConst3 =
  ArrayFlatten[{{HurGlobalMMatrix, -Transpose[JacHeelSW]}}].HurList2Column[
     {q1dp, q2dp, q3dp, q4dp, q5dp, q6dp, q7dp, q8dp, q9dp, FimpHeelX, FimpHeelY}] -
   HurGlobalMMatrix.HurList2Column[{q1'[t], q2'[t], q3'[t],
      q4'[t], q5'[t], q6'[t], q7'[t], q8'[t], q9'[t]}];

impDynConst4 =
  JacHeelSW.HurList2Column[{q1dp, q2dp, q3dp, q4dp, q5dp, q6dp, q7dp, q8dp, q9dp}];
```

HurToJulia[impDynConst1[[9, 1]]]

```
(-1*FimpToeY+((mb+2*(mf+(ms+mt)))*q9dp+(q1dp*(-1*(lfa*mf+lfe*(mb+(mf+2*(ms+mt))))*
  cos(q1)+-1*(lfd*(mb+(mf+2*(ms+mt)))+lfc*(mb+2*(mf+(ms+mt))))*sin(q1))+(-1*(lsb*(
  mb+(mf+(ms+2*mt)))+lsa*(mb+(mf+2*(ms+mt))))*q2dp*sin(q2)+(-1*(ltb*(mb+(mf+(ms+mt
  )))+lta*(mb+(mf+(ms+2*mt))))*q3dp*sin(q3)+(-1*lba*mb*q4dp*sin(q4)+((lta*(mf+ms)+
  ltb*(mf+(ms+mt)))*q5dp*sin(q5)+((lsa*mf+lsb*(mf+ms))*q6dp*sin(q6)+(mf*q7dp*((-1*
  lfa+lfe)*cos(q7)+lfd*sin(q7)))+(-1*(-1*(lfa*mf+lfe*(mb+(mf+2*(ms+mt))))*cos(q1)+-1
  *(lfd*(mb+(mf+2*(ms+mt)))+lfc*(mb+2*(mf+(ms+mt))))*sin(q1))*q1d+((lsb*(mb+(mf+(
  ms+2*mt)))+lsa*(mb+(mf+2*(ms+mt))))*sin(q2)*q2d+((ltb*(mb+(mf+(ms+mt)))+lta*(mb+
  (mf+(ms+2*mt))))*sin(q3)*q3d+(lba*mb*sin(q4)*q4d+(-1*(lta*(mf+ms)+ltb*(mf+(ms+mt)
  ))*sin(q5)*q5d+(-1*(lsa*mf+lsb*(mf+ms))*sin(q6)*q6d+(-1*mf*((-1*lfa+lfe)*cos(q7)+
  lfd*sin(q7))*q7d+-1*(mb+2*(mf+(ms+mt)))*q9d)))))))))))))))))
```

HurToJulia[impDynConst2[[2, 1]]]

```
(q9dp+(q1dp*(-1*lfe*cos(q1)+-1*(lfc+lfd)*sin(q1))+(-1*(lsa+lsb)*q2dp*sin(q2)+(-1*(
  lta+ltb)*q3dp*sin(q3)+((lta+ltb)*q5dp*sin(q5)+((lsa+lsb)*q6dp*sin(q6)+q7dp*(lfe*
  cos(q7)+(lfc+lfd)*sin(q7)))))))))
```

HurToJulia[impDynConst3[[9, 1]]]

```
(-1*FimpHeelY+((mb+2*(mf+(ms+mt)))*q9dp+(q1dp*(-1*(lfa*mf+lfe*(mb+(mf+2*(ms+mt))))*
  cos(q1)+-1*(lfd*(mb+(mf+2*(ms+mt)))+lfc*(mb+2*(mf+(ms+mt))))*sin(q1))+(-1*(lsb*(
  mb+(mf+(ms+2*mt)))+lsa*(mb+(mf+2*(ms+mt))))*q2dp*sin(q2)+(-1*(ltb*(mb+(mf+(ms+mt
  )))+lta*(mb+(mf+(ms+2*mt))))*q3dp*sin(q3)+(-1*lba*mb*q4dp*sin(q4)+((lta*(mf+ms)+
  ltb*(mf+(ms+mt)))*q5dp*sin(q5)+((lsa*mf+lsb*(mf+ms))*q6dp*sin(q6)+(mf*q7dp*((-1*
  lfa+lfe)*cos(q7)+lfd*sin(q7)))+(-1*(-1*(lfa*mf+lfe*(mb+(mf+2*(ms+mt))))*cos(q1)+-1
  *(lfd*(mb+(mf+2*(ms+mt)))+lfc*(mb+2*(mf+(ms+mt))))*sin(q1))*q1d+((lsb*(mb+(mf+(
  ms+2*mt)))+lsa*(mb+(mf+2*(ms+mt))))*sin(q2)*q2d+((ltb*(mb+(mf+(ms+mt)))+lta*(mb+
  (mf+(ms+2*mt))))*sin(q3)*q3d+(lba*mb*sin(q4)*q4d+(-1*(lta*(mf+ms)+ltb*(mf+(ms+mt)
  ))*sin(q5)*q5d+(-1*(lsa*mf+lsb*(mf+ms))*sin(q6)*q6d+(-1*mf*((-1*lfa+lfe)*cos(q7)+
  lfd*sin(q7)))*q7d+-1*(mb+2*(mf+(ms+mt)))*q9d)))))))))))))))))
```

HurToJulia[impDynConst4[[2, 1]]]

```
(q9dp+(q1dp*(-1*lfe*cos(q1)+-1*(lfc+lfd)*sin(q1))+(-1*(lsa+lsb)*q2dp*sin(q2)+(-1*(
  lta+ltb)*q3dp*sin(q3)+((lta+ltb)*q5dp*sin(q5)+((lsa+lsb)*q6dp*sin(q6)+q7dp*(-1*(
  lfa+lfb)*cos(q7)+(lfe*cos(q7)+(lfc+lfd)*sin(q7)))))))))
```

```
HurGlobalMMatrix
HurToJulia[%]
```

```
[(Is+(2*lsa*lsb*(mb+(ms+2*mt))+((lsb)^(2)*(mb+(ms+2*mt))+(lsa)^(2)*(mb+2*(ms+mt))
  )) (lsa+lsb)*(ltb*(mb+(ms+mt))+lta*(mb+(ms+2*mt)))*cos((q1+-1*q2))
  1/2*lb*(lsa+lsb)*mb*cos((q1+-1*q3))
  -1*(lsa+lsb)*(lta*ms+ltb*(ms+mt))*cos((q1+-1*q4))
  -1*lsb*(lsa+lsb)*ms*cos((q1+-1*q5));(lsa+lsb)*(ltb*(mb+(ms+mt))+lta*(mb+(ms+2*mt)
  ))*cos((q1+-1*q2))
  (It+(2*lta*ltb*(mb+(ms+mt))+((ltb)^(2)*(mb+(ms+mt))+(lta)^(2)*(mb+(ms+2*mt)))))
  1/2*lb*(lta+ltb)*mb*cos((q2+-1*q3))
  -1*(lta+ltb)*(lta*ms+ltb*(ms+mt))*cos((q2+-1*q4))
  -1*lsb*(lta+ltb)*ms*cos((q2+-1*q5));1/2*lb*(lsa+lsb)*mb*cos((q1+-1*q3))
  1/2*lb*(lta+ltb)*mb*cos((q2+-1*q3)) (Ib+1/4*(lb)^(2)*mb)
  0 0;-1*(lsa+lsb)*(lta*ms+ltb*(ms+mt))*cos((q1+-1*q4))
  -1*(lta+ltb)*(lta*ms+ltb*(ms+mt))*cos((q2+-1*q4)) 0
  (It+((lta)^(2)*ms+(2*lta*ltb*ms+(ltb)^(2)*(ms+mt))))
  lsb*(lta+ltb)*ms*cos((q4+-1*q5));-1*lsb*(lsa+lsb)*ms*cos((q1+-1*q5))
  -1*lsb*(lta+ltb)*ms*cos((q2+-1*q5)) 0
  lsb*(lta+ltb)*ms*cos((q4+-1*q5)) (Is+(lsb)^(2)*ms)]
```

```
HurGlobalCMatrix
HurToJulia[%]
```

```
[0 (lsa+lsb)*(ltb*(mb+(ms+mt))+lta*(mb+(ms+2*mt)))*sin((q1+-1*q2))*q2d
  1/2*lb*(lsa+lsb)*mb*sin((q1+-1*q3))*q3d
  -1*(lsa+lsb)*(lta*ms+ltb*(ms+mt))*sin((q1+-1*q4))*q4d
  -1*lsb*(lsa+lsb)*ms*sin((q1+-1*q5))*q5d;-1*(lsa+lsb)*(ltb*(mb+(ms+mt))+lta*(mb+(
  ms+2*mt)))*sin((q1+-1*q2))*q1d 0 1/2*lb*(lta+ltb)*mb*sin((q2+-1*q3))*q3d
  -1*(lta+ltb)*(lta*ms+ltb*(ms+mt))*sin((q2+-1*q4))*q4d
  -1*lsb*(lta+ltb)*ms*sin((q2+-1*q5))*q5d;-1/2*lb*(lsa+lsb)*mb*sin((q1+-1*q3))*q1d
  -1/2*lb*(lta+ltb)*mb*sin((q2+-1*q3))*q2d 0 0
  0;(lsa+lsb)*(lta*ms+ltb*(ms+mt))*sin((q1+-1*q4))*q1d
  (lta+ltb)*(lta*ms+ltb*(ms+mt))*sin((q2+-1*q4))*q2d 0 0
  lsb*(lta+ltb)*ms*sin((q4+-1*q5))*q5d;lsb*(lsa+lsb)*ms*sin((q1+-1*q5))*q1d
  lsb*(lta+ltb)*ms*sin((q2+-1*q5))*q2d 0 -1*lsb*(lta+ltb)*ms*sin((q4+-1*q5))*q4d 0]
```

```
HurGlobalGVector
HurToJulia[HurList2Column[%]]
```

```
[-1*g*(lsb*(mb+(ms+2*mt))+lsa*(mb+2*(ms+mt)))*sin(q1);-1*g*(ltb*(mb+(ms+mt))+lta*(
  mb+(ms+2*mt)))*sin(q2);-1/2*g*lb*mb*sin(q3);g*(lta*ms+ltb*(ms+mt))*sin(q4);g*lsb*
  ms*sin(q5)]
```

```
JacFootSW = HurGetJacobian[FootSW, e, n];
JacFootSW.HurList2Column[{q1'[t], q2'[t], q3'[t], q4'[t], q5'[t]}]
verticalVel = %[[2, 1]]
HurToJulia[verticalVel]
```

```
(-1*(lsa+lsb)*sin(q1)*q1d+(-1*(lta+ltb)*sin(q2)*q2d+((lta+ltb)*sin(q4)*q4d+(lsa+lsb
  )*sin(q5)*q5d)))
```

```
JacFootSW.HurList2Column[{q1'[t], q2'[t], q3'[t], q4'[t], q5'[t]}]
horizontalVel = %[[1, 1]]
HurToJulia[horizontalVel]
```

```
(-1*(lsa+lsb)*cos(q1)*q1d+(-1*(lta+ltb)*cos(q2)*q2d+((lta+ltb)*cos(q4)*q4d+(lsa+lsb
  )*cos(q5)*q5d)))
```

```
HurSaveData["data1.m", "FootST", "ShankSTCOM", "KneeST", "ThighSTCOM", "Hip", "TorsoCOM",
 "ThighSWCOM", "KneeSW", "ShankSWCOM", "FootSW", "dyn1", "dyn2", "dyn3", "dyn4", "dyn5",
 "stepLength", "stepHeight", "verticalVel", "horizontalVel", "JacFootSW", "invans"]
```

```
HurUnifyTriadsCoord[FootSW, n];
HurToJulia[%[[1]]]
```

```
(-1*(lsa+lsb)*sin(q1)+(-1*(lta+ltb)*sin(q2)+((lta+ltb)*sin(q4)+(lsa+lsb)*sin(q5))))
```

```
HurUnifyTriadsCoord[FootSW, n];
HurToJulia[%[[2]]]
```

```
((lsa+lsb)*cos(q1)+((lta+ltb)*cos(q2)+(-1*(lta+ltb)*cos(q4)+-1*(lsa+lsb)*cos(q5))))
```

```
HurUnifyTriadsCoord[KneeSW, n];
HurToJulia[%[[1]]]
```

```
(-1*(lsa+lsb)*sin(q1)+-1*(lta+ltb)*(sin(q2)+-1*sin(q4)))
```

```
HurUnifyTriadsCoord[KneeSW, n];
HurToJulia[%[[2]]]
```

```
((lsa+lsb)*cos(q1)+(lta+ltb)*(cos(q2)+-1*cos(q4)))
```

```
HurUnifyTriadsCoord[Hip, n];
HurToJulia[%[[1]]]
```

```
(-1*(lsa+lsb)*sin(q1)+-1*(lta+ltb)*sin(q2))
```

```
HurUnifyTriadsCoord[Hip, n];
HurToJulia[%[[2]]]
```

```
((lsa+lsb)*cos(q1)+(lta+ltb)*cos(q2))
```

```
HurUnifyTriadsCoord[TorsoCOM, n];
HurToJulia[%[[1]]]
```

```
(-1*(lsa+lsb)*sin(q1)+(-1*(lta+ltb)*sin(q2)+-1/2*lb*sin(q3)))
```

```
HurUnifyTriadsCoord[TorsoCOM, n];
HurToJulia[%[[2]]]
```

```
((lsa+lsb)*cos(q1)+((lta+ltb)*cos(q2)+1/2*lb*cos(q3)))
```

```
HurUnifyTriadsCoord[KneeST, n];
HurToJulia[%[[1]]]
```

```
-1*(lsa+lsb)*sin(q1)
```

```
HurUnifyTriadsCoord[KneeST, n];
HurToJulia[%[[2]]]
```

```
(lsa+lsb)*cos(q1)
```

```
Transpose[HurGetJacobian[Hip, c, n]].
  HurList2Column[{forcex, forcey, 0, 0, 0, 0}] // MatrixForm
```

```
HurToJulia[%[[2, 1]] ]
```

```
HurGetJacobian[Hip, c, n] // MatrixForm
```

```
HurTurnOffSimplify[]
```

```
False
```

```
invans = HurELInverse[]
```

```
{{q1''[t] →
    -((( -((Is + lsb^2 ms) (… 1 …) - (… 1 …) (… 1 … + … 1 …))) (… 1 …) +
          … 1 …) (… 1 …) - … 1 …) /
      (-(-(((Ib + lb^2 mb/4) (Is + lsb^2 ms) (… 1 …) - … 1 …) (… 1 …) +
          (… 1 …) … 1 …) (… 1 …) + … 1 …)), … 3 …, q5''[t] → … 1 …}}
```

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```
q5''[t] /. invans[[1]];
HurToJulia[%]
```

Whole body COM

```
COMWhole = Total[Table[HurGlobalCOMPos[[i]] * HurGlobalMass[[i]],
    {i, 2, Length[HurGlobalRF]}]] / Total[HurGlobalMass]
```

$$\frac{1}{mb + 2\,ms + 2\,mt}\left(\left(\frac{c2\,lb}{2} + a2\,(lsa + lsb) + b2\,(lta + ltb)\right) mb + a2\,lsa\,ms + \left(-e2\,lsb + a2\,(lsa + lsb) + b2\,(lta + ltb) - d2\,(lta + ltb)\right) ms + \left(a2\,(lsa + lsb) + b2\,lta\right) mt + \left(a2\,(lsa + lsb) - d2\,ltb + b2\,(lta + ltb)\right) mt\right)$$

Whole body COM linear momentum

```
LinearMomentumWholeBody =
  D[HurUnifyTriadsCoord[COMWhole, n], t] * Total[HurGlobalMass] // Simplify;
LinearMomentumWholeBody // MatrixForm
```

$$\begin{pmatrix} -\left(lsb\,(mb + ms + 2\,mt) + lsa\,(mb + 2\,(ms + mt))\right) \text{Cos}[q1[t]]\,q1'[t] - \left(ltb\,(mb + ms + mt) + lta\,(mb + \\ -\left(lsb\,(mb + ms + 2\,mt) + lsa\,(mb + 2\,(ms + mt))\right) \text{Sin}[q1[t]]\,q1'[t] - \left(ltb\,(mb + ms + mt) + lta\,(mb + \end{pmatrix}$$

Whole body COM linear momentum rate change

```
LinearMomentumRateWholeBody =
  D[LinearMomentumWholeBody, t] * Total[HurGlobalMass] // Simplify;
LinearMomentumRateWholeBody // MatrixForm
```

$$\begin{pmatrix} (mb + 2\,(ms + mt))\left(\left(lsb\,(mb + ms + 2\,mt) + lsa\,(mb + 2\,(ms + mt))\right) \text{Sin}[q1[t]]\,q1'[t]^2 + \left(ltb\,(mb + \\ (mb + 2\,(ms + mt))\left(-\left(lsb\,(mb + ms + 2\,mt) + lsa\,(mb + 2\,(ms + mt))\right) \text{Cos}[q1[t]]\,q1'[t]^2 - \left(ltb\,(mb \end{pmatrix}$$

Whole body Angular Momentum

```
Table[HurCross[HurGlobalCOMPos[[i]] - COMWhole, HurGlobalLinearMomentum[[i]], n] +
  HurGlobalAngularMomentum[[i]], {i, 2, Length[HurGlobalRF]}]
HurUnifyTriadsCoord[Total[%], n] // Simplify
```

$$\{a3\,Is\,q1'[t] + n3\left(\cdots 96 \cdots + \frac{\cdots 1 \cdots}{\cdots 1 \cdots^2} + \right.$$
$$\left(2\,lsa\,ltb\,ms^3\,Sin[q1[t]]\,Sin[q4[t]]\,q1'[t]\right) / \left(mb + 2\,ms + 2\,mt\right)^2 +$$
$$\left(lsa\,ltb\,mb\,ms\,mt\,Sin[q1[t]]\,Sin[q4[t]]\,q1'[t]\right) / \left(mb + 2\,ms + 2\,mt\right)^2 +$$
$$\left(2\,lsa\,lta\,ms^2\,mt\,Sin[q1[t]]\,Sin[q4[t]]\,q1'[t]\right) / \left(mb + 2\,ms + 2\,mt\right)^2 +$$
$$\left(4\,lsa\,ltb\,ms^2\,mt\,Sin[q1[t]]\,Sin[q4[t]]\,q1'[t]\right) / \left(mb + 2\,ms + 2\,mt\right)^2 +$$
$$\left(2\,lsa\,ltb\,ms\,mt^2\,Sin[q1[t]]\,Sin[q4[t]]\,q1'[t]\right) / \left(mb + 2\,ms + 2\,mt\right)^2 +$$
$$\left(lsa\,lsb\,mb\,ms^2\,Sin[q1[t]]\,Sin[q5[t]]\,q1'[t]\right) / \left(mb + 2\,ms + 2\,mt\right)^2 +$$
$$\left(2\,lsa\,lsb\,ms^3\,Sin[q1[t]]\,Sin[q5[t]]\,q1'[t]\right) / \left(mb + 2\,ms + 2\,mt\right)^2 +$$
$$\left.\left(2\,lsa\,lsb\,ms^2\,mt\,Sin[q1[t]]\,Sin[q5[t]]\,q1'[t]\right) / \left(mb + 2\,ms + 2\,mt\right)^2\right),$$

$$b3\,It\,q2'[t] + n3\left(\frac{lsa\ \cdots 7 \cdots\ \cdots 1 \cdots}{\left(\cdots 1 \cdots\right)^2} + \cdots 310 \cdots + \frac{\cdots 1 \cdots}{\cdots 1 \cdots}\right),$$

$$\cdots 1 \cdots,$$
$$\cdots 1 \cdots,$$
$$e3\,Is\,q5'[t] +$$
$$n3\left(\left(lsa\,lsb\,mb\,ms^2\,Cos[q1[t]]\,Cos[q1[t] - q5[t]]\,Cos[q5[t]]\,q1'[t]\right) / \right.$$
$$\left(mb + 2\,ms + 2\,mt\right)^2 +$$
$$\left(lsb^2\,mb\,ms^2\,Cos[q1[t]]\,Cos[q1[t] - q5[t]]\,Cos[q5[t]]\,q1'[t]\right) / \left(mb + 2\,ms + 2\,mt\right)^2 +$$
$$\left(2\,lsa\,lsb\,ms^3\,Cos[q1[t]]\,Cos[q1[t] - q5[t]]\,Cos[q5[t]]\,q1'[t]\right) /$$
$$\left(mb + 2\,ms + 2\,mt\right)^2 + \cdots 1036 \cdots + \left(4\,lsb^2\,mb\,ms\,mt\,Sin[q5[t]]^2\,q5'[t]\right) /$$
$$\left.\left(mb + 2\,ms + 2\,mt\right)^2 + \frac{6\,lsb^2\,ms^2\,mt\,Sin[q5[t]]^2\,q5'[t]}{(mb+2\,ms+2\,mt)^2} + \frac{4\,lsb^2\,ms\,mt^2\,Sin[q5[t]]^2\,q5'[t]}{(mb+2\,ms+2\,mt)^2}\right)\}$$

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$$\left\{0,\ 0,\ \frac{1}{2\left(\mathrm{mb}+2\left(\mathrm{ms}+\mathrm{mt}\right)\right)}\right.$$
$$\Big(\left(2\,\mathrm{lsb}\,\mathrm{ms}\left(\mathrm{ltb}\left(\mathrm{mb}+\mathrm{ms}+\mathrm{mt}\right)+\mathrm{lta}\left(\mathrm{mb}+\mathrm{ms}+2\,\mathrm{mt}\right)\right)\mathrm{Cos}[\mathrm{q1}[t]-\mathrm{q2}[t]]+\mathrm{lb}\,\mathrm{lsb}\,\mathrm{mb}\,\mathrm{ms}\right.$$
$$\mathrm{Cos}[\mathrm{q1}[t]-\mathrm{q3}[t]]+2\left(\mathrm{Is}\,\mathrm{mb}+2\,\mathrm{Is}\,\mathrm{ms}+\mathrm{lsb}^2\,\mathrm{mb}\,\mathrm{ms}+\mathrm{lsb}^2\,\mathrm{ms}^2+2\,\mathrm{Is}\,\mathrm{mt}+2\,\mathrm{lsb}^2\,\mathrm{ms}\,\mathrm{mt}-\right.$$
$$\left.\left.\mathrm{lsb}\,\mathrm{ms}\left(\mathrm{lta}\,\mathrm{ms}+\mathrm{ltb}\left(\mathrm{ms}+\mathrm{mt}\right)\right)\mathrm{Cos}[\mathrm{q1}[t]-\mathrm{q4}[t]]-\mathrm{lsb}^2\,\mathrm{ms}^2\,\mathrm{Cos}[\mathrm{q1}[t]-\mathrm{q5}[t]]\right)\right)$$
$$\mathrm{q1}'[t]+\Big(2\,\mathrm{lsb}\,\mathrm{ms}\left(\mathrm{ltb}\left(\mathrm{mb}+\mathrm{ms}+\mathrm{mt}\right)+\mathrm{lta}\left(\mathrm{mb}+\mathrm{ms}+2\,\mathrm{mt}\right)\right)\mathrm{Cos}[\mathrm{q1}[t]-\mathrm{q2}[t]]+$$
$$\mathrm{lb}\,\mathrm{mb}\left(\mathrm{lta}\,\mathrm{ms}+\mathrm{ltb}\left(\mathrm{ms}+\mathrm{mt}\right)\right)\mathrm{Cos}[\mathrm{q2}[t]-\mathrm{q3}[t]]+$$
$$2\Big(\mathrm{It}\,\mathrm{mb}+2\,\mathrm{It}\,\mathrm{ms}+\mathrm{lta}^2\,\mathrm{mb}\,\mathrm{ms}+2\,\mathrm{lta}\,\mathrm{ltb}\,\mathrm{mb}\,\mathrm{ms}+\mathrm{ltb}^2\,\mathrm{mb}\,\mathrm{ms}+\mathrm{lta}^2\,\mathrm{ms}^2+$$
$$2\,\mathrm{lta}\,\mathrm{ltb}\,\mathrm{ms}^2+\mathrm{ltb}^2\,\mathrm{ms}^2+2\,\mathrm{It}\,\mathrm{mt}+\mathrm{ltb}^2\,\mathrm{mb}\,\mathrm{mt}+2\,\mathrm{lta}^2\,\mathrm{ms}\,\mathrm{mt}+2\,\mathrm{lta}\,\mathrm{ltb}\,\mathrm{ms}\,\mathrm{mt}+$$
$$2\,\mathrm{ltb}^2\,\mathrm{ms}\,\mathrm{mt}+\mathrm{ltb}^2\,\mathrm{mt}^2-\left(\mathrm{lta}\,\mathrm{ms}+\mathrm{ltb}\left(\mathrm{ms}+\mathrm{mt}\right)\right)^2\mathrm{Cos}[\mathrm{q2}[t]-\mathrm{q4}[t]]-$$
$$\mathrm{lsb}\,\mathrm{ms}\left(\mathrm{lta}\,\mathrm{ms}+\mathrm{ltb}\left(\mathrm{ms}+\mathrm{mt}\right)\right)\mathrm{Cos}[\mathrm{q2}[t]-\mathrm{q5}[t]]\Big)\Big)\,\mathrm{q2}'[t]+$$
$$2\,\mathrm{Ib}\,\mathrm{mb}\,\mathrm{q3}'[t]+4\,\mathrm{Ib}\,\mathrm{ms}\,\mathrm{q3}'[t]+\mathrm{lb}^2\,\mathrm{mb}\,\mathrm{ms}\,\mathrm{q3}'[t]+4\,\mathrm{Ib}\,\mathrm{mt}\,\mathrm{q3}'[t]+$$
$$\mathrm{lb}^2\,\mathrm{mb}\,\mathrm{mt}\,\mathrm{q3}'[t]+$$
$$\mathrm{lb}\,\mathrm{lsb}\,\mathrm{mb}\,\mathrm{ms}\,\mathrm{Cos}[\mathrm{q1}[t]-\mathrm{q3}[t]]\,\mathrm{q3}'[t]+$$
$$\mathrm{lb}\,\mathrm{lta}\,\mathrm{mb}\,\mathrm{ms}\,\mathrm{Cos}[\mathrm{q2}[t]-\mathrm{q3}[t]]\,\mathrm{q3}'[t]+$$
$$\mathrm{lb}\,\mathrm{ltb}\,\mathrm{mb}\,\mathrm{ms}\,\mathrm{Cos}[\mathrm{q2}[t]-\mathrm{q3}[t]]\,\mathrm{q3}'[t]+$$
$$\mathrm{lb}\,\mathrm{ltb}\,\mathrm{mb}\,\mathrm{mt}\,\mathrm{Cos}[\mathrm{q2}[t]-\mathrm{q3}[t]]\,\mathrm{q3}'[t]+$$
$$\mathrm{lb}\,\mathrm{lta}\,\mathrm{mb}\,\mathrm{ms}\,\mathrm{Cos}[\mathrm{q3}[t]-\mathrm{q4}[t]]\,\mathrm{q3}'[t]+$$
$$\mathrm{lb}\,\mathrm{ltb}\,\mathrm{mb}\,\mathrm{ms}\,\mathrm{Cos}[\mathrm{q3}[t]-\mathrm{q4}[t]]\,\mathrm{q3}'[t]+$$
$$\mathrm{lb}\,\mathrm{ltb}\,\mathrm{mb}\,\mathrm{mt}\,\mathrm{Cos}[\mathrm{q3}[t]-\mathrm{q4}[t]]\,\mathrm{q3}'[t]+$$
$$\mathrm{lb}\,\mathrm{lsb}\,\mathrm{mb}\,\mathrm{ms}\,\mathrm{Cos}[\mathrm{q3}[t]-\mathrm{q5}[t]]\,\mathrm{q3}'[t]+$$
$$2\,\mathrm{It}\,\mathrm{mb}\,\mathrm{q4}'[t]+4\,\mathrm{It}\,\mathrm{ms}\,\mathrm{q4}'[t]+2\,\mathrm{lta}^2\,\mathrm{mb}\,\mathrm{ms}\,\mathrm{q4}'[t]+$$
$$4\,\mathrm{lta}\,\mathrm{ltb}\,\mathrm{mb}\,\mathrm{ms}\,\mathrm{q4}'[t]+2\,\mathrm{ltb}^2\,\mathrm{mb}\,\mathrm{ms}\,\mathrm{q4}'[t]+$$
$$2\,\mathrm{lta}^2\,\mathrm{ms}^2\,\mathrm{q4}'[t]+4\,\mathrm{lta}\,\mathrm{ltb}\,\mathrm{ms}^2\,\mathrm{q4}'[t]+2\,\mathrm{ltb}^2\,\mathrm{ms}^2\,\mathrm{q4}'[t]+$$
$$4\,\mathrm{It}\,\mathrm{mt}\,\mathrm{q4}'[t]+2\,\mathrm{ltb}^2\,\mathrm{mb}\,\mathrm{mt}\,\mathrm{q4}'[t]+4\,\mathrm{lta}^2\,\mathrm{ms}\,\mathrm{mt}\,\mathrm{q4}'[t]+$$
$$4\,\mathrm{lta}\,\mathrm{ltb}\,\mathrm{ms}\,\mathrm{mt}\,\mathrm{q4}'[t]+4\,\mathrm{ltb}^2\,\mathrm{ms}\,\mathrm{mt}\,\mathrm{q4}'[t]+$$
$$2\,\mathrm{ltb}^2\,\mathrm{mt}^2\,\mathrm{q4}'[t]-2\,\mathrm{lsb}\,\mathrm{lta}\,\mathrm{ms}^2\,\mathrm{Cos}[\mathrm{q1}[t]-\mathrm{q4}[t]]\,\mathrm{q4}'[t]-$$
$$2\,\mathrm{lsb}\,\mathrm{ltb}\,\mathrm{ms}^2\,\mathrm{Cos}[\mathrm{q1}[t]-\mathrm{q4}[t]]\,\mathrm{q4}'[t]-$$
$$2\,\mathrm{lsb}\,\mathrm{ltb}\,\mathrm{ms}\,\mathrm{mt}\,\mathrm{Cos}[\mathrm{q1}[t]-\mathrm{q4}[t]]\,\mathrm{q4}'[t]-$$
$$2\,\mathrm{lta}^2\,\mathrm{ms}^2\,\mathrm{Cos}[\mathrm{q2}[t]-\mathrm{q4}[t]]\,\mathrm{q4}'[t]-4\,\mathrm{lta}\,\mathrm{ltb}\,\mathrm{ms}^2\,\mathrm{Cos}[\mathrm{q2}[t]-\mathrm{q4}[t]]\,\mathrm{q4}'[t]-$$
$$2\,\mathrm{ltb}^2\,\mathrm{ms}^2\,\mathrm{Cos}[\mathrm{q2}[t]-\mathrm{q4}[t]]\,\mathrm{q4}'[t]-4\,\mathrm{lta}\,\mathrm{ltb}\,\mathrm{ms}\,\mathrm{mt}\,\mathrm{Cos}[\mathrm{q2}[t]-\mathrm{q4}[t]]\,\mathrm{q4}'[t]-$$
$$4\,\mathrm{ltb}^2\,\mathrm{ms}\,\mathrm{mt}\,\mathrm{Cos}[\mathrm{q2}[t]-\mathrm{q4}[t]]\,\mathrm{q4}'[t]-2\,\mathrm{ltb}^2\,\mathrm{mt}^2\,\mathrm{Cos}[\mathrm{q2}[t]-\mathrm{q4}[t]]\,\mathrm{q4}'[t]+$$
$$\mathrm{lb}\,\mathrm{lta}\,\mathrm{mb}\,\mathrm{ms}\,\mathrm{Cos}[\mathrm{q3}[t]-\mathrm{q4}[t]]\,\mathrm{q4}'[t]+\mathrm{lb}\,\mathrm{ltb}\,\mathrm{mb}\,\mathrm{ms}\,\mathrm{Cos}[\mathrm{q3}[t]-\mathrm{q4}[t]]\,\mathrm{q4}'[t]+$$
$$\mathrm{lb}\,\mathrm{ltb}\,\mathrm{mb}\,\mathrm{mt}\,\mathrm{Cos}[\mathrm{q3}[t]-\mathrm{q4}[t]]\,\mathrm{q4}'[t]+2\,\mathrm{lsb}\,\mathrm{lta}\,\mathrm{mb}\,\mathrm{ms}\,\mathrm{Cos}[\mathrm{q4}[t]-\mathrm{q5}[t]]\,\mathrm{q4}'[t]+$$
$$2\,\mathrm{lsb}\,\mathrm{ltb}\,\mathrm{mb}\,\mathrm{ms}\,\mathrm{Cos}[\mathrm{q4}[t]-\mathrm{q5}[t]]\,\mathrm{q4}'[t]+2\,\mathrm{lsb}\,\mathrm{lta}\,\mathrm{ms}^2\,\mathrm{Cos}[\mathrm{q4}[t]-\mathrm{q5}[t]]\,\mathrm{q4}'[t]+$$
$$2\,\mathrm{lsb}\,\mathrm{ltb}\,\mathrm{ms}^2\,\mathrm{Cos}[\mathrm{q4}[t]-\mathrm{q5}[t]]\,\mathrm{q4}'[t]+4\,\mathrm{lsb}\,\mathrm{lta}\,\mathrm{ms}\,\mathrm{mt}\,\mathrm{Cos}[\mathrm{q4}[t]-\mathrm{q5}[t]]\,\mathrm{q4}'[t]+$$
$$2\,\mathrm{lsb}\,\mathrm{ltb}\,\mathrm{ms}\,\mathrm{mt}\,\mathrm{Cos}[\mathrm{q4}[t]-\mathrm{q5}[t]]\,\mathrm{q4}'[t]+2\,\mathrm{Is}\,\mathrm{mb}\,\mathrm{q5}'[t]+$$
$$4\,\mathrm{Is}\,\mathrm{ms}\,\mathrm{q5}'[t]+2\,\mathrm{lsb}^2\,\mathrm{mb}\,\mathrm{ms}\,\mathrm{q5}'[t]+2\,\mathrm{lsb}^2\,\mathrm{ms}^2\,\mathrm{q5}'[t]+4\,\mathrm{Is}\,\mathrm{mt}\,\mathrm{q5}'[t]+$$
$$4\,\mathrm{lsb}^2\,\mathrm{ms}\,\mathrm{mt}\,\mathrm{q5}'[t]-2\,\mathrm{lsb}^2\,\mathrm{ms}^2\,\mathrm{Cos}[\mathrm{q1}[t]-\mathrm{q5}[t]]\,\mathrm{q5}'[t]-$$
$$2\,\mathrm{lsb}\,\mathrm{lta}\,\mathrm{ms}^2\,\mathrm{Cos}[\mathrm{q2}[t]-\mathrm{q5}[t]]\,\mathrm{q5}'[t]-2\,\mathrm{lsb}\,\mathrm{ltb}\,\mathrm{ms}^2\,\mathrm{Cos}[\mathrm{q2}[t]-\mathrm{q5}[t]]\,\mathrm{q5}'[t]-$$
$$2\,\mathrm{lsb}\,\mathrm{ltb}\,\mathrm{ms}\,\mathrm{mt}\,\mathrm{Cos}[\mathrm{q2}[t]-\mathrm{q5}[t]]\,\mathrm{q5}'[t]+\mathrm{lb}\,\mathrm{lsb}\,\mathrm{mb}\,\mathrm{ms}\,\mathrm{Cos}[\mathrm{q3}[t]-\mathrm{q5}[t]]\,\mathrm{q5}'[t]+$$
$$2\,\mathrm{lsb}\,\mathrm{lta}\,\mathrm{mb}\,\mathrm{ms}\,\mathrm{Cos}[\mathrm{q4}[t]-\mathrm{q5}[t]]\,\mathrm{q5}'[t]+2\,\mathrm{lsb}\,\mathrm{ltb}\,\mathrm{mb}\,\mathrm{ms}\,\mathrm{Cos}[\mathrm{q4}[t]-\mathrm{q5}[t]]\,\mathrm{q5}'[t]+$$
$$2\,\mathrm{lsb}\,\mathrm{lta}\,\mathrm{ms}^2\,\mathrm{Cos}[\mathrm{q4}[t]-\mathrm{q5}[t]]\,\mathrm{q5}'[t]+2\,\mathrm{lsb}\,\mathrm{ltb}\,\mathrm{ms}^2\,\mathrm{Cos}[\mathrm{q4}[t]-\mathrm{q5}[t]]\,\mathrm{q5}'[t]+$$
$$\left.4\,\mathrm{lsb}\,\mathrm{lta}\,\mathrm{ms}\,\mathrm{mt}\,\mathrm{Cos}[\mathrm{q4}[t]-\mathrm{q5}[t]]\,\mathrm{q5}'[t]+2\,\mathrm{lsb}\,\mathrm{ltb}\,\mathrm{ms}\,\mathrm{mt}\,\mathrm{Cos}[\mathrm{q4}[t]-\mathrm{q5}[t]]\,\mathrm{q5}'[t]\Big),\ \mathrm{n}\right\}$$

```
JacWhole = HurGetJacobian[COMWhole, n, n][[1 ;; 2, ;;]] // Simplify;
JacWhole // MatrixForm
```

$$\begin{pmatrix} -\frac{(\mathrm{lsb}\,(\mathrm{mb}+\mathrm{ms}+2\,\mathrm{mt})+\mathrm{lsa}\,(\mathrm{mb}+2\,(\mathrm{ms}+\mathrm{mt})))\,\mathrm{Cos}[\mathrm{q1}[t]]}{\mathrm{mb}+2\,(\mathrm{ms}+\mathrm{mt})} & -\frac{(\mathrm{ltb}\,(\mathrm{mb}+\mathrm{ms}+\mathrm{mt})+\mathrm{lta}\,(\mathrm{mb}+\mathrm{ms}+2\,\mathrm{mt}))\,\mathrm{Cos}[\mathrm{q2}[t]]}{\mathrm{mb}+2\,(\mathrm{ms}+\mathrm{mt})} & -\frac{\mathrm{lb}\,\mathrm{mb}\,\mathrm{Cos}[\mathrm{q3}[t]]}{2\,(\mathrm{mb}+2\,(\mathrm{ms}+\mathrm{mt}))} & (\mathrm{l} \\ -\frac{(\mathrm{lsb}\,(\mathrm{mb}+\mathrm{ms}+2\,\mathrm{mt})+\mathrm{lsa}\,(\mathrm{mb}+2\,(\mathrm{ms}+\mathrm{mt})))\,\mathrm{Sin}[\mathrm{q1}[t]]}{\mathrm{mb}+2\,(\mathrm{ms}+\mathrm{mt})} & -\frac{(\mathrm{ltb}\,(\mathrm{mb}+\mathrm{ms}+\mathrm{mt})+\mathrm{lta}\,(\mathrm{mb}+\mathrm{ms}+2\,\mathrm{mt}))\,\mathrm{Sin}[\mathrm{q2}[t]]}{\mathrm{mb}+2\,(\mathrm{ms}+\mathrm{mt})} & -\frac{\mathrm{lb}\,\mathrm{mb}\,\mathrm{Sin}[\mathrm{q3}[t]]}{2\,(\mathrm{mb}+2\,(\mathrm{ms}+\mathrm{mt}))} & (\mathrm{l} \end{pmatrix}$$

```
HurToJulia[JacWhole]
```

```
[-1*((mb+2*(ms+mt)))^(-1)*(lsb*(mb+(ms+2*mt))+lsa*(mb+2*(ms+mt)))*cos(q1)
  -1*((mb+2*(ms+mt)))^(-1)*(ltb*(mb+(ms+mt))+lta*(mb+(ms+2*mt)))*cos(q2)
  -1/2*lb*mb*((mb+2*(ms+mt)))^(-1)*cos(q3)
  ((mb+2*(ms+mt)))^(-1)*(lta*ms+ltb*(ms+mt))*cos(q4)
  lsb*ms*((mb+2*(ms+mt)))^(-1)*cos(q5);-1*((mb+2*(ms+mt)))^(-1)*(lsb*(mb+(ms+2*mt))
  )+lsa*(mb+2*(ms+mt)))*sin(q1)
  -1*((mb+2*(ms+mt)))^(-1)*(ltb*(mb+(ms+mt))+lta*(mb+(ms+2*mt)))*sin(q2)
  -1/2*lb*mb*((mb+2*(ms+mt)))^(-1)*sin(q3)
  ((mb+2*(ms+mt)))^(-1)*(lta*ms+ltb*(ms+mt))*sin(q4)
  lsb*ms*((mb+2*(ms+mt)))^(-1)*sin(q5)]
```

```
NJacWhole = NullSpace[JacWhole] // Simplify;
NJacWhole // MatrixForm (*I should expect 3 5D column vectors. It'
  s weird that Mathematica gives 3x5 matrix, not 5x3 matrix. Anyway,
 a vector with 5 element is the basis vector for the null space.*)
```

$$\begin{pmatrix} -\frac{lsb\,ms\,Csc[q1[t]-q2[t]]\,Sin[q2[t]-q5[t]]}{lsb\,(mb+ms+2\,mt)+lsa\,(mb+2\,(ms+mt))} & \frac{lsb\,ms\,Csc[q1[t]-q2[t]]\,Sin[q1[t]-q5[t]]}{ltb\,(mb+ms+mt)+lta\,(mb+ms+2\,mt)} & 0 & 0 \\ -\frac{(lta\,ms+ltb\,(ms+mt))\,Csc[q1[t]-q2[t]]\,Sin[q2[t]-q4[t]]}{lsb\,(mb+ms+2\,mt)+lsa\,(mb+2\,(ms+mt))} & \frac{(lta\,ms+ltb\,(ms+mt))\,Csc[q1[t]-q2[t]]\,Sin[q1[t]-q4[t]]}{ltb\,(mb+ms+mt)+lta\,(mb+ms+2\,mt)} & 0 & 1 \\ \frac{lb\,mb\,Csc[q1[t]-q2[t]]\,Sin[q2[t]-q3[t]]}{2\,(lsb\,(mb+ms+2\,mt)+lsa\,(mb+2\,(ms+mt)))} & -\frac{lb\,mb\,Csc[q1[t]-q2[t]]\,Sin[q1[t]-q3[t]]}{2\,(ltb\,(mb+ms+mt)+lta\,(mb+ms+2\,mt))} & 1 & 0 \end{pmatrix}$$

```
JacWhole.HurList2Column[NJacWhole[[1, ;;]]] // Simplify
```

```
{{0}, {0}}
```

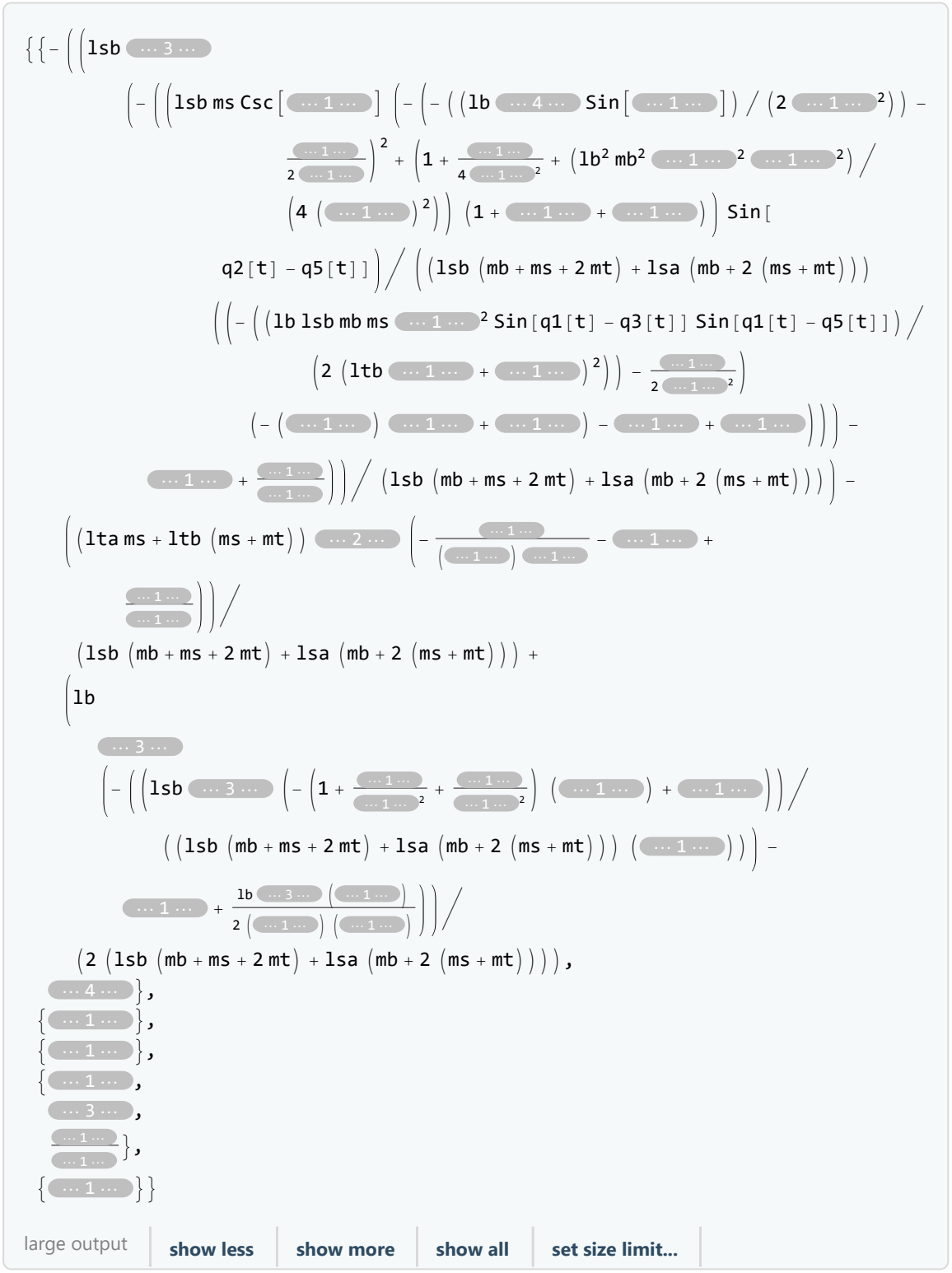
```
Nmat = Transpose[NJacWhole];
Nmat // MatrixForm
```

$$\begin{pmatrix} -\frac{lsb\,ms\,Csc[q1[t]-q2[t]]\,Sin[q2[t]-q5[t]]}{lsb\,(mb+ms+2\,mt)+lsa\,(mb+2\,(ms+mt))} & -\frac{(lta\,ms+ltb\,(ms+mt))\,Csc[q1[t]-q2[t]]\,Sin[q2[t]-q4[t]]}{lsb\,(mb+ms+2\,mt)+lsa\,(mb+2\,(ms+mt))} & \frac{lb\,mb\,Csc[q1[t]-q2} \\ \frac{lsb\,ms\,Csc[q1[t]-q2[t]]\,Sin[q1[t]-q5[t]]}{ltb\,(mb+ms+mt)+lta\,(mb+ms+2\,mt)} & \frac{(lta\,ms+ltb\,(ms+mt))\,Csc[q1[t]-q2[t]]\,Sin[q1[t]-q4[t]]}{ltb\,(mb+ms+mt)+lta\,(mb+ms+2\,mt)} & -\frac{lb\,mb\,Csc[q1[t]-q2} \\ 0 & 0 & \\ 0 & 1 & \\ 1 & 0 & \end{pmatrix}$$

```
HurToJulia[Nmat]
```

```
[-1*lsb*ms*((lsb*(mb+(ms+2*mt))+lsa*(mb+2*(ms+mt))))^(-1)*csc((q1+-1*q2))*sin((q2+
  -1*q5))
  -1*(lta*ms+ltb*(ms+mt))*((lsb*(mb+(ms+2*mt))+lsa*(mb+2*(ms+mt))))^(-1)*csc((q1+-
  1*q2))*sin((q2+-1*q4))
  1/2*lb*mb*((lsb*(mb+(ms+2*mt))+lsa*(mb+2*(ms+mt))))^(-1)*csc((q1+-1*q2))*sin((q2
  +-1*q3));lsb*ms*((ltb*(mb+(ms+mt))+lta*(mb+(ms+2*mt))))^(-1)*csc((q1+-1*q2))*sin
  ((q1+-1*q5))
  (lta*ms+ltb*(ms+mt))*((ltb*(mb+(ms+mt))+lta*(mb+(ms+2*mt))))^(-1)*csc((q1+-1*q2)
  )*sin((q1+-1*q4))
  -1/2*lb*mb*((ltb*(mb+(ms+mt))+lta*(mb+(ms+2*mt))))^(-1)*csc((q1+-1*q2))*sin((q1+
  -1*q3));0 0 1;0 1 0;1 0 0]
```

Projector = Nmat.Inverse[Transpose[Nmat].Nmat].Transpose[Nmat]



large output | show less | show more | show all | set size limit...

Projector[[1, 1]] // Simplify

$Aborted

```
HurSaveData["data1.m", "FootST", "ShankSTCOM", "KneeST", "ThighSTCOM",
 "Hip", "TorsoCOM", "ThighSWCOM", "KneeSW", "ShankSWCOM", "FootSW", "dyn1",
 "dyn2", "dyn3", "dyn4", "dyn5", "stepLength", "stepHeight", "verticalVel",
 "horizontalVel", "JacFootSW", "COMWhole", "LinearMomentumWholeBody",
 "LinearMomentumRateWholeBody", "JacWhole", "NJacWhole", "invans"]

HurGetRelativeDCM[a, n] // MatrixForm // Simplify
HurGetRelativeDCM[b, a] // MatrixForm // Simplify
HurGetRelativeDCM[c, b] // MatrixForm // Simplify
HurGetRelativeDCM[d, c] // MatrixForm // Simplify
HurGetRelativeDCM[e, d] // MatrixForm // Simplify
HurGetRelativeDCM[e, n] // MatrixForm // Simplify
```

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

$$\begin{pmatrix} \text{Cos}[q1[t]-q2[t]] & \text{Sin}[q1[t]-q2[t]] & 0 \\ -\text{Sin}[q1[t]-q2[t]] & \text{Cos}[q1[t]-q2[t]] & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

$$\begin{pmatrix} \text{Cos}[q2[t]-q3[t]] & \text{Sin}[q2[t]-q3[t]] & 0 \\ -\text{Sin}[q2[t]-q3[t]] & \text{Cos}[q2[t]-q3[t]] & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

$$\begin{pmatrix} \text{Cos}[q3[t]-q4[t]] & \text{Sin}[q3[t]-q4[t]] & 0 \\ -\text{Sin}[q3[t]-q4[t]] & \text{Cos}[q3[t]-q4[t]] & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

$$\begin{pmatrix} \text{Cos}[q4[t]-q5[t]] & \text{Sin}[q4[t]-q5[t]] & 0 \\ -\text{Sin}[q4[t]-q5[t]] & \text{Cos}[q4[t]-q5[t]] & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

$$\begin{pmatrix} \text{Cos}[q5[t]] & -\text{Sin}[q5[t]] & 0 \\ \text{Sin}[q5[t]] & \text{Cos}[q5[t]] & 0 \\ 0 & 0 & 1 \end{pmatrix}$$